Casing and Tubing

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Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the standard.

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

Can: As used in a standard, “can” denotes a statement of possibility or capability.

In the interests of worldwide application of this standard, 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 or the ASTM International. 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.

In this standard, data are expressed in both the International System of Units (SI) and the United States customary (USC) 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, conformance with the requirements of this standard as expressed in one system provides conformance with requirements expressed in the other system. In the text, data in SI units are followed by data in USC units in parentheses.

See Annex A of API Specification Q1 or the API website for information pertaining to the API Monogram Program and use of the API Monogram on applicable products, or for information about the Monogram licensing program, please contact certification@api.org.

For API Monogram Program licensees and APIQR program registrants, this edition and any normative references (see Section 2) shall become effective on the program date printed on the cover but may be used voluntarily from the date of publication.

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Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every 5 years. A one-time extension of up to 2 years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

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

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Casing and Tubing

1 Scope

1.1 Coverage

This standard specifies the technical delivery conditions for steel pipes (casing, tubing, and pup joints), coupling stock, coupling material, and accessory material.

For products covered by this standard, the sizes, masses, and wall thicknesses, as well as grades and applicable end-finishes, are provided. API 5L pipe may be ordered as casing in accordance with API 5C6.

By agreement between the purchaser and the manufacturer, this standard can also be applied to other plain-end pipe sizes and wall thicknesses.

1.2 Applicability—Connections

This standard is applicable to the following connections in accordance with API 5B:

— short round thread casing (SC);

— long round thread casing (LC);

— buttress thread casing (BC);

— non-upset tubing (NU);

— external upset tubing (EU);

— integral tubing (IJ).

For such connections, this standard specifies the technical delivery conditions for couplings and thread protection. Supplementary requirements (SRs) that can optionally be agreed upon for enhanced leak resistance connections (LC) are provided.

This standard also can be applied to products with connections not covered by API standards.

This standard is not applicable to threading requirements.

NOTE Dimensional requirements on threads and thread gauges, stipulations on gauging practice, gauge specifications, and instruments and methods for inspection of threads are given in API 5B.

1.3 Applicability—Grades

The products to which this standard is applicable include the following grades: H40, J55, K55, N80 (all types), L80 (all types), C90, R95, T95, P110, C110, and Q125. In this standard, when the symbol L80 is used alone, it is applicable to Grades L80 Type 1, L80 3Cr, L80 9Cr, and L80 13Cr; when the symbol N80 is used alone, it is applicable to Grades N80 Type 1 and N80Q.

Caution—Any sulfide stress cracking (SSC) test performed as part of this standard is for quality control purposes only and does not qualify the material for any specific sour service application. NACE MR0175/ISO 15156 provides guidelines for material selection in H_2S (sour) service environment for resistance to cracking; however, grades are not necessarily immune to cracking under all service conditions. It is the product user's responsibility to ensure that the product is suitable for the intended application with consideration of all environmental degradation threats during both normal operation and system upsets.

1.4 Supplementary Requirements

SRs that may be specified by the purchaser or agreed between the purchaser and the manufacturer for nondestructive examination (NDE), coupling blanks, upset casing, electric-welded pipe, impact testing and shear area, seal-ring couplings, tensile testing, SSC testing, supplemental inspection, straightening requirements, yield strength of Grade Q125, hardenability, hardness testing, and wall thickness measurement are provided.

1.5 Eligibility for Licensed/Registered Industry Mark

Products manufactured in accordance with this standard are eligible for marking with a licensed/registered industry mark, at the option of the manufacturer or if required by the purchaser.

NOTE Refer to Foreword for information regarding the API Monogram Program.

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 addenda or errata) applies.

API Recommended Practice 5A3, *Thread Compounds for Casing, Tubing, Line Pipe, and Drill Stem Elements*

API Specification 5B, *Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

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

ASNT SNT-TC-1A [1], *Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370 [2], *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 B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM E4, *Standard Practices for Force Calibration and 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 E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*

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

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

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

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1 American Society for Nondestructive Testing, 1201 Dublin Road, Columbus, Ohio 43215, www.asnt.org.

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

ASTM E273, *Standard Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing*

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

ASTM E543, *Standard Specification for Agencies Performing Nondestructive Testing*

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

ASTM E3024, *Standard Practice for Magnetic Particle Testing for General Industry*

IADC [3]/SPE [4] 11396, Dale B.A., Moyer M.C., Sampson T.W., *A Test Program for the Evaluation of Oilfield Thread Protectors,* IADC/SPE Drilling Conference, New Orleans, Louisiana, February 1983

ISO 643 [5], *Steels—Micrographic determination of the apparent grain size*

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

ISO 6506-2, *Metallic materials—Brinell hardness test—Part 2: Verification and calibration of testing machines*

ISO 6508-1, *Metallic materials—Rockwell hardness test—Part 1: Test method*

ISO 6508-2, *Metallic materials—Rockwell hardness test—Part 2: Verification and calibration of testing machines and indenters*

ISO 6892-1, *Metallic materials—Tensile testing—Part 1: Method of test at room 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 8501-1, *Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

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

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

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

ISO 10400, *Petroleum and natural gas industries—Formulae and calculations for the properties of casing, tubing, drill pipe and line pipe used as casing or tubing*

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*

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3 International Association of Drilling Contractors, 3657 Briarpark Drive #200, Houston, Texas 77042, www.iadc.org.

4 Society of Petroleum Engineers, 222 Palisades Creek Drive, Richardson, Texas 75080, www.spe.org.

5 International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

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*

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 10893-11, *Non-destructive testing of steel tubes—Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

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

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

ISO 80000-1, *Quantities and units—Part 1: General*

NACE TM0177-2016 [6], *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments*

3 Terms, Definitions, Symbols, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1
accessory material
Seamless casing or tubing, or seamless thick-walled tubes or mechanical tubes, or bar stock or hot forgings used for the manufacture of accessories.

3.1.2
API threads
Threads as specified in API 5B.

3.1.3
arc burn
Localized point of surface melting caused by arcing between an electrode or ground (earth) and the product surface.

NOTE Contact marks, which are intermittent marks adjacent to the weld seam of electric-welded process (EW) pipe resulting from electrical contact between the electrodes supplying the welding current and the pipe surface, or contact marks resulting from the use of a spectrometer for the detection of steel chemical composition, are not arc burns.

3.1.4
carload
Quantity of product loaded on a railway car for shipment from the product-making facilities.

[6] Association for Materials Protection and Performance (formerly the National Association of Corrosion Engineers), 15835 Park Ten Place, Houston, Texas 77084, www.ampp.org.

3.1.5
casing
Pipe run from the surface and intended to line the walls of a drilled well.

3.1.6
connection
Threaded assembly of tubular components.

3.1.7
controlled cooling
Cooling from an elevated temperature in a predetermined manner to avoid hardening, cracking, or internal damage or to produce a desired microstructure or mechanical properties.

3.1.8
coupling
Internally threaded cylinder for joining two lengths of threaded pipe.

3.1.9
coupling blank
Unthreaded material used to produce an individual coupling.

3.1.10
coupling material
Thick-walled seamless tube used to manufacture coupling blanks.

NOTE The main difference between coupling material and coupling stock is that coupling material has no mandatory NDE inspection requirements (see 9.15); see Section 8 for mandatory NDE requirements for finished couplings.

3.1.11
coupling stock
Coupling material that meets the coupling stock requirements.

3.1.12
defect
Imperfection of sufficient magnitude to warrant rejection of the product based on criteria defined in this standard.

3.1.13
electric-welded pipe
Pipe having one longitudinal seam formed by electric-resistance or electric-induction welding, without the addition of filler metal, wherein the edges to be welded are mechanically pressed together and the heat for welding is generated by the resistance to flow of electric current.

3.1.14
full-body
Complete cross-section of the product.

3.1.15
full-length
Complete length of the product (end to end).

3.1.16
handling tight
Sufficiently tight so that the coupling cannot be removed except by the use of a wrench.

3.1.17
heat
Metal produced by a single cycle of a batch melting process.

3.1.18
heat analysis
Chemical analysis representative of a heat as reported by the metal producer.

3.1.19
imperfection
Discontinuity in the product wall or on the product surface that can be detected by an NDE method included in this standard.

NOTE See Table C.37 or Table E.37.

3.1.20
inspection
Process of measuring, examining, testing, gauging, or otherwise comparing a unit of product with the applicable requirements.

3.1.21
inspection lot
Definite quantity of product manufactured under conditions that are considered uniform for the attribute to be inspected.

3.1.22
inspection lot sample
One or more units of product selected from an inspection lot to represent that inspection lot.

3.1.23
inspection lot size
Number of units of product in an inspection lot.

3.1.24
interrupted quenching
Quenching in which the product being quenched is removed from the quenching medium while the product is at a temperature substantially higher than that of the quenching medium.

3.1.25
Label 1
Dimensionless designation for the size or specified outside diameter that may be used when ordering pipe.

3.1.26
Label 2
Dimensionless designation for the mass per unit length that may be used when ordering pipe.

3.1.27
length
Piece of pipe that may be plain-end, threaded, or threaded and coupled, that is in accordance with the length requirements in this standard.

NOTE See Table C.22 or Table E.22.

3.1.28
linear imperfection
Imperfection that includes, but is not limited to, seams, laps, cracks, plug scores, cuts, and gouges.

NOTE See API 5T1.

3.1.29
machine vision technique
Automated system function of acquiring, processing, and analysing images to evaluate a test object or to provide information or interpretation for human interpretation.

NOTE 1 A typical machine vision system consists of a light source, video camera, video digitizer, computer, and an image display.

NOTE 2 This term and definition are consistent with the ASNT *Nondestructive Testing Handbook*, Volume 9 (Visual Testing), chapter on machine vision for visual testing.

3.1.30
manufacturer
One or more of the following, depending on the context: pipe mill, processor, threader, coupling manufacturer, pup joint manufacturer, and accessory manufacturer.

NOTE See Section 13.

3.1.31
nonlinear imperfection
Imperfection that includes, but is not limited to, pits and round-bottom die stamping.

NOTE See API 5T1.

3.1.32
pipe
Casing, tubing, and pup joints as a group.

3.1.33
pipe mill
Firm, company, or corporation that operates pipe-making facilities.

3.1.34
plain-end pipe
Pipe, either upset or non-upset, furnished without threads.

3.1.35
processor
Firm, company, or corporation that operates facilities capable of heat-treating products made by a pipe mill.

3.1.36
product
Pipe, coupling, coupling stock, coupling material, coupling blank, or accessory material, either individually or collectively as applicable.

3.1.37
product test block
Test block removed from the product, the tensile test specimen, or through-wall hardness test ring.

3.1.38
pup joint
Casing or tubing of length shorter than Range 1.

NOTE See Table C.22 or Table E.22.

3.1.39
pup joint material
Casing or tubing, or thick-wall tubes or mechanical tubes, or bar stock used for the manufacture of pup joints.

3.1.40
purchaser
Party responsible for the definition of requirements for a product order and payment for that order.

3.1.41
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.

3.1.42
seamless
Wrought steel tubular product made without a weld seam.

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

3.1.43
skelp
Hot-rolled steel strip used for manufacturing EW pipe.

3.1.44
special end-finish
Threads with thread form and features, manufacturing specifications, dimensions, connection make-up, and performance properties that are beyond the scope of this standard or types of threaded end-finish not covered by Table C.1 or Table E.1 and Table C.2 or Table E.2.

3.1.45
standardized test block
Test block, certified to a mean hardness number, used for the verification of the performance of hardness testing machines.

3.1.46
target chemical composition
Minimum and maximum concentrations for all elements intentionally added or controlled, regardless of the purpose of the addition, of the chemistry code (steel types or grades) of the manufacturer.

3.1.47
test assembly (assemblies)
Assembly that consists of a pin with a protector or a box with a protector used for testing thread protectors, in accordance with the requirements of Annex F.

3.1.48
thread protector
Cap or insert used to protect threads and seals during handling, transportation, and storage.

3.1.49
tubing
Pipe placed in a well to produce or inject fluids.

3.1.50
upper critical temperature
Temperature at which austenite begins to transform to ferrite during cooling.

3.2 Symbols

Ar_3 upper critical temperature

B_f maximum bearing face diameter

C_v Charpy V-notch impact test minimum absorbed energy

D specified outside diameter for pipe

d calculated inside diameter

F_{ax} axial force

k constant used in the calculation of elongation

S_c minimum acceptable result of the NACE TM0177-2016 Method B test

t specified wall thickness

W specified outside diameter for regular couplings with API threads

W_c specified outside diameter of special clearance couplings with API threads

Ys_{max} specified maximum yield strength

Ys_{min} specified minimum yield strength

3.3 Acronyms and Abbreviations

BC API 5B buttress thread casing connection

CVN Charpy V-notch

EDI electronic data interchange

EMI electromagnetic inspection

ET eddy current testing

EU API 5B external upset tubing connection

EW electric-welded process

HBW Brinell hardness, when testing with a tungsten carbide ball

HRC Rockwell hardness C-scale

IJ API 5B integral tubing connection

LC API 5B long round thread casing connection

MT magnetic particle testing

N (heat-treat process) full-body, full-length normalized

N&T normalized and tempered

NDE nondestructive examination

NU API 5B non-upset tubing connection

PE unthreaded pipe either upset or non-upset

RC regular coupling

SC API 5B short round thread casing connection

SCC special clearance coupling

SF special end-finish

SI International System of Units

SR supplementary requirement

SSC sulfide stress cracking

USC United States customary

UT ultrasonic testing

4 Information to Be Supplied by the Purchaser

4.1 Ordering Products According to This Standard

Subsections 4.2 (casing), 4.3 (tubing), and 4.4 (coupling stock, coupling material, and accessory material) describe items that should be specified in the purchase order. In each subsection, the first table describes mandatory items for the purchaser to specify, the second table describes items that are optional for the purchaser to specify, and the third table describes items that are subject to agreement between the purchaser and the manufacturer (in 4.4, a simple list replaces a table for these items).

NOTE For casing sizes larger than Label 1: 4 1/2 but smaller than Label 1: 10 3/4 can be specified by the purchaser to be used in tubing service; see Tables C.1, C.18, C.22, and C.23 or Tables E.1, E.18, E.22, and E.23.

4.2 Casing

4.2.1 When inquiring or placing orders for pipe manufactured in accordance with this standard, the manufacturer shall obtain from the purchaser the following according to Table 1.

Table 1—Purchaser-supplied Information (Casing)

Requirement	Reference
Standard	API 5CT
Quantity	
Type of pipe or couplings	
Casing:	
Threaded or plain-end	7.12.1, Table C.1 or Table E.1
Type of connection: SC, LC or BC, or other connection	7.12.2, 7.12.6, Table C.1 or Table E.1
With or without couplings	7.12.2, Table C.1 or Table E.1
Special clearance couplings—BC	8.6, Tables C.1, C.28 or Tables E.1, E.28
Special clearance couplings with special bevel—BC	8.6
Label 1 or specified outside diameter	Table C.1 or Table E.1
Label 2 or specified mass or wall thickness	Table C.1 or Table E.1
Grade and type where applicable	Tables C.1, C.4 or Tables E.1, E.4
Length	7.6, Table C.22 or Table E.22
Seamless or electric-welded	5.1, Table C.3 or Table E.3
Critical thickness for SF couplings, stock, or blanks	6.3.2
Delivery date and shipping instructions	
Inspection by the purchaser	Annex B
For all Grades except L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 63.5 mm (2.5 in.)	Table C.14 or Table E.14
For Grade L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 35.6 mm (1.4 in.)	Table C.14 or Table E.14

4.2.2 When specified in a purchase order, the optional requirements in Table 2 shall apply.

Table 2—Optional Requirements Specified by the Purchaser (Casing)

Requirement	Reference
Heat treatment	5.2, Table C.3 or Table E.3
Hot rotary straightening minimum temperature—Grades L80, C90, T95, R95, P110, and Q125	5.3.2, 5.3.3, A.14 (SR 42)
Traceability for Grades other than C110 and Q125	5.4.1
Yield strength for Grade Q125	6.2.3, A.15 (SR 43)
Impact test minimum percent shear area for Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125	6.3.3, A.16 (SR 44)
Minimum percentage martensite required for quenched and tempered products for Grades L80 Type 1, C90, and T95	6.10.2, A.17 (SR 45)
Lower alternative impact test temperature	9.7.5
Impact testing for Grades N80, L80, R95, C90, T95, and P110	6.5.2, A.9 (SR 16)
Impact testing for Grades H40, J55, and K55	6.5.1, A.9 (SR 16)
SSC test requirements for Grades C90 and T95	6.14.2, 9.10.2, A.18 (SR 46)
SSC test method(s) and test solution(s) for Grade C110	6.14, 9.10, A.11 (SR 39)
Casing jointers SC and LC	7.7
Alternative drifting requirements	7.10
Casing with couplings detached	7.14
Coupling make-up (other than power-tight)	7.14
Coupling grade	8.2
Seal-ring couplings	8.8, A.8 (SR 13)
Heat and supplementary analyses	9.3
Frequency of hardness testing for non-upset, Grades C90 and T95	9.6.4, A.19 (SR 47)
Wall thickness measurement for 100 % coverage	9.13.4, A.21 (SR 49)
NDE of pipe ends (all Grades)	9.15.13, A.20 (SR 48)
Additional markings	1.5, 10
Pipe coatings	11.1
Alternative grades or heat treatments of coupling	8.2
Combination couplings	8.7
Class A or customer-supplied thread protectors	11.2.1

4.2.3 Upon agreement between the purchaser and the manufacturer, the additional casing requirements in Table 3 shall apply.

Table 3—Purchaser/Manufacturer Agreement (Casing)

Requirement	Reference
Upset—Grade C110	5.1
Statistical tensile testing	6.2.4, A.10 (SR 38)
Statistical impact testing	9.7.6, A.7 (SR 12)
Impact of non-heat-treated product	6.5.1, A.9 (SR 16)
SSC test acceptance criteria	6.14.4
SSC test Method D requirement for Grade C110 product over 50.8 mm (2.0 in.) wall thickness	6.14.4, Table 13
Length other than specified in Table C.22 or Table E.22	7.6
End shaping of Grade C90 and higher strength	7.12.4
Surface treatment of C110 threads	7.12.5
Thread and storage compound	7.14
Waiving NDE of Grades H40, J55, K55 couplings	8.11.3
Coupling thread surface treatment Grade Q125 only	8.14
Reduced section tensile specimens Grade Q125	9.4.6
Additional hardness testing	9.6.2
Number of specimens for NACE Method A Grades C90, T95, and C110	9.10.2
Test specimen selection and location	9.10.4
Invalidation of test for Method D mechanical compliance	9.10.6
Alternative hydrostatic test pressures	9.12.3
Plain-end Grade Q125 casing hydrostatic testing	9.12.2
NDE	9.15, A.2 (SR 1), A.3 (SR 2), A.5 (SR 10), A.6 (SR 11)
Marking requirements	10
Marking only with bands on Grade L80 3Cr couplings and pup joints with surface treatment	10.4.2–10.4.5
Driftable thread protectors	11.2.4
Include coupling certification with pipe certification	12.3 r)
Special wall thickness with S, L, and B end-finish	Table C.1 or Table E.1, footnote [e]; see API 5B for acceptable wall thickness ranges
Coupling blanks Grade Q125 only	8.4.2, A.4 (SR 9)
Upset casing Grade Q125 only	A.5 (SR 10)
Electric-weld casing and pup joints Grades H40, J55, K55, N80, L80 Type 1, R95	A.12 (SR 40)
Electric-weld casing and pup joints Grades P110 and Q125	5.1, A.6 (SR 11)
Alternative F factor for statistical impact testing	A.7.2 (SR 12.2)
Special size and wall thickness plain-end pipe	7.2
Supplemental inspection when hydrostatic test pressure is limited to 69.0 MPa (10,000 psi)	A.13.1 (SR 41.1), A.13.2 (SR 41.2)

4.3 Tubing

4.3.1 When inquiring or placing orders for pipe manufactured in accordance with this standard, the manufacturer shall obtain from the purchaser the following according to Table 4.

Table 4—Purchaser-supplied Information (Tubing)

Requirement	Reference
Standard	API 5CT
Quantity	
Type of pipe or couplings	
Tubing:	
Non-upset, external upset, or integral joint	Table C.2 or Table E.2
Threaded, plain-end, or other connection	7.12
With or without couplings	7.12
Regular couplings with special bevel NU, EU	8.9, Tables C.19, C.29, and C.35 or Tables E.19, E.29, and E.30
Special clearance couplings—EU	8.6, Tables C.19 and C.30 or Tables E.19 and E.30
Label 1 or specified outside diameter	Table C.2 or Table E.2
Label 2 or specified mass or wall thickness	Table C.2 or Table E.2
Grade and type, where applicable	Table C.2 or Table E.2, Table C.4 or Table E.4
Length	7.6, Table C.22 or Table E.22
Seamless or electric-welded	5.1, Table C.3 or Table E.3
Critical thickness for SF couplings	6.3.2
Delivery date and shipping instructions	
Inspection by the purchaser	Annex B
For all Grades except L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 63.5 mm (2.5 in.)	Table C.14 or Table E.14
For Grade L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 35.6 mm (1.4 in.)	Table C.14 or Table E.14

4.3.2 When specified in a purchase order, the optional requirements in Table 5 shall apply.

Table 5—Optional Requirements Specified by the Purchaser (Tubing)

Requirement	Reference
Heat treatment	5.2, Table C.3 or Table E.3
Hot rotary straightening minimum temperature—Grades L80, C90, T95, R95, and P110	5.3.2, 5.3.3, A.14 (SR 42)
Traceability for Grades other than C110 and Q125	5.4.1
Impact test minimum percent shear area for Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125	6.3.3, A.16 (SR 44)
Minimum percentage martensite required for quenched and tempered products for Grades L80 Type 1, C90, and T95	6.10.2, A.17 (SR 45)
Lower alternative impact test temperature	9.7.5
Impact testing for Grades N80, L80, R95, C90, T95, and P110	6.5.2, A.9 (SR 16)
Impact testing for Grades H40 and J55	6.5.1, A.9 (SR 16)
SSC test requirements for Grades C90 and T95	6.14.2, 9.10.2, A.18 (SR 46)
Alternative drift requirements	7.10
Extended-length upset	7.11.6
Rounded nose for EU	7.12.3
Coupling make-up (other than power-tight)	7.14
Tubing with couplings detached	7.14
Coupling grade	8.2
Alternative grades or heat treatments of coupling	8.2
Combination couplings	8.7
Seal-ring couplings	8.8, A.8 (SR 13)
Heat and supplementary analyses	9.3
Additional hardness testing	9.6.2
Frequency of hardness testing for non-upset, Grades C90 and T95	9.6.4, A.19 (SR 47)
Wall thickness measurement for 100 % coverage	9.13.4, A.21 (SR 49)
NDE of pipe ends (all Grades)	9.15.13, A.20 (SR 48)
Additional markings	1.5, 10
Pipe coatings	11.1
Class A or customer-supplied thread protectors	11.2.1

4.3.3 Upon agreement between the purchaser and the manufacturer, the tubing requirements in Table 6 shall apply.

Table 6—Purchaser/Manufacturer Agreement (Tubing)

Requirement	Reference
Statistical tensile test	6.2.4, A.10 (SR 38)
Statistical impact testing	9.7.6, A.7 (SR 12)
Impact testing of non-heat-treated product	6.5.1, A.9 (SR 16)
SSC test acceptance criteria	6.14.4
Length other than specified in Table C.22 or Table E.22	7.6
End shaping of Grade C90 and higher strength	7.12.4
Thread and storage compound	7.14
Waiving NDE of Grades H40, J55, K55 couplings	8.11.3
Additional hardness testing	9.6.2
Number of specimens for NACE Method A Grades C90 and T95	9.10.2
Test specimen selection and location	9.10.4
Invalidation of test for Method D mechanical compliance	9.10.6
Alternative hydrostatic test pressures	9.12.3
NDE	9.15, A.2 (SR 1), A.3 (SR 2), A.5 (SR 10), and A.6 (SR 11)
Marking requirements	10
Marking only with bands on Grade L80 3Cr couplings and pup joints with surface treatment	10.4.2 to 10.4.5
Driftable thread protectors	11.2.4
Include coupling certification with pipe certification	12.3 r)
Electric-weld tubing and pup joints—Grades H40, J55, K55, N80, L80 Type 1, R95	A.12 (SR 40)
Supplemental inspection when hydrostatic test pressure is limited to 69.0 MPa (10,000 psi)	A.13.1 (SR 41.1), A.13.2 (SR 41.2)
Electric-weld tubing and pup joints—Grade P110	A.6 (SR 11)
Special size and wall thickness	7.2
Casing used for tubing	7.2, Table C.22 or Table E.22

4.4 Coupling Stock, Coupling Material, and Accessory Material

4.4.1 When inquiring or placing orders for coupling stock, coupling material or accessory material manufactured in accordance with this standard, the manufacturer shall obtain from the purchaser the following according to Table 7.

4.4.2 When specified in a purchase order, the optional requirements in Table 8 shall apply.

4.4.3 Upon agreement between the purchaser and the manufacturer, the following requirement regarding coupling stock and material and accessory material shall apply:

— SSC test Method D requirement for Grade C110 product over 50.8 mm (2.0 in.) wall thickness according to 6.14.4 (Table 13).

Table 7—Purchaser-supplied Information (Coupling Stock and Material and Accessory Material)

Requirement	Reference
Standard	API 5CT
Quantity	
Kind of product: coupling stock, coupling material, or accessory material	
Traceability for Grades other than C110 and Q125	5.4.1
Yield strength for Grade Q125	6.2.3, A.15 (SR 43)
Impact test minimum percent shear area for Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125	6.3.3, A.16 (SR 44)
Minimum percentage martensite required for quenched and tempered products for Grades L80 Type 1, C90, and T95	6.10.2, A.17 (SR 45)
SSC test requirements for Grades C90 and T95	6.14.2, 9.10.2, A.18 (SR 46)
SSC test method(s) and test solution(s) for Grade C110	6.14, 9.10, A.11 (SR 39)
Outside diameter and tolerances	7.2
Wall thickness and tolerances	7.2
Straightness tolerance	7.9.2
Length	7.6
Grade and type, where applicable	Tables C.3 and C.4 or Tables E.3 and E.4
Impact requirements or critical thickness	6.4
Inspection by the purchaser	Annex B
Critical thickness for SF accessory material	6.3.2
Wall thickness verification of SF accessory material	9.13.4
NDE of product ends (all Grades)	9.15.13, A.20 (SR 48)
Delivery date and shipping instructions	
For all Grades except L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 63.5 mm (2.5 in.)	Table C.14 or Table E.14
For grade L80 13 Cr, impact test minimum absorbed energy requirement in wall thickness greater than 35.6 mm (1.4 in.)	Table C.14 or Table E.14

Table 8—Optional Requirements Specified by the Purchaser (Coupling Stock and Material and Accessory Material)

Requirement	Reference
Heat treatment	5.2, Table C.3 or Table E.3
Statistical tensile testing	6.2.4, A.10 (SR 38)
Statistical impact testing	9.7.6, A.7 (SR 12)
Impact testing	6.4, 9.7, A.9 (SR 16)
SSC test acceptance criteria	6.14.4
Heat and supplementary analyses	9.3
Number of specimens for NACE Method A Grades C90, T95, and C110	9.10.2
Test specimen selection and location	9.10.4
Invalidation of test for Method D mechanical compliance	9.10.6
Additional markings	1.5, 10

5 Process of Manufacture

5.1 General

The product furnished to this standard shall be made to a fine-grain practice. Steel made to a fine-grain 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.

Pipe furnished to this standard shall be made by the seamless or electric-weld process as shown in Table C.3 or Table E.3 and as specified in the purchase agreement. Pup joints shall be made from the materials listed in 3.1.39. Material for couplings, coupling stock, and coupling material shall be manufactured by the seamless process.

Accessory material for casing and tubing shall be seamless unless otherwise specified in the purchase agreement.

Electric-welded Grade P110 pipe and Grade Q125 casing shall be provided only when the SR in A.6 (SR 11) is specified in the purchase agreement.

Grade C110 product shall not be upset unless agreed between the purchaser and the manufacturer.

Grade Q125 upset casing shall be provided only when the SR in A.5 (SR 10) is specified in the purchase agreement.

5.2 Heat Treatment

5.2.1 General

Product shall be heat-treated in accordance with a documented procedure as stipulated in Table C.3 or Table E.3 for the particular grade and type specified in the purchase agreement. Product requiring heat treatment shall be heat-treated full-body, full-length. When heat-treated, upset product shall be heat-treated full-body, full-length after upsetting. Individually heat-treated coupling blanks are acceptable. All pipe processed through a hot-stretch mill (i.e. stretch-reduced) shall be considered normalized, provided the exit temperature is above the upper critical temperature (Ar_3) for the steel being processed and the pipe is air-cooled.

Cold-drawn tubular products without appropriate heat treatment shall not be provided.

The weld seam of electric-welded pipe shall be heat-treated after welding to a minimum temperature of 540 °C (1000 °F) or processed in such a manner that no untempered martensite remains.

NOTE In addition to the terms and definitions given in Section 3, users seeking more information about heat treatment operations may refer to the terms and definitions in ASTM A941.

5.2.2 Grades J55, K55, N80, and R95

For Grade J55 and K55 products, heat treatment is not mandatory. A heat treatment, consistent with Table C.3 footnote [b] or Table E.3 footnote [b], shall be applied if specified in the purchase agreement or may be applied at the manufacturer's option. For upset products, heat treatment shall be applied after upsetting.

Grade N80 Type 1 product shall be normalized or, at the manufacturer's option, shall be normalized and tempered. Grade N80Q product shall be quenched and tempered.

Grade R95 product shall be quenched and tempered.

5.2.3 Grades L80, C90, T95, and C110

When requested by the purchaser, the manufacturer shall produce evidence to show that the tempering practice will result in the pipe attaining the minimum tempering temperature.

Tempering Grade L80 13Cr at a temperature below 620 °C (1150 °F) shall be permitted only if all product satisfies 6.3, 6.4.4, 6.5.2, and 9.7.

5.3 Straightening

5.3.1 General

Straightening shall be performed using a documented procedure, and for cold straightening the process shall be validated (see 5.5).

5.3.2 Grades H40, J55, K55, N80, R95, and P110

No specific methods are required.

Optional requirements for Grades R95 and P110 are specified in A.14 (SR 42).

5.3.3 Grade L80

When straightening is necessary, product may be hot rotary straightened or cold straightened. If hot rotary straightened, the minimum temperature at the exit of rotary straightening shall be 480 °C (900 °F), unless a higher minimum temperature is specified in the purchase agreement. If cold rotary straightened, then the product shall be stress relieved after straightening. The minimum temperature for stress relieving shall be 480 °C (900 °F). For gag straightening, see 5.3.6.

5.3.4 Grades C90, T95, and C110

When straightening is necessary, product may be hot rotary straightened or cold straightened. If hot rotary straightened, the minimum temperature at the exit of rotary straightening shall not be more than 165 °C (300 °F) below the final specified tempering temperature. If cold rotary straightened, then the product shall be stress relieved after straightening. The stress relief temperature shall be 30 °C to 55 °C (50 °F to 100 °F) below the final specified tempering temperature. For gag straightening, see 5.3.6.

5.3.5 Grade Q125

When straightening is necessary, product may be hot rotary straightened or cold straightened. If hot rotary straightened, the minimum temperature at the exit of rotary straightening shall be 400 °C (750 °F), unless a higher minimum temperature is specified in the purchase agreement. If cold rotary straightened, then the product shall be stress relieved after straightening. The minimum stress relief temperature shall be 510 °C (950 °F). For gag straightening, see 5.3.6.

5.3.6 Gag Straightening

When gag straightening is used, stress relieving after straightening shall be required only if the maximum fiber strain is greater than the value established by the manufacturer during process validation (see 5.5). When stress relieving is required, the minimum stress relieving temperature for cold rotary straightening of that grade shall apply, as specified in 5.3.2, 5.3.3, or 5.3.4. The amount of fiber strain shall be calculated using Equation (1):

$$\varepsilon = 6Dy / L^2 \tag{1}$$

where (see Figure D.15)

ε is the outer fiber strain;

D is the specified outside diameter for product;

y is the maximum deflection distance;

L is the distance between straightener product supports.

5.4 Traceability

5.4.1 General

The manufacturer shall establish and follow procedures for maintaining heat or lot identity, or both, until all required heat or lot tests, or both, are performed and conformance with specification requirements has been shown.

For C110, Q125, and for other Grades when specified in the purchase agreement, the procedures shall provide a means of tracing the product to the proper heat and lot and to all applicable chemical and mechanical test results.

5.4.2 Serialization of Grades C90, T95, C110, and Q125

The serial number shall be marked on products as specified below. Identification of the material shall be maintained until it is received by the purchaser.

Each length of pipe shall be uniquely numbered so that test data can be related to individual lengths. In addition, when SR A.7 (SR 12) is specified, the number shall identify the sequence in which the lengths were tempered in order to allow retest in accordance with A.7.3 (SR 12.3).

Each length of coupling stock, coupling material, coupling blank, pup joint, or accessory material shall be uniquely numbered so that test data can be related to individual lengths. When cut from material that has been heat-treated full-body, full-length, the pieces shall be marked with the serial number of the full-length piece. When heat-treated in coupling blank or individual lengths, each heat-treat lot (see 9.2.3) shall be uniquely numbered. Additionally, when coupling blanks, or pup joints or accessory material in individual lengths, are heat-treated as a unit in a continuous process-run, the pieces within the lot shall be sequentially numbered in the order in which they are heat-treated.

5.5 Processes Requiring Validation

5.5.1 Final operations performed during product manufacturing that affect attribute conformance as required in this standard (except chemical composition and dimensions) shall have their processes validated.

Those processes requiring validation are as follows:

a) for seamless, as-rolled product: final reheating practice and hot sizing or stretch-reducing; if applicable, upsetting, cold-working;

b) for seamless, heat-treated product: heat treatment;

c) for electric-welded, as-rolled product: sizing and seam welding; if applicable, seam heat treatment and upsetting;

d) for electric-welded, heat-treated product: seam welding and full-body, full-length heat treatment;

e) cold straightening, unless subsequently heat treated.

5.5.2 Validation of cold straightening shall address the range of product manufactured and the method used. Validation shall include verification of mechanical properties (tensile, impact, and hardness as applicable for the product) at the middle and both ends. Validation of gag straightening shall also include validation of mechanical properties in the tension region of the extrados with the highest possible induced fiber strain (see Figure D.15).

6 Material Requirements

6.1 Chemical Composition

Product shall conform to the requirements specified in Table C.4 or Table E.4 for the grade and type specified.

For Grades C90, T95, and C110, the manufacturer shall inform the purchaser at the time of inquiry of the minimum and maximum concentrations for all elements intentionally added to each heat, regardless of the purpose of the addition.

6.2 Tensile Properties

6.2.1 General

Product shall conform to the tensile requirements specified in Table C.5 or Table E.5.

The tensile properties of upset casing and tubing, except elongation of the upset ends, shall conform to the requirements given for the pipe body. In case of dispute, the properties (except elongation) of the upset shall be determined from a tensile test specimen cut from the upset. Records of such tests shall be available to the purchaser.

6.2.2 Elongation

The minimum elongation, e, expressed in percent, shall be calculated as given by Equation (2):

$$e = k \times (A^{0.2} / U^{0.9}) \tag{2}$$

where

e is the minimum gauge length extension in 50.8 mm (2.0 in.), expressed in percent, rounded to the nearest 0.5 % below 10 % and to the nearest unit percent for 10 % and larger;

k is a constant: 1942.57 (625,000);

A is the cross-sectional area of the tensile test specimen, expressed in square millimeters (square inches), based on specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 10 mm^2 (0.01 $in.^2$), or 490 mm^2 (0.75 $in.^2$), whichever is smaller;

U is the minimum specified tensile strength, in megapascals (pounds per square inch).

The minimum elongation for both round bar tensile specimens [8.9 mm (0.350 in.) diameter with 35.6 mm (1.40 in.) gauge length and 12.7 mm (0.500 in.) diameter with 50.8 mm (2.0 in.) gauge length] shall be determined using an area A of 130 mm^2 (0.20 $in.^2$).

Table C.6 or Table E.6 gives minimum elongation values for various sizes of tensile specimens and for various grades.

6.2.3 Yield Strength

The yield strength shall be the tensile stress required to produce the elongation under load specified in Table C.5 or Table E.5 as determined by an extensometer.

NOTE See A.15 (SR 43) for optional requirements for Grade Q125.

6.2.4 Statistical Tensile Testing—Grades C90, T95, and C110

By agreement between the purchaser and the manufacturer, the SRs for statistical tensile testing of Grades C90, T95, and C110 in A.10 (SR 38) shall apply.

6.3 Charpy V-notch Test—General Requirements

6.3.1 Absorbed Energy

A test shall consist of a set of three specimens taken from one location from a single tubular product length. The average value of the three impact specimens shall equal or exceed the absorbed energy requirement specified in 6.4, 6.5, and 6.6. 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 two-thirds of the minimum average absorbed energy requirement.

The absorbed energy requirements are based on the critical thickness (see 6.3.2).

6.3.2 Critical Thickness

The critical thickness for couplings with API threads is defined as the thickness at the root of the thread at the middle of the coupling, based on the specified coupling diameter and the specified thread dimensions. For coupling stock and coupling material where the critical thickness is not specified in the purchase agreement, the critical thickness shall be the specified wall thickness of this coupling stock or coupling material and not of the corresponding pipe. The critical thickness for all couplings with API threads is provided in Table C.7 or Table E.7. For pipe, the critical thickness is the specified wall thickness.

For accessory material and SF material, unless otherwise specified in the purchase agreement:

a) the critical thickness for determining the impact energy requirements shall be based on the thickness of the cross-section of the accessory that has the lowest t/D ratio, where D is the specified outside diameter and t is the calculated wall thickness at that section;

b) for an accessory with API internal threads, the critical thickness for these API threads shall be as shown in Table C.7 or Table E.7, and D shall be the specified outside diameter of the connection as specified in 8.4 and 8.6;

c) for SF connections, the critical thickness for externally threaded members shall be the specified pipe body thickness, whereas for internally threaded members, the critical thickness shall be the calculated thickness of the internally threaded member at the plane of the small end of the pin (when the connection is made up power-tight).

6.3.3 Shear Area

For all Grades other than C110, shear area is not required unless the purchase agreement specifies A.16 (SR 44).

For Grade C110, either:

a) the minimum shear area shall be 75 %, in accordance with ASTM E23; or

b) the manufacturer shall use a documented procedure (taking into account, as a minimum, variations in chemical composition, diameter, and wall thickness) together with the impact test results to demonstrate that the upper shelf behavior is achieved.

If the minimum shear area is less than 75 % or if the requirements of 6.3.3 b) are not met, then either the material shall be rejected or a transition curve shall be made to demonstrate that the product is on the upper shelf at the specified test temperature (either the standard test temperature or a reduced test temperature specified by the purchaser; see 9.7.5).

NOTE See A.16 (SR 44) for optional shear area requirements for Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125.

6.4 Charpy V-notch—Absorbed Energy Requirements for Coupling Stock, Coupling Material, Coupling Blanks, and Couplings

6.4.1 General

Coupling stock, coupling material, and coupling blanks suitable for more than one type of connection may be qualified by a test to demonstrate conformance to the most stringent requirements. The test specimen orientation and size shall be the highest possible listed on the hierarchy in Table C.9 or Table E.9, and the absorbed energy requirement shall equal or exceed the applicable requirements.

6.4.2 Grade H40

There is no mandatory Charpy V-notch (CVN) impact energy requirement, unless A.9 (SR 16) is specified by the purchaser.

6.4.3 Grades J55 and K55

The minimum full-size transverse absorbed energy requirement C_V shall be 20 J (15 ft·lb) for all wall thicknesses. The minimum full-size longitudinal absorbed energy requirement C_V shall be 27 J (20 ft·lb) for all wall thicknesses.

6.4.4 Grades N80, R95, L80, C90, T95, P110, C110, and Q125

The minimum absorbed energy requirements, C_V, for full-size test specimens shall be calculated based on the equations in Table 9,

where

Ys_{max} is the specified maximum yield strength for the grade evaluated, in megapascals (thousand pounds per square inch);

t is the critical wall thickness, in millimeters (inches), based on the specified dimensions for couplings.

Table 9—Full-size Test Specimen Minimum Absorbed Energy Requirements (Grades N80, R95, L80, C90, T95, P110, C110, and Q125)

Unit System	Transverse Requirement C_V	Longitudinal Requirement C_V
SI units, joules	$Ys_{max} \times (0.00118t + 0.01259)$ or Table C.12, whichever is greater up to the maximum thickness in Table C.12	$Ys_{max} \times (0.00236t + 0.02518)$ or Table C.13, whichever is greater
USC units, foot-pounds	$Ys_{max} \times (0.152t + 0.064)$ or Table E.12, whichever is greater up to the maximum thickness in Table E.12	$Ys_{max} \times (0.304t + 0.128)$ or Table E.13, whichever is greater

6.5 Charpy V-notch—Absorbed Energy Requirements for Pipe

6.5.1 Grades H40, J55, and K55

There is no mandatory CVN impact requirement, unless A.9 (SR 16) is specified by the purchaser.

6.5.2 Grades N80, R95, L80, C90, T95, and P110

The requirements shall be calculated based on the equations given in Table 10,

where

Ys_{min} is the specified minimum yield strength, in megapascals (thousand pounds per square inch);

t is the specified wall thickness, in millimeters (inches).

Table 10—Full-size Test Specimen Minimum Absorbed Energy Requirements (Grades N80, R95, L80, C90, T95, and P110)

Unit System and Grade	Transverse Requirement C_v	Longitudinal Requirement C_v
SI units, joules	$Ys_{min} \times (0.00118t + 0.01259)$ or Table C.14, whichever is greater	$Ys_{min} \times (0.00236t + 0.02518)$ or Table C.15, whichever is greater
USC units, foot-pounds	$Ys_{min} \times (0.152t + 0.064)$ or Table E.14, whichever is greater	$Ys_{min} \times (0.304t + 0.128)$ or Table E.15, whichever is greater

6.5.3 Grades C110 and Q125

The requirements shall be calculated based on the equations given in Table 11,

where

Ys_{max} is the specified maximum yield strength, in megapascals (thousand pounds per square inch);

t is the specified wall thickness, in millimeters (inches).

Table 11—Full-size Test Specimen Minimum Absorbed Energy Requirements (Grades C110 and Q125)

Unit System and Grade	Transverse Requirement C_v	Longitudinal Requirement C_v
SI units, joules	$Ys_{max} \times (0.00118t + 0.01259)$ or Table C.14, whichever is greater up to the maximum thickness in Table C.14	$Ys_{max} \times (0.00236t + 0.02518)$ or Table C.15 whichever is greater
USC units, foot-pounds	$Ys_{max} \times (0.152t + 0.064)$ or Table E.14 whichever is greater up to the maximum thickness in Table E.14	$Ys_{max} \times (0.304t + 0.128)$ or Table E.15, whichever is greater

6.5.4 Test Specimen

Table C.10 or Table E.10 for transverse specimens and Table C.11 or Table E.11 for longitudinal specimens provide the calculated wall thickness required to machine full-size, $^3/_4$-size, and $^1/_2$-size impact test specimens. The impact test specimen size that shall be selected from these tables is the largest impact test specimen having a calculated wall thickness that is less than the specified wall thickness for the pipe tested.

6.5.5 Testing Conditions

For Grades C110 and Q125 pipe, impact testing shall be performed in accordance with 9.7. For other grades, except Grades H40, J55, and K55 (which have no mandatory impact requirements for pipe), conformance with the requirements of 6.5.2 may be qualified by a documented procedure in lieu of testing, at the manufacturer's option, unless A.9 (SR 16) is specified in the purchase agreement, in which case testing shall be performed as specified in 9.7. Pipe qualified by a documented procedure that fails to show conformance to the specified impact energy requirements after shipment shall be rejected.

6.6 Charpy V-notch—Absorbed Energy Requirements for Accessory Material

For accessory material for accessories with internal threads, the requirements in 6.4 shall apply.

For accessory material for accessories with external threads, the requirements in 6.5 shall apply.

6.7 Maximum Hardness

6.7.1 Grades L80, C90, T95, and C110

a) Grades L80, C90, T95, and C110—Through-wall hardness.

The mean hardness numbers obtained shall conform to the requirements in Table C.5 or Table E.5. In addition, the following shall apply.

1) For L80, any mean hardness number not exceeding 23.0 HRC (Rockwell hardness C-scale) shall be acceptable. If any hardness number from a single indentation exceeds 24.0 HRC, the length or piece shall be rejected.

2) For Grades C90 and T95, any mean hardness number not exceeding 25.4 HRC shall be acceptable. If any hardness number from a single indentation exceeds 27.0 HRC, the length or piece shall be rejected. Products with mean hardness numbers between 25.4 HRC and 27.0 HRC shall be retested.

3) For Grade C110, any mean hardness number not exceeding 29.0 HRC shall be acceptable. If any hardness number from a single indentation exceeds 31.0 HRC, the length or piece shall be rejected. Products with mean hardness numbers between 29.0 HRC and 31.0 HRC shall be retested.

b) Grades C90, T95, and C110—Surface hardness (when required in accordance with 9.6).

For Grades C90 and T95, the Brinell or Rockwell C-scale hardness number shall not exceed 255 HBW (Brinell hardness) or 25.4 HRC, respectively. If any of the hardness numbers are over 255 HBW or 25.4 HRC, two additional indentations may be made in the immediate area. If either of the second test hardness numbers exceeds 255 HBW or 25.4 HRC, the length or piece shall be rejected.

For Grade C110, the Brinell or Rockwell C-scale hardness number shall not exceed 279 HBW or 29.0 HRC, respectively. If any of the hardness numbers are over 279 HBW or 29.0 HRC, two additional indentations may be made in the immediate area. If either of the second test hardness numbers exceeds 279 HBW or 29.0 HRC, the piece shall be rejected.

c) Grades C90 and T95—Alternative maximum hardness requirements.

By agreement between the purchaser and the manufacturer, the maximum mean hardness numbers may be altered from those stated above, based on sulfide stress corrosion cracking tests specified in 6.14.

6.7.2 Grade Q125

No maximum mean hardness number or maximum hardness number is required, but the maximum variation is restricted as a manufacturing control in accordance with 6.8 and 6.9.

6.8 Hardness Variation—Grades C90, T95, C110, and Q125

Material shall conform to the hardness variation requirements of Table C.5 or Table E.5. Hardness variation is defined as the difference between any two mean hardness numbers within one quadrant. This criterion shall not apply between specimens.

6.9 Process Control—Grades C90, T95, C110, and Q125

All individually heat-treated coupling blanks, pup joints, or accessory material shall be surface hardness tested to verify process control. For Grades C90, T95, and C110, the surface hardness test results shall be used in the selection of the pieces for through-wall hardness testing. The process-control hardness test results need not be provided by the manufacturer or processor unless specified in the purchase agreement.

6.10 Hardenability—Minimum Percentage Martensite for Quenched and Tempered Products

6.10.1 Grade L80 3Cr

For each size, mass, chemical composition, and austenitize-and-quench combination, a through-wall hardness test shall be made on products after quenching and prior to tempering for each production run to characterize the hardening response. These tests shall be made on the body of products or, in the case of accessory material, shall be made in the design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness as determined by Equation (3) or Equation (4):

$$\text{For (\% carbon)} < 0.15: \quad HRC_{\text{min}} = [97 \times (\text{\% carbon})] + 21.15 \tag{3}$$

or

$$\text{For (\% carbon)} \geq 0.15: \quad HRC_{\text{min}} = [58 \times (\text{\% carbon})] + 27 \tag{4}$$

If agreed between the purchaser and the manufacturer, an alternative hardenability requirement for products with a wall thickness of 30 mm (1.181 in.) or larger shall be permitted.

NOTE Equation (3) was derived from data on low-carbon steels as producing an adequate quenching for the grade.

6.10.2 Grades C90 and T95

For each size, mass, chemical composition, and austenitize-and-quench combination, a through-wall hardness test shall be made on products after quenching and prior to tempering for each production run to characterize the hardening response. These tests shall be made on the body of products or, in the case of upset products or accessory material, shall be made in the upset or design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to a minimum of 90 % martensite, as determined by Equation (5):

$$HRC_{\text{min}} = [58 \times (\text{\% carbon})] + 27 \tag{5}$$

NOTE Equation (5) was derived from data in Reference [10]. Based on these data, Equation (5) is valid from 0.15 % carbon to 0.50 % carbon.

See A.17.2 (SR 45.2) for optional hardenability requirements for Grades C90 and T95.

Alternative hardenability requirements shall be permitted for thick-walled Grades C90 and T95 as defined in 6.10.5.

6.10.3 Grade C110

For each size, mass, chemical composition, and austenitize-and-quench combination, a through-wall hardness test shall be made after quenching and prior to tempering for each production run. These tests shall be made on the body of products or, in the case of accessory material, shall be made in the design

area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to 95 % minimum martensite as determined by Equation (6):

$$HRC_{\text{min}} = [59 \times (\%\ \text{carbon})] + 29 \quad (6)$$

NOTE Equation (6) was derived from data in Reference [10]. Based on these data, Equation (6) is valid from 0.15 % carbon to 0.50 % carbon.

Alternative hardenability requirements shall be permitted for thick-walled Grade C110 as defined in 6.10.5.

6.10.4 Grades N80 Type Q, R95, L80 Type 1, L80 9Cr, L80 13Cr, P110, and Q125

For each size, mass, chemical composition, and austenitize-and-quench combination, a through-wall hardness test shall be made after quenching and prior to tempering as part of a documented procedure to confirm sufficient hardening. These tests shall be made on the body of products or, in the case of upset products or accessory material, shall be made in the upset or design area of greatest wall thickness. Mean hardness numbers shall equal or exceed the hardness corresponding to a minimum of 50 % martensite, as determined by Equation (7):

$$HRC_{\text{min}} = [52 \times (\%\ \text{carbon})] + 21 \quad (7)$$

See A.17.1 (SR45.1) for optional hardenability requirements for Grade L80 Type 1.

6.10.5 Validation Requirements for Thick-walled Grades C90, T95, and C110

6.10.5.1 General

Alternative hardenability requirements for thick-walled Grades C90, T95, and C110, defined as tubular product with a wall thickness of 30 mm (1.181 in.) or larger, shall be permitted. Alternative hardness requirements shall be qualified through validation testing of specific samples according to NACE TM0177-2016 and the chemical, mechanical, and SSC test requirements according to API 5CT [grade, SR (as applicable) and SSC test method(s)]. The validation report number and revision shall be reported in the certification of the material. The validation report shall be available to the purchaser upon request.

For product with wall thickness 30 mm (1.181 in.) or larger, the criteria for a passing validation shall be based on the SSC testing, lowest mean hardenability hardness result for the product chemical composition, lowest carbon content, and austenitize-and-quench combination in the validation.

6.10.5.2 Validation Criteria

Validation does not need to be performed again if production material meets the following criteria:

a) specified production material wall thickness shall not exceed the wall thickness utilized in validation;

b) same target chemical composition shall be used as the samples validated;

c) carbon content of the production material shall not fall below carbon content of validation material;

d) same austenitize-and-quench combination (i.e. continuous heat treatment, single or double heat treatment, OD or OD & ID quenching, etc.).

6.10.5.3 Validation Samples

Two validation samples shall be taken in the quenched and tempered condition from the same length and end of the piece with the following:

a) a sample shall be taken from the hardenability test location (outside-wall, mid-wall, and inside-wall) with the lowest mean as-quenched hardness;

b) a sample shall be taken from the quenched and tempered hardness location (outside-wall, mid-wall, and inside-wall) with the highest mean hardness result.

6.10.5.4 Validation Report

The validation report shall include the following:

a) report number and revision;

b) manufacturer name and location;

c) grade;

d) SR (as applicable);

e) heat number;

f) heat treat lot number;

g) product size and wall thickness;

h) product chemical composition [see 3.1.46, 6.10.5.2 b), and 6.10.5.2 c)];

i) austenitize-and-quench combination [see 6.10.5.2 d)];

j) tensile test results of the lot, according to 12.3 g);

k) impact test results of the lot, according to 12.3 h);

l) length and end identification of validation samples;

m) when NACE Method A is performed, the SSC tests performed (including specimen location) according to 12.3 l) shall be provided and reported;

n) when NACE Method D is performed, the SSC tests performed (including specimen location) according to 12.3 m) shall be provided and reported;

o) hardenability test results of validation samples (including Rockwell hardness numbers and mean hardness numbers, test type and criterion, and specimen location and orientation);

p) quenched and tempered hardness test results of validation samples (including Rockwell hardness numbers and mean hardness numbers, test type and criterion, and specimen location and orientation);

q) declaration of validation and validated criteria according to 6.10.5; validation conclusions and statement whether the validation passed or failed.

6.11 Grain Size—Grades C90, T95, and C110

Prior austenitic grain size shall be ASTM 5 or finer for Grades C90 and T95, and ASTM 6 or finer for Grade C110 (determined in accordance with ISO 643 or ASTM E112).

6.12 Surface Condition—Grades L80 9Cr and L80 13Cr

The internal surface of the pipe shall be free from scale after the final heat treatment.

All pipe shall be delivered with the internal surface grit blasted or pickled to meet the requirements for $S_a\,2\,{}^1/_2$ in. ISO 8501-1. Grit blasting shall be carried out using stainless steel, aluminum oxide grit, or other blasting media that do not cause surface iron contamination.

6.13 Flattening—Electric-welded Pipe

All products that are produced by the electric-weld process of manufacture shall be flattening-tested and shall meet the requirements shown in Table C.17 or Table E.17.

6.14 Sulfide Stress Cracking Test—Grades C90, T95, and C110

6.14.1 General Guidance

The purchaser should refer to NACE MR0175/ISO 15156-1 and ISO 15156-2 for guidance on the usage of Grades C90, T95, and C110. Particular attention should be given to the application of Grade C110 in NACE MR0175/ISO 15156-2 SSC Regions 2 or 3, as this material is not suitable for all sour (hydrogen sulfide-containing) service applications.

NOTE The SSC test is for quality control purposes only and does not qualify the material for any specific sour service application; it is the product user's responsibility to ensure that the product is suitable for the intended application.

6.14.2 SSC Test Methods—Grades C90, T95, and C110

The level of resistance to sulfide stress cracking shall satisfy the requirements in 6.14.4 using one or more of the following test methods as specified by the purchaser:

a) For Grades C90 and T95:

   1) uniaxial tensile method (Method A);

   2) bent-beam method (Method B);

   3) DCB method (Method D).

b) For Grade C110:

   1) uniaxial tensile method (Method A);

   2) DCB method (Method D).

6.14.3 Test Solution

The following solutions shall be used for the tests identified in 6.14.2:

a) Method A: NACE TM0177-2016, Solution A;

b) Method B: NACE TM0177-2016, Section 9.3.1; or

   NOTE The solution used for Method B is similar to Solution A for Method A but without the addition of NaCl.

c) Method D: NACE TM0177-2016, Solution A.

Where NACE TM0177-2016 requires documented validation of test solution saturation, then analysis stall be done using the iodometric titration procedure in NACE TM0177-2016—Appendix C or other validated and documented method.

An additional informative Method D (DCB) test may be specified according to A.11 (SR39) using NACE TM0177-2016 Solution D.

6.14.4 Minimum SSC Requirements

As specified by 9.2, for each lot of Grades C90, T95, and C110, manufacturers shall demonstrate that the product meets or exceeds the minimum SSC requirements described herein. If the purchaser requires an SSC requirement more stringent than the minimum, then agreement shall be reached between the purchaser and the manufacturer.

a) NACE TM0177-2016 Method A, Uniaxial Tensile.

For Method A, standard tensile test specimens shall be used except where subsize tensile specimens are required because of product dimensional constraints, when loaded to a stress level according to Table 12.

Table 12—NACE Method A Requirements for Tensile Test Specimens

Specimen Size	Yield Strength Percentage	Minimum Applied Stress
Standard (6.35 mm [0.250 in.] diameter) specimen	80 % of Ys_{min}	496 MPa (72,000 psi) for C90 524 MPa (76,000 psi) for T95
	85 % of Ys_{min}	644 MPa (93,500 psi) for C110
	90 % of Ys_{min}	559 MPa (81,000 psi) for C90, see A.18 (SR 46) 590 MPa (85,500 psi) for T95, see A.18 (SR 46)
Subsize (3.81 mm [0.150 in.] diameter) specimen	72 % of Ys_{min}	447 MPa (64,800 psi) for C90 472 MPa (68,400 psi) for T95
	76 % of Ys_{min}	576 MPa (83,600 psi) for C110
	81 % of Ys_{min}	503 MPa (72,900 psi) for C90, see A.18 (SR 46) 531 MPa (77,000 psi) for T95, see A.18 (SR 46)

b) NACE TM0177-2016 Method B, Bent Beam.

For Grades C90 and T95, the minimum acceptable result of the NACE TM0177-2016 Method B test, S_c, shall be as follows:

— S_c of 12.0, for C90;

— S_c of 12.6, for T95.

NOTE 1 The requirement for Method B is stated only in United States customary (USC) units, based on industry convention.

NOTE 2 There is no Method B requirement for Grade C110.

c) NACE TM0177-2016 Method D (DCB).

For Method D, standard specimens shall be used except where subsize DCB specimens can only be machined due to product dimensions. Acceptance criteria for standard specimens are stated in Table 13. When Method D subsize or alternative specimens are required, acceptance criteria shall be agreed upon by the purchaser and the manufacturer.

Table 13—NACE Method D Requirements for Standard Specimens

Minimum Requirement for DCB	C90 and T95	C110 [b]
Mean value (average of at least 3 valid specimens) [a]	33.0 MPa·m$^{1/2}$ (30.0 ksi·in.$^{1/2}$)	26.4 MPa·m$^{1/2}$ (24.0 ksi·in.$^{1/2}$)
Individual value	29.7 MPa·m$^{1/2}$ (27.0 ksi·in.$^{1/2}$)	23.1 MPa·m$^{1/2}$ (21.0 ksi·in.$^{1/2}$)

[a] All valid test results shall be included when calculating the mean value.

[b] For wall thickness greater than 50.8 mm (2 in.) for Grade C110, the requirements shall be according to these values, unless otherwise agreed upon between the purchaser and the manufacturer.

6.14.5 Invalidation of Tests

An SSC test shall be deemed invalid and a replacement test performed only when an assignable cause is identified and not simply because it fails to exhibit the minimum SSC requirement. Assignable causes include, but are not limited to, the following:

— test specimen machining defects;

— testing errors.

7 Dimensions, Masses, Tolerances, Product Ends, and Defects

7.1 Labels and Sizes

In the dimensional tables in this standard, pipe is designated by labels and by size (outside diameter). The outside diameter size of external upset pipe is the outside diameter of the body of the pipe, not the upset portion.

7.2 Dimensions and Masses

Pipe shall be furnished in the sizes, wall thicknesses and masses (as shown in Tables C.18 to C.21 inclusive, or Tables E.18 to E.21 inclusive) as specified in the purchase agreement. Other plain-end pipe sizes and wall thicknesses may be furnished by agreement between the purchaser and the manufacturer. By agreement between the purchaser and the manufacturer, casing with S, L, or B end-finishes may be furnished with intermediate wall thicknesses within the particular S, L, or B series of wall thicknesses and grade for the applicable Label 1 size specified in Table C.1 or Table E.1. See API 5B for acceptable pipe wall thickness ranges.

Coupling stock, coupling material, and accessory material shall be furnished in dimensions specified in the purchase agreement or, in the case of coupling material, the dimensions shall be specified in the manufacturer's internal requirements. Coupling stock and coupling material outside diameter and wall thickness combinations shall exclude those in Tables C.1 and C.2 or Tables E.1 and E.2.

Dimensions shown without tolerances are related to the basis for design and are not subject to measurement to determine acceptance or rejection of product.

Casing sizes larger than Label 1: 4 $^{1}/_{2}$ but smaller than Label 1: 10 $^{3}/_{4}$ may be specified by the purchaser to be used in tubing service; see Tables C.1, C.18, C.22, and C.23 or Tables E.1, E.18, E.22, and E.23.

The accuracy and/or condition of all measuring equipment used for acceptance or rejection, except ring-and-plug thread gauges and weighing devices, shall be verified at least once each operating shift as indicated below.

a) Adjustable gauges (gauges having a moving contact or indicator, such as micrometers and calipers): verify the condition and accuracy of measuring devices by inspection for wear and measurement conformance with established reference standard(s).

b) Nonadjustable gauges—High wear (gauges where friction occurs during measurement, such as drift mandrels): verify the accuracy and condition by inspection for wear and conformance to the specified dimensions.

c) Nonadjustable gauges—Low wear (gauges where friction does not occur as part of measurement, such as rules and length-measuring tapes): perform a visual check for the legibility of markings and general wear of fixed reference points.

d) Noncontact systems (such as optical or laser): verify the accuracy and function by checking measurement conformance with established reference standard(s).

NOTE Required verification is in addition to established equipment calibrations. If the established equipment calibration frequency is at least once each operating shift, this activity satisfies the requirements for verification.

The manufacturer shall document the measuring devices utilized as “adjustable,” “nonadjustable—high-wear,” “nonadjustable—low-wear,” or “noncontact.”

The verification procedure for working ring-and-plug thread gauges shall be documented. The accuracy of all weighing devices shall be verified at periods not to exceed those required by the manufacturer’s documented procedure in accordance with the National Institute of Standards and Technology standards or equivalent regulations in the country of manufacture of products made to this standard.

If measuring equipment whose calibration or verification is required under the provisions of this standard is subjected to unusual or severe conditions sufficient to make its accuracy questionable, recalibration or reverification shall be performed before further use of the equipment.

7.3 Diameter

7.3.1 Measurement

Measurement requirements are as follows.

a) Using International System of Units (SI) units.

   For sizes larger than Label 1: 6 $^{5}/_{8}$, the diameter shall be measured to one decimal place. For sizes smaller than or equal to Label 1: 6 $^{5}/_{8}$, the diameter shall be measured to two decimal places. In this standard, two decimal places are used to ensure interchangeability.

b) Using USC units.

   The diameter shall be measured to three decimal places.

7.3.2 Requirements

The outside diameter for pipe shall be within the tolerances specified in 7.11.1. For pipe furnished non-upset and plain-end and that is specified in the purchase agreement for the manufacture of pup joints, the non-upset plain-end tolerances shall apply to the full length.

For coupling stock, coupling material and accessory material outside diameter tolerances shall be specified in the purchase agreement or, in the case of coupling material and accessory material, the outside diameter tolerances shall be specified in the manufacturer’s internal requirements.

For threaded pipe, the outside diameter at the threaded ends shall be such that the total thread length, L_4, (excluding BC) and the full-crest thread length, L_c, shall be within the dimensions and tolerances specified in API 5B.

7.4 Wall Thickness

For pipe, the wall thickness at any place shall not be less than the specified thickness, t, minus the permissible under-tolerance specified in 7.11.2.

For coupling stock, coupling material, and accessory material, the wall thickness tolerance shall be specified in the purchase agreement or, in the case of coupling material and accessory material, the wall thickness shall be specified in the manufacturer’s internal requirements.

7.5 Mass

The masses determined as described in 9.13.7 shall conform to the calculated masses as specified herein (or adjusted calculated masses for martensitic chromium grades L80 9Cr or L80 13Cr) for the end-finish specified in the purchase agreement, within the tolerances stipulated in 7.11.3. Calculated masses shall be determined in accordance with Equation (8):

$$W_{\mathrm{L}} = [(w_{\mathrm{pe}})\,(L_{\mathrm{ef}}) + (e_{\mathrm{m}})]\,(k_{\mathrm{m}}) \tag{8}$$

where (according to API 5C3 or ISO 10400)

W_{L} is the calculated mass of a pipe of length L, in kilograms (pounds);

w_{pe} is the plain-end mass in kilograms per meter (pounds per foot);

L_{ef} is the length of pipe, including end-finish, in meters (feet), as defined in 7.6;

e_{m} is the mass gain due to end-finishing, in kilograms (pounds);

k_{m} is the mass correction factor: 1.000 for carbon steels; 0.989 for martensitic chromium steels.

7.6 Length

Unless otherwise agreed upon between the purchaser and the manufacturer, casing, tubing, and pup joints shall be furnished in lengths conforming to Table C.22 or Table E.22. The length of API couplings shall be as specified in Tables C.27 to C.30 or Tables E.27 to E.30 as applicable. The length of coupling stock, coupling material, and accessory material shall be as specified in the purchase agreement or, in the case of coupling material and accessory material, the length shall be specified in the manufacturer's internal requirements. The length of each finished product shall be determined for conformance to length requirements. Length determination shall be in meters and hundredths of a meter (feet and tenths of a foot).

The accuracy of length-measuring devices for lengths of product less than 30 m (100 ft) shall be ±0.03 m (±0.1 ft).

7.7 Casing Jointers

If specified in the purchase agreement, for round thread casing only, jointers (two pieces coupled to make a standard length) may be furnished to a maximum of 5 % of the order, but no length used in making a jointer shall be less than 1.52 m (5.0 ft).

7.8 Height and Trim of Electric-weld Flash

7.8.1 Trimming Electric-weld Flash

The outside flash of electric-welded pipe shall be trimmed to an essentially flush condition.

It shall be the aim of the manufacturer to provide an inside surface at the weld of electric-weld pipe that is:

a) reasonably close to flush after trimming;

b) contains no jagged edges from the original weld flash.

It may be desirable for the manufacturer to provide an inside surface at the trimmed weld with a slight groove to meet this aim. The inside flash of electric-welded pipe shall be trimmed as given in 7.8.2 and 7.8.3.

7.8.2 All Grades Except P110 and Q125

The height of the inside weld flash shall not exceed 1.14 mm (0.045 in.) for casing or casing pup joints or 0.38 mm (0.015 in.) for tubing or tubing pup joints, measured from the inside surface adjacent to the flash.

The depth of groove resulting from removal of the inside flash shall not be greater than the amount listed in Table 14 for the various wall thicknesses. Depth of groove is the difference between the wall thickness measured approximately 25 mm (1 in.) from the weld seam and the remaining wall under the groove.

Table 14—Electric-weld Flash Height and Trim (All Grades Except P110 and Q125)

Wall Thickness	Maximum Depth of Trim
3.84 mm to 7.64 mm (0.151 in. to 0.301 in.)	0.38 mm (0.015 in.)
≥ 7.64 mm (≥ 0.301 in.)	0.05 t

7.8.3 Grades P110 and Q125

No inside flash height shall be permitted. The groove on the inside weld surface shall not exceed a depth of 0.38 mm (0.015 in.) and shall not contain sharp corners that would interfere with ultrasonic inspection. Depth of groove is the difference between the wall thickness measured approximately 25 mm (1 in.) from the weld seam and the remaining wall under the groove.

7.8.4 Disposition

Pipe with weld flash exceeding the limits specified in 7.8.2 or 7.8.3, as applicable, shall be either rejected or repaired by grinding.

7.9 Straightness

7.9.1 Pipe

Deviation from straight or chord height shall not exceed the following:

a) Label 1: 4 $^1/_2$ and larger:

   1) 0.2 % of the total length measured from one end to the other end;

   2) 3.18 mm ($^1/_8$ in.) maximum drop in the 1.5 m (5.0 ft) length at each end; see Figure D.13 and Figure D.14.

b) Label 1: less than 4 $^1/_2$:

   1) no requirement for full length bow;

   2) 3.18 mm ($^1/_8$ in.) maximum drop in the 1.5 m (5.0 ft) length at each end;

   3) for upset ends, the measurement shall be taken using a minimum 1.8 m (6 ft) straight-edge shouldered on the pipe-body surface beyond the runout of the upset (reference L_a in Table C.20 or Table E.20 and see Figure D.16), or an equivalent method.

7.9.2 Coupling Stock, Coupling Material, and Accessory Material

Straightness requirements shall be as agreed upon between the purchaser and the manufacturer or, in the case of coupling material and accessory material, the straightness shall be specified in the manufacturer's internal requirements.

7.10 Drift Requirements

Each length of pipe shall be drift-tested throughout its entire length. Drift testing may be done plain end or in threaded condition. For API threaded products and SF products with couplings, if pipe has been drift-tested full-length before coupling installation, it shall also be drift-tested for a minimum distance of 0.6 m (24 in.) from the coupled end on casing and 1.1 m (42 in.) from the coupled end on tubing after coupling power-tight make-up and include any area potentially affected by the make-up equipment. Drift dimensions (length and diameter) shall conform to Table C.23 or Table E.23.

When specified by the purchaser as “alternative drift pipe”:

a) pipe in sizes and masses in Table C.24 or Table E.24 shall be tested with the alternative drift mandrels as shown, unless another size is specified in the purchase agreement;

b) pipe in sizes and masses not in Table C.24 or Table E.24 shall be tested with the alternative drift mandrels as specified in the purchase agreement.

Pipe that is drift-tested with the alternative drift mandrels shall be marked as described in Section 10.

7.11 Tolerances on Dimensions and Masses

7.11.1 Outside Diameter

The tolerances in Table 15 shall apply to the outside diameter, D, of pipe.

Table 15—Dimension Tolerances (Pipe OD)

Label 1	Tolerance on Outside Diameter, D
< 4 1/2	±0.79 mm (±0.031 in.)
≥ 4 1/2	$\frac{+1}{-0.5}$ %

For upset integral tubing connection, the tolerances in Table 16 shall apply to the outside diameter of the pipe body immediately behind the upset for a distance of approximately 127 mm (5.0 in.) for sizes Label 1: 5 1/2 and smaller, and a distance approximately equal to the outside diameter for sizes larger than Label 1: 5 1/2. Measurements shall be made with calipers or snap gauges.

Table 16—Dimension Tolerances (Upset Integral Tubing)

Label 1	Tolerances behind m_{eu} or L_0
≤ 3 1/2	$\frac{+2.38}{-0.79}$ mm ($\frac{+3/32}{-1/32}$ in.)
> 3 1/2 to ≤ 5	+2.78 mm to –0.75 % D (+7/64 in. to –0.75 % D)
> 5 to ≤ 8 5/8	+3.18 mm to –0.75 % D (+1/8 in. to –0.75 % D)
> 8 5/8	+3.97 mm to –0.75 % D (+5/32 in. to –0.75 % D)

For Label 1: 2 3/8 and larger EU tubing, the tolerances in Table 17 shall apply to the outside diameter at distance L_a (see Figure D.5) from the end of the pipe.

Changes in diameter between L_a and L_b shall be smooth and gradual. Pipe body, outside diameter tolerances do not apply for a distance of L_b from the end of the pipe.

Table 17—Dimension Tolerances (External Upset Tubing)

Label 1	Tolerances
≥ 2 $^{3}/_{8}$ to ≤ 3 $^{1}/_{2}$	$\frac{+2.38}{-0.79}$ mm ($\frac{+3/32}{-1/32}$ in.)
> 3 $^{1}/_{2}$ to ≤ 4	$\frac{+2.78}{-0.79}$ mm ($\frac{+7/64}{-1/32}$ in.)
> 4	+2.78 mm to –0.75 % D (+$^{7}/_{64}$ in. to –0.75 % D)

7.11.2 Wall Thickness

Tolerance for pipe shall be –12.5 %.

7.11.3 Mass

Table 18 identifies requirements for standard mass tolerances. When the specified minimum wall thickness is equal to or greater than 90 % of the specified wall thickness, the single length positive mass tolerance shall increase to +10 %.

Table 18—Standard Mass Tolerances

Amount	Tolerance
Single lengths	$\frac{+6.5}{-3.5}$ %
Carload 18,144 kg (40,000 lb) or more	–1.75 %
Carload less than 18,144 kg (40,000 lb)	–3.5 %
Order items 18,144 kg (40,000 lb) or more	–1.75 %
Order items less than 18,144 kg (40,000 lb)	–3.5 %

7.11.4 Inside Diameter

Inside diameter, d, shall be governed by the outside diameter and mass tolerances.

7.11.5 Upset Dimensions

Tolerances on upset dimensions shall be as specified in Tables C.20 and C.21 or Tables E.20 and E.21.

7.11.6 Extended-length Upsets

EU tubing may be ordered with extended-length upsets (L_{el}) as agreed upon between the purchaser and the manufacturer. A minimum of 95 % of the number of lengths (both ends) shall meet the L_{el} with the remaining balance meeting L_{eu} requirements, unless otherwise agreed upon between the purchaser and the manufacturer.

7.12 Product Ends

7.12.1 Plain-end Pipe

Plain-end pipe is pipe furnished unthreaded, either upset or non-upset, but conforming with all requirements of this standard for a particular grade, and shall be marked as specified in 10.5.2.

7.12.2 Product with API Threads

Product shall be furnished with one of the end-finishes specified in Tables C.1 and C.2 or Tables E.1 and E.2, as specified in the purchase agreement.

Additionally, seal-ring configuration in accordance with A.8 (SR 13) may be ordered.

Some items of Grades H40, J55, or K55 casing are available in either short or long thread forms (see Table C.1 or Table E.1). If long thread is desired on these items, the manufacturer shall obtain such information from the purchaser in the purchase agreement. Otherwise, short-thread casing in accordance with Table C.18 or Table E.18 shall be furnished.

7.12.3 Rounded Nose

In lieu of the conventional corner breaks on the threaded ends of EU tubing, the “round” or “bullet-nose” end may be supplied at the manufacturer’s option or may be specified by the purchaser. The modified end shall be rounded to provide for coatable service, and the radius transition shall be smooth with no sharp corners, burrs, or slivers on the inside-wall or outside-wall chamfer surfaces. See Figure D.6 for an illustration and dimensions. The dimensions in Figure D.6 are recommended values and are not subject to measurement to determine acceptance or rejection of the product.

7.12.4 Threading

Product threads, gauging practice, and thread inspection shall conform to the requirements of API 5B. Product ends shall not be rounded out by hammering but may be slightly shaped if required to secure conformance with threading requirements. For Grade C90 and higher-strength grades, this shaping shall be carried out only if agreed upon with the purchaser.

7.12.5 Workmanship of Ends

The inside and outside edges of the ends of all product shall be free of burrs.

For Grade C110, the pin and box threads shall be abrasive-blasted, unless processed by any appropriate technique, including the threading process, which has been agreed upon between the purchaser and the manufacturer to be sufficient to avoid the presence of material susceptible to detaching or causing galling during connection make-up.

7.12.6 Special End-finish

Pipe with end-finish not specified in this standard may be furnished if specified in the purchase agreement. This pipe shall have the body of the pipe manufactured in accordance with the requirements of this standard. When threaded by the pipe mill or processor, the pipe shall be marked as specified in 10.5.2.

Couplings and accessories with end-finish not specified in this standard may be furnished if specified in the purchase agreement. These items shall be manufactured in accordance with the requirements of this standard, except for end-finish and dimensions, and shall be marked as specified in 10.5.2.

When applying API 5B-conforming thread to products not listed in Table C.1 or Table E.1 and Table C.2 or Table E.2, the product shall be marked as specified in 10.5.2.

7.13 Defects

7.13.1 Pipe and Accessory Material from Pipe

Pipe and accessory material from pipe shall be free from the following defects:

a) quench crack;

b) arc burn;

c) surface-breaking imperfection that is proven to reduce the net effective wall thickness below 87.5 % of the specified wall thickness;

d) when NDE (except visual) is specified by this standard [see 9.15, A.2 (SR 1) and A.3 (SR 2)] or specified in the purchase agreement, any non-surface-breaking imperfection detected that, when outlined on the outside surface, has an area greater than 260 mm^2 (0.40 $in.^2$);

e) non-surface-breaking weld seam imperfection within 1.6 mm ($^1/_{16}$ in.) of either side of the weld seam that is proven to reduce the net effective wall thickness below 87.5 % of the specified wall thickness;

f) linear imperfection on the outside or inside surface, of any orientation, with a depth greater than those tabulated in Table C.25 or Table E.25;

g) surface-breaking pipe upset imperfection, of any orientation, with a depth greater than those tabulated in Table C.26 or Table E.26;

h) nonlinear inside surface breaking imperfection located in the external thread section of the pipe body with a depth greater than 10 % of the specified wall thickness;

i) on the internal upset configuration on all upset products, any sharp corner or drastic change of section that would cause a 90° hook-type tool to hang up (see Figure D.23).

7.13.2 Coupling Stock, Coupling Material, and Accessory Material Not from Pipe

Coupling stock, coupling material, or accessory material not from pipe shall be free from any quench crack or arc burn.

Coupling stock and coupling material shall be free from, or have clearly marked, outside surface-breaking imperfections that have a depth greater than 5 % of the manufactured wall thickness or that reduce the outside diameter or wall thickness below specified tolerances. The requirement of 7.13.1 d) also shall apply.

7.13.3 Process Control Plan

The manufacturer, based on knowledge of the production process and the requirements of Section 9, shall apply a process control plan to conform to the above requirements.

7.14 Coupling Make-up and Thread Protection

7.14.1 All Grades Except Q125

All casing couplings and regular tubing couplings shall be screwed onto the pipe power-tight, except that they shall be screwed on handling-tight (see NOTE 1) or shipped separately if specified in the purchase agreement. Special clearance tubing couplings shall be screwed onto the pipe handling-tight, except that they shall be shipped separately if specified in the purchase agreement.

A thread compound shall be applied to cover the full surface on the engaged thread of either the coupling or pipe before making up the connection. Application on both coupling and pipe may be agreed upon between the purchaser and the manufacturer. Unless otherwise specified by the purchaser, the thread compound shall conform to API 5A3 or ISO 13678. When pipe is furnished threaded and coupled, the field end and the coupling shall be provided with thread protectors. When pipe is furnished threaded, but without couplings attached, each end shall be provided with a thread protector. Thread protectors shall conform to

the requirements of 11.2. All exposed threads shall be coated with thread compound. A storage compound of distinct color may be substituted for this thread compound on all exposed threads. The compound shall be applied to a surface that is clean and reasonably free of moisture and cutting fluids.

NOTE 1 Applying couplings handling-tight enables the removal of the couplings to clean and inspect threads and to apply fresh thread compound before using the pipe.

NOTE 2 Martensitic chromium steels are sensitive to galling; special precautions can be necessary for thread surface treatment or lubrication, or both, to minimize galling during hydrostatic testing (plug application and removal).

7.14.2 Grade Q125

The requirements for Grade Q125 shall be the same as that shown in 7.14.1, except that couplings with API threads shall be shipped separately unless power-tight make-up is specified in the purchase agreement.

8 Couplings

8.1 General Requirements

Couplings shall:

a) be seamless;

b) be of the same grade and type as the pipe body, except as provided in 8.2;

c) be given the same heat treatment as the pipe body, except as provided in 8.2;

d) meet the same SR as the pipe body, when the SR is also applicable to couplings (see Table A.1).

Couplings shall be machined from coupling blanks made from coupling stock, coupling material, or hot forgings, except Grades C110 and Q125 couplings that shall not be made from hot forgings.

For Grade C110 coupling blanks heat-treated individually, only method 9.2.3 c) shall be used. See A.4 (SR 9) for optional requirements for Grades C110 and Q125 coupling blanks.

When couplings are electroplated, the electroplating process should be controlled to minimize hydrogen absorption.

8.2 Alternative Grades or Heat Treatments

8.2.1 Unless the purchaser specifies a heat treatment in the purchase agreement, Grade H40 pipe shall be furnished with Grade H40, J55, or K55 couplings that are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

8.2.2 Unless the purchaser specifies a heat treatment in the purchase agreement, Grade J55 pipe shall be furnished with Grade J55 or K55 couplings that are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

8.2.3 Unless the purchaser specifies a heat treatment in the purchase agreement, Grade K55 pipe shall be furnished with Grade K55 couplings that are either as-rolled, normalized, normalized and tempered, or quenched and tempered.

8.2.4 Grade J55 EU tubing shall be furnished with Grade L80 Type 1 special clearance couplings (SCCs) when specified in the purchase agreement.

8.2.5 Grades J55 and K55 buttress casing shall be furnished with Grade L80 Type 1 couplings when specified in the purchase agreement.

8.2.6 Normalized Grade N80 Type 1 pipe shall be furnished with either Grade N80 Type 1 or N80Q couplings.

8.2.7 Normalized and tempered Grade N80 Type 1 pipe shall be furnished with either normalized and tempered Grade N80 Type 1 or N80Q couplings.

8.2.8 Grades N80 Type 1 and N80Q EU tubing shall be furnished with Grade P110 SCCs when specified in the purchase agreement.

8.2.9 Grades N80 Type 1 and N80Q buttress casing shall be furnished with Grade P110 couplings when specified in the purchase agreement.

8.2.10 Grade P110 buttress casing shall be furnished with Grade Q125 couplings when specified in the purchase agreement.

8.3 Mechanical Properties

Couplings shall conform to the mechanical requirements specified in Sections 6 and 9, including the frequency of testing, retest provision, and so forth. Records of these tests shall be open to inspection by the purchaser.

8.4 Dimensions and Tolerances

8.4.1 All Grades Except Q125

Couplings shall conform to the dimensions and tolerances shown in Tables C.27 to C.30 or Tables E.27 to E.30. Unless otherwise specified in the purchase agreement, threaded and coupled casing and tubing shall be furnished with regular couplings (RCs).

8.4.2 Grade Q125

Couplings may be machined on the outside surface in addition to the inside surface. Dimensions shall be as specified in the purchase agreement unless couplings with standard API threads are ordered, in which case the dimensions shall be as shown in Tables C.27 and C.28 or Tables E.27 and E.28.

8.5 Regular Couplings

RCs have diameters (W) as shown in Tables C.27 to C.30 or Tables E.27 to E.30. The inside and outside edges of the bearing face shall be rounded or broken but shall not materially reduce the width of the bearing face (dimension b) so that enough thickness is left to safely support the mass of the pipe on the elevator. The ends of couplings shall be faced true at right angles to the axis.

8.6 Special Clearance Couplings—All Grades Except Q125

When specified in the purchase agreement, special clearance (reduced outside diameter W_c) couplings for buttress casing and EU tubing shall be furnished. Unless otherwise specified, special clearance EU tubing couplings shall have a special bevel on both ends as specified in 8.9 and shown in Figure D.5.

When specified in the purchase agreement, special clearance buttress thread casing couplings shall have a special bevel on both ends as shown in Figure D.3. The inside and outside edges of the bearing face shall be rounded or broken as shown in Figures D.3 and D.5.

The ends (or root face when beveled) of couplings shall be faced at right angles to the axis. SCCs shall conform to the dimensions (except b) and tolerances given in Tables C.28 and C.30 or Tables E.28 and E.30, and as shown in Figures D.3 and D.5.

See Section 10 for marking and color identification.

8.7 Combination Couplings

Combination couplings with different types of thread of the same specified size shall be furnished when specified in the purchase agreement. The minimum length and minimum outside diameter of combination couplings shall be sufficient to accommodate the specified size and type of threads.

8.8 Seal-ring Couplings

Seal-ring couplings conforming to the requirements of A.8 (SR 13) shall be furnished when specified in the purchase agreement.

8.9 Special Bevel Tubing Regular Couplings—All Grades Except C110 and Q125

When specified in the purchase agreement, special bevel tubing RCs conforming to the requirements of Tables C.29 and C.30 or Tables E.29 and E.30 shall be furnished for NU and EU tubing. Unless otherwise specified, special bevel tubing RCs shall be beveled on both ends as shown in Figures D.4 and D.5. The inside and outside edges of the bearing face shall be rounded or broken as shown in Figures D.4 and D.5. The root faces of the couplings shall be faced at right angles to the axis.

8.10 Threading

8.10.1 General Requirements

Coupling threads, gauging practice, and thread inspection shall conform to the requirements of API 5B. Couplings shall not be expanded.

NOTE Couplings with API threads may not have a leak resistance as high as the internal yield pressure of the pipe body due to inadequate bearing pressure between the coupling and pin.

8.10.2 Couplings

Casing couplings shall be furnished with one of the end-finishes specified in Tables C.1 and C.2 or Tables E.1 and E.2 as specified in the purchase agreement.

Tubing couplings shall be furnished with one of the end-finishes specified in Table C.2 or Table E.2 as specified in the purchase agreement.

8.11 Surface Inspection

8.11.1 Couplings shall be free from imperfections with the exception of those external imperfections given in 8.11.5, Table C.31 or Table E.31.

8.11.2 Couplings shall be inspected on the outside and inside surfaces after finish machining and before inside or outside surface plating, using the wet fluorescent magnetic particle method in accordance with ISO 10893-5 or ASTM E3024 with a circumferentially oriented magnetic field for the detection of longitudinal surface imperfections, or by another nondestructive method of equal sensitivity as demonstrated to the purchaser. Records shall be maintained in accordance with 9.15.4. In case of dispute, wet fluorescent magnetic particle method shall govern.

8.11.3 By agreement between the purchaser and the manufacturer, NDE of Grades H40, J55, and K55 couplings may be waived. However, in this case, the couplings shall be inspected visually on the outside and inside surfaces after finish machining and before plating and shall be free from all visible seams, cracks, and porosity. See Table C.43 or Table E.43 for marking requirements.

NOTE Visible seams or cracks are those that can be seen without the aid of magnetic particle inspection, dye penetrant, or other nondestructive methods of inspection.

8.11.4 The threaded surfaces of all couplings shall be visually inspected for adequate plating or coating after application.

8.11.5 External imperfections revealed during inspection at the manufacturing facility, except for the external imperfections allowed in Table C.31 or Table E.31, shall be removed. When the coupling inspection method used can determine imperfection depth, imperfections less than 5 % of the critical wall thickness do not need to be removed based on the limitations identified in 8.11.7.

8.11.6 Except as stated in 8.11.7, finished couplings reinspected outside the manufacturer's facility in accordance with 8.11.2 or 8.11.3 shall be free from imperfections except for the external imperfections allowed in Table C.31 or Table E.31.

8.11.7 Couplings shall not be rejected for imperfections less than 5 % of the critical wall thickness detected on subsequent reinspection outside the manufacturer's facility based on the following:

a) for Grades J55 and K55 material that is impact-tested at or below 0 °C (32 °F), that demonstrates a shear area greater than 80 %, and that exceeds the minimum absorbed energy requirements;

b) Grades N80, R95, L80, C90, T95, C110, P110, and Q125 material; the critical thickness is defined in 6.3.2.

8.11.8 Couplings shall be free from any arc burn and defects originated by cracks or nonsurface breaking imperfections that appear to the coupling surface after threading.

8.12 Measurement of Imperfections

The depth of an imperfection shall be measured from the normal surface or contour of the coupling extended over the imperfection. The outside diameter of the finished coupling shall be measured across the finished surface or contour of the coupling (that is, the initial surface or grind contour resulting from the removal of an imperfection or defect). The outside diameter shall not be measured at the base of an acceptable pit.

8.13 Repair and Removal of Imperfections and Defects

Repair welding is not permitted.

Grinding or machining of quench cracks and arc burns is not permitted.

Nonpermissible imperfections defined in 8.11.5 shall be completely removed.

Permissible imperfections (see Table C.31 or Table E.31) may be removed or reduced by machining or grinding on the outer surface.

The area affected by grinding or machining shall be blended smoothly into the contour of the coupling. The outside diameter of the finished coupling shall be within the specified tolerances.

After removal of the defect, the affected zone shall be reinspected by the same inspection method at the same sensitivity used to perform the initial inspection or by a different inspection method of equal or greater sensitivity.

8.14 Thread Surface Treatment—Grade Q125

Thread surface treatment shall be as specified in the purchase agreement.

8.15 Couplings and Coupling Blank Protection—Grades C90, T95, C110, and Q125

Loose couplings and coupling blanks that have been machined to its final outside diameter shall be boxed to prevent contact with one another during shipment. Other coupling blanks shall be boxed to prevent nicks and gouges that will not be removed by subsequent machining. Boxes shall be manufactured from suitable materials that prevent damage to the material surfaces during transportation and shall be designed to be easily handled by a forklift.

9 Inspection and Testing

9.1 Test Equipment

The manufacturer shall determine and document the appropriate calibration and verification frequency to be able to certify that all products conform to the requirements of this standard. When the calibration or verification frequency is based on a month, the maximum interval shall be up to and including the last day in the month in which the calibration is due.

If test or measuring equipment, whose calibration or verification is required under the provisions of this standard, is subjected to unusual or severe conditions that make its accuracy questionable, recalibration or reverification shall be performed before further use of the equipment.

9.2 Lot Definition for Testing of Mechanical Properties

9.2.1 Grades H40, J55, K55, L80 Type 1, L80 3Cr, N80, R95, and P110—Coupling Stock, Coupling Material, Accessory Material, and Pipe (Except Coupling Blanks, Pup Joints, or Accessory Material Heat-treated after Cutting to Blank or Individual Length)

A lot is defined as all those lengths with the same specified dimensions and grade that are either as-rolled or heat-treated as part of a continuous operation (or as an individual batch) and are from a single heat of steel or from different heats that are grouped according to a documented procedure, which will ensure that the appropriate requirements of this standard are met.

When different heats are grouped according to a documented procedure, at a minimum, the procedure shall ensure that the following requirements are met.

a) The identification of the grouped heats shall be unique and different from the heats grouped.

b) Product from each heat that is grouped shall have been previously processed and demonstrated to meet this specification.

c) Each heat that is grouped shall have a chemistry that meets the documented chemistry limits of the previously established process validation.

d) Traceability to each of the original heats grouped shall be documented.

e) A grouped set of heats shall not be grouped with another grouped set of heats.

f) Grouped heats involving grades that do not require heat treatment in accordance with Table C.3 or Table E.3 and are grouped prior to manufacture shall be produced using the same control parameters previously used for product from every heat within the group.

g) Grouped heats that will be further heat treated shall be processed with the same validated heat treatment parameters previously used for product from every heat within the group.

9.2.2 Grades L80 9Cr, L80 13Cr, C90, T95, C110, and Q125—Coupling Stock, Coupling Material, Accessory Material, and Pipe (Except Coupling Blanks, Pup Joints, or Accessory Material Heat-treated after Cutting to Blank or Individual Length)

A lot is defined as all those lengths with the same specified dimensions and grade, from the same heat of steel, which are heat-treated as part of a continuous operation (or as an individual batch).

9.2.3 Coupling Blanks, Pup Joints, or Accessory Material Heat-treated after Cutting to Blank or Individual Length

A lot is defined as that group of pieces with the same specified dimensions and grade, from the same heat of steel that has been:

a) batch heat-treated concurrently in the same heat-treatment line or equipment;

b) heat-treated in sequential loads using the same process parameters without interruption in the same heat treatment line or equipment equipped with a recording controller to provide documentation of heat-treating control through the run, or

c) individually heat-treated using the same process parameters without interruption in a continuous production run of 8 h or less in the same heat treatment line or equipment equipped with a recording controller to provide documentation of heat-treating control through the run.

In addition, for Grades C90, T95, C110, and Q125, a lot shall not exceed 30 coupling blanks, pup joints, or accessory material for Label 1: 9 $^{5}/_{8}$ and larger casing, or 50 coupling blanks, pup joints, or accessory material for smaller sizes of individually heat-treated pieces.

9.3 Testing of Chemical Composition

9.3.1 Heat Analyses

For Grades H40, J55, K55, N80, R95, L80, C90, T95, and P110, the manufacturer shall furnish a report giving the heat analysis of each heat of steel used in the manufacture of product specified in the purchase agreement. In addition, the purchaser, upon request, shall be furnished the results of quantitative analyses for other elements used by the manufacturer to control mechanical properties.

For Grades C110 and Q125, the manufacturer shall furnish a report giving the heat analysis of each heat of steel used in the manufacture of product specified in the purchase agreement. The report shall include quantitative analyses for other elements used by the manufacturer to control mechanical properties.

9.3.2 Product Analyses

Two tubular products from each heat used shall be analyzed for product analyses. Product analyses shall be made by the manufacturer on the finished tubular product before or after heat treatment. For electric-welded products, the chemical analysis may be determined on samples of skelp.

Product analyses shall include the results of quantitative determinations of all elements listed in Table C.4 or Table E.4, including elements used by the manufacturer to control mechanical properties.

NOTE For couplings, pup joints, and accessory material, the product analyses requested can be furnished by the steel manufacturer or processor, and can be taken from material in tubular or bar form.

9.3.3 Test Method

Chemical composition shall be determined by any of the procedures commonly used for determining chemical composition, 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.

9.3.4 Recheck of Product Analyses—All Grades

If the product analyses of both lengths of tubular product representing the heat fail to conform to the specified requirements, then at the manufacturer's option, either the heat shall stand rejected or the remaining lengths in the heat shall be tested individually for conformance to the specified requirements. If only one of two samples fails, then at the manufacturer's option, either the heat shall stand rejected or two recheck product analyses shall be made on two additional lengths from the same heat. If both recheck product analyses conform to the requirements, the heat shall be accepted except for the length represented by the initial analysis that failed. If one or both of the recheck product analyses fail, then at the manufacturer's option, the entire heat shall be rejected or each of the remaining lengths shall be tested individually. In the individual testing of the remaining lengths in any heat, analyses for only the rejecting element or elements need to be determined. Samples for recheck product analyses shall be taken in the same manner as specified for product analysis samples. The results of all recheck product analyses shall be provided to the purchaser when specified in the purchase agreement.

9.4 Tensile Tests

9.4.1 Stress-relief Temperature—All Grades

For the purpose of tensile test frequency, stress-relief of tempered products shall not be considered "heat treatment" provided the stress-relief temperature is at least 55 °C (100 °F) below the final tempering temperature.

For Grades L80 13Cr, C90 T95, C110, and Q125, the stress relief of tempered products shall not be considered "heat treatment" provided the stress relief temperature is at least 30 °C (50 °F) below the final tempering temperature.

9.4.2 Heat-control Tensile Tests—All Grades Except Grade Q125

One tensile test shall be made as a control on each heat of steel used by the manufacturer for the production of product under this standard. For electric-welded product, these tensile tests shall be made on either the skelp or the finished product, at the manufacturer's option.

A heat-control test made on a length of product may also be considered as a product test for the lot being tested.

9.4.3 Frequency of Testing and Location of Test Specimen—Casing and Tubing

The frequency of testing for casing and tubing of all grades is defined in Table C.32 or Table E.32.

The lengths for testing shall be selected at random and, when more than one test is required, the selection procedures shall provide samples representing the start and finish of the heat-treat cycle (as applicable) and front and back ends of the tubes. When more than one test is required, the test specimens shall be from different lengths, except for upset pipe or a single piece lot where the test specimens may be taken from both ends of one length.

9.4.4 Frequency of Testing and Test Specimen Location—Coupling Stock, Coupling Material, Coupling Blanks, Pup Joints, and Accessory Material

The frequency of testing is defined for coupling stock, coupling material, and coupling blanks in Table C.33 or Table E.33 and for pup joints and accessory material in Table C.34 or Table E.34. When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

For Grades H40, J55, K55, N80, R95, L80, and P110 for accessory material, the test specimens from bar stock shall be taken from a location corresponding to the mid-wall of the finished accessory.

For Grades C90, T95, C110, and Q125, tensile test specimens for coupling stock, coupling material, coupling blanks, pup joint, or accessory material heat-treated in tube length shall be removed from locations shown in Figure D.9.

No test is required for pup joints or accessory material manufactured from a length of casing, tubing, coupling stock, coupling blank, or coupling material, provided that it has been previously tested and conforms to requirements and there is no subsequent heat treatment.

A heat-control test may also be considered as a product test for the lot being tested.

9.4.5 Test Specimens—General

Product-body tensile test specimens shall be either full-section specimens, strip specimens, or round bar specimens, as shown in Figure D.8, at the manufacturer's option. Strip specimens from seamless product shall be taken from any location about the product circumference at the option of the manufacturer. Round bar specimens shall be taken from the mid-wall. Strip specimens and round bar specimens from welded pipe shall be taken approximately 90° from the weld, or, at the option of the manufacturer, from the skelp parallel to the direction of rolling and approximately midway between the edge and the center. Tensile test specimens for heat-treated product shall be removed from the product subsequent to final heat treatment on the production line.

All strip specimens shall be approximately 38 mm (1.500 in.) wide in the gauge length if suitable curved-face testing grips are used, or if the ends of the specimen are machined or cold-flattened to reduce the curvature in the grip area; otherwise, they shall be approximately 19 mm (0.750 in.) wide for product smaller than Label 1: 4, approximately 25 mm (1.000 in.) wide for product from Label 1: 4 up to and including Label 1: 7 $^{5}/_{8}$, and approximately 38 mm (1.500 in.) wide for product larger than Label 1: 7 $^{5}/_{8}$.

All product-body tensile specimens shall represent the full wall thickness of the product from which the specimen was cut, except for round bar tensile specimens, and shall be tested without flattening. Round bar specimens shall be 12.7 mm (0.500 in.) in diameter when the product size allows, and 8.9 mm (0.350 in.) in diameter for other sizes. For product sizes too small to allow 8.9 mm (0.350 in.) diameter specimen, round bar tensile specimens are not permitted. 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 diameter and gauge length when round bar specimens are used, or shall state when full-section specimens are used.

When tensile testing of the upset is required, the purchaser and the manufacturer shall agree upon the most representative type and size of test specimen to be used for the test.

9.4.6 Test Specimens—Additional Requirements for Coupling Blanks, Coupling Stock, Coupling Material, Pup Joints, and Accessory Materials—Grades C110 and Q125

In addition to the requirements in 9.4.5, longitudinal tensile test specimens shall be removed from coupling blanks, coupling stock, coupling material, pup joint and accessory materials and individually heat-treated coupling blanks, pup joints, or accessory material subsequent to final heat treatment. Tensile test specimens shall be either strip specimens or, if the wall thickness of the tubular is over 19.1 mm (0.750 in.), a round specimen 12.7 mm (0.500 in.) in diameter may be used as shown in Figure D.8.

Tensile test specimens for coupling blanks and pup joint or accessory material heat-treated in coupling blank or individual lengths shall be removed from the piece as illustrated in Figure D.9. Reduced-section strip specimens may be used by agreement between the purchaser and the manufacturer.

9.4.7 Test Method

Tensile properties shall be determined by tests on longitudinal specimens conforming to the requirements of 9.4.5, ISO 6892-1 or ASTM A370, and 9.4.6 for Grades C110 and Q125 products covered therein. Tensile tests shall be made with the specimens at room temperature. The strain rate during tensile testing shall be in accordance with the requirements of ISO 6892-1 or ASTM A370.

Tensile test machines shall have been calibrated within the 15 months preceding any test in accordance with the procedures of ISO 7500-1 or ASTM E4. Extensometers shall be calibrated within 15 months preceding any test in accordance with the procedures of ISO 9513 or ASTM E83. Records retention shall be in accordance with 12.4.

9.4.8 Invalidation of Tests

Any test specimen that shows defective preparation or material imperfections unrelated to the test's intent, observed before or after testing, may be discarded and replaced by another specimen from the same length of product.

9.4.9 Retests—All Products (Except Coupling Blanks, Coupling Stock, Coupling Material, Pup Joints, or Accessory Material—Grades C90, T95, C110, and Q125)

If a tensile test representing a lot fails to conform to the specified requirements, the manufacturer may elect to make retests on three additional lengths from the same lot. Specimens for retests shall be taken with the same specimen type and approximate location relative to the weld (as applicable) as specified in 9.4.5 and 9.4.6. For Grades L80 and R95, the tensile retest specimens shall be taken from the same end as the original test specimen.

If all of the retests conform to the requirements, the lot shall be accepted, except the failed length.

If more than one of the original test specimens fails or one or more of the retest specimens fails to conform to the specified requirements, the manufacturer may elect to test each of the remaining lengths in the lot. All of the retests that conform to the requirements shall be accepted, except the failed lengths.

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

9.4.10 Retests—Coupling Blanks, Coupling Stock, Coupling Material, Pup Joints, or Accessory Material in Grades C90, T95, C110, and Q125

For material heat-treated in tube lengths, if a tensile specimen fails to conform to the specified requirements, the manufacturer shall either make tests on both ends of the tube in question or reject the length. No other additional testing shall be allowed to qualify a length of coupling stock, coupling material, pup joint, or accessory material. Both test results shall conform to the specified requirements or the length shall be rejected. Rejected lengths may be reheat-treated and tested as new lots.

For material heat-treated in coupling blank or individual product lengths, if a tensile specimen fails to conform to the specified requirements, the manufacturer shall either reject the lot or make three additional tests from the lot. If one or more of the additional tests fail, the lot shall be rejected. Rejected lots may be reheat-treated and tested as new lots.

9.5 Flattening Test

9.5.1 General Requirement for Testing

Flattening tests shall be made for all welded pipe with D/t ratios as shown in Table C.17 or Table E.17.

In 9.5.2 to 9.5.7, the 0° position shall have the weld contacting the parallel plate (defined as 12 o'clock or 6 o'clock). The 90° position shall have the weld positioned at 3 o'clock or 9 o'clock.

9.5.2 Frequency of Testing

The frequency of testing shall be in accordance with Table C.36 or Table E.36.

9.5.3 Test Specimens

Test specimens shall be rings or crop ends not less than 63.5 mm (2 $^{1}/_{2}$ in.) long.

On pipe cut from multiple lengths of a coil, the test on one end of one piece shall represent a test on the adjacent end of the next piece of pipe. If the pipe is intended to be upset, the test specimen shall be taken from the tube prior to upsetting.

The test specimens may be cut before heat treating and given the same type heat treatment as the pipe represented. If lot testing is used, precaution shall be taken so that the test specimens can be identified with respect to the length of pipe from which they are cut. Each heat in each lot shall be subjected to a flattening test.

For electric-welded pipe that is full-body, full-length normalized, including pipe that is processed through a hot-stretch mill in accordance with the requirements in 5.2.1, flattening test specimens shall be obtained either prior to or after such treatment at the option of the manufacturer.

9.5.4 Test Method

Test specimens shall be flattened between parallel plates. From each pair of flattening test specimens, one shall be flattened with the weld located in the 90° position and the other with the weld located in the 0° position. Test specimens shall be flattened until opposite walls of the pipe meet.

No cracks, breaks, or tears and no opening of the weld shall occur in the specimen until the distance between the plates is less than that specified in Table C.17 or Table E.17.

There shall be no evidence of lack of fusion or incomplete fusion in the weld, or laminations during the entire flattening process.

Cracking at the test piece edge shall be acceptable if there is no evidence that these imperfections propagate to the rest of the test piece. The edges of the test piece may be rounded or chamfered.

NOTE Definitions and illustrations are contained in API 5T1.

9.5.5 Additional Requirements for Grade P110 Pipe and Grade Q125 Casing

The requirements in A.6 (SR 11) shall apply when EW pipe and A.6 (SR 11) are specified in the purchase agreement (see 5.1).

9.5.6 Invalidation of Tests

A test specimen that shows defective preparation or material imperfections unrelated to the intent of the test, whether observed before or after testing, may be discarded and be replaced by another specimen from the same length of product.

9.5.7 Retests

If either test specimen representing a single length of pipe fails to meet the requirements specified, the manufacturer may elect to make additional tests on specimens cut from the same end of the same length of pipe, until the requirements are met, except that the finished pipe shall not be shorter than 80 % of its length after the initial cropping. If any test specimen from a length of pipe representing a lot fails to conform

to the requirements specified, the manufacturer may elect to repeat the tests on specimens cut from two additional lengths of pipe from the same lot. If such specimens conform to the specified requirements, all the lengths in the lot shall be accepted except the length initially selected for the test. If any of the retest specimens fails to pass the specified requirements, the manufacturer may elect to test specimens cut from the individual lengths remaining in the lot. Specimens for retests shall be taken in the same manner as specified in 9.5.3. At the option of the manufacturer, any lot of pipe may be reheat-treated and tested as a new lot.

9.6 Hardness Test

9.6.1 Frequency of Testing—General

The frequency of hardness testing for all products shall be as specified in Table C.35 or Table E.35. When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

Additional hardness testing on the outside surface and through-wall hardness testing of pipe and upsets may be carried out as agreed upon between the purchaser and the manufacturer. Test procedures for this additional testing shall be agreed upon between the purchaser and the manufacturer.

No test is required for pup joints, coupling blanks, or accessory material manufactured from a length of Grades L80, C90, T95, C110, or Q125 pipe, coupling stock, coupling material, or accessory material previously tested, provided there is no subsequent heat treatment.

9.6.2 Frequency of Testing—Heat-control Tests—Grade L80

A product test block from each heat-control tensile test specimen shall be through-wall hardness-tested to verify conformance with hardness requirements.

A heat-control hardness test made on a product may also be considered as a product test for the lot being tested.

9.6.3 Frequency of Testing—Grade L80

On pipe, coupling stock, coupling blanks, coupling material, and accessory material, hardness testing shall be carried out at the same frequency as tensile testing for each of these products.

9.6.4 Frequency of Testing and Test Specimen Location—Non-upset Pipe—Grades C90, T95, and C110

a) For Grades C90 and T95, one through-wall hardness test in one quadrant shall be made from one end of each length. Approximately 50 % of these test rings shall be cut from the front ends and approximately 50 % from the back ends of the pipe.

b) For Grade C110, one through-wall hardness test in one quadrant shall be made on both ends of each length. If the manufacturer applies a process control plan that has been demonstrated to the satisfaction of the purchaser to be sufficient to ensure that the entire length of the pipe has homogeneous hardness properties, the testing frequency may be reduced to the frequency applicable for Grades C90 and T95 in a).

NOTE See A.19 (SR 47) for optional frequency of hardness testing for non-upset, Grades C90 and T95.

9.6.5 Frequency of Testing and Test Specimen Location—Upset Pipe—Grades C90 and T95

The pipe body of each length tensile-tested as required by 9.4.3 shall also be through-wall hardness-tested in all four quadrants to verify conformance to the requirements. The test frequency of the upset shall be one in every 20 lengths within each lot. One through-wall hardness test in four quadrants shall be made on one upset from that length in the section of that upset with the maximum wall thickness.

In addition to the through-wall hardness tests, an external-surface Brinell or Rockwell C-scale test shall be made on the pipe body and one upset of each length.

9.6.6 Frequency of Testing and Test Specimen Location—Coupling Blanks, Coupling Stock, Coupling Material, Pup Joints, and Accessory Material—Grades C90, T95, and C110

For thick-wall tube used for making more than one coupling blank, pup joint, or accessory, through-wall hardness tests shall be made on each of two test rings, one from each end.

For coupling blanks, pup joints, and accessory material heat-treated in individual lengths, the piece having the highest surface hardness in the lot shall be selected for through-wall testing.

For individually heat-treated coupling blanks, the hardness test ring shall be removed from the piece as shown in Figure D.9. The hardness test ring shall be removed at mid-length position of individually heat-treated coupling blanks. For individually heat-treated pup joints and accessory material, the hardness test ring shall be removed from either the mid-length, as shown in Figure D.9, or from a prolongation.

Through-wall hardness tests shall be made in four quadrants.

9.6.7 Frequency of Testing—Grade Q125

For casing, through-wall hardness tests shall be made on three lengths per lot. The lengths for testing shall be selected at random, provided the selection procedure provides samples representing the start and finish of the heat-treat cycle and front and back ends of the tubes.

For coupling stock, coupling material, pup joint, or accessory material heat-treated in tube length, one end of each length shall be through-wall hardness tested (approximately 50 % each end).

For coupling blanks, pup joints or accessory material heat-treated in coupling blank or individual length, one piece from each lot shall be through-wall hardness tested.

Through-wall hardness tests shall be made in one quadrant.

9.6.8 Test Specimens

Test specimens for hardness testing shall be removed from products according to locations shown in Figure D.9, or removed from the end of the length or from a prolongation as specified in this standard. For all grades, through-wall hardness tests shall be made on either rings or product test blocks.

Through-wall hardness tests for one quadrant shall be made on a product test block or a ring. Through-wall hardness tests for four quadrants shall be made on a ring or on product test blocks cut from a ring. Through-wall hardness test rings shall be prepared as specified in Figure D.10 in either one or four quadrants.

Hardness test surfaces shall be ground parallel and smooth and shall be free from oxide scale, foreign matter, and lubricants.

9.6.9 Test Method

Hardness tests shall be made in accordance with ISO 6506-1 or ASTM E10 for HBW tests and ISO 6508-1 or ASTM E18 for Rockwell hardness tests.

Two types of hardness test are used in these standards:

— external surface tests involving a single indentation;

— through-wall hardness tests involving multiple indentations.

External surface tests may be made using either the Rockwell or the Brinell method and may be used for product acceptance and process control as specified in this standard.

Through-wall hardness tests shall be made by the Rockwell method and used for product acceptance for maximum hardness and allowable hardness variation and for as-quenched hardenability. Through-wall hardness tests shall be made transverse to the axis of the product. When the hardness ring is removed from the end of the length, the hardness tests shall be made on the side of the specimen farthest from the end of the length (that is, away from the quenched end surface). The first indentation on each product test block or ring quadrant shall be performed mid-wall and shall be disregarded in order to reduce the possibility of errors.

For Grades L80, C90, T95, and C110 the through-wall hardness test shall only be made using hardness testers with digital readout (one or more decimal places).

When the specified wall thickness of a product is less than 7.62 mm (0.30 in.), three indentations in the mid-wall of the specimen in each quadrant are acceptable for through-wall hardness tests. For all other products, in each quadrant three indentations shall be made in each of three locations. The hardness numbers from three indentations in each location, i.e. outside-wall, mid-wall, and inside-wall, shall be combined to give a mean hardness number for each location. A through-wall hardness test comprises mean hardness numbers for each location in a quadrant, in either one or four quadrants as specified in this standard.

Indentations at the outside-wall and inside-wall locations shall be made between 2.54 mm (0.10 in.) and 3.81 mm (0.15 in.) from the applicable outer or inner surface, but not closer than $2\ ^1/_2$ indentation diameters from the center of an indentation to the edge of the surface. Indentations shall be no closer than three indentation diameters from another indentation, measured center to center. Alternate spacing of rows of indentations is permitted for thin-wall product.

The surfaces of the product test block or ring that contact the anvil and the indenter shall be parallel within 0.5°. When product test blocks or rings are prepared using a magnetic platen surface grinder, or other consistent machining processes that ensure that this requirement is met, verification of parallelism is not required. When other methods are used to prepare the product test blocks or rings, the parallelism shall be verified on each product test block or ring.

The surface of the product test block or ring that contacts the anvil shall have a finish not rougher than that produced by dry grinding with 240 (P240) grit paper.

The surfaces of the product test block or ring that contact the anvil and the test machine components (e.g. indenter, indenter-holder, anvil, and anvil seat) shall be visually inspected and shall be free of visible foreign matter, lubricants, rust, and burrs.

Overhang of product test blocks or rings beyond the anvil support of less than or equal to 40 % of the surface area of the product test block or ring is acceptable. The overhang may exceed 40 % of the surface area of the product test block or ring when the testing equipment is designed and validated to yield consistently accurate results for such use. External support is not permitted.

The anvil and anvil seat shall not have protrusions or indentations that adversely affect the hardness result.

When standardized test blocks are used for the verification of a hardness machine, the same anvil shall be used for the verification as will be used for acceptance testing following the verification.

Only indenters that have been calibrated (verified) for use with the specific test machine to be used, such as during an indirect verification, shall be used. When other indenters are used, they shall be verified using an indirect verification with respect to a more accurate indenter (e.g. reference indenter with less error). The polished portion of the HRC indenter shall be visually inspected periodically for damage (e.g. cracks, chips, pits, and so forth) with the aid of adequate magnification (e.g. 20x or higher).

If two or more hardness indentations at a location (same outside-wall, mid-wall, or inside-wall in a quadrant) are greater than 20 HRC, and if the difference between the highest and lowest indentations at that location is greater than 2.5 HRC, then three additional indentations in the same location shall be taken. In such case, the mean hardness number shall be based on the three additional indentations. The test report shall indicate that additional indentations were made, and the original test data shall be available upon request. Additional indentations are not allowed if any Rockwell hardness number is over 27.0 HRC for Grades C90 or T95 or over 31.0 HRC for Grade C110.

The through-wall hardness test is usually made using the Rockwell C-scale. It is acceptable to use the Rockwell C-scale on materials having a hardness below 20 HRC. Care should be exercised when evaluating hardness below 20 HRC because of a potential lack of precision, but nevertheless these results may be used to determine hardness. The use of the Rockwell B-scale on materials having a hardness below 20 HRC is at the option of the manufacturer or as specified in the purchase agreement. Rockwell hardness numbers and mean hardness numbers shall be reported in Rockwell C, from actual or converted numbers, to the first or second decimal place.

Hardness conversions shall be made in accordance with an appropriate conversion table selected by the manufacturer, unless otherwise specified in the purchase agreement.

HBW test numbers shall be rounded to three significant digits and the test conditions reported if test forces other than 29.42 kN (3000 kgf), ball diameters other than 10 mm (0.394 in.), and test force application duration other than 10 s to 15 s are used.

Laboratory Rockwell C scale shall be used as a referee method in cases of disagreement.

9.6.10 Invalidation of Tests

Any test specimen that shows defective preparation or material imperfections unrelated to the intent of the test, whether observed before or after testing, may be discarded and be replaced by another specimen from the same length of product.

9.6.11 Periodic Checks of Hardness-testing Machines

Periodic checks of testing machines shall be made using the procedures in ISO 6506-1 or ASTM E10 for HBW test machines, or ISO 6508-1 or ASTM E18 for Rockwell hardness test machines.

NOTE Both relevant ISO texts are entitled “Procedure for Periodic Checks of the Testing Machines by the User” and both ASTM paragraphs are entitled “Daily Verification.”

For through-wall hardness testing of Grades L80, C90, T95, and C110, the standardized test block shall have a maximum nonuniformity of 0.4 HRC. For all other grades and hardenability tests, the standardized test block shall have a maximum nonuniformity of 1.0 HRC. The nonuniformity of the standardized test block shall be determined by the difference between the highest and lowest indentation number stated in the standardized test block certificate.

At least two preliminary indentations on each standardized test block should be disregarded in order to reduce the possibility of errors. After the preliminary indentations, at least three hardness indentations shall be made on the standardized test block. For through-wall hardness testing of Grades L80, C90, T95, and C110 the error shall not exceed ±0.5 HRC. For all other grades and hardenability tests, the error shall not exceed ±1.0 HRC. The error shall be determined by the certified mean hardness number of the standardized test block minus the mean hardness number determined during the periodic check.

The testing machine shall be checked at the beginning and completion of a continuous run of testing and at such times as are required to assure the operator of the equipment and the purchaser (or representative) that the machine is satisfactory. In any event, checks should be made at least once every 8 h of a continuous run of testing. Checks shall be made on standardized test blocks within the following hardness ranges:

a) Grades L80, C90, and T95: 20 HRC to 27 HRC;

b) Grade C110: 24 HRC to 32 HRC;

c) Grade Q125: 24 HRC to 35 HRC;

d) all hardenability tests: 35 HRC to 55 HRC.

If the checks indicate that the testing machine results are unsatisfactory, the machine shall be verified by indirect verification using standardized test blocks according to the procedures in ISO 6506-2 or ASTM E10 for HBW test machines, or ISO 6508-2 or ASTM E18 for Rockwell hardness test machines.

In cases of disagreement, for Grades C90, T95, and C110 one standardized test block shall be within 20 HRC to 26 HRC and another standardized test block shall be within 30 HRC to 46 HRC to confirm accuracy and linearity using a two-block verification. The standardized test blocks shall have a maximum nonuniformity of 0.4 HRC (difference between the highest and lowest indentation number stated in the standardized test block certificate). The error shall not exceed ±0.5 HRC (determined by the certified mean hardness number of the standardized test block minus the mean hardness number determined during the periodic check).

The results obtained from the periodic checks shall be recorded and should be analyzed using accepted statistical process control techniques, such as, but not limited to, X-bar (measurement averages) and R charts (measurement ranges) and histograms.

9.6.12 Verification of Hardness-testing Machines and Indenters

Indirect verification of hardness testing machines shall be performed at least once every 12 months and after a direct verification has been performed, in accordance with the procedures in ISO 6506-2 or ASTM E10 for HBW test machines, or ISO 6508-2 or ASTM E18 for Rockwell hardness test machines.

The HRC standardized test blocks shall be within 20 to 55 HRC to confirm accuracy and linearity using a two-block verification. The standardized test blocks used shall bracket the HRC range for acceptance testing. The standardized test blocks shall have a maximum nonuniformity of 0.4 HRC (difference between the highest and lowest indentation number stated in the standardized test block certificate). The error shall not exceed ±0.5 HRC (determined by the certified mean hardness number of the standardized test block minus the mean hardness number determined during the indirect verification).

The indenter should be directly verified at least every 24 months. HRC indenters shall be certified by the manufacturer for performance error (deviation) with respect to a more accurate indenter (e.g. reference indenter with less error) and standardized test blocks in the range being tested. HRC indenters shall have a maximum performance error of ±0.4 HRC.

A calibration certificate (verification report) for the hardness tester shall be issued by an independent certifying agency. The calibration agency that is used to conduct verifications of hardness testing machines and HRC indenters should be accredited to the requirements of ISO 17025 (or an equivalent) by a recognized accrediting body that operates to the requirements of ISO/IEC 17011. As a minimum, the calibration certificate shall identify:

a) the reference standard (ISO 6506-2 or ASTM E10, or both; ISO 6508-2 or ASTM E18, or both);

b) method of verification (direct or indirect, or both);

c) means of verification (reference blocks, elastic proving devices, and so forth);

d) temperature;

e) hardness scale(s) verified;

f) date of the verification;

g) standardized test blocks (mean hardness number, scale, serial number, manufacturer, and nonuniformity);

h) results obtained;

i) identification of the hardness test machine (manufacturer, model number, and serial number);

j) serial number of indenter;

k) certifying agency;

l) name of their representative performing the verification.

9.6.13 Retests—Grade L80

For Grade L80 products, if a through-wall hardness test specimen representing a lot fails to conform to the specified requirements, the manufacturer may elect to make retests on two additional lengths from the same lot from the same end as the original test specimen. If all the retests conform to the requirements, the lot shall be accepted except the failed length. If one or more of the retest specimens fails to conform to the specified requirements, the manufacturer may elect to test each of the remaining lengths in the lot or reject the lot.

9.6.14 Retests—Grades C90, T95, and C110 Products Except for Coupling Blanks, Pup Joints, or Accessory Material Heat-treated after Cutting to Individual Lengths

For Grades C90 and T95, if any mean hardness number falls between 25.4 HRC and 27.0 HRC inclusive, three additional indentations shall be made in the immediate area to determine a new mean hardness number. If the new mean hardness number does not exceed 25.4 HRC, the piece shall be accepted. If the new mean hardness number exceeds 25.4 HRC, the piece shall be rejected.

For Grade C110, if any mean hardness number falls between 29.0 HRC and 31.0 HRC inclusive, three additional indentations shall be made in the immediate area to determine a new mean hardness number. If the new mean hardness number does not exceed 29.0 HRC, the piece shall be accepted. If the new mean hardness number exceeds 29.0 HRC, the piece shall be rejected.

9.6.15 Retests—Grades C90, T95, and C110 Coupling Blanks, Pup Joints, or Accessory Material Heat-treated after Cutting to Individual Lengths

For coupling blanks, pup joints, or accessory material heat-treated after cutting to blank or individual lengths, if the hardness test specimen representing a lot fails to conform to the specified requirement, the piece or length shall be rejected. The manufacturer shall either reheat-treat the lot or make three additional tests from the lot using the same selection criteria for the pieces selected in the original test. If any of these three retests fail, the entire heat-treat lot shall be rejected.

9.6.16 Retests—Grade Q125—General

If the allowable hardness variation as specified in Table C.5 or Table E.5 is exceeded on a specimen, the surface in that quadrant may (at the option of the manufacturer) be reground below the initial hardness impressions and retested. Only one re-grind and retest is allowed for each specimen. After retest, product that fails to conform to the specified requirements shall be rejected.

9.6.17 Retests—Grade Q125—Casing, Coupling Stock, and Coupling Material

If more than one of the initial three lengths required to qualify a lot of casing is rejected, then the manufacturer may elect to test each of the remaining lengths in the lot. Retests of these lengths shall only be allowed as specified in 9.6.17.

If only one of the initial three lengths required to qualify a lot of casing is rejected, then an additional three lengths may be tested to attempt to qualify the lot of casing. Retests of the additional lengths shall only be allowed as specified in 9.6.17. If any of the additional three lengths required to qualify a lot of casing is rejected, then the manufacturer may elect to test each of the remaining lengths in the lot or reprocess the lot (that is, five of the six lengths tested shall meet the requirements of 6.8 and Table C.5 or Table E.5 to qualify the casing on a lot basis).

9.6.18 Retests—Grade Q125—Coupling Blanks, Pup Joints, and Accessory Material

In the case of coupling blanks, pup joints, or accessory material heat-treated as individual pieces, if the hardness variation as specified in 6.8 and Table C.5 or Table E.5 is exceeded, the manufacturer may carry out through-wall hardness testing of three more pieces from the lot in question. If a specimen from any one of the three pieces exceeds the allowable hardness variation, the lot shall be rejected.

9.6.19 Rejected Lots—Grades L80, C90, T95, C110, and Q125

For all products, rejected lots may be reprocessed (that is, heat-treated again) and hardness-tested again as new lots.

9.7 Impact Test

9.7.1 Specimen Size and Orientation

When the use of full-size (10 mm × 10 mm) transverse test specimens is not possible, the largest possible subsize transverse test specimen listed in Table C.8 or Table E.8 shall be used. When it is not possible (or allowed in accordance with 9.7.3) to test using any of these transverse test specimens, the largest possible longitudinal test specimen listed in Table C.8 or Table E.8 shall be used.

Specimen notch axis shall be oriented perpendicular to the axis of the tube (normal to the tube surface) (see Figure D.11).

Impact test specimens shall not be machined from flattened tubulars.

When testing EW pipe using a transverse test specimen, the weld seam shall be positioned at the notch in the CVN test specimen.

When longitudinal impact test specimens are used for EW pipe, the test specimens shall be taken from a location approximately 90° from the weld.

The surface of the finish-machined transverse test specimen may contain the outside diameter curvature of the original tubular product, provided that the requirements of Figure D.12 are met. These specimens shall be used only to permit the use of a transverse specimen of maximum possible thickness consistent with Table C.8 or Table E.8.

When the outside diameter or wall thickness precludes the machining of longitudinal impact test specimens $^1/_2$-size or larger, the product need not be tested; however, the manufacturer shall use a chemical composition and processing that is documented and demonstrated to result in impact-energy absorption, which meets or exceeds the minimum specified requirement.

9.7.2 Hierarchy of Test Specimens

The hierarchy of test specimen orientation and size is specified in Table C.9 or Table E.9.

9.7.3 Alternative Size Impact Test Specimens

At the manufacturer's option, impact test specimens of an alternative size, listed in Table C.8 or Table E.8, may be used in lieu of the minimum size specified in Tables C.10 and C.11 or Tables E.10 and E.11. However, the alternative test specimen selected shall be higher on the hierarchy table (Table C.9 or Table E.9) than the specified size, and the absorbed energy requirement shall be adjusted consistent with the orientation and size of the impact specimen.

9.7.4 Subsize Test Specimens

The minimum CVN absorbed energy requirement for subsize test specimens shall be that specified for a full-size test specimen multiplied by the reduction factor in Table C.8 or Table E.8; however, in no event shall a subsize test specimen be used if the reduced absorbed energy requirement is less than 10 J (7 ft·lb).

9.7.5 Test Temperature

The test temperature shall be 0 °C (32 °F) for all grades except Grades J55 and K55. Grades J55 and K55 shall be tested at 21 °C (70 °F). An alternative lower test temperature may be specified in the purchase agreement or selected by the manufacturer for any grade. The tolerance on the test temperature shall be ±3 °C (±5 °F). If material is tested at a lower temperature and meets requirements, testing at a higher temperature is not required.

9.7.6 Statistical Impact Testing

By agreement between the purchaser and the manufacturer, the SRs for statistical impact testing in A.7 (SR 12) shall apply.

9.7.7 Reference Information

API 5C3 or ISO 10400 includes reference information on fracture mechanics and equations and tables used in preparing impact requirements.

9.7.8 Sampling—Grades J55 and K55

For accessory material, when required in 6.6, and for coupling stock, coupling material and coupling blanks, one set of test specimens shall be taken from each lot.

Frequency of testing is specified in Table C.16 or Table E.16.

9.7.9 Sampling—Grades N80, R95, L80, C90, T95, C110, and P110

For pipe, when impact testing is required, one set of test specimens shall be taken from each lot.

For accessory material, when required in 6.6, and for coupling stock, coupling material, and coupling blanks, one set of test specimens shall be taken from each lot.

Frequency of testing is specified in Table C.16 or Table E.16.

9.7.10 Sampling and Test Specimen Location—Grade Q125

For casing, three lengths per lot shall be tested. The lengths for testing shall be selected at random, provided the selection procedures give samples representing the start and completion of the heat-treat cycle and the front and back ends, as processed, of the casing.

For coupling stock, coupling material, pup joint, or accessory material heat-treated in tube length, one piece from an end of each length shall be tested. Front and back ends, as processed, shall be tested on an approximate 50 % basis.

For coupling blanks, pup joints, or accessory material heat-treated as individual pieces, one piece from each lot shall be tested.

Frequency of testing is specified in Table C.16 or Table E.16.

9.7.11 Test Method

CVN impact tests shall be conducted as specified in ASTM A370 and ASTM E23.

The shear area shall be measured and, for Grade C110 and A.16 (SR 44) products (see 12.3), shall be reported.

To determine conformance with these requirements, the observed result of a test shall be rounded to the nearest whole number. The impact energy value for a set of test specimens (i.e. average of three tests) shall be expressed as a whole number, rounded if necessary. Rounding shall be in accordance with the rounding method of ISO 80000-1 or ASTM E29.

9.7.12 Invalidation of Tests

Any test specimen that shows defective preparation or material imperfections unrelated to the intent of the test, whether observed before or after testing, may be discarded and be replaced by another specimen from the same length of product. Specimens shall not be judged defective simply because they failed to exhibit the minimum absorbed energy requirement (see 9.7.13 to 9.7.15).

9.7.13 Retest of a Length—All Grades

If the results of more than one specimen are below the specified minimum absorbed energy requirement, or if the result of one specimen is below two-thirds of the minimum specified absorbed energy requirement, a retest of three additional specimens shall be made from the same length. The impact energy of each of the retest specimens shall equal or exceed the specified minimum absorbed energy requirement or the length shall be rejected.

9.7.14 Replacement of a Reject Length—All Grades

If the results of a test do not meet the requirements of 6.4 to 6.6, as applicable, and do not qualify for retesting in accordance with 9.7.13, then an additional three test specimens shall be removed from each of three additional lengths from the lot. If all the additional lengths tested conform to the requirements, then the lot shall be qualified except for the length that was initially rejected. If one or more of the additional lengths tested fail to conform to the specified requirements, the manufacturer may elect to test individually the remaining lengths in the lot or reheat-treat and test the lot as a new lot.

9.7.15 Multiple Length Rejection—Grade Q125

If more than one of the initial three lengths required to qualify a lot of casing is rejected, retesting to qualify the lot is not permitted. The manufacturer may elect to test each of the remaining pieces in the lot, or to reheat-treat and test the lot as a new lot.

9.8 Grain Size Determination—Grades C90, T95, and C110

9.8.1 Sampling

Grain size determination shall be made on each as-quenched hardenability test sample.

9.8.2 Test Method

Grain size shall be determined by metallurgical evaluations, such as the McQuaid-Ehn test or other methods as specified in ISO 643 or ASTM E112.

9.9 Hardenability—Grades C90, T95, and C110

Hardenability shall be determined on one sample per production run or heat-treatment practice. Through-wall hardness tests in four quadrants shall be made at the beginning of each order, and thereafter whenever a size change occurs or the austenitization and quenching process conditions are not within the validated process conditions for the product.

9.10 Sulfide Stress Cracking Test—Grades C90, T95, and C110

9.10.1 General

When not specified in this standard, the details of the manufacturer’s qualification, frequency of SSC testing, retest procedures, and testing practices should be addressed by the purchaser and the manufacturer prior to placing or accepting a purchase agreement.

NACE TM0177-2016 shall be used in conjunction with the requirements in 6.14 to determine the room temperature SSC resistance of Grades C90, T95, and C110 products.

9.10.2 Frequency of Testing

For Grades C90, T95, and C110, the level of resistance to SSC shall be evaluated with the requirements in 6.14 using one or more of the following as specified by the purchaser:

a) For Method A:

   1) For Grades C90 and T95, one specimen per lot, as specified by 9.2, unless otherwise agreed. Also see requirements in A.18 (SR 46).

   2) For Grade C110, three specimens per lot, as specified by 9.2, unless otherwise agreed. Specimens shall be taken from the ends of three different products selected from sublots composed of the front one-third, middle one-third, and back one-third of the lot.

   3) By agreement between the purchaser and the manufacturer, the number of specimens for NACE Method A per lot can be modified as follows:

      i) For Grades C90 and T95 may be increased up to three per lot.

      ii) For Grade C110 may be reduced to one per lot with a qualified process control that is sufficient to ensure the product performance as described in 6.14.4.

b) For Method B:

   1) For Grades C90 and T95, one sample per lot shall be tested, as specified by 9.2.

   2) Samples shall be selected according to 9.10.4.

c) For Method D:

   1) For Grades C90, T95, and C110, at least three valid specimens per lot, as specified by 9.2, taken from a single sample, shall be tested.

   2) Samples shall be selected in accordance with 9.10.4.

9.10.3 Test Specimens—General

For Method A, standard NACE tensile test specimens [6.35 mm (0.250 in.)] shall be used, except where NACE subsize tensile specimens are required because of product dimensional constraints.

For Method D, standard DCB specimens [9.53 mm (0.375 in.)] shall be used, except where subsize DCB specimens are required because of product dimensional constraints.

When the outside diameter or wall thickness impedes the machining of subsize specimens, the manufacturer shall demonstrate that the chemical composition and processing manufacturing route used is documented to meet or exceed the minimum specified requirement on a larger OD and/or wall thickness product.

9.10.4 Test Specimens—Selection and Location

Where possible, based on product size and type of test specimen required, and unless otherwise specific by the purchaser, the SSC test specimens, for all test methods, shall be taken at mid-wall, from a length and end selected using one of the following criteria.

a) For all test methods, for Grades C90 and T95 a mean hardness of 24.4 HRC or higher, or for Grade C110 a mean hardness of 28.0 HRC or higher.

b) For all test methods, the highest mean hardness number based on preliminary hardness testing with a minimum of five lengths per lot and a frequency of not less than one length per 20 spaced uniformly in the sequence of the lot.

NOTE Preliminary hardness testing is intended to capture 5 % of the required hardness tests in order to expedite SSC testing; these lengths are part of the pipe required to be tested in 6.7.1.

c) For all test methods, specimens shall be taken from product representing the highest mean hardness for a particular lot. Or

d) For all test methods, when agreed upon by the purchaser, the manufacturer may use randomly selected samples provided prior documented validation test results or previous qualification of the manufacturing procedure (in accordance with NACE MR0175/ISO 15156) confirm that the manufacturing procedure results in products that meet the SSC requirements as described in 6.14.4.

Hardness data obtained on the SSC test specimens shall be for information only.

9.10.5 Retests—SSC Grades C90, T95, and C110

a) Grades C90 and T95: For Method A or Method B, retesting may be performed on two test specimens taken from an area of the product adjacent to where the initial failed test specimen was taken. If one or both of the retest specimens fails, the lot shall be rejected. Rejected lots may be re-heat treated and tested as new lots.

If retests conform to the requirements, the lot shall be accepted.

b) For Grade C110, Method A:

1) When initial testing is undertaken with three specimens per lot [as in 9.10.2 a) 2)], if more than one initial specimens fails, the lot shall be rejected. If only one of the initial three specimens fails, a retest may be performed as follows: two additional specimens shall be taken adjacent to where the initial three specimens were removed. Rejected lots may be re-heat treated and tested as new lots.

2) When initial testing is undertaken with one specimen [as in 9.10.2 a) 3) ii)]; if the specimen fails, the lot shall be rejected unless a retest is performed on two additional specimens taken adjacent to where the initial specimen was removed. If one or both of the retest specimens fails, the lot shall be rejected. Rejected lots may be re-heat treated and tested as new lots.

If the results of the retests (comprising both specimens) conforms to the requirements, the lot shall be accepted.

c) For Method D, the following retesting criteria shall apply:

1) If the average K_{Issc} does not meet the minimum requirement, three additional test specimens may be taken from an area of the product adjacent to where the initial failed test specimens were taken. A new average K_{Issc} value shall be calculated by including the original results of the failed DCB set in addition to the retest specimens. The retest specimens shall conform to both the minimum individual value and the minimum mean K_{Issc} requirement.

2) If only one individual K_{Issc} does not meet the minimum requirement, a retest may be performed on three test specimens taken from an area of the product adjacent to where the initial failed test specimen was taken. These test specimens shall conform to both the minimum individual value and the minimum mean K_{Issc} requirement.

If retesting fails, the lot shall be rejected. Rejected lots may be reheat treated and tested as new lots. If the results of the retest conforms to the requirements, the lot shall be accepted.

9.10.6 Invalidation of Tests

An SSC test shall be deemed invalid and a replacement test performed only when an assignable cause is identified and not simply because it fails to exhibit the minimum SSC requirement. Assignable causes include, but are not limited to, the following:

a) test specimen machining defects;

b) testing errors;

c) any identified cause of invalidation detailed in NACE TM0177-2016; for Method D, specific causes are found in paragraph 11.6.

For Method D, the user may request the preparation of the mechanical assurance graph, according to NACE TM0177-2016, Appendix D. Invalidation of results based on the application of such appendix shall be accepted upon agreement between the manufacturer and the purchaser.

NOTE Refer to NACE TM0177-2016—Appendix D, Recommendation for Determining Mechanical Quality Assurance of Test Results for Method D (DCB test).

9.10.7 Additional Testing Provisions for NACE TM0177-2016, Method D

Either non-pre-cracked or fatigue pre-cracked specimens may be used. If fatigue pre-cracking of specimens is employed, the maximum stress intensity factor during pre-cracking shall not exceed:

a) 29.7 $MPa \cdot m^{1/2}$ (27.0 $ksi \cdot in.^{1/2}$) for Grades C90 and T95; or

b) 20.4 $MPa \cdot m^{1/2}$ (18.6 $ksi \cdot in.^{1/2}$) for Grade C110.

The arm displacement values and maximum/minimum tolerances are shown in Table 19.

Table 19—Arm Displacement Values and Max/Min Tolerances

Grade	SI Units (+0.03 mm/−0.05 mm)	USC Units (+0.001 in./−0.002 in.)
C90	0.76 mm	0.030 in.
T95	0.71 mm	0.028 in.
C110	0.51 mm	0.020 in.

Before the SSC test, Rockwell C hardness tests (minimum of three indentations) shall be made as shown in Figure D.28. Hardness data obtained on the DCB test specimens shall be for information only.

9.11 Metallographic Evaluation—EW Grades J55, K55, N80, L80 Type 1, R95, P110, and Q125

For Grades P110 and Q125, and for Grades J55, K55, N80, L80 Type 1, and R95, a metallographic evaluation of the electric-weld zone shall be performed at the beginning of the welding process for each size of tubular, again at least each 4 h during the welding and after any substantial interruption of the welding process. The samples shall be obtained prior to heat treatment, when applicable. The manufacturer shall have objective criteria to evaluate the acceptability of the electric-welded zone.

9.12 Hydrostatic Tests

9.12.1 Hydrostatic Test Procedures

Each length of pipe shall be tested full-length subsequent to upsetting (if applicable) and subsequent to final heat treatment (as applicable) to at least the hydrostatic pressure specified in 9.12.2 without leakage. The test conditions shall be held for not less than 5 s at full pressure. For electric-weld pipe, the pipe seam shall be inspected for leaks and sweats while under full test pressure. The entity performing the threading shall perform a hydrostatic test (or arrange for such a test) on the full length of pipe unless previously tested full-length to at least the pressure required for the final end condition. The test shall be performed in one of the following conditions:

a) plain-end non-upset provided no upsetting or further heat treatment will be performed;

b) plain-end non-upset after heat treatment;

c) plain-end after upsetting, provided no further heat treatment will be performed;

   NOTE If such pipe has been tested full-length to the threaded-and-coupled test pressure in the plain-end condition prior to upsetting, the test of the upset portion may be made after upsetting using an end tester that seals behind the portion of the pipe that was heated for upsetting.

d) plain-end upset after heat treatment;

e) threaded without couplings applied;

f) threaded and coupled with couplings applied power-tight.

For pipe requiring heat treatment, the test shall take place after the final heat treatment. The test pressure shall be at least the threaded-and-coupled test pressure for all pipe with threaded ends.

Pup joints, after machining to the final plain-end dimensions and after any heat treatment, shall be tested either plain-end or threaded.

The tester shall be equipped with devices for assuring that the specified test pressure and time interval requirements are met. The test pressure-measuring device shall be calibrated by means of a deadweight tester, or equivalent. For mechanical pressure devices (e.g. Bourdon tube and dial readout), the maximum calibration interval shall be 6 months. For electronic pressure devices (i.e. pressure transducers), the maximum calibration interval shall be 12 months. Calibration and verification records retention shall be as given in 12.4.

No hydrostatic test is required for pup joints manufactured from a length of tubing or casing previously hydrostatic tested, provided there is no subsequent heat treatment.

NOTE 1 Martensitic chromium steels are sensitive to galling; special precautions can be necessary for thread surface treatment or lubrication, or both, to minimize galling during hydrostatic testing (plug application and removal).

NOTE 2 Various types of hydro-test systems are available; the entity performing the hydro-test is responsible for establishing a test procedure that minimizes the potential for damage to the pipe and threads of both the pipe and coupling.

9.12.2 Hydrostatic Test Requirements

Pipe shall conform to the test requirements for the size, grade, and end-finish.

For threaded pipe, the hydrostatic test pressures shall be standard pressures calculated as described in 9.12.3, or a higher pressure as agreed upon between the purchaser and the entity performing the threading.

For plain-end pipe, except Grade Q125, the hydrostatic test pressures shall be the pressures calculated as described in 9.12.3, or a higher pressure as agreed upon between the purchaser and the manufacturer. This does not preclude conducting subsequent hydrostatic tests at a fiber stress not exceeding 80 % of specified minimum yield strength, in accordance with the formula listed in Equation (9). Failure to pass this hydrostatic test without leakage is basis for rejection.

Plain-end Grade Q125 pipe shall be tested as agreed upon between the purchaser and the manufacturer.

Testing is not required on coupling stock, coupling material, accessory material or Grade Q125 pup joints, except by agreement between the purchaser and the manufacturer.

NOTE 1 The hydrostatic test pressures specified herein are inspection test pressures, are not intended as a basis for design and do not necessarily have any direct relationship to working pressures.

NOTE 2 The user should be aware that couplings having API threads with special clearance or standard outside diameters can leak at a pressure less than the alternative test pressure for the plain-end or threaded-and-coupled tube, due to inadequate bearing pressure between the coupling and pin.

9.12.3 Test Pressure Calculation

The standard hydrostatic test pressures shall be calculated using Equation (9), rounded to the nearest 0.5 MPa (100 psi) and limited to a maximum of 69.0 MPa (10,000 psi):

$$p = (2 \times f \times Ys_{\text{min}} \times t) / D \tag{9}$$

where

p is the hydrostatic test pressure, in megapascals (pounds per square inch);

f is a factor:

— 0.6 for Grades H40, J55, and K55 larger than Label 1: 9 $^{5}/_{8}$;

— 0.8 for Grades H40, J55, and K55 less than or equal to Label 1: 9 $^{5}/_{8}$;

— 0.8 for all other grades and sizes;

Ys_{min} is the specified minimum yield strength for the pipe body, in megapascals (pounds per square inch);

D is the specified outside diameter, in millimeters (inches);

t is the specified wall thickness, in millimeters (inches).

NOTE The formula (Equation [9]) for hydrostatic test pressure is applicable to both SI and USC units.

a) By agreement between the purchaser and the manufacturer, an alternative test pressure may be used.

   Alternative test pressures for Grades H40, J55, and K55 in sizes larger than Label 1: 9 $^{5}/_{8}$ are calculated using a factor f of 0.8.

b) A test pressure lower than the calculated value is allowed under the following conditions.

   1) The calculated test pressure value exceeds 69.0 MPa (10,000 psi).

i) In this situation, the test pressure shall be at least 69.0 MPa (10,000 psi).

ii) By agreement between the purchaser and the manufacturer, an alternative test pressure greater than 69.0 MPa (10,000 psi) shall apply or the provisions of A.13 (SR 41.1 or SR 41.2) shall apply.

2) The test equipment is physically limited.

i) The manufacturer shall have a documented design basis to establish the physical limitations of the hydrostatic test equipment. If the calculated test pressure [based on Equation (6)] is greater than the physical capability of the hydrostatic test equipment, the manufacturer, upon agreement with the purchaser, shall use a test pressure equal to the physical capability of the test equipment.

ii) The hydrostatic test equipment capability may be less than 20.5 MPa (3000 psi) only for those products where the calculated test pressure is less than 20.5 MPa (3000 psi).

3) The pipe is threaded and coupled, and a lower pressure is required to avoid leakage due to insufficient coupling strength or interface pressure between pipe and coupling threads.

The lower pressure shall be calculated for threaded and coupled pipe, as specified in API 5C3 and ISO 10400.

NOTE If the calculated hydrostatic test pressure would exceed the contact pressure of the connector, hydrostatic test may be performed in plain end condition or without the coupling installed.

9.13 Dimensional Testing

9.13.1 General

Diameter or wall thickness shall be reported to the number of decimal places shown in the relevant tables, that is Tables C for SI units or Tables E for USC units, except that for sizes in SI units larger than Label 1: 6 $^{5}/_{8}$ in Table C.1 the diameter shall be reported to one decimal place.

NOTE In this standard, the specified pipe outside diameter, expressed in SI units, always uses two decimal places for design purposes to ensure interchangeability of actual product regardless of whether it was produced using dimensions in SI or USC units.

9.13.2 Diameter Measurement

9.13.2.1 General Requirements

For pipe, coupling stock, coupling material, and accessory material, the manufacturer shall demonstrate conformance to the requirements of 7.3.2 in a single diametric plane at a minimum frequency of one length of pipe, coupling stock, coupling material or accessory material per one hundred lengths.

For non-upset pipe, coupling stock, coupling material, and accessory material, the measurements shall be made with pi-tapes (wrap tapes), micrometers, calipers, snap gauges, semiautomated or automated systems.

For upset casing and Label 1: 2 $^{3}/_{8}$ and larger EU tubing, the measurements shall be made with micrometers, calipers, snap gauges, semiautomated or automated systems.

The manufacturer shall measure the diameter of both ends of pipe ordered as plain-end, coupling stock, or coupling material at a minimum frequency of one per one hundred.

If any product fails to meet the requirements, the provisions of 9.13.3 shall apply.

In case of dispute of the minimum diameter requirements, micrometer measurements shall govern. In case of dispute of the maximum diameter requirements, pi-tape (wrap tape) measurements shall govern. When using a micrometer, three measurements shall be made in the nonconforming area and averaged. The average of the three readings shall be used to determine the conformance of the diameter.

9.13.2.2 Requirements for Automated or Semiautomated Systems

In the case of semiautomated or automated diameter measurement systems, the manufacturer shall maintain records verifying the system(s) capabilities in accordance with the requirements of 7.3.2.

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

   1) size range;

   2) coverage details;

   3) accuracy of measurement;

   4) repeatability;

   5) documentation demonstrating that out-of-tolerance pipe are detected using the diameter measurement equipment; where the reject threshold for diameter measurement shall be established using reference standards within the specified diameter for the product to be inspected;

   6) set-up parameters.

b) The manufacturer shall maintain documentation relating to:

   1) measurement equipment description;

   2) personnel qualification requirements to operate the measurement equipment;

   3) measurement equipment operation procedures;

   4) type of reference standard utilized to satisfy the applicable 7.3.2 and 7.11.1 requirements;

   5) dynamic data demonstrating the measurement equipment capabilities during normal operation conditions.

9.13.3 Diameter Retests

If any pipe, coupling stock, coupling material, or accessory material fails to meet the specified diameter requirements when measured with calipers, micrometers, or snap gauges, the manufacturer may elect to make measurements on three additional lengths from the same lot. If any pipe, coupling stock, coupling material, or accessory material fails to meet the specified diameter requirements when measured with a pi-tape, and unless the manufacturer can show evidence of a specific problem affecting only that length of pipe, coupling stock, coupling material or accessory material, each pipe, coupling stock, coupling material, or accessory material from the same lot shall be measured for conformance.

If all retest measurements conform to the specified diameter requirements, all lengths in the lot shall be accepted except the length initially selected for measurement. If any of the retest measurements fails to meet the specified requirements, the manufacturer may elect to measure the individual lengths remaining in the lot. Individual lengths that fail the specified requirements may be cut back and measured again for conformance.

At the option of the manufacturer, any lot of pipe, coupling stock, coupling material, or accessory material may be reprocessed and measured as a new lot.

NOTE Once the pipe, coupling stock, coupling material, or accessory material has proceeded past its last manufacturing quality control point for diameter, some deviations in the maximum and minimum diameters can occur due to handling and storage and should not be cause for rejection, provided the average diameter as measured by a pi-tape is within the diameter tolerances.

9.13.4 Wall Thickness Measurement

Each length of pipe, coupling stock, coupling material, or accessory material shall be measured to verify conformance with wall thickness requirements. Wall thickness measurements shall be made with a mechanical caliper, a go/no-go gauge or with a properly calibrated NDE device of appropriate accuracy.

In case of dispute, the measurement determined by use of the mechanical caliper shall govern. The mechanical caliper shall be fitted with contact pins having circular cross-sections of 6.4 mm ($^1/_4$ in.) diameter. The end of the pin contacting the inside surface of the product shall be rounded to a maximum radius of 38.1 mm (1 $^1/_2$ in.) for product sizes Label 1: 6 $^5/_8$, and larger, a maximum radius of $d/4$ for products less than Label 1: 6 $^5/_8$, with a minimum radius of 3.2 mm ($^1/_8$ in.). The end of the pin contacting the outside surface of the product shall be either flat or rounded to a radius of not less than 38.1 mm (1 $^1/_2$ in.).

To ensure conformance to wall thickness requirements, all seamless pipe and coupling stock requiring electromagnetic or ultrasonic inspection as specified in Table C.37 or Table E.37 shall have the wall thickness verified in a helical or longitudinal path over the full length of the pipe or coupling stock, excluding end areas not covered by automated systems, in accordance with a documented procedure. The location of the wall-thickness verification equipment shall be at the discretion of the manufacturer.

For Grades L80 13Cr, C90, T95, C110, and Q125, wall thickness shall be measured over the full body, with a minimum coverage of 100 % of the surface area covered by the automatic system. The minimum measured wall thickness for each length shall be recorded. Traceability and/or reporting of each length is only required when specified in the purchase agreement.

NOTE See A.21 (SR 49) for additional requirements for all other grades.

Accessory material shall have the wall thickness verified if specified in the purchase agreement.

9.13.5 Drift Test

All drift testing shall be performed with a drift mandrel containing a cylindrical portion conforming to the requirements shown in Tables C.23 and C.24 or Tables E.23 and E.24 as applicable. See 7.10 for requirements for casing used as tubing. The ends of the drift mandrel extending beyond the specified cylindrical portion shall be shaped to permit easy entry into the pipe. The drift mandrel shall pass freely through the length using a manual or power drift procedure. In case of dispute, the manual drift procedure shall be used. Pipe shall not be rejected until it has been drift-tested when it is free of all foreign matter and properly supported to prevent sagging.

9.13.6 Length Measurement

For plain-end pipe, and for other products if specified in the purchase agreement, the length shall be measured from end to end.

For threaded and coupled pipe:

a) when measured with the coupling installed, the length shall be measured from the end of the pin to the outer face of the coupling;

b) when measured without coupling, the length shall be measured from pin end to pin end and proper allowance for the length of the coupling shall be added.

For integral-joint tubing, the length shall be measured from the pin end to the outer face of the box end.

For pup joints and accessories, the length shall be measured from end to end.

9.13.7 Mass (Weight) Determination

Each length of casing and each length of tubing in sizes Label 1: 1.660 and larger shall be weighed separately. Lengths of tubing in sizes smaller than Label 1: 1.660 shall be weighed either individually or in convenient bundles.

The pipe manufacturer applying the markings to the pipe body (see Section 10) shall be responsible for weighing the pipe to determine conformance with mass tolerance. The pipe may be weighed plain-end, upset, non-upset, threaded, or threaded and coupled. Threaded-and-coupled pipe may be weighed with the couplings screwed on or without couplings, provided proper allowance is made for the mass of the couplings. Threaded-and-coupled pipe, integral-connection pipe and threaded pipe shipped without couplings shall be weighed with or without thread protectors if proper allowances are made for the mass of the thread protectors. Weighing of a pipe by a threader is not mandatory.

9.13.8 Straightness Evaluation

9.13.8.1 General Requirements

All pipe, coupling stock, coupling material, and accessory material shall be visually examined. The straightness of questionably bent lengths or crooked extremities shall be measured as follows.

a) For Label 1: 4 $^{1}/_{2}$ and larger, using a straightedge or taut string (wire) from one end of the length to the other end.

b) Using a straightedge with a minimum length of 1.8 m (6 ft) of which at least 0.3 m (1 ft) shall contact the surface beyond the extent of the hooked extremity or an equivalent method. In the case of dispute, the straightedge measurement shall govern.

c) By semiautomated or automated method(s) with demonstrated capability for detecting deviations from straightness as defined in 7.9.1. Records for validation and verification shall be maintained in accordance with 9.13.8.2. In case of dispute, the methodologies in a) or b) shall govern.

The taut string and straightedge shall be positioned to highlight the maximum deviation.

Deviation from the straight, or chord height, shall not exceed the requirements in 7.9. See Figures D.13 and D.14. Measurement of the deviation shall not be made in the plane of the upset, the upset fade-away or the coupling.

9.13.8.2 Semiautomated and Automated Straightness Evaluation System Capability

Before introducing semiautomated or automated straightness evaluation systems in production, the manufacturer shall qualify the system by performing trial measurements to verify and demonstrate the system capability, accuracy, and repeatability in accordance with 7.9.1. Records of qualification shall include all the items mentioned below.

The manufacturer shall maintain equipment system records verifying the system(s) accuracy in accordance with the requirements of 7.9.1.

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

    1) size range;

    2) coverage details;

    3) accuracy of measurement;

    4) repeatability;

5) documentation demonstrating that out of tolerance hooked and or bowed pipe are detected using the straightness measurement equipment; the reject threshold for straightness measurement shall be established using reference standards within the specified straightness for the product to be inspected;

6) set-up parameters.

b) In addition, the manufacturer shall maintain documentation relating to:

1) measurement equipment description;

2) personnel qualification requirements to operate the measurement equipment;

3) measurement equipment operation procedures;

4) type of reference standard utilized to satisfy the applicable 7.9.1 requirements;

5) dynamic data demonstrating the measurement equipment capabilities during normal operation conditions.

9.13.9 Internal Upset Inspection

Inspection of the internal upset configuration shall be made with a 90° hook-type tool. The contact pin shall have a circular cross-section of 4.8 mm ($^3/_{16}$ in.) diameter that is visually determined to be attached perpendicular to the handle. The end of the pin contacting the inside surface of the pipe shall be rounded to a height (between the radius tangent point and the vertical surface of the contact point shaft) that shall not exceed 0.30 mm (0.012 in.). The contact point radius shall not exceed the inside radius of the pipe being inspected. Sharp edges on the contact point shall be removed. See Figure D.23. The 90° hook-type tool contact point should be maintained perpendicular to the longitudinal axis of the pipe while the contact point is passed axially throughout the inside upset transition length. Pressure on the contact point shall be no greater than the pressure created by the mass of the 90° hook-type tool.

9.14 Visual Inspection

9.14.1 General

All visual inspection shall be carried out by trained personnel with satisfactory visual acuity to detect surface imperfections. 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).

All visual inspection may be at any appropriate point in the manufacturing process, except that end-area inspection, when required, shall be after the final heat treatment.

If another method is applied with demonstrated capability of detecting defects as defined in 7.13, visual inspection is not required.

If end cropping is performed to remove defects, the end of the pipe revealed after cropping shall be subjected to a repeat internal surface inspection as previously performed.

9.14.2 Pipe Body, Coupling Stock, and Coupling Material (Excluding Pipe Ends)

Each length of pipe, coupling stock, and coupling material shall be visually inspected over the entire outside surface for the detection of imperfections.

9.14.3 Pipe Ends

Pipe ends shall be visually inspected on the outside surface for a minimum distance of 450 mm (18 in.).

For non-upset products, pipe ends shall be visually inspected on the inside surface for a minimum distance of 2.5D or 450 mm (18 in.), whichever is the lesser.

For upset products, pipe ends shall be visually inspected on the inside surface for a minimum distance of the length of upset including the run-out interval.

9.14.4 Disposition

Surface imperfections disclosed by visual inspection shall be treated in accordance with 9.15.16, 9.15.17, and 9.15.18.

9.14.5 Machine Vision Technique for Visual Inspection

9.14.5.1 General

If other visual technique(s) with demonstrated capability for detecting defects as defined in 7.13 are applied, physical visual inspection is not required.

9.14.5.2 Machine Vision Technique System Capability

Before introducing machine vision technique systems in production, the manufacturer shall qualify the system by performing trial measurements to verify and demonstrate the system capability, accuracy, and repeatability. Records of qualification shall include all the items mentioned below.

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

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

   1) size range;

   2) coverage details (for inside or outside surfaces);

   3) repeatability based on reference artificial or natural indicators;

   4) documentation demonstrating that the defects typical of the manufacturing process are detected using the inspection equipment;

   5) set-up parameters.

b) In addition, the manufacturer shall maintain documentation relating to:

   1) inspection equipment description;

   2) personnel qualification requirements to operate the inspection equipment;

   3) inspection equipment operation procedures;

   4) type of reference standard used to satisfy the applicable requirements in 7.13;

   5) dynamic test data, demonstrating the inspection equipment capabilities during normal operation conditions.

9.14.5.3 Disposition

Surface imperfections disclosed by the machine vision inspection equipment shall be treated in accordance with 9.15.16, 9.15.17, and 9.15.18.

In case of dispute, inspection as in 9.14.1 to 9.14.4 shall govern.

9.15 Nondestructive Examination

9.15.1 General

Subsection 9.15 specifies the NDE requirements and inspection levels for seamless and electric-welded pipe and for coupling stock. For NDE of couplings, see 8.11. A summary of the required NDE operations for seamless pipe, coupling stock, and the body of welded pipe is given in Table C.37 or Table E.37. All pipe and coupling stock that require NDE (except visual inspection) shall be inspected full-body, full-length for defects.

The NDE standards referenced in this section are based on traditional proven NDE methods and techniques practiced and adopted worldwide for the inspection of tubular products. However, other NDE methods/techniques, which have demonstrated capability in detecting defects as defined in 7.13, can be used. Records shall be maintained in accordance with 9.15.4.

At the discretion of the manufacturer, the notches referenced in Table C.38 or Table E.38 may be oriented at an oblique angle such that detection of defects typical of the manufacturing process is optimized. The technical justification for modification of the orientation shall be documented.

For Grades C90, T95, and C110, the oblique angle inspected shall be stated on the certificate. In the case of material shipped directly to a processor from the seamless pipe mill, the pipe mill shall provide the processor documentation regarding the oblique angle to be inspected. The technical justification for the orientation shall be documented.

If the provisions for purchaser inspection of pipe or witnessing of NDE operations, or both, are stated in the purchase agreement, they shall be in accordance with Annex B.

If the provisions for purchaser inspection of pipe or witnessing of NDE operations, or both, are stated in the purchase agreement, they shall be in accordance with Annex B.

The inspections performed in accordance with 9.15, with the equipment calibrated to the reference indicators in Table C.39 or Table E.39, should not be construed as ensuring that the material requirements in 7.13 have been met.

NDE equipment calibration shall be performed in accordance with ASTM E543.

For full-body, full-length NDE, the inspection equipment shall provide 100 % coverage for imperfections other than wall thickness. For untested pipe ends, see 9.15.13.

When performing wet magnetic particle inspection, wet particle concentration shall be checked every 8 h or every shift change, whichever is more frequent. When performing fluorescent magnetic particle inspection, the minimum black light intensity at the examination surface shall not be less than 1000 $\mu W \cdot cm^{-2}$ (10 $W \cdot m^{-2}$).

9.15.2 Nondestructive Examination Personnel

ISO 9712, ISO 11484, ASNT-SNT-TC-1A, or equivalent recognized industry standard shall be the basis for the qualification of nondestructive inspection personnel (excluding visual inspection). Such personnel shall be requalified for any method previously qualified, if they have not performed nondestructive inspection in that method for a period exceeding 12 months. The manufacturer or inspection company shall have a training program to qualify or certify, or both, the NDE personnel for the method, technique, and equipment that are used for the inspection(s) specified in this standard.

Nondestructive inspection shall be conducted by level 1, 2, or 3 personnel, using procedures approved by level 3 personnel.

Evaluation of indications shall be performed by level 2 or 3 personnel, or by level 1 personnel under the supervision of level 2 or 3 personnel.

9.15.3 Reference Standards

When ultrasonic inspection or electromagnetic inspection (EMI) systems are used for verification of pipe body, coupling stock, or weld seam, other than wall thickness verification, reference standards containing notches or holes as described in Tables C.38 and C.39 or Tables E.38 and E.39 shall be used to verify equipment response from artificial reference indicators.

When holes are used to establish the reject threshold, the manufacturer shall use a documented procedure to ensure the correct transducer alignment with the weld seam.

The manufacturer may use any documented procedure to establish the reject threshold for ultrasonic inspection or EMI provided the artificial reference indicators described in Tables C.38 and C.39 or Tables E.38 and E.39 are detected dynamically, at or above the reject threshold, under normal operating conditions. Such detection capability shall be demonstrated dynamically. At the option of the manufacturer, this may be performed either online or offline.

Tables C.38 and C.39 or Tables E.38 and E.39 list the acceptance (inspection) levels and associated artificial reference indicators that manufacturers shall use in establishing thresholds for sorting pipe that may contain defects as defined in 7.13. The reference indicators, used during automated ultrasonic inspection or EMI, are not to be construed as being the defect sizes defined in 7.13, or to be used by those other than the manufacturer as the only basis for pipe rejection.

When standardizing EMI equipment using drilled holes, the inspection system shall be capable of producing signals from both outside-wall and inside-wall notches that are equal to or greater than the reject threshold established using the drilled hole. Records in accordance with 9.15.4 shall be maintained.

When standardizing EMI equipment using notches, the notches shall be in accordance with Table C.39 or Table E.39 to provide a reproducible signal when the reference standard is passed through the equipment three times at the production examination speed for the pipe being inspected.

9.15.4 Nondestructive Examination System Capability Records

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

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

a) coverage calculation (i.e. scan plan), including wall thickness verification;

b) capability for the intended wall thickness;

c) repeatability;

d) transducer orientation that provides detection of defects typical of the manufacturing process (see 9.15.1);

e) documentation demonstrating that defects typical of the manufacturing process are detected using the NDE methods in Table C.37 or Table E.37;

f) threshold-setting parameters.

In addition, the manufacturer shall maintain documentation relating to:

a) NDE system operating procedures;

b) NDE equipment description;

c) NDE personnel qualification information;

d) dynamic test data demonstrating the NDE system/operation capabilities under production test conditions.

9.15.5 Pipe Body or Coupling Stock Inspection—General

Unless otherwise agreed upon, all required NDE operations (except visual inspection, but including the final end-area inspection in accordance with 9.15.13) for pipe and coupling stock shall be carried out after final heat treatment and rotary straightening operations, with the following exceptions:

a) certain types of pup joint (see 9.15.11);

b) when more than one pipe-body NDE method is applied, one of these (other than ultrasonic inspection) may take place prior to heat treatment/rotary straightening.

9.15.6 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grades N80, L80, and R95

All pipe shall be inspected for the detection of imperfections on the outside and inside surfaces by one or more of the following methods:

a) ultrasonic testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-10 or ASTM E213;

b) flux leakage testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-3 or ASTM E570;

c) eddy current concentric coil testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-2 or ASTM E309;

d) for pipe outside surface, magnetic particle inspection in accordance with ISO 10893-5 or ASTM E3024.

9.15.7 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grade P110 to A.9 (SR 16)

All pipe shall be inspected for the detection of both longitudinal and transverse imperfections on the outside and inside surfaces to acceptance level L4 by one or more of the following methods:

a) ultrasonic testing in accordance with ISO 10893-10 or ASTM E213 (longitudinal) and ISO 10893-10 or ASTM E213 (transverse);

b) flux leakage testing in accordance with ISO 10893-3 or ASTM E570 (longitudinal) and ISO 10893-3 or ASTM E570 (transverse);

c) eddy current concentric coil testing in accordance with ISO 10893-2 or ASTM E309.

9.15.8 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grade P110 and Grade P110 to A.9 (SR 16) and A.3 (SR 2)

All pipe shall be inspected for the detection of both longitudinal and transverse imperfections on the outside and inside surfaces to acceptance level L2 by one or more of the following methods:

a) ultrasonic testing in accordance with ISO 10893-10 or ASTM E213 (longitudinal) and ISO 10893-10 or ASTM E213 (transverse);

b) flux leakage testing in accordance with ISO 10893-3 or ASTM E570 (longitudinal) and ISO 10893-3 or ASTM E570 (transverse);

c) eddy current concentric coil testing in accordance with ISO 10893-2 or ASTM E309.

9.15.9 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grades C90, T95, C110, and Q125

9.15.9.1 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grades C90, T95, C110, and Q125, Longitudinal and Transverse Inspection Requirements

All pipe shall be inspected for the detection of imperfections on the outside and inside surfaces by ultrasonic testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-10 or ASTM E213.

In addition, all pipes shall be inspected for the detection of imperfections on the outside surface by one of the following methods:

a) flux leakage testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-3 or ASTM E570;

b) eddy current testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-2 or ASTM E309;

c) magnetic particle inspection for the detection of longitudinal and transverse imperfections in accordance with ISO 10893-5 or ASTM E3024.

9.15.9.2 Full-body, Full-length Nondestructive Examination of Casing and Tubing—Grades C90, T95, and C110, Additional Oblique Inspection Requirements

All pipe shall be inspected for the detection of oblique imperfections that are typically generated by the manufacturing process, on the outside and inside surfaces by one or more of the following methods:

a) ultrasonic testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-10 or ASTM E213;

b) flux leakage testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-3 or ASTM E570;

c) eddy current testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-2 or ASTM E309.

9.15.10 Nondestructive Examination of the Weld Seam of Welded Pipe

For quenched and tempered welded pipe, weld seam inspection shall take place after final heat treatment and rotary straightening operations. For other welded pipe, unless otherwise agreed upon, the timing of the weld seam inspection of welded pipe shall be at the manufacturer's discretion.

NDE of the weld seam of electric-welded pipe shall be carried out using inspection equipment capable of full volumetric inspection over a 3 mm ($^1/_8$ in.) wide zone centered on the fusion line.

If the NDE of the weld seam is performed simultaneously with the full-body, full-length NDE, then the reference standard shall contain all of the required artificial reference indicators (for pipe body and weld seam) as described in Table C.39 or Table E.39.

NOTE As described in Table C.38 or Table E.38, the acceptance level for the pipe body and the weld seam can be different.

For Grades H40, J55, K55, N80, R95, and L80, the weld seam shall be inspected for the detection of longitudinal imperfections by one or more of the following methods:

a) ultrasonic testing to acceptance level U3/L3 in accordance with ISO 10893-11 or ASTM E273 or ISO 10893-10 or ASTM E213;

b) flux leakage testing to acceptance level F3/L3 in accordance with ISO 10893-3 or ASTM E570;

c) eddy current testing to acceptance level E3/L3 in accordance with ISO 10893-2 or ASTM E309.

For Grades P110 and Q125, the requirements of A.6.5 (SR 11.5) shall apply.

When A.12 (SR 40) is specified in the purchase agreement for all Grades except P110 and Q125, the additional requirements of A.12 (SR 40) shall apply.

9.15.11 Nondestructive Examination of Coupling Stock (Except Grades L80 13Cr, C90, T95, C110, and Q125), Accessory Material (Except Grades L80 13Cr, C90, T95, C110, and Q125), and Pup Joints (All Grades)

9.15.11.1 When NDE is required for coupling stock or accessory material, according to Table C.37 or Table E.37, the inspection shall be for the detection of imperfections on the outside surface by one or more of the following methods:

a) ultrasonic testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-10 or ASTM E213;

b) flux leakage testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-3 or ASTM E570;

c) eddy current testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-2 or ASTM E309;

d) magnetic particle inspection in accordance with ISO 10893-5 or ASTM E3024.

The reference indicators used by the manufacturer to calibrate the compression and shear wave ultrasonic equipment may be retained in the coupling stock. If the reference indicators are retained in the reference standard, the outside-wall surface area adjacent to the reference indicators shall be stenciled with the letters “RI.” The reference indicators shall be considered defects and marked in accordance with 9.15.18 b).

Coupling stock for couplings that will be fully machined may have imperfections on the unmachined surfaces; however, the final machined surfaces shall meet the specified dimensions and surface inspection criteria of 8.11.

9.15.11.2 Pup joints shall be inspected and meet the same requirements as casing and tubing.

a) For pup joints made from full-length casing and tubing, the required inspection for inside and outside defects shall take place either before or after cutting into final length, provided there is no subsequent upsetting or heat treatment.

b) For pup joints machined from pipe or bar stock, the required inspection shall take place either before or after machining to final product dimensions; however, the outside surface shall be visually inspected subsequent to being machined to final product dimensions.

c) For all other pup joints, except for those round thread pup joints in d), the required inspection shall be performed according to a) above.

d) For API round thread pup joints in size designations listed in Table C.2 or Table E.2 for Grades H40, J55, K55, N80, R95, L80, and P110, the required inspections, unless otherwise agreed upon between the purchaser and the manufacturer, are as specified in e).

e) For outside surface and end areas, the required inspection shall be performed following any upset process and final heat treatment. For Grade P110 pup joints, magnetic particle inspection for the detection of longitudinal and transverse defects may be substituted for the required outside surface inspection.

9.15.12 Nondestructive Examination of Coupling Stock and Accessory Material—Grades L80 13Cr, C90, T95, C110, and Q125

9.15.12.1 General

All coupling stock and accessory material shall be inspected for the detection of imperfections on the outside and inside surfaces by one or more of the following methods:

a) ultrasonic testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-10 or ASTM E213;

b) flux leakage testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-3 or ASTM E570;

c) eddy current testing to acceptance level as specified in Table C.38 or Table E.38 in accordance with ISO 10893-2 or ASTM E309;

d) magnetic particle inspection in accordance with ISO 10893-5 or ASTM E3024.

9.15.12.2 Permitted Imperfections before Machining

Coupling stock for couplings that will be fully machined may have imperfections on the unmachined surfaces. However, the final machined surfaces shall meet the specified dimensions and the surface inspection criteria of 8.11 [A.4.3 (SR 9.3)].

9.15.12.3 Further Evaluation

Coupling stock containing imperfections may be given further evaluation in accordance with 9.15.15, except the maximum size of the non-surface-breaking imperfection specified in 7.13.1 d) shall be reduced to 32 mm^2 (0.05 $in.^2$). Coupling stock containing defects shall either be given a disposition in accordance with 9.15.18, or the section of coupling stock containing the defect shall be cut off within the limits of the requirements on length specified on the coupling stock purchase agreement.

9.15.12.4 Ultrasonic Testing—Through-wall

Coupling stock shall be inspected full-body, full-length from the outside surface using ultrasonic compression-wave techniques to detect and identify imperfections. The reference indicator shall be a 6.4 mm ($^1/_4$ in.) flat-bottomed round hole from the inside surface as shown in Figure D.18 d). The minimum coverage shall be 100 % of the inspected surface [see 9.15.4 a)].

9.15.12.5 Ultrasonic Testing—Inside Surface

Coupling stock shall be inspected for longitudinal, transverse, and oblique imperfections on the inside surface using ultrasonic shear-wave techniques to acceptance level as specified in Table C.38 or Table E.38 with a maximum notch length of 25 mm (1 in.) for longitudinal and transverse, 50 mm (2 in.) for oblique. By agreement between the purchaser and the manufacturer, alternative NDE methods that demonstrate the capability to detect the reference indicators may be used.

9.15.13 Untested Pipe Ends, Coupling Stock Ends, and Accessory Material Ends

The end-area inspections shall be subsequent to all heat treatment.

It is emphasized that many of the automatic NDE operations specified in this standard result in a short length at each end that cannot be tested. In such cases, the untested ends shall be either:

a) cropped off;

b) subjected to magnetic particle inspection of the outside and inside surfaces around the full periphery and over the length of the untested ends; or

c) subjected to a manual/semiautomatic test that achieves, as a minimum, the same degree of inspection as the automatic NDE.

Grade C110 pipe, with the ends treated in accordance with 9.15.13 b), shall be inspected after end-finishing (and before coupling installation on threaded and coupled tubulars) using the wet magnetic particle method, or a method agreed upon between the purchaser and the manufacturer.

Records shall be maintained in accordance with 9.15.4.

NOTE See A.20 (SR 48) for additional requirements.

9.15.14 Pipe Upsets

Forged upsets (including the upset run-out interval) on all grades, except Grades H40, J55, and K55, shall be subjected, after all heat-treatment operations, to NDE for the detection of transverse defects on the outside and inside surfaces of the upset, using the criteria given in 7.13. For grades manufactured by the quench-and-temper process, the end-area inspection shall include inspection for longitudinal defects.

Records in accordance with 9.15.4 shall be maintained.

9.15.15 Pipe, Coupling Stock, and Accessory Material Requiring Further Evaluation

In all cases, indications producing a threshold alarm condition from the specified NDE operation(s) shall have the indications evaluated in accordance with 9.15.16, unless it can be demonstrated that the imperfection causing the indication is not a defect as described in 7.13.

9.15.16 Evaluation of Indications (Prove-up)

For an indication that is greater than or equal to the reject threshold, the manufacturer shall either evaluate it in accordance with the requirements herein (9.15.16) or dispose of the indication as a defect in accordance with 9.15.17. Evaluation of indications shall be performed by NDE Level I certified inspectors under the supervision of NDE Level II or III certified inspectors, or by NDE Level II or III certified inspectors. Evaluation of indications shall be performed in accordance with documented procedures.

When no imperfection is found in the area of the original indication and there is no explanation for the indication, then the product shall be rejected, or at the option of the manufacturer, reinspected full-body, full-length, as required by Table C.37 or Table E.37 and 9.15.10 and applicable SRs, either using the same inspection method or using ultrasonic inspection methods. At the manufacturer's option, the inspection equipment shall be adjusted either to the same sensitivity level as that used to perform the original inspection or to a reduced sensitivity that meets the specified requirements.

All magnetic particle indications that are produced by leakage fields originating from imperfections shall be evaluated in accordance with 9.15.16 a).

For the evaluation of an indicated imperfection, the depth shall be measured by one of the following methods.

a) Using a mechanical measuring device (for example, pit gauge, calipers, and so forth)—Removal of material by grinding or other means to facilitate measurement shall not, for pipe, reduce the remaining wall thickness below 87.5 % of the specified wall thickness, or for coupling stock, reduce the remaining outside diameter or wall thickness below the minimum specified in the purchase agreement. Abrupt changes in wall thickness caused by material removal during prove-up shall be removed.

b) Using an ultrasonic technique(s) (time- or amplitude-based, or both), or other comparable techniques—Verification of the ultrasonic technique(s) shall be documented and shall show capability to differentiate imperfection sizes larger and smaller than the appropriate defect size stated in 7.13.

If the purchaser and the manufacturer do not agree on the evaluation test results, either party may require destructive evaluation of the material, after which disposition shall be as described in B.4.

Imperfections that have been evaluated and found to be defects shall be given a disposition in accordance with 9.15.17.

9.15.17 Disposition of Pipe Containing Defects

Imperfections that satisfy the material requirements and are less than the defect size stated in 7.13 are allowed to remain in the pipe. Repair welding is not permitted.

Pipe containing cracks or quench cracks, or both, within a distance of twice the diameter from the end, may be cut back only once to remove the cracks. After cutting the pipe, it shall be reinspected full-body, full-length. Where cracks or quench cracks, or both, are detected at a distance more than twice the diameter from the ends, the pipe shall be rejected.

Pipe containing defects shall be given one of the following dispositions:

a) Grinding or machining:

Grinding or machining of quench cracks or arc burns is not permitted. Defects shall be completely removed by grinding or machining, provided the remaining wall thickness is within specified limits. The area affected by grinding or machining shall be blended smoothly into the contour of the tube. Where the depth of the removal exceeds 10 % of the specified wall thickness, the remaining wall thickness shall be verified in accordance with 9.13.4. When the defect is located on the inside surface in the external thread section of the pipe body, the depth of the removal shall not exceed 10 % of the specified wall thickness as measured using a dial depth gauge or other suitable device, and the length of the removal shall be limited to that which allows for accurate depth measurement. After removal of the defect, the affected area shall be reinspected to verify that the defect was completely removed. The reinspection shall be either:

1) by the same inspection unit at the same sensitivity that performed the initial inspection; or

2) by another NDE method, or combination of methods, that demonstrate equal or greater sensitivity than the original NDE.

When method 2) above is used, the NDE method (or combination of methods) shall be documented and shall demonstrate equal or greater sensitivity than the original NDE. In addition, method 2) shall address the possibility that there may be other coincident defects in the affected area.

b) Cut-off:

The section of pipe containing the defect shall be cut off within the limits of requirements on length of the intended product.

c) Rejection:

The length shall be rejected.

9.15.18 Disposition of Coupling Stock and Accessory Material Containing Defects

Imperfections that satisfy the material requirements and are less than the defect size stated in 7.13 are allowed to remain in the coupling stock and accessory material. Repair welding is not permitted.

Coupling stock and accessory material containing cracks and or quench cracks within twice the diameter from the end may be cut back, once only, to remove the cracks. After cutting the piece shall be reinspected full-body, full-length. Where cracks or quench cracks, or both, are detected at a distance more than twice the diameter from the ends, the piece shall be rejected.

Coupling stock and accessory material containing defects shall be given one of the following dispositions:

a) Grinding or machining:

   Grinding or machining of quench cracks or arc burns is not permitted.

   Defects shall be completely removed by grinding or machining, provided the remaining wall thickness is within specified limits. The area affected by grinding or machining shall be blended smoothly into the contour of the tube. Where the depth of the removal exceeds 10 % of the specified wall thickness, the remaining wall thickness shall be verified in accordance with 9.13.4 and the resultant outside diameter at the site of imperfection removal shall be verified to ensure conformance with specified outside diameter requirements. After removal of the defect, the affected area shall be reinspected to verify that the defect was completely removed. The reinspection shall be either:

   1) by the same inspection unit at the same sensitivity that performed the initial inspection; or

   2) by another NDE method, or combination of methods, that demonstrate equal or greater sensitivity than the original NDE.

   When method 2) above is used, the NDE method (or combination of methods) shall be documented and shall demonstrate equal or greater sensitivity than the original NDE. In addition, method 2) shall address the possibility that there may be other coincident defects in the affected area.

b) Marking the area of defect:

   If a defect is not removed from coupling stock and accessory material within acceptable limits, then the area shall be marked to indicate the presence of a defect. The marking shall consist of a paint band encircling the tube body that covers the entire defect area, if this area is equal to or less than 50 mm (2 in.) in axial length, or bands in a cross-hatched pattern, if this area is greater than 50 mm (2 in.) in length. The band color shall be as agreed upon between the purchaser and the manufacturer.

c) Cut-off:

   The section of coupling stock or accessory material containing the defect shall be cut off within the limits of requirements on length of the intended product.

d) Rejection:

   The coupling stock or accessory material shall be rejected.

10 Marking

10.1 General

10.1.1 Products manufactured in conformance with this standard shall be marked by the manufacturer as specified herein.

10.1.2 For all manufacturers except threaders, the marking instructions in Section 10, except those in 10.6, are applicable. For threaders, the marking instructions in 10.5 and 10.6 and Table C.43 or Table E.43 are applicable. Processors shall remove any identity that is not indicative of the new condition of the product as a result of heat treatment (for example, prior grade identity and original pipe manufacturer’s name or logo).

10.1.3 Products shall be color-coded as specified in 10.4.

10.1.4 Products shall be marked by stenciling, or a combination of stenciling and stamping, at the option of the manufacturer, as stipulated, with three exceptions.

a) By agreement between the purchaser and the manufacturer, stamping can be required, in which case a combination of stamping and stencil marking shall be used.

b) At the option of the manufacturer, hot-rolled or hot-stamped markings on pipe and couplings may be substituted for die-stamped markings and are permitted at intervals along the length.

c) Alternative systems to stenciling may be used. The system shall mark all the information required for a paint stencil in Table C.43 or Table E.43. If the alternative system has the potential to modify the mechanical or corrosion properties of the material on the applied surfaces, process control parameters shall be validated through a documented procedure ensuring that on the underlying surface, the cracking resistance for sour service and the surface hardness (as in 6.7) are maintained and defects (as in 7.13) were not created.

10.1.5 Requirements for optional stamp markings are specified in 10.2, and stencil markings shall be as specified in 10.3. Marking instructions and sequence of markings are specified in Table C.43 or Table E.43, which includes only those items that are stamped or stenciled for product identification. If die stamp marking is selected, it is not required to also stencil mark the information. Examples of markings are shown in Figures D.17. Marking shall not overlap and shall be applied in such a manner as not to injure the product.

10.1.6 Additional markings for compatible standards shall be listed after “API 5CT.”

10.1.7 In a circumstance where it is necessary to re-mark product with the original marking information, the accuracy and traceability of the transferred markings shall be the responsibility of the entity re-marking the product. The transferred markings shall include the words “transferred by << >>” with the name of the entity responsible for transferring the markings shown between the << >>.

10.1.8 The date of manufacture is defined for marking purposes as the first two digits representing the month and the last two digits representing the year with a hyphen (dash) or slash in between (e.g. 05-12 or 05/12 for May 2012).

10.1.9 Products manufactured in accordance with this edition of API 5CT during the period of overlap of application with the previous edition shall be identified by including the edition number after the manufacture date separated by a hyphen (dash) or slash (e.g. 11th Edition during 10th Edition applicability, 05-24-11ED or 05/24/11ED for 11th Edition). Once the new edition is effective, marking of the edition is at the manufacturer’s discretion. The edition marking applies to the pipe body characteristics and does not apply to changes in API 5B.

10.1.10 Other additional markings are allowed and may be applied as desired by the manufacturer or as requested by the purchaser, but shall be applied after the markings specified in Table C.43 or Table E. 43.

10.1.11 Marking for coupling material and accessory material shall be specified in the purchase agreement, or in the case of coupling material, in the manufacturer’s internal marking requirements, but shall be traceable to, as a minimum, this standard, the manufacturer, the date of manufacture and the grade. When the purchase agreement specifies marking with color bands, these bands shall be consistent with Table C.41 or Table E.41.

10.2 Stamp Marking Requirements

10.2.1 Methods

Permitted methods of stamp marking are shown in Table 20.

Table 20—Stamp Marking

Number	Method
1	Hot-rolled or hot-stamped markings
2	Cold die stamping with standard dies
3	Cold die stamping with interrupted dot-face dies
4	Cold die stamping with rounded-face dies
5	Vibratory

After stamp marking, Grades R95, L80, C90, T95, C110, and Q125 products may require subsequent heat treatment as specified in 10.2.5. Such heat treatment shall be in accordance with 5.2. The sequence of stamp markings shall be as shown in Table C.43 or Table E.43.

10.2.2 Size

Sizes of stamp markings shall be as shown in Table C.40 or Table E.40.

10.2.3 Location

Placements of these markings on casing and tubing sizes Label 1: 1.660 and larger shall be on the outside surface of each length within 0.3 m (1 ft) from the coupling or box, either end of plain-end pipe or either end of pin-by-pin threaded pipe. The optional stamp marking on sizes smaller than Label 1: 1.660 may be on a metal tag affixed to each length, or for bundled tubing, stamped on a metal tag affixed to each bundle.

10.2.4 Grades H40, J55, K55, N80, and P110

When specified in the purchase agreement, products shall be stamped by one or more of the methods in 10.2.1 at the option of the manufacturer.

10.2.5 Grades R95, L80, C90, T95, C110, and Q125

When specified in the purchase agreement, products shall be stamped by one or more of the methods in 10.2.1 at the option of the manufacturer. In addition, the following apply:

a) Products for Grades R95 and L80 shall be heat-treated subsequent to using method 2 in 10.2.1.

b) Products for Grades C90, T95, C110, and Q125 shall be heat-treated subsequent to using methods 2 and 4 in 10.2.1, with the following exceptions:

   1) when the stamp markings are removed by cropping or by grinding, machining, threading to a depth not less than twice the depth of the stamping;

   2) by agreement between the purchaser and the manufacturer, the stamp marks may be left in the product.

10.2.6 Make-up Triangle Marking

For buttress casing in all sizes and grades and for round thread casing in sizes Label 1: 16 and larger in Grades H40, J55, and K55, the make-up triangle shall be stamped on the outside of each length on both ends. By agreement between the purchaser and the manufacturer, the make-up triangle may be replaced with a transverse white paint band 10 mm ($^3/_8$ in.) wide by 76 mm (3 in.) long. To assist in locating the triangle or transverse white paint band on buttress casing, a 25 mm (1 in.) wide by 610 mm (24 in.) long longitudinal white paint stripe shall be placed adjacent to the triangle or transverse paint band on the field end; additionally, a 25 mm (1 in.) wide by 100 mm (4 in.) long longitudinal white paint stripe shall be placed adjacent to the triangle or transverse paint band on the mill end.

For Grades H40, J55, K55, N80, and P110, the triangle shall be stamped by method 2, 3, 4, or 5 only.

For Grades C90, T95, and Q125, the triangle shall be stamped by method 3 only.

For Grades R95 and L80, the triangle shall be stamped by method 3 or 4 only.

10.3 Stencil Marking Requirements

Stencil markings shall be placed on the outside surface of each length of pipe, beginning at least 0.6 m (2 ft) from the coupling or box or from either end of plain-end pipe, pin-by-pin threaded pipe or coupling stock. For accessory material and pup joints less than 1.8 m (6 ft) in length, the required stencil markings may be placed on a decal attached to the outside surface within 0.3 m (1 ft) of the end. These markings shall be separated by a dash or shall be adequately spaced.

The sequence of stencil markings shall be as specified in Table C.43 or Table E.43, except the thread marking shall be at a location convenient to the manufacturer.

10.4 Color Identification

10.4.1 Color Coding

Each product shall be color-coded as specified in 10.4.2 through 10.4.6, unless otherwise specified in the purchase agreement.

10.4.2 Product 1.8 m (6 ft) and Longer

The following methods shall be used, as applicable.

a) For threaded pipe, pup joints and accessory material: paint a band encircling the product at a distance not greater than 0.6 m (24 in.) from the coupling or internally threaded end.

b) For plain-end or pin-by-pin threaded product: paint a band encircling the product at a distance not greater than 0.6 m (24 in.) from either end.

c) Couplings: for all Grades, except L80 3Cr, L80 9Cr, and L80 13Cr, the entire outside circumferential surface of the coupling shall be painted, including the appropriate coupling color bands.

   NOTE The coupling faces do not need to be painted.

d) Couplings: for Grades L80 9Cr and L80 13Cr, apply only the appropriate color bands with a band width of 12.7 mm ($^1/_2$ in.) to the outside surface of the coupling.

e) Couplings: for Grade L80 3Cr, paint at least the entire outside circumferential surface of the coupling, including the appropriate coupling color bands. By agreement between the purchaser and the manufacturer, when surface treatment (such as plating) is applied, only the appropriate color bands shall be applied to the outside surface of the coupling with a band width of 12.7 mm ($^1/_2$ in.).

f) If the pipe is furnished with SCCs or if the pipe and couplings are of a different grade (except Grades H40, J55, and K55 applied in accordance with 8.2.1), paint both the pipe and couplings as specified in items a), b) and c) above.

10.4.3 Loose Couplings

For all Grades, except L80 3Cr, L80 9Cr, and L80 13Cr, the entire outside circumferential surface of the coupling shall be painted, including the appropriate color bands.

NOTE The coupling faces do not need to be painted.

For Grades L80 9Cr and L80 13Cr, only the appropriate color bands shall be applied to the outside surface of the coupling with a band width of 12.7 mm ($^1/_2$ in.).

For Grade L80 3Cr, paint the entire outside circumferential surface of the coupling, including the appropriate coupling color bands. By agreement between the purchaser and the manufacturer, when thread surface treatment (such as plating) is applied, only the appropriate color bands shall be applied to the outside surface of the coupling with a band width of 12.7 mm ($^1/_2$ in.).

10.4.4 Special Clearance Couplings

For all Grades, except L80 3Cr, L80 9Cr, and L80 13Cr, the entire circumferential surface of the coupling shall be painted, including the appropriate colors and a black band around the center.

For Grades L80 9Cr and L80 13Cr, only the appropriate color bands and a black band around the center shall be applied with a band width of 12.7 mm ($^1/_2$ in.).

For Grade L80 3Cr, the entire outside circumferential surface of the coupling, including the appropriate colors and a black band around the center. By agreement between the purchaser and the manufacturer, when thread surface treatment (such as plating) is applied, only the appropriate color bands shall be applied to the outside surface of the coupling with a band width of 12.7 mm ($^1/_2$ in.).

10.4.5 Pup Joints Shorter Than 1.8 m (6 ft) in Length

For all Grades, except L80 3Cr, L80 9Cr, and L80 13Cr, the entire circumferential surface of the pup joint, except the threads, shall be painted, including the appropriate color bands.

For Grades L80 9Cr and L80 13Cr, apply only the appropriate color bands with a band width of 12.7 mm ($^1/_2$ in.) to the outside surface.

For Grade L80 3Cr, the entire outside surface except the threads shall be painted, including the appropriate color bands. By agreement between the purchaser and the manufacturer, only the appropriate color bands shall be applied to the outside surface with a band width of 12.7 mm ($^1/_2$ in.).

10.4.6 Grade Color—Codes

The color and number of bands for each grade shall be as shown in Table C.41 or Table E.41.

10.5 Thread and End-finish Marking

10.5.1 API Thread Marking

Manufacturers shall stencil thread identification on casing with round or buttress threads. For threaders, thread identification is required on casing and tubing. Thread identification shall be as shown in Table C.42 or Table E.42.

10.5.2 Plain-end and Special End-finish Markings

Marking requirements for the following shall be as shown in Table C.43 or Table E.43:

a) plain-end pipe furnished either upset or non-upset;

b) pipe with SF not specified herein but having the body of the pipe manufactured in accordance with the requirements specified herein; or

c) couplings and accessories furnished with SF not specified herein but that meet all the other requirements specified herein for these products except dimensions.

When applying API 5B-compliant thread to products not listed in Table C.1 or Table E.1 and Table C.2 or Table E.2, the product shall be marked as “SF” and the API thread designator (as shown in Table C.42 or E.42) placed after the API marking sequence specified in Table C.43 or Table E.43 (see also 10.1.10).

10.6 Pipe-threader Marking Requirements

Pipe threaded by a facility other than the original pipe manufacturer shall be identified, by a stamp or stencil consistent with 10.1, 10.2, and 10.3 adjacent to the threads, with the name or mark of the threader, the specification mark, and size and type of thread as listed in 10.5 and Table C.42 or Table E.42.

The threader shall mark on the body of the pipe the actual hydrostatic test pressure, unless the pipe has been previously tested to the pressure required for the thread and marked as specified in Table C.43 or Table E.43.

EXAMPLE For Label 1: 7, Label 2: 29.00, R95, long thread coupling:

Case 1—If the pipe manufacturer produced plain-end pipe and hydrostatic pressure tested to 34.5 MPa (5000 psi) based on the documented design basis of the tester for 177.8 mm (7 in.) pipe (see 9.12.3), and marked P34.5 (P5000), then the threader shall pressure test the pipe to 60.5 MPa (8.800 psi) and mark the pipe in accordance with Figure D.17.

Case 2—If the pipe manufacturer produced plain-end pipe and hydrostatic pressure tested to 61.0 MPa (8900 psi) and marked the pipe P61.0 (P8900), then the threader is not required to pressure test the pipe or mark the test pressure.

The markings applied to the body of the pipe by the original pipe manufacturer shall not be removed or altered. Use of the letters “API” to identify or certify that threads on tubular goods conform to API 5B is not permitted.

11 Coating and Protection

11.1 Coatings

11.1.1 Coatings for Protection during Transit

Unless otherwise specified in the purchase agreement, pipe and couplings shall be given an external coating for protection from rust while in transit. An attempt should be made to make these coatings smooth, hard to the touch, and with minimum sags. The coating shall be rated to protect the product for at least 3 months.

Unless otherwise specified in the purchase agreement, coupling stock, coupling material, and accessory material shall be supplied without external coating (bare), except for a protective coating that may be applied over the stencil.

The purchase agreement shall specify when bare pipe or specially coated pipe is required. For special coatings, the purchase agreement shall further specify whether the coating shall be applied to the full length or whether a certain specific distance from the end shall be left uncoated. Unless otherwise specified, such bare ends are commonly given a coating with oil for protection in transit.

NOTE 13 % Cr tubulars have shown a tendency toward localized pitting corrosion when stored in moist environments; special precautions during coating, shipping, and storage are worthwhile.

11.1.2 Coatings for Long-term Storage

By agreement between the purchaser and the manufacturer, protective coatings, internal and external, may be required for pipe for long-term storage to protect against corrosion, especially when stored in a marine environment.

The following points shall apply.

a) The protection shall be effective against corrosion in a marine environment during the long-term storage period defined by the purchaser and the manufacturer; minor surface discoloration shall be acceptable.

b) There shall be no need for removal of the protective coating before the running of the tubulars.

c) Correct application of the coating is essential and the following parameters shall be assessed:

   1) dryness of the pipe;

   2) cleanliness of the pipe;

   3) temperature at application;

   4) thickness of the coating film.

11.2 Thread Protectors

11.2.1 General

The entity performing the threading shall apply thread protectors. All thread protectors supplied by the threading entity shall meet the requirements of Annex F Class B, unless a Class A thread protector is specified in the purchase agreement. However, if specified in the purchase agreement, the customer may supply thread protectors that do not conform to Annex F requirements.

11.2.2 Thread Protector Coverage and Performance

External thread protectors shall cover the full length of the thread and internal thread protectors shall cover the equivalent total length of the internal thread. Thread protectors shall be of such design, material, and mechanical strength to protect the thread and end of the pipe from damage under normal handling and transportation and to inhibit infiltration of dust and water to the threads during transportation and normal storage period. Normal storage period shall be considered as approximately 1 year. The thread forms in protectors shall be such that the product threads are not damaged by the protectors. Thread protectors are not required for pup joints and accessories provided they are packaged in a manner that protects the threads.

NOTE Damage is an injury resulting from impact that causes an out-of-specification condition to the threads or pipe end, or both.

11.2.3 Grade L80 Types 9Cr and 13Cr

Bare steel thread protectors shall not be used on Grade L80 Types 9Cr and 13Cr tubulars.

11.2.4 Driftable Thread Protectors

By agreement between the purchaser and the manufacturer, open-ended, driftable protectors may be supplied. Thread compound shall cover the entire thread and seal surfaces of the connection.

11.2.5 Thread Protector Marking

Thread protectors shall be marked at a minimum with the following:

a) manufacturer’s name;

b) product size;

c) thread type;

d) “5CT” followed by the thread protector class-designation (A or B), i.e. “5CTA” or “5CTB.”

12 Documents

12.1 Electronic Media

A material test report, certificate of conformance or similar document 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 certifier'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 manufacturer.

12.2 Certification Requirements

A certification shall be provided by the manufacturer for all delivered products. In addition to the data listed in 12.3, the certificate shall include a statement that the product has been manufactured, sampled, tested or inspected, or both, in accordance with this standard and has been found to meet the requirements.

12.3 Certification Content

The certificate shall, as applicable to each item, contain at least the following information:

a) reference to this standard, the edition, and the revision date thereof;

b) applicable SRs;

c) heat or lot traceability identification according to 5.4.1;

d) specified diameter, wall thickness, grade, process of manufacture, and type of heat treatment;

e) the minimum tempering temperature allowed by the documented procedure for each lot of quenched and tempered or normalized and tempered casing and tubing (except coupling stock and coupling material);

f) the chemical analyses for heat, product, control, and eventual recheck, showing the mass fraction, expressed as a percent, of all elements whose limits or reporting requirements are set in this standard;

g) the tensile tests results, including yield strength, tensile strength, and elongation; the type, size, and orientation of the specimens shall be reported; the report shall show the nominal width of the test specimen when strip specimens are used, the diameter and gauge length when round bar specimens are used, or it shall state when full-section specimens are used;

h) where impact testing is required by this standard, impact test results include the following:

    1) acceptance test criteria;

    2) size, location, and orientation of the test specimens;

    3) nominal test temperature (i.e. actual test temperature);

    4) absorbed energy measured for each test specimen;

    5) average absorbed energy for each test; and

    6) percent shear area for Grade C110 (see 6.3.3) and A.16 (SR 44) products.

i) where hardness testing is required, hardness test results (including Rockwell hardness numbers and mean hardness numbers, test type and criterion, and specimen location and orientation);

j) where grain size determination is required, the size and test method used for the determination;

k) for SSC testing, a statement specifying the NACE test method(s) and solution(s) used;

l) the information specified in the NACE TM0177-2016, “NACE Uniform Material Testing Report Form (Part 2): Testing in accordance with NACE TM0177 Method A—NACE Standard Tensile Test” shall be provided (where the mechanical tensile test result of the lot is accepted to be used in the SSC report);

m) the information specified in the NACE TM0177-2016, “NACE Uniform Material Testing Report Form (Part 2): Testing in accordance with NACE TM0177 Method D—NACE Standard DCB Test” with supplemental information comprising crack length, the occurrence of dry cracks and dry crack length, and reason for invalidations for each specimen (and when applicable the mechanical assurance curve according to NACE TM0177-2016 Appendix D) shall be provided;

n) the minimum hydrostatic test pressure and duration;

o) for welded pipe for which NDE of the weld seam is required by this standard, the method of NDE employed (ultrasonic testing, EMI, or magnetic particle testing) and the type and size of the artificial reference indicators used;

p) for seamless products for which NDE is specified (either in the body of the standard, in the SRs, or in the purchase order), the method of NDE employed (UT, EMI, ET, or MT), the acceptance criteria, the location, orientation, and oblique angles (when specified) of the reference indicator used, and the type and size of the artificial reference indicators used;

q) for electric-welded pipe, the minimum temperature for heat treatment of the weld seam; if such treatment is not performed, “no seam heat treatment” shall be stated in the certificate;

r) when agreed upon between the manufacturer and the purchaser, certification of couplings (e.g. made-up power-tight) with the material test results, inspection results, statement of conformance to the connection requirements, and traceability identification;

s) the results of any supplemental testing required by the purchaser;

t) hardenability validation report number and revision (see 6.10.5), if applicable.

12.4 Retention of Records

Tests and inspections requiring retention of records in this standard are shown in Table C.44 or Table E.44. Such records shall be retained by the manufacturer and shall be available to the purchaser on request for a period of 5 years after the date of purchase from the manufacturer.

13 Minimum Facility Requirements for Various Categories of the Manufacturer

13.1 Pipe Mill

A pipe mill shall operate one or more pipe-making facilities capable of producing products as described in Section 6 of this standard. A pipe mill shall also have suitable equipment and be responsible for weighing pipe and marking pipe, coupling stock, coupling material, or accessory material.

A pipe mill shall also have facilities for conducting all required tests and inspections. Alternatively, and at the option of the pipe mill, any of these tests or inspections may be provided by a subcontractor and may be located offsite. In the event that a subcontractor performs any of these services, the conduct of such

inspections and tests shall be controlled and monitored by the pipe mill in accordance with a documented procedure to ensure conformance with the relevant requirements of this standard.

13.2 Processor

A processor shall operate heat-treating facilities capable of heat-treating full-lengths of pipe, coupling stock, coupling material, or accessory material. A processor shall also have suitable equipment and be responsible for weighing pipe and marking pipe, coupling stock, coupling material, or accessory material.

A processor shall also have facilities for conducting all required tests and inspections. Alternatively, and at the option of the processor, any of these tests or inspections may be provided by a subcontractor and may be located offsite. In the event that a subcontractor performs any of these services, the conduct of such inspections and tests shall be controlled and monitored by the processor in accordance with a documented procedure to ensure conformance with the relevant requirements of this standard.

13.3 Pipe Threader

A pipe threader shall operate one or more threading machines capable of threading pipe ends to the dimensions and tolerances specified in API 5B. A threader shall also have suitable equipment for, and be responsible for, markings. A threader shall also have access to master plug and ring gauges, as well as the required working gauges, for each size and type of thread.

A threader shall either have or have access to facilities for:

a) applying couplings to specified make-up;

b) hydrostatic testing the entire length to the pressure required for finished pipe;

c) drift-testing the ends after threading and coupling in accordance with specification requirements;

d) measuring length.

In the event that a subcontractor performs any of items a), b), c), or d), such services shall be carried out in accordance with documented procedures and shall be controlled and monitored by the threader to ensure conformance with the relevant requirements of this standard.

A threader (or a subcontractor) shall not change or alter the markings on the pipe body or certify that the pipe body conforms to any API/ISO specification. When subcontract work is performed for the threader, it shall be the responsibility of the threader to ensure that such work conforms to the requirements of this standard.

13.4 Coupling, Pup Joint, or Accessory Manufacturer

A coupling, pup joint, or accessory manufacturer shall operate equipment capable of machining and threading products in accordance with the dimensions and tolerances provided in the applicable specifications. The manufacturer shall also have access to master plug and ring gauges, as well as the required working gauges, for each size and type of thread produced on products marked by the manufacturer in accordance with Section 10.

A coupling, pup joint, or accessory manufacturer shall have access to facilities for conducting all other aspects of the manufacturing process for the products (e.g. heat treatment). In the event that subcontractors perform these services, the conduct of inspections and tests shall be controlled and monitored by the coupling, pup joint, or accessory manufacturer in accordance with documented procedures to ensure conformance with the relevant requirements of this standard.

In accordance with the requirements of this standard, pup joint manufacturers shall either have or have access to facilities for:

a) hydrostatic testing;

b) drift-testing finished products.

In the event that a subcontractor performs any of items a) or b), such services shall be carried out in accordance with documented procedures and shall be controlled and monitored by the manufacturer to ensure conformance with the relevant requirements of this standard.

Coupling manufacturers shall be capable of inspecting couplings by the magnetic particle inspection or other adequate nondestructive testing method.

Annex A
(normative)

Supplementary Requirements

A.1 General

This annex describes supplementary requirements (SRs) that may be specified by the purchaser or agreed between the purchaser and the manufacturer. These requirements apply only when stated in the purchase agreement.

See Table A.1 for SRs applicable to couplings.

Table A.1—Supplementary Requirements Applicable to Couplings

Requirement	SR
Statistical impact testing	A.7 (SR 12)
Seal-ring couplings	A.8 (SR 13)
Statistical tensile testing, Grades C90, T95, and C110	A.10 (SR 38)
Alternative NACE TM0177-2016 Method D SSC test, Grade C110	A.11 (SR 39)
Yield strength, Grade Q125	A.15 (SR 43)
Charpy V-notch test properties (shear area) for Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125	A.16 (SR 44)
Hardenability, minimum percentage martensite required for quenched and tempered products	A.17 (SR 45)
SSC test, Grades C90 and T95 (Method A of NACE TM0177-2016, 90 % Ys_{min})	A.18 (SR 46)

A.2 SR 1—Supplementary Nondestructive Examination for Grades H40, J55, and K55

The specified casing and tubing shall be inspected for imperfections that are greater than 12.5 % of the specified wall thickness or that reduce the net effective wall thickness below 87.5 % of the specified wall thickness.

These imperfections shall be considered defects and shall be given a disposition in accordance with 9.15.17. The inspection(s), including forged upsets, shall be performed to minimum requirements stated in 9.15 for Grades N80Q, L80, and R95, including full-body, full-length wall thickness verification according to 9.13.4.

A.3 SR 2—Supplementary Nondestructive Examination for Grades H40, J55, K55, N80, L80, R95, and P110 to A.9 (SR 16)

The specified casing and tubing shall be inspected for imperfections that are greater than 5 % of the specified wall thickness or that reduce the net effective wall thickness below 87.5 % of the specified wall thickness. These imperfections shall be considered defects and shall be given a disposition in accordance with 9.15.17. The inspection(s), including forged upsets, shall be performed to the minimum requirements stated in 9.15 for Grade P110, including full-body, full-length wall thickness verification according to 9.13.4.

A.4 SR 9—Coupling Blanks—Grades C110 and Q125

A.4.1 SR 9.1—Coupling Blank Size

Coupling blank dimensions shall be adequate to yield a fully machined cylinder with uniform wall thickness with an outside diameter, inside diameter and length as specified in the purchase agreement. The coupling blanks shall be provided fully machined by the manufacturer only when specified in the purchase agreement.

A.4.2 SR 9.2—Dimensional Tolerances

For fully machined coupling blanks, the tolerance on outside diameter shall be $^{+2.38}/_{0}$ mm ($^{+3/32}/_{0}$ in.) and the tolerance on the inside diameter shall be $^{0}/_{-2.38}$ mm ($^{0}/_{-3/32}$ in.), unless otherwise agreed upon between the purchaser and the manufacturer.

Coupling blanks ordered with as-rolled outside diameter surface shall have an outside diameter tolerance of ±1 %, but not greater than $^{+3.18}/_{-1.59}$ mm ($^{+1/8}/_{-1/16}$ in.).

A.4.3 SR 9.3—Imperfections

Coupling blanks that will not be fully machined by either the manufacturer or the purchaser shall be inspected and meet the same requirements as finished couplings. Coupling blanks that will be fully machined by either the manufacturer or the purchaser may have imperfections on the as-rolled surface; however, the machined surface shall meet the surface inspection criteria of 8.11 and be to the specified dimensions.

A.4.4 SR 9.4—Marking

All coupling blanks meeting the requirements of A.4 (SR 9) shall be marked as specified in Table C.43 or Table E.43.

A.5 SR 10—Upset Casing—Grade Q125

A.5.1 SR 10.1—Dimensions

Grade Q125 casing shall be provided with upset end(s). Dimensions of the upset shall be specified in the purchase agreement.

A.5.2 SR 10.2—Material Properties

Tensile, impact, and hardness properties of the pipe and upset shall conform to the requirements of Section 6. The allowable hardness variation of the upset shall be based on the nominal wall thickness of the upset specified in the purchase agreement. The tensile test specimens for the upset shall be the largest round specimen feasible. The size to be used shall be agreed by the purchaser and the manufacturer prior to testing.

A.5.3 SR 10.3—Heat Treatment

Upset pipe shall be heat-treated full-body, full-length after upsetting.

A.5.4 SR 10.4—Other Testing Considerations

The frequency of testing, retest provisions, identification, and so forth, for both the pipe body and the upset material shall be as specified in Section 9.

A.5.5 SR 10.5—End Area Inspection

The outside and inside surfaces of the ends of upset pipe shall be inspected after final heat treatment and before threading for transverse and longitudinal defects by the magnetic particle method.

A.6 SR 11—Electric-welded Grades P110 and Q125 Pipe

A.6.1 SR 11.1—General

Casing (Grades P110 and Q125) and tubing (Grade P110) may be produced by the electric-weld process only when detailed quality control provisions are jointly agreed by the purchaser and the manufacturer prior to the manufacture of the pipe. Tensile, impact, and hardness testing shall be performed as frequently as required for seamless pipe.

A.6.2 SR 11.2—Flattening Test Frequency

A.6.2.1 SR 11.2.1—Grade P110

The flattening test frequency shall be as specified in Table C.36 or Table E.36.

A.6.2.2 SR 11.2.2—Grade Q125

The flattening test frequency shall be as specified in Table C.36 or Table E.36. On one end, flattening tests shall be made with weld at 6 o'clock and, on the other end, with weld at 3 o'clock. All inspection shall be performed and imperfections removed (cut-backs made) prior to removal of flattening test specimens.

A.6.3 SR 11.3—Flattening Test Procedures

The test specimens shall be flattening-tested as specified in 9.5.3, 9.5.4, and 9.5.7.

A.6.4 SR 11.4—Other Material Properties

Electric-welded pipe shall meet the same tensile, impact, and hardness requirements as seamless pipe. The impact test specimen shall be machined with the notch at the weld seam. The requirements of Section 9 (for seamless pipe) shall also apply to electric-welded pipe.

A.6.5 SR 11.5—Inspection and Rejection

A.6.5.1 SR 11.5.1—Nonweld Area Inspection

The pipe body shall be inspected in the same manner as the seamless product as specified in Section 9.

A.6.5.2 SR 11.5.2—Nondestructive Examination of Weld Seam

The weld seam of pipe (except upset ends) furnished to this standard shall be inspected nondestructively full-length (100 %) by ultrasonic methods. The inspection shall be performed after all heat treatment and any subsequent rotary straightening operation. Pipe upsets shall be inspected as specified in 9.15.14.

A.6.5.3 SR 11.5.3—Equipment

Any equipment utilizing the ultrasonic principles capable of continuous and uninterrupted inspection of the weld seam shall be used. The equipment shall be checked with an applicable reference standard as described in A.6.5.4 (SR 11.5.4) at least once every working shift to demonstrate the effectiveness of the inspection equipment and procedures. The equipment shall be adjusted to produce well-defined indications when the reference standard is scanned by the inspection unit in a manner simulating the inspection of the product, and shall be capable of inspecting 1.6 mm ($^1/_{16}$ in.) on either side of the weld seam for the entire wall thickness.

A.6.5.4 SR 11.5.4—Reference Standards

A reference standard having the same specified diameter and thickness as the product being inspected shall be used to demonstrate the effectiveness of the inspection equipment and procedures at least once every working shift. The reference standard may be of any convenient length as determined by the

manufacturer. It shall be scanned by the inspection unit in a manner simulating the inspection of the product. For ultrasonic inspection, the reference standard, with similar acoustic properties to the product being inspected, shall contain two notches, one on the outer and one on the inner surface as specified in Figure D.18. The 1.6 mm ($^1/_{16}$ in.) diameter hole shall be drilled radially through the wall of the reference standard. The inspection equipment shall be adjusted to produce a well-defined indication from each reference indicator when the reference standard is scanned by the inspection system(s). Responses from the notches and hole shall meet the required system(s) sensitivity level. Outside-wall and inside-wall notches of reduced length may be used by agreement between the purchaser and the manufacturer.

A.6.5.5 SR 11.5.5—Rejection Limits

Any imperfection that produces a signal greater than or equal to the signal received from the reference standard shall be considered a defect unless it can be demonstrated by the manufacturer that the imperfection does not exceed the provisions of A.6.5.6 (SR 11.5.6).

A.6.5.6 SR 11.5.6—Disposition

Imperfections revealed by magnetic particle inspection and determined to be greater in depth than 5 % but not greater than 12.5 % of the specified wall thickness shall be removed by grinding or machining, or the pipe shall be rejected. All imperfections classified as defects by the ultrasonic or electromagnetic equipment that do not exceed 12.5 % of the specified wall thickness in depth shall be removed by grinding or machining, or the pipe shall be rejected.

Pipe with defects whose removal requires grinding or machining to a depth exceeding 12.5 % of the specified wall thickness shall be given a disposition in accordance with 9.15.17. Where grinding or machining is done, generous radii shall be used to prevent abrupt changes in wall thickness, and such areas shall be reinspected by one of the nondestructive inspection methods specified herein to verify complete removal of the defect.

A.7 SR 12—Statistical Impact Testing

A.7.1 SR 12.1—General

This SR specifies a statistical approach to testing. It is applicable only to those items that are accepted or rejected on a lot basis. The frequency of testing is based on standard statistical techniques for properties that have a normal distribution and where the standard deviation for a particular manufacturer, size, chemistry, and so forth, is not well established. The statistical acceptance and rejection procedures are required only for impact properties; however, the tensile and hardness properties shall be measured on all product where impact samples are taken. Tensile, impact, and hardness requirements are as required in Section 6.

A.7.2 SR 12.2—Frequency of Testing

Each length of product shall be uniquely numbered. This number shall be used for all subsequent identification. Tensile, impact, and hardness test specimens for product shall be taken at the same frequency from locations shown in Figure D.9. The sample size for each lot of product shall be selected by the manufacturer from Table A.2 (SR 12).

The factor F shown for the sample size selected shall be used in A.7.4 (SR 12.4) to determine acceptance or rejection of a lot based on the applicable transverse or longitudinal impact requirements. The number of samples is not dependent on the size of the lot. The lengths for testing shall be selected at random, provided the selection procedure provides samples representing at least the start and end of the heat treat cycle and both ends of the tubes (approximately 50 % each end).

By agreement between the purchaser and the manufacturer, a factor F of 3.090 may be used in lieu of the values given in Table A.2 (SR 12) provided the standard deviation of the new lot of material is consistent with past experience.

A.7.3 SR 12.3—Retest

If a tensile test specimen fails to conform to the specified requirements, the manufacturer shall make additional tests on each end of the length. If an impact test specimen fails to conform to the specified requirements, the manufacturer shall follow the retest provisions of 9.7.14 and 10.7.15 (as applicable). If a hardness test specimen fails to conform to the specified requirements, the manufacturer shall follow the retest provisions of 9.6.14 to 9.6.19 (as applicable).

If any product is rejected from a lot due to failure to demonstrate acceptable tensile, impact, or hardness requirements, then the product tempered immediately before and after the length rejected shall be tested on the same end as the product that was rejected. If one or both of the additional test lengths fail to conform to the specified requirements, the manufacturer may elect to test individually the remaining lengths in the lot, in which case determinations are required only for the particular requirement where specimens failed to conform in the preceding tests (i.e. a lot that meets the hardness and impact criteria, but has been rejected due to low elongation, shall be retested to verify tensile properties). Specimens for all retests shall be taken in the same manner as the initial test specimen. Lengths that fail the requirements of Section 7 shall be rejected.

A.7.4 SR 12.4—Acceptable Impact Energy for Any Lot of Product

Subsequent to impact testing, the mean and standard deviation shall be calculated for the average impact energy values. This calculation shall be made including the data for all lengths rejected due to low impact energy. The lot minimum impact energy S_{min} shall then be estimated (based on the sample data) using Equation (A.1):

$$S_{min} = \overline{S} - (F \times \sigma_{lot}) \quad \text{(A.1)}$$

where

S_{min} is the minimum impact energy in joules (foot-pounds);

$\overline{S}$ is the test lot mean impact energy in joules (foot-pounds);

F is the factor determined from Table A.2 (SR 12);

σ_{lot} is the lot standard deviation.

Table A.2 (SR 12)—Inspection Lot Sample Sizes vs F Factor

Sample Size	F	Sample Size	F
1	*2*	*3*	*4*
3	13.857	16	4.534
4	9.215	18	4.415
5	7.501	20	4.319
6	6.612	25	4.143
7	6.061	30	4.022
8	5.686	35	3.937
9	5.414	40	3.866
10	5.203	45	3.811
12	4.900	50	3.766
14	4.690	∞	3.090

A.7.5 SR 12.5—Lot Acceptance/Rejection

The lot shall be accepted provided S_{min} is greater than or equal to C_V determined in 6.4, 6.5, or 6.6 (as applicable). If S_{min} is less than C_V then additional random lengths may be selected for testing. The $\overline{S}, \sigma_{lot}$, and S_{min} shall be determined as above based on all the data and the new F value. The new S_{min} shall exceed C_V determined in 6.4, 6.5, or 6.6; otherwise, the lot shall be rejected. Additional random samples may be taken from additional product as many times as necessary. If the product is rejected as a lot, then each length may be tested to demonstrate that it meets the minimum impact energy requirements of 6.4, 6.5, or 6.6 (as applicable).

EXAMPLE Commentary regarding testing frequency, according to A.7.2 (SR 12.2):

— Since a string of product consists of more than one length of product, analysis should consider the probability that the string includes one or more lengths whose impact properties do not meet the desired minimum.

— Table A.3 (SR 12) gives the probability of a product string of 100 lengths including one or more unacceptable lengths. If the probability of any length being unacceptable is 1 in 1000 then there is a 10 % chance that the product string will include one or more unacceptable lengths. If the probability of any length being unacceptable is 1 in 10,000, then there is a 1 % chance that the product string will include one or more unacceptable lengths. The statistical model used for the examination frequency is designed to yield an individual tube reliability of 99.9 %. A typical confidence limit of 95 % is used with a tolerance interval approach, since the standard deviation is neither well established nor expected to be consistent for all manufacturers, product sizes, heat treatments, chemistries, and so forth.

Table A.3 (SR 12)—Probability of Defective Product

Probability of One Length Being Defective	Probability That One or More Defective Lengths Is Included in a String of 100 Products
1/10	0.99997 (or 100 %)
1/100	0.634 (or 63 %)
1/1000	0.095 (or 10 %)
1/10,000	0.00995 (or 1 %)

— The tolerance interval approach assumes that the standard deviation is not well known. The factor F is large because it includes variations that can be expected in the standard deviation. For example, if the impact requirement is 27 J (20 ft·lb), 5 lengths are sampled and the standard deviation is determined to be 4.1, then the factor F is 7.501. For the lot to be acceptable, the average transverse impact value shall exceed 27 + (7.501 × 4.1) or 58 J [20 + (7.501 × 3.0) or 43 ft·lb]. If 10 lengths had been sampled and the standard deviation was still 4.1, then the average impact value shall exceed 27 + (5.203 × 4.1) or 48 J [20 + (5.203 × 3.0) or 36 ft·lb]. If the standard deviation from a mill is well known, then the factor F is taken for an infinite number of samples of $F = 3.090$. Assuming the standard deviation for an infinite number of samples from a given size tubular and one mill is 4.1, then the average impact value shall exceed 27 + (3.090 × 4.1) or 40 J [20 + (3.090 × 3.0) or 29 ft·lb]. The method is applicable to both SI and USC units.

NOTE The procedure in A.7 (SR 12) is taken from Reference [14]; Table A.2 (SR 12) is taken from Table A.7 in Reference [14]. The procedure to calculate the mean and standard deviation for the average transverse impact energy for the lot can also be found in Reference [14], Chapter 1, Sections 1–6.

A.8 SR 13—Seal-ring Couplings

A.8.1 SR 13.1—Seal-ring Groove

Seal-ring couplings shall be grooved in accordance with dimensions and tolerance specified in Figures D.19 (SR 13.1) to D.22 (SR 13.4). Grooves may be cut before or after threading at manufacturer's option. Grooves and threads shall be free of fins, wickers, and ribbons that are loose or can become loose and fold into the thread form. Couplings shall be inspected after final machining of the groove. The inspection shall be by the

wet fluorescent magnetic particle method, using a circumferentially oriented magnetic field, or by another nondestructive method of equal sensitivity as demonstrated to the purchaser. The inspection shall encompass both the inside and outside surfaces. The inspection shall exclude the dry magnetic particle method.

Seal-ring grooves shall be machined in the same set-up used to machine the box threads. The seal-ring groove eccentricity shall be no greater than 0.13 mm (0.005 in.) and shall be verified for each machine set-up. Seal-ring groove eccentricity is the maximum difference between the values of the distance from the root of the seal-ring groove to the minor cone of the coupling threads in a plane at any location around the circumference.

NOTE The seal-ring groove dimensions are not the same as those used historically and may not be interchangeable with them.

A.8.2 SR 13.2—Nonmetallic Ring

Dimensions and tolerances of nonmetallic rings for seal-ring couplings shall be as specified in Figures D.19 (SR 13.1) to D.22 (SR 13.4). Rings shall be made from virgin polytetrafluoroethylene with 25 % fiberglass filler. The starting polytetrafluoroethylene shall be free of filler.

Unless otherwise specified in the purchase agreement, seal rings for field-end box thread shall be shipped separately in a sealed package labelled with the quantity, connection description, connection manufacturer, date inspected, and date packaged.

NOTE The seal-ring groove dimensions are not the same as those used historically and may not be interchangeable with them.

A.8.3 SR 13.3—Marking

All couplings that meet the requirements of A.8 (SR 13) shall be marked “S13” and have a blue band painted around the coupling (see Figure D.28). If the coupling size does not permit separation of markings as shown in Figure D.28, stencil marking may cross over the paint bands. When this occurs, the stencil shall be on top of the band and be of a contrasting color.

A.9 SR 16—Impact Testing (Charpy V-notch)

A.9.1 SR 16.1—Testing Requirements

When A.9 (SR 16) is specified in the purchase agreement for Grades N80, R95, L80, C90, T95, and P110, the testing provisions of 9.7, which are optional for the manufacturer in accordance with 6.5.5, become mandatory. When A.9 (SR 16) is specified in the purchase agreement for Grades H40, J55, and K55, the requirements in A.9.2 are mandatory.

A.9.2 SR 16.2—Charpy V-notch Test—General Requirements

A test shall consist of three specimens from a pipe. The average result from the three impact specimens shall equal or exceed the absorbed energy requirement specified in A.9.3 (SR 16.3).

All testing shall be done in conformance with 6.3 through 6.6 and 9.7.

A.9.3 SR 16.3—Charpy V-notch Test—Impact Requirements for Pipe and for Accessory Material for Externally Threaded Accessories

A.9.3.1 SR 16.3.1—Grade H40 Only

The minimum full-size transverse CVN absorbed energy requirement, C_V, is 16 J (12 ft·lb) for all wall thicknesses. The minimum full-size longitudinal CVN absorbed energy requirement, C_V, is 20 J (15 ft·lb) for all wall thicknesses.

A.9.3.2 SR 16.3.2—Grades J55 and K55 Only

The minimum full-size transverse CVN absorbed energy requirement, C_V, is 20 J (15 ft·lb) for all wall thicknesses. The minimum full-size longitudinal CVN absorbed energy requirement, C_V, is 27 J (20 ft·lb) for all wall thicknesses.

A.9.4 SR 16.4—Accessory Material

The requirements in 6.6 shall apply.

A.9.5 SR 16.5—Frequency of Testing

A.9.5.1 SR 16.5.1—General

A test shall be taken from each lot in accordance with Table C.16 or Table E.16.

A.9.5.2 SR 16.5.2—Retest of a Pipe or Accessory Material

Retesting shall be in accordance with 9.7.13.

A.9.5.3 SR 16.5.3—Replacement of a Reject Pipe or Accessory Material

Replacement of a rejected length of pipe or accessory material shall be in accordance with 9.7.14 and 9.7.15.

A.9.6 SR 16.6—Reporting

The size and orientation of the test specimen (i.e. full-size, $^3/_4$-size, or $^1/_2$-size), the actual test temperature, the results of the individual specimens (i.e. the impact energy absorption and the percentage shear), and the average absorbed energy shall be reported to the purchaser.

A.9.7 SR 16.7—Marking

Product tested in accordance with this SR shall be marked to indicate A.9 (SR 16), the minimum full-size energy absorption requirement, and the specified test temperature preceded by a positive or negative sign. This marking shall be paint-stenciled after the grade designation.

Example for SI units: S16-20-10C.

Example for USC units: S16-15+14F.

A.10 SR 38—Statistical Tensile Testing—Grades C90, T95, and C110

A.10.1 SR 38.1—General

This method shall be used when specified in the purchase agreement or at the option of the manufacturer to either:

a) test all lengths in the lot; or

b) determine the acceptance of the minimum yield strength for the lot, as defined in 9.2 on a statistical basis.

NOTE A.10 (SR 38) is intended to be used when the specified yield strength range is less than 103 MPa (15 ksi).

A.10.2 SR 38.2—Frequency of Testing

The tensile test frequency shall not be less than one per 20 pipes. If the lot size is less than 20 pipes, each pipe shall be tested. The selection of the pipes for testing shall be at random but shall include samples over the full lot. The lot may contain any number of lengths, provided the requirements of 9.2.2 are met.

A.10.3 SR 38.3—Yield Strength Determination

The yield strength of each pipe shall be determined as specified in 9.4. The acceptance or rejection of the yield strength for a lot shall be determined based on the mean and standard deviation for the lot. The mean and standard deviation shall be determined using standard statistical methods.

When determining the mean and standard deviation for the lot, all valid (see 9.4.8) test data on pipe from the lot shall be included. This includes data for all tests for mill control and any pipes that are determined not to conform to the yield strength requirements. The lot is acceptable if the mean yield strength for the lot minus 1.74 times the standard deviation for the lot is greater than or equal to the specified minimum yield strength in Table C.5 or Table E.5.

NOTE The factor of 1.74 above is based on an acceptable quality limit (AQL) of 0.01, a rejectable quality limit (RQL) of 0.10, an alpha of 0.05, and a beta of 0.10.

A.10.4 SR 38.4—Additional Testing to Qualify a Lot

The manufacturer may elect to tensile test additional pipes [i.e. in excess of the minimum of 20 pipes per lot specified in A.10.2 (SR 38.2)]. The additional pipes shall be selected at random. The data from the original tests and the additional tests shall be used to determine acceptance as specified in A.10.3 (SR 38.3).

The manufacturer may elect to test as many additional pipes as necessary to attempt to improve the mean yield strength or to lower the standard deviation to meet the acceptance criteria in A.10.3 (SR 38.3).

A.10.5 SR 38.5—Retests to Qualify a Pipe

If the original tensile specimen from a pipe fails to conform to the specified requirements, the manufacturer shall either reject the pipe or make additional tensile tests (as specified in 9.4) on both ends of the pipe in question. The results of both retests shall meet the requirements of Table C.5 or Table E.5. In addition, the average of the initial test data and the two retests shall meet the requirements of Table C.5 or Table E.5, or the pipe shall be rejected. The average yield strength for the pipe (i.e. based on the original test and the two retests) shall replace the original test data and be used to determine the mean and standard deviation for the qualification of the lot as specified in A.10.3 (SR 38.3).

No other additional testing shall be allowed to qualify a pipe. Rejected lots may be reheat-treated and tested as new lots.

A.11 SR 39—Alternative NACE TM0177-2016 Method D Sulfide Stress Cracking Tests—Grade C110

A.11.1 SR 39.1—Test Requirements

For each lot, as defined in 9.2, manufacturers shall carry out an NACE TM0177-2016 Method D test with the test solution specified in A.11.3 (SR 39.3). The test results shall not be used to determine conformance of the product to this standard.

A.11.2 SR 39.2—Test Sample Selection and Location

Test sample selection and location shall be in accordance with 6.14.2.

A.11.3 SR 39.3—Alternative Test Solution

NACE TM0177-2016 test solution D shall be used.

The test gas shall be premixed and certified by the provider of the gas.

The NACE TM0177-2016—Section 11.5.6 requirement for documented validation of test solution saturation

shall include analysis using the iodometric titration procedure in NACE TM0177-2016—Appendix C or other validated and documented method.

A.11.4 SR 39.4—Test Conditions

All valid test results shall be included when calculating the mean value.

A standard test specimen thickness of 9.53 mm (0.375 in.) shall be used except as allowed by 6.14.4 c).

Either non-pre-cracked or fatigue pre-cracked specimens may be used. If fatigue pre-cracking of specimens is employed, the maximum stress intensity factor during pre-cracking shall not exceed 20.4 MPa·√m (18.6 ksi·√in.).

The arm displacement shall be 0.89 mm, +0.03 mm, –0.05 mm (0.035 in., +0.001 in., –0.002 in.).

A.11.5 SR 39.5—Invalidation of Tests

Invalidation of tests shall be in accordance with 6.14.5.

A.11.6 SR 39.6—Additional Testing Provisions

Either non-pre-cracked or fatigue pre-cracked specimens may be used. If fatigue pre-cracking of specimens is employed, the maximum stress intensity factor during pre-cracking shall not exceed 20.4 MPa·$m^{1/2}$ (18.6 ksi·in. $^{1/2Fi}$).

Before the SSC test, Rockwell C hardness tests (minimum of three indentations) shall be made as shown in Figure D.28. Hardness data obtained on the DCB test specimens shall be for information only.

The length of the dry cracking, if any, shall be reported for information only.

A.12 SR 40—Electric-welded Casing, Tubing, and Pup Joints—Grades H40, J55, K55, N80, L80 Type 1, and R95

A.12.1 SR 40.1—Height and Trim of Electric-weld Flash

No inside flash height shall be permitted. The groove on the inside weld surface shall not exceed a depth of 0.38 mm (0.015 in.) and shall not contain any geometry that would interfere with ultrasonic inspection.

Pipe with weld flash exceeding these limits shall be either rejected or repaired by grinding.

A.12.2 SR 40.2—Nondestructive Examination of Weld Seam

For the weld seam of welded pipe, ultrasonic inspection systems for verification, other than wall thickness verification, shall use reference standards containing notches and holes as described in Table C.38 and Table C.39, or Table E.38 and Table E.39, to verify equipment response from artificial reference indicators.

The inspection equipment shall be adjusted to produce a well-defined indication from each reference indicator when the reference standard is scanned by the inspection system(s). Responses from the notches and hole shall meet the required system(s) sensitivity level. Outside-wall and inside-wall notches of reduced length may be used by agreement between the purchaser and the manufacturer.

A.13 SR 41—Supplemental Inspection When Hydrostatic Test Pressure Is Limited to 69.0 MPa (10,000 psi)

A.13.1 SR 41.1—Wall Thickness Measuring, Recording, and Reporting

For each length of pipe, the wall thickness shall be measured and recorded over the full length with a

minimum coverage of 100 % of the surface area covered by the automatic system. The minimum measured wall thickness for each length shall be recorded. Traceability and/or reporting of minimum measured wall thickness to each unique length is required only when specified in the purchase agreement.

A.13.2 SR 41.2—Nondestructive Examination of Pipe

Additionally, when agreed between the purchaser and the manufacturer, for each length of pipe a full-body imperfection NDE utilizing oblique OD/ID reference indicators consistent with the defects typical of the manufacturer's manufacturing process as required in 9.15.4 e) shall be performed.

A.14 SR 42—Straightening Requirements—Grades R95 and P110

When straightening is necessary, product may be hot rotary straightened or cold straightened. If hot rotary straightened, the minimum temperature at the exit of rotary straightening shall be 400 °C (750 °F), unless a higher minimum temperature is specified in the purchase agreement. If cold rotary straightened, then the product shall be stress relieved after straightening. The minimum stress relief temperature shall be 510 °C (950 °F). For gag straightening, see 5.3.6.

A.15 SR 43—Yield Strength—Grade Q125

A.15.1 Maximum Yield Strength

The maximum yield strength shall be 965 MPa (140 ksi).

A.15.2 Marking

All products meeting the requirements of A.15 SR 43 shall be marked as specified in Table C.43 or Table E.43.

A.16 SR 44—Charpy V-notch Test Properties—Grades N80, L80 Type 1, L80 3Cr, C90, R95, T95, P110, and Q125

Either:

a) the minimum shear area shall be 75 %, in accordance with ASTM E23; or

b) the manufacturer may use a documented procedure (taking into account, as a minimum, variations in chemical composition, diameter and wall thickness) together with the impact test results to demonstrate that the upper shelf behavior is achieved.

If the minimum shear area is less than 75 % or if the requirements of b) are not met, then the material shall be rejected unless a transition curve demonstrates that the product is on the upper shelf at the specified test temperature (either the standard test temperature or a reduced test temperature specified by the purchaser; see 9.7.5).

A.17 SR 45—Hardenability—Minimum Percentage Martensite Required for Quenched and Tempered Products

A.17.1 SR 45.1—Grade L80 Type 1

A full-body as-quenched sample shall be taken in accordance with a documented procedure to confirm sufficient hardening for each size, mass, chemical composition, and austenitize-and-quench combination. To be in conformance with this standard, the mean hardness numbers (see 9.6.9) obtained during the documented procedure shall equal or exceed the hardness corresponding to 90 % minimum martensite, as

determined by Equation (A.2) (SR 45):

$$HRC_{min} = 58 \times (\% \text{ carbon}) + 27 \quad \text{(A.2)}$$

A.17.2 SR 45.2—Grades C90 and T95

The mean hardness numbers obtained as specified in 6.10.1 shall equal or exceed the hardness corresponding to a minimum of 95 % martensite as determined by Equation (A.3) (SR 45):

$$HRC_{min} = 59 \times (\% \text{ carbon}) + 29 \quad \text{(A.3)}$$

Alternative hardenability requirements may be used for thick-walled Grades C90 and T95 as defined in 6.10.5.

A.18 SR 46—Sulfide Stress Cracking Test—Grades C90 and T95

If Method A is specified for the SSC test (in accordance with NACE TM0177-2016), manufacturers shall, for each lot as defined in 9.2, demonstrate that the product meets or exceeds the 90 % Ys_{min} requirement for three specimens, one each from the ends of three different products selected from sublots composed of the front one-third, middle one-third, and back one-third of the lot. The selection criteria in 9.10.4 shall apply to each of the sublots, including the random selection by agreement.

In case that subsize 3.81 mm (0.150 in.) diameter specimens are used, tests shall be conducted at 81 % Ys_{min}.

A re-test may be carried out if only one of the initial specimens fails. If more than one of the initial specimens fails, the lot shall be rejected. A retest may be performed on two further test specimens taken from an area of the product adjacent to where the initial failed test specimen was taken. If either of the retest specimens fails, the lot shall be rejected. Rejected lots may be re-heat treated and tested as new lots.

By agreement between the purchaser and the manufacturer, the number of specimens per lot required may be reduced to no less than one with a process control plan that is sufficient to ensure that the product meets or exceeds the 90 % Ys_{min} threshold.

A.19 SR 47—Hardness Testing Frequency Non-upset Pipe—Grades C90 and T95

A test ring shall be cut from both ends of each pipe.

A.20 SR 48—NDE of Pipe Ends—All Grades Except C110 (9.15.13)

The pipe ends shall be either treated in accordance with 9.15.13 a) or c), or inspected after end-finishing (and before coupling installation on threaded and coupled tubulars) using the wet magnetic particle method or a method agreed between the purchaser and the manufacturer.

A.21 SR 49—Wall Thickness Measurement—All Grades (9.13.4)

Wall thickness shall be measured over the full body, with a minimum coverage of 100 % of the surface area covered by the automatic system. The minimum measured wall thickness for each pipe shall be recorded. Traceability and/or reporting of each pipe is only required when specified in the purchase agreement.

Annex B
(normative)

Purchaser Inspection

B.1 Inspection Notice

If the inspector representing the purchaser desires to inspect the product or witness a test, reasonable notice shall be given of the time at which the run is intended to be made.

B.2 Plant Access

All inspections should be made prior to shipment at the place of manufacture or processing, unless otherwise specified in the purchase agreement, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

B.3 Conformance

The manufacturer is responsible for conforming to all the provisions of this standard. The purchaser may investigate to ensure conformance by the manufacturer and may reject any product that does not conform to this standard.

B.4 Rejection

Unless otherwise provided, material that shows defects on inspection or after acceptance at manufacturer's works, or that proves defective when properly applied in service, may be rejected, and the manufacturer so notified. If tests that require the destruction of material are made, any product that is proven not to meet the requirements of this standard shall be rejected. Disposition of rejected product shall be a matter of agreement between the purchaser and the manufacturer.

Annex C
(normative)

Tables in SI Units

Table C.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	2	D mm	kg/m	t mm	H40	J55 K55	L80 R95	N80	C90 T95	C110	P110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
4 1/2	9.50	114.30	14.38	5.21	PS	PS	—	—	—	—	—	—
4 1/2	10.50	114.30	15.73	5.69	—	PSB	—	—	—	—	—	—
4 1/2	11.60	114.30	17.38	6.35	—	PSLB	PLB	PLB	PLB	P	PLB	—
4 1/2	13.50	114.30	19.87	7.37	—	—	PLB	PLB	PLB	P	PLB	—
4 1/2	15.10	114.30	22.69	8.56	—	—	—	—	—	—	PLB	PLB
5	11.50	127.00	17.19	5.59	—	PS	—	—	—	—	—	—
5	13.00	127.00	19.69	6.43	—	PSLB	—	—	—	—	—	—
5	15.00	127.00	22.69	7.52	—	PSLB	PLB	PLB	PLB	P	PLB	—
5	18.00	127.00	27.19	9.19	—	—	PLB	PLB	PLB	P	PLB	PLB
5	21.40	127.00	32.13	11.10	—	—	PLB	PLB	PLB	P	PLB	PLB
5	23.20	127.00	34.76	12.14	—	—	PLB	PLB	PLB	P	PLB	PLB
5	24.10	127.00	36.15	12.70	—	—	PLB	PLB	PLB	P	PLB	PLB
5 1/2	14.00	139.70	20.91	6.20	PS	PS	—	—	—	—	—	—
5 1/2	15.50	139.70	23.48	6.98	—	PSLB	—	—	—	—	—	—
5 1/2	17.00	139.70	25.72	7.72	—	PSLB	PLB	PLB	PLB	P	PLB	—
5 1/2	20.00	139.70	30.05	9.17	—	—	PLB	PLB	PLB	P	PLB	—
5 1/2	23.00	139.70	34.05	10.54	—	—	PLB	PLB	PLB	P	PLB	PLB
5 1/2	26.80	139.70	40.15	12.70	—	—	—	—	P	P	—	—
5 1/2	29.70	139.70	44.47	14.27	—	—	—	—	P	P	—	—
5 1/2	32.60	139.70	48.74	15.88	—	—	—	—	P	P	—	—
5 1/2	35.30	139.70	52.80	17.45	—	—	—	—	P	P	—	—
5 1/2	38.00	139.70	56.82	19.05	—	—	—	—	P	P	—	—
5 1/2	40.50	139.70	60.64	20.62	—	—	—	—	P	P	—	—
5 1/2	43.10	139.70	64.41	22.22	—	—	—	—	P	P	—	—
6 5/8	20.00	168.28	29.76	7.32	PS	PSLB	—	—	—	—	—	—
6 5/8	24.00	168.28	35.72	8.94	—	PSLB	PLB	PLB	PLB	P	PLB	—
6 5/8	28.00	168.28	41.67	10.59	—	—	PLB	PLB	PLB	P	PLB	—
6 5/8	32.00	168.28	47.62	12.06	—	—	PLB	PLB	PLB	P	PLB	PLB
7	17.00	177.80	25.60	5.87	PS	—	—	—	—	—	—	—
7	20.00	177.80	29.91	6.91	PS	PS	—	—	—	—	—	—
7	23.00	177.80	34.67	8.05	—	PSLB	PLB	PLB	PLB	P	—	—
7	26.00	177.80	39.14	9.19	—	PSLB	PLB	PLB	PLB	P	PLB	—
7	29.00	177.80	43.60	10.36	—	—	PLB	PLB	PLB	P	PLB	—
7	32.00	177.80	47.92	11.51	—	—	PLB	PLB	PLB	P	PLB	—
7	35.00	177.80	52.09	12.65	—	—	PLB	PLB	PLB	P	PLB	PLB
7	38.00	177.80	56.10	13.72	—	—	PLB	PLB	PLB	P	PLB	PLB
7	42.70	177.80	63.84	15.88	—	—	—	—	P	P	—	—
7	46.40	177.80	69.35	17.45	—	—	—	—	P	P	—	—
7	50.10	177.80	74.85	19.05	—	—	—	—	P	P	—	—
7	53.60	177.80	80.21	20.62	—	—	—	—	P	P	—	—
7	57.10	177.80	85.42	22.22	—	—	—	—	P	P	—	—

Table C.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)
(continued)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	2	D mm	kg/m	t mm	H40	J55 K55	L80 R95	N80	C90 T95	C110	P110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
7 5/8	24.00	193.68	35.72	7.62	PS	—	—	—	—	—	—	—
7 5/8	26.40	193.68	39.29	8.33	—	PSLB	PLB	PLB	PLB	P	—	—
7 5/8	29.70	193.68	44.20	9.52	—	—	PLB	PLB	PLB	P	PLB	—
7 5/8	33.70	193.68	50.15	10.92	—	—	PLB	PLB	PLB	P	PLB	—
7 5/8	39.00	193.68	58.04	12.70	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	42.80	193.68	63.69	14.27	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	45.30	193.68	67.41	15.11	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	47.10	193.68	70.09	15.88	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	51.20	193.68	76.19	17.45	—	—	—	—	P	P	—	—
7 5/8	55.30	193.68	82.30	19.05	—	—	—	—	P	P	—	—
7 3/4	46.10	196.85	68.60	15.11	—	—	P	P	P	P	P	P
8 5/8	24.00	219.08	35.72	6.71	—	PS	—	—	—	—	—	—
8 5/8	28.00	219.08	41.67	7.72	PS	—	—	—	—	—	—	—
8 5/8	32.00	219.08	47.62	8.94	PS	PSLB	—	—	—	—	—	—
8 5/8	36.00	219.08	53.57	10.16	—	PSLB	PLB	PLB	PLB	P	—	—
8 5/8	40.00	219.08	59.53	11.43	—	—	PLB	PLB	PLB	P	PLB	—
8 5/8	44.00	219.08	65.48	12.70	—	—	PLB	PLB	PLB	P	PLB	—
8 5/8	49.00	219.08	72.92	14.15	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	32.30	244.48	48.07	7.92	PS	—	—	—	—	—	—	—
9 5/8	36.00	244.48	53.57	8.94	PS	PSLB	—	—	—	—	—	—
9 5/8	40.00	244.48	59.53	10.03	—	PSLB	PLB	PLB	PLB	P	—	—
9 5/8	43.50	244.48	64.73	11.05	—	—	PLB	PLB	PLB	P	PLB	—
9 5/8	47.00	244.48	69.94	11.99	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	53.50	244.48	79.62	13.84	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	58.40	244.48	86.91	15.11	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	59.40	244.48	88.40	15.47	—	—	—	—	P	P	—	—
9 5/8	64.90	244.48	96.58	17.07	—	—	—	—	P	P	—	—
9 5/8	70.30	244.48	104.62	18.64	—	—	—	—	P	P	—	—
9 5/8	75.60	244.48	112.50	20.24	—	—	—	—	P	P	—	—
10 3/4	32.75	273.05	48.74	7.09	PS	—	—	—	—	—	—	—
10 3/4	40.50	273.05	60.27	8.89	PS	PSB	—	—	—	—	—	—
10 3/4	45.50	273.05	67.71	10.16	—	PSB	—	—	—	—	—	—
10 3/4	51.00	273.05	75.90	11.43	—	PSB	PSB	PSB	PSB	P	PSB	—
10 3/4	55.50	273.05	82.59	12.57	—	—	PSB	PSB	PSB	P	PSB	—
10 3/4	60.70	273.05	90.33	13.84	—	—	—	—	PSB	P	PSB	PSB
10 3/4	65.70	273.05	97.77	15.11	—	—	—	—	PSB	P	PSB	PSB
10 3/4	73.20	273.05	108.93	17.07	—	—	—	—	P	P	—	—
10 3/4	79.20	273.05	117.86	18.64	—	—	—	—	P	P	—	—
10 3/4	85.30	273.05	126.94	20.24	—	—	—	—	P	P	—	—
11 3/4	42.00	298.45	62.50	8.46	PS	—	—	—	—	—	—	—
11 3/4	47.00	298.45	69.94	9.53	—	PSB	—	—	—	—	—	—
11 3/4	54.00	298.45	80.36	11.05	—	PSB	—	—	—	—	—	—
11 3/4	60.00	298.45	89.29	12.42	—	PSB	PSB	PSB	PSB	P	PSB	PSB
11 3/4	65.00	298.45	96.73	13.56	—	—	P	P	P	P	P	P
11 3/4	71.00	298.45	105.66	14.78	—	—	P	P	P	P	P	P

Table C.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)
(continued)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	**2**	*D* mm	kg/m	t mm	**H40**	**J55 K55**	**L80 R95**	**N80**	**C90 T95**	**C110**	**P110**	**Q125**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
13 3/8	48.00	339.72	71.43	8.38	PS	—	—	—	—	—	—	—
13 3/8	54.50	339.72	81.10	9.65	—	PSB	—	—	—	—	—	—
13 3/8	61.00	339.72	90.78	10.92	—	PSB	—	—	—	—	—	—
13 3/8	68.00	339.72	101.19	12.19	—	PSB	PSB	PSB	PSB	P	PSB	—
13 3/8	72.00	339.72	107.15	13.06	—	—	PSB	PSB	PSB	P	PSB	PSB
16	65.00	406.40	96.73	9.53	PS	—	—	—	—	—	—	—
16	75.00	406.40	111.61	11.13	—	PSB	—	—	—	—	—	—
16	84.00	406.40	125.01	12.57	—	PSB	—	—	—	—	—	—
16	109.00	406.40	162.21	16.66	—	P	P	P	—	—	P	P
18 5/8	87.50	473.08	130.21	11.05	PS	PSB	—	—	—	—	—	—
20	94.00	508.00	139.89	11.13	PSL	PSLB	—	—	—	—	—	—
20	106.50	508.00	158.49	12.70	—	PSLB	—	—	—	—	—	—
20	133.00	508.00	197.93	16.13	—	PSLB	—	—	—	—	—	—

NOTE B = buttress thread; L = long round thread; P = plain-end; S = short round thread; T&C = threaded and coupled.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses (column 4) are shown for information only.

[c] The densities of martensitic chromium steels (L80 Types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 may be used.

[d] Buttress casing is available with regular, special clearance couplings or special clearance couplings with special bevel.

[e] For casing with S, L, B connections, intermediate wall thicknesses are allowed in accordance with 4.2.3 and 7.2 and API 5B.

Table C.2—API Tubing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)

Labels				Outside Diameter	Nominal Linear Masses [a, b]			Wall Thick-ness	Type of End-finish						
1	2				Non-upset T&C	Ext. Upset T&C	Integ. Joint								
	NU T&C	EU T&C	IJ	D mm	kg/m	kg/m	kg/m	t mm	H40	J55	L80 R95	N80	C90	T95	P110
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1.050	1.14	1.20	—	26.67	1.70	1.79	—	2.87	PNU	PNU	PNU	PNU	PNU	PNU	—
1.050	1.48	1.54	—	26.67	2.20	2.29	—	3.91	PU	PU	PU	PU	PU	PU	PU
1.315	1.70	1.80	1.72	33.40	2.53	2.68	2.56	3.38	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	—
1.315	2.19	2.24	—	33.40	3.26	3.33	—	4.55	PU	PU	PU	PU	PU	PU	PU
1.660	2.09	—	2.10	42.16	—	—	3.13	3.18	PI	PI	—	—	—	—	—
1.660	2.30	2.40	2.33	42.16	3.42	3.57	3.47	3.56	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	—
1.660	3.03	3.07	—	42.16	4.51	4.57	—	4.85	PU	PU	PU	PU	PU	PU	PU
1.900	2.40	—	2.40	48.26	—	—	3.57	3.18	PI	PI	—	—	—	—	—
1.900	2.75	2.90	2.76	48.26	4.09	4.32	4.11	3.68	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI
1.900	3.65	3.73	—	48.26	5.43	5.55	—	5.08	PU	PU	PU	PU	PU	PU	PU
1.900	4.42	—	—	48.26	6.58	—	—	6.35	—	—	P	—	P	P	—
1.900	5.15	—	—	48.26	7.66	—	—	7.62	—	—	P	—	P	P	—
2.063	3.24	—	3.25	52.40	—	—	4.84	3.96	PI	PI	PI	PI	PI	PI	—
2.063	4.50	—	—	52.40	—	—	—	5.72	P	P	P	P	P	P	P
2 3/8	4.00	—	—	60.32	5.95	—	—	4.24	PN	PN	PN	PN	PN	PN	PN
2 3/8	4.60	4.70	—	60.32	6.85	6.99	—	4.83	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2 3/8	5.80	5.95	—	60.32	8.63	8.85	—	6.45	—	—	PNU	PNU	PNU	PNU	PNU
2 3/8	6.60	—	—	60.32	9.82	—	—	7.49	—	—	P	—	P	P	—
2 3/8	7.35	7.45	—	60.32	10.94	11.09	—	8.53	—	—	PU	—	PU	PU	—
2 7/8	6.40	6.50	—	73.02	9.52	9.67	—	5.51	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2 7/8	7.80	7.90	—	73.02	11.61	11.76	—	7.01	—	—	PNU	PNU	PNU	PNU	PNU
2 7/8	8.60	8.70	—	73.02	12.80	12.95	—	7.82	—	—	PNU	PNU	PNU	PNU	PNU
2 7/8	9.35	9.45	—	73.02	13.91	14.06	—	8.64	—	—	PU	—	PU	PU	—
2 7/8	10.50	—	—	73.02	15.63	—	—	9.96	—	—	P	—	P	P	—
2 7/8	11.50	—	—	73.02	17.11	—	—	11.18	—	—	P	—	P	P	—
3 1/2	7.70	—	—	88.90	11.46	—	—	5.49	PN	PN	PN	PN	PN	PN	—
3 1/2	9.20	9.30	—	88.90	13.69	13.84	—	6.45	PNU	PNU	PNU	PNU	PNU	PNU	PNU
3 1/2	10.20	—	—	88.90	15.18	—	—	7.34	PN	PN	PN	PN	PN	PN	—
3 1/2	12.70	12.95	—	88.90	18.90	19.27	—	9.52	—	—	PNU	PNU	PNU	PNU	PNU
3 1/2	14.30	—	—	88.90	21.28	—	—	10.92	—	—	P	—	P	P	—
3 1/2	15.50	—	—	88.90	23.07	—	—	12.09	—	—	P	—	P	P	—
3 1/2	17.00	—	—	88.90	25.30	—	—	13.46	—	—	P	—	P	P	—
4	9.50	—	—	101.60	14.14	—	—	5.74	PN	PN	PN	PN	PN	PN	—
4	10.70	11.00	—	101.60	—	16.37	—	6.65	PU	PU	PU	PU	PU	PU	—
4	13.20	—	—	101.60	19.64	—	—	8.38	—	—	P	—	P	P	—
4	16.10	—	—	101.60	23.96	—	—	10.54	—	—	P	—	P	P	—
4	18.90	—	—	101.60	28.13	—	—	12.70	—	—	P	—	P	P	—
4	22.20	—	—	101.60	33.04	—	—	15.49	—	—	P	—	P	P	—
4 1/2	12.60	12.75	—	114.30	18.75	18.97	—	6.88	PNU	PNU	PNU	PNU	PNU	PNU	—
4 1/2	15.20	—	—	114.30	22.62	—	—	8.56	—	—	P	—	P	P	—
4 1/2	17.00	—	—	114.30	25.30	—	—	9.65	—	—	P	—	P	P	—
4 1/2	18.90	—	—	114.30	28.13	—	—	10.92	—	—	P	—	P	P	—
4 1/2	21.50	—	—	114.30	32.00	—	—	12.70	—	—	P	—	P	P	—
4 1/2	23.70	—	—	114.30	35.27	—	—	14.22	—	—	P	—	P	P	—
4 1/2	26.10	—	—	114.30	38.84	—	—	16.00	—	—	P	—	P	P	—

NOTE I = integral joint; N = non-upset threaded and coupled; P = plain-end; T&C = threaded and coupled; U = external upset threaded and coupled.

[a] Nominal linear masses (columns 6, 7, and 8) are shown for information only.

[b] The densities of martensitic chromium steels (L80 types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 may be used.

Table C.3—Process of Manufacture and Heat Treatment

Grade	Type	Manufacturing Process [a]	Heat Treatment [e]	Tempering Temperature °C min
1	*2*	*3*	*4*	*5*
H40	—	S or EW	—	—
J55 [i]	—	S or EW	— [b]	—
K55	—	S or EW	— [b]	—
N80	1 [i]	S or EW	[c]	—
N80	Q	S or EW	Q [d]	—
R95 [i]	—	S or EW	Q	538
L80	1	S or EW	Q	566
L80	3Cr	S	Q	566
L80	9Cr [i]	S	Q [f]	593
L80	13Cr	S	Q [f]	593 [j]
C90	—	S	Q	621
T95	—	S	Q	649
C110	—	S	Q	649
P110	—	S or EW [g, h]	Q	—
Q125	—	S or EW [h]	Q	—

[a] EW = electric-welded process; S = seamless process.

[b] Full-body, full-length normalized, normalized and tempered or quenched and tempered at the manufacturer's option, or as specified in the purchase agreement (see 5.2.2).

[c] Full-body, full-length heat treatment is mandatory; at the manufacturer's option either normalized or normalized and tempered.

[d] Includes the method of interrupted quenching followed by controlled cooling.

[e] Q = quenched and tempered.

[f] L80 9Cr and L80 13Cr may be air-quenched.

[g] Special chemical requirements for electric-welded P110 pipe are specified in Table C.4.

[h] Products shall be heat-treated full-body, full-length; special requirements unique to electric-welded P110 and Q125 are specified in A.6 (SR 11).

[i] Quenched and tempered product in large D/t ratio combinations and nonquenched and tempered product may exhibit ductile rupture values lower than internal yield values; see API 5C3/ISO 10400 calculated performance values in columns 15 and 18 in Table K.1 and Table L.1.

[j] See 5.2.3.

Table C.4—Chemical Composition, Mass Fraction (%)

Grade	Type	C		Mn		Mo		Cr		Nb	Ni	Cu	P	S	Si
		min	max	min	max	min	max	min	max	max	max	max	max	max	max
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
H40	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
J55	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
K55	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
N80	1	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
N80	Q	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
R95	—	—	0.45 [c]	—	1.90	—	—	—	—	—	—	—	0.030	0.030	0.45
L80	1	—	0.43 [a]	—	1.90	—	—	—	1.50	—	0.25	0.35	0.030	0.030	0.45
L80	3Cr	—	0.30	—	1.20	—	—	2.50	3.90	0.30	0.25	0.35	0.020	0.010	0.45
L80	9Cr	—	0.15	0.30	0.60	0.90	1.10	8.00	10.0	—	0.50	0.25	0.020	0.010	1.00
L80	13Cr	0.15	0.22	0.25	1.00	—	—	12.0	14.0	—	0.50	0.25	0.020	0.010	1.00
C90	—	—	0.35	—	1.20	0.25 [b]	0.85	—	1.50	—	0.99	—	0.020	0.010	—
T95	—	—	0.35	—	1.20	0.25 [d]	0.85	0.40	1.50	—	0.99	—	0.020	0.010	—
C110	—	—	0.35	—	1.20	0.25	1.00	0.40	1.50	—	0.99	—	0.020	0.005	—
P110	—	—	—	—	—	—	—	—	—	—	—	—	0.030 [e]	0.030 [e]	—
Q125	—	—	0.35	—	1.35	—	0.85	—	1.50	—	—	—	0.020	0.010	—

NOTE Elements shown shall be reported in product analysis.

[a] The carbon content for L80 may be increased up to 0.50 % maximum if the product is oil-quenched or polymer-quenched.

[b] The molybdenum content for Grade C90 Type 1 has no minimum tolerance if the wall thickness is less than 17.78 mm.

[c] The carbon content for R95 may be increased up to 0.55 % maximum if the product is oil-quenched.

[d] The molybdenum content for T95 Type 1 may be decreased to 0.15 % minimum if the wall thickness is less than 17.78 mm.

[e] For EW Grade P110, the phosphorus content shall be 0.020 % maximum and the sulfur content 0.010 % maximum.

Table C.5—Tensile and Hardness Requirements

Grade	Type	Total Elongation Under Load %	Yield Strength MPa		Tensile Strength min MPa	Hardness [a, c] max		Specified Wall Thickness	Allowable Hardness Variation [b]
			min	max		HRC	HBW	mm	HRC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
H40	—	0.5	276	552	414	—	—	—	—
J55	—	0.5	379	552	517	—	—	—	—
K55	—	0.5	379	552	655	—	—	—	—
N80	1	0.5	552	758	689	—	—	—	—
N80	Q	0.5	552	758	689	—	—	—	—
R95	—	0.5	655	758	724	—	—	—	—
L80	1	0.5	552	655	655	23.0	241	—	—
L80	3Cr	0.5	552	655	655	23.0	241	—	—
L80	9Cr	0.5	552	655	655	23.0	241	—	—
L80	13Cr	0.5	552	655	655	23.0	241	—	—
C90	—	0.5	621	724	689	25.4	255	≤ 12.70	3.0
								12.71 to 19.04	4.0
								19.05 to 25.39	5.0
								≥ 25.40	6.0
T95	—	0.5	655	758	724	25.4	255	≤ 12.70	3.0
								12.71 to 19.04	4.0
								19.05 to 25.39	5.0
								≥ 25.40	6.0
C110	—	0.7	758	828	793	29.0	279	≤ 12.70	3.0
								12.71 to 19.04	4.0
								19.05 to 25.39	5.0
								≥ 25.40	6.0
P110	—	0.6	758	965	862	—	—	—	—
Q125	—	0.65	862	1034	931	[b]	—	≤ 12.70	3.0
								12.71 to 19.04	4.0
								≥ 19.05	5.0

[a] In case of dispute, laboratory Rockwell C hardness testing shall be used as the referee method.

[b] No hardness limits are specified, but the maximum variation is restricted as a manufacturing control in accordance with 6.8 and 6.9.

[c] For through-wall hardness tests of Grades L80, C90, T95, and C110, the requirements stated in HRC scale are for maximum mean hardness number.

Table C.6—Elongation Table

Tensile Test Specimen				Minimum Elongation in 50.8 mm %							
				Grade							
				H40	J55	K55 L80	N80 C90	R95 T95	C110	P110	Q125
Specimen Area mm²	Specified Wall Thickness mm			Specified Minimum Tensile Strength MPa							
	Specimen Width 19 mm	Specimen Width 25 mm	Specimen Width 38 mm	414	517	655	689	724	793	862	931
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
490	≥ 25.53	≥ 19.41	≥ 12.77	30	24	20	19	18	16	15	14
480	25.00–25.52	19.00–19.40	12.51–12.76	29	24	19	19	18	16	15	14
470	24.48–24.99	18.61–18.99	12.24–12.50	29	24	19	19	18	16	15	14
460	23.95–24.47	18.20–18.60	11.98–12.23	29	24	19	18	18	16	15	14
450	23.43–23.94	17.81–18.19	11.72–11.97	29	24	19	18	18	16	15	14
440	22.90–23.42	17.40–17.80	11.45–11.71	29	24	19	18	18	16	15	14
430	22.37–22.89	17.01–17.39	11.19–11.44	29	24	19	18	17	16	15	14
420	21.85–22.36	16.60–17.00	10.93–11.18	29	23	19	18	17	16	15	14
410	21.32–21.84	16.21–16.59	10.66–10.92	29	23	19	18	17	16	15	14
400	20.79–21.31	15.80–16.20	10.40–10.65	28	23	19	18	17	16	15	14
390	20.27–20.78	15.41–15.79	10.14–10.39	28	23	19	18	17	16	15	14
380	19.74–20.26	15.00–15.40	9.87–10.13	28	23	19	18	17	16	15	14
370	19.22–19.73	14.61–14.99	9.61–9.86	28	23	19	18	17	16	14	13
360	18.69–19.21	14.20–14.60	9.35–9.60	28	23	18	18	17	16	14	13
350	18.16–18.68	13.81–14.19	9.08–9.34	28	23	18	17	17	15	14	13
340	17.64–18.15	13.40–13.80	8.82–9.07	28	23	18	17	17	15	14	13
330	17.11–17.63	13.01–13.39	8.56–8.81	27	22	18	17	17	15	14	13
320	16.58–17.10	12.60–13.00	8.29–8.55	27	22	18	17	16	15	14	13
310	16.06–16.57	12.21–12.59	8.03–8.28	27	22	18	17	16	15	14	13
300	15.53–16.05	11.80–12.20	7.77–8.02	27	22	18	17	16	15	14	13
290	15.01–15.52	11.41–11.79	7.51–7.76	27	22	18	17	16	15	14	13
280	14.48–15.00	11.00–11.40	7.24–7.50	26	22	18	17	16	15	14	13
270	13.95–14.47	10.61–10.99	6.98–7.23	26	22	17	17	16	15	14	13
260	13.43-13.94	10.20–10.60	6.72–6.97	26	21	17	16	16	15	13	13
250	12.90–13.42	9.81–10.19	6.45–6.71	26	21	17	16	16	14	13	12
240	12.37–12.89	9.40–9.80	6.19–6.44	26	21	17	16	16	14	13	12
230	11.85–12.36	9.01–9.39	5.93–6.18	25	21	17	16	15	14	13	12
220	11.32–11.84	8.60–9.00	5.66–5.92	25	21	17	16	15	14	13	12
210	10.79–11.31	8.21–8.59	5.40–5.65	25	20	17	16	15	14	13	12
200	10.27–10.78	7.80–8.20	5.14–5.39	25	20	16	16	15	14	13	12
190	9.74–10.26	7.41–7.79	4.87–5.13	24	20	16	15	15	14	13	12
180	9.22–9.73	7.00–7.40	4.61–4.86	24	20	16	15	15	13	13	12
170	8.69–9.21	6.61–6.99	4.35–4.60	24	20	16	15	14	13	12	12

Table C.6—Elongation Table *(continued)*

Tensile Test Specimen				Minimum Elongation in 50.8 mm %							
				Grade							
				H40	J55	K55 L80	N80 C90	R95 T95	C110	P110	Q125
Specimen Area mm^2	Specified Wall Thickness mm			Specified Minimum Tensile Strength MPa							
	Specimen Width 19 mm	Specimen Width 25 mm	Specimen Width 38 mm	414	517	655	689	724	793	862	931
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
160	8.16–8.68	6.20–6.60	4.08–4.34	24	19	16	15	14	13	12	11
150	7.64–8.15	5.81–6.19	3.82–4.07	23	19	15	15	14	13	12	11
140	7.11–7.63	5.40–5.80	3.56–3.81	23	19	15	15	14	13	12	11
130	6.58–7.10	5.01–5.39	3.29–3.55	23	19	15	14	14	13	12	11
120	6.06–6.57	4.60–5.00	3.03–3.28	22	18	15	14	14	12	12	11
110	5.53–6.05	4.21–4.59	2.77–3.02	22	18	15	14	13	12	11	11
100	5.01–5.52	3.80–4.20	2.51–2.76	22	18	14	14	13	12	11	10
90	4.48–5.00	3.41–3.79	2.24–2.50	21	17	14	13	13	12	11	10
80	3.95–4.47	3.00–3.40	1.98–2.23	21	17	14	13	12	11	11	10
70	3.43–3.94	2.61–2.99	1.72–1.97	20	16	13	13	12	11	10	9.5
60	2.90–3.42	2.20–2.60	1.45–1.71	19	16	13	12	12	11	10	9.5
50	2.37–2.89	1.81–2.19	1.19–1.44	19	15	12	12	11	10	9.5	9

NOTE The calculations of the elongation requirements are based on the cross-sectional area in column 1, which is shown rounded to two significant figures. The applicable wall thickness ranges shown in columns 2, 3, and 4 were calculated based on the specified specimen width (shown above the column numbers 2, 3, and 4) taking into account the rounding rules for the specimen area (i.e. to two significant figures) but with the wall thickness rounded down to two significant figures for SI units. When making these wall thickness ranges for USC units, 3 significant figures are used.

Table C.7—Critical Thickness for Couplings with API Threads

Dimensions in millimeters

Label 1	Critical Thickness for Couplings						
	NU	EU	Special Clearance		BC	LC	SC
			EU	BC			
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	4.29	5.36	—	—	—	—	—
1.315	5.36	6.55	—	—	—	—	—
1.660	6.07	6.10	—	—	—	—	—
1.900	4.98	6.38	—	—	—	—	—
2 3/8	7.72	7.62	5.69	—	—	—	—
2 7/8	9.65	9.09	6.45	—	—	—	—
3 1/2	11.46	11.53	7.47	—	—	—	—
4	11.53	11.63	—	—	—	—	—
4 1/2	11.05	12.52	—	6.58	11.35	12.04	11.74
5	—	—	—	6.76	12.17	12.98	12.47
5 1/2	—	—	—	6.81	12.28	13.06	12.57
6 5/8	—	—	—	6.96	11.91	12.90	12.32
7	—	—	—	7.11	13.46	14.43	13.72
7 5/8	—	—	—	8.84	13.61	14.55	13.87
8 5/8	—	—	—	8.94	15.29	16.43	15.54
9 5/8	—	—	—	8.94	15.29	16.69	15.60
10 3/4	—	—	—	8.94	15.29	—	15.70
11 3/4	—	—	—	—	15.29	—	15.70
13 3/8	—	—	—	—	15.29	—	15.70
16	—	—	—	—	16.94	—	16.05
18 5/8	—	—	—	—	21.69	—	20.80
20	—	—	—	—	16.94	17.09	16.10

NOTE The coupling blank thickness is greater than those indicated above due to thread height and manufacturing allowance to avoid black crest threads.

Table C.8—Acceptable Size Impact Specimens and Absorbed Energy Reduction Factor

Test Specimen Size	Specimen Dimensions mm	Reduction Factor
Full-size	10.0 × 10.0	1.00
3/4-size	10.0 × 7.5	0.80
1/2-size	10.0 × 5.0	0.55

Table C.9—Hierarchy of Test Specimen Orientation and Size

Choice	Orientation	Size
1st	Transverse	Full-size
2nd	Transverse	3/4-size
3rd	Transverse	1/2-size
4th	Longitudinal	Full-size
5th	Longitudinal	3/4-size
6th	Longitudinal	1/2-size

Table C.10—Transverse Impact Specimen Size Required

Label 1	Calculated Wall Thickness Required to Machine Transverse Charpy Impact Specimens mm		
	Full-size	3/4-size	1/2-size
1	*2*	*3*	*4*
3 1/2	20.53	18.03	15.53
4	19.09	16.59	14.09
4 1/2	18.05	15.55	13.05
5	17.26	14.76	12.26
5 1/2	16.64	14.14	11.64
6 5/8	15.62	13.12	10.62
7	15.36	12.86	10.36
7 5/8	14.99	12.49	9.99
7 3/4	14.92	12.42	9.92
8 5/8	14.51	12.01	9.51
9 5/8	14.13	11.63	9.13
10 3/4	13.80	11.30	8.80
11 3/4	13.56	11.06	8.56
13 3/8	13.24	10.74	8.24
16	12.87	10.37	7.87
18 5/8	12.60	10.10	7.60
20	12.49	9.99	7.49

NOTE The wall thicknesses in columns 2, 3, and 4 that are in excess of the maximum wall thicknesses for API pipe are for information only. The information in this table provides a 0.50 mm inside-wall and a 0.50 mm outside-wall machining allowance.

Table C.11—Longitudinal Impact Specimen Size Required

Label 1	Calculated Wall Thickness Required to Machine Longitudinal Charpy Impact Specimens mm		
	Full-size	3/4-size	1/2-size
1	*2*	*3*	*4*
1.050	11.97	9.47	6.97
1.315	11.77	9.27	6.77
1.660	11.60	9.10	6.60
1.900	11.52	9.02	6.52
2.063	11.48	8.98	6.48
2 3/8	11.42	8.92	6.42
2 7/8	11.34	8.84	6.34
3 1/2	11.28	8.78	6.28
4	11.25	8.75	6.25
4 1/2	11.22	8.72	6.22
5	11.20	8.70	6.20
5 1/2	11.18	8.68	6.18
6 5/8	11.15	8.65	6.15
7	11.14	8.64	6.14
7 5/8	11.13	8.63	6.13
7 3/4	11.13	8.63	6.13
8 5/8	11.11	8.61	6.11
9 5/8	11.10	8.60	6.10
10 3/4	11.09	8.59	6.09
11 3/4	11.08	8.58	6.08
13 3/8	11.07	8.57	6.07
16	11.06	8.56	6.06
18 5/8	11.05	8.55	6.05
20	11.05	8.55	6.05

NOTE The wall thicknesses in columns 2, 3, and 4 that are in excess of the maximum wall thicknesses for API pipe are for information only. The measurements in this table provide a 0.50 mm inside-wall and a 0.50 mm outside-wall machining allowance.

Table C.12—Minimum Absorbed Energy for Couplings, Coupling Stock, Coupling Material, and Coupling Blanks—Transverse Orientation (Joules)

Critical Thickness mm	L80 [a, b, c, d, e]	N80 [a, b, c, d]	C90 [a, b, c, d]	R95/T95 [a, b, c, d]	P110 [a, b, c, d]	C110 [a, b, c, d]	Q125 [a, b, c, d]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
≤ 12.7	27	27	27	27	27	27	34
15.2	27	27	27	27	30	27	34
17.8	27	27	27	27	32	28	35
20.3	27	28	27	27	35	30	38
22.9	27	30	29	30	38	33	41
25.4	28	32	31	32	41	35	44
27.9	30	35	33	35	44	38	47
30.5	32	37	35	37	47	40	50
33.0	34	39	37	39	50	43	53
35.6	36	41	39	41	53	45	56
38.1	38	44	42	44	56	48	60
40.6	40	46	44	46	58	50	63
43.2	42	48	46	48	61	53	66
45.7	44	50	48	50	64	55	69
48.3	46	53	50	53	67	58	72
50.8	48	55	53	55	70	60	75
53.3	49	57	55	57	73	62	78
55.9	51	60	57	60	76	65	81
58.4	53	62	59	62	79	67	84
61.0	55	64	61	64	82	70	87
63.5	57	66	63	66	84	72	90

[a] Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

[b] If transverse specimens of $^1/_2$-size cannot be taken, refer to 9.7.1.

[c] For wall thicknesses not listed, the manufacturer has the option to utilize the applicable formula in accordance with 6.4.4 or the next higher wall in this table.

[d] For all Grades except L80 13 Cr, wall thickness greater than 63.5 mm, refer to 4.2.1 or 4.3.1 or 4.4.3.

[e] For Grade L80 13 Cr, wall thickness greater than 35.6 mm, refer to 4.2.1 or 4.3.1 or 4.4.3.

Table C.13—Minimum Absorbed Energy for Couplings, Coupling Stock, Coupling Material, and Coupling Blanks—Longitudinal Orientation (Joules)

L80	N80	C90	R95/T95	P110	C110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*
54	40	54	54	54	54	54

NOTE 1 Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

NOTE 2 Longitudinal testing is required only if transverse testing is not possible. Coupling, coupling stock tested in the transverse direction does not need to be tested or demonstrate compliance to these values.

Table C.14—Minimum Absorbed Energy for Pipe—Transverse Orientation (Joules)

Wall Thickness mm	L80 [a, b, c, d, e]	N80 [a, b, c, d]	C90 [a, b, c, d]	R95/T95 [a, b, c, d]	P110 [a, b, c, d]	C110 [a, b, c, d]	Q125 [a, b, c, d]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
≤ 17.8	20	20	20	20	27	27	34
20.3	20	20	23	24	28	30	38
22.9	22	22	25	26	30	33	41
25.4	23	23	26	28	32	35	44
27.9	25	25	28	30	35	38	47
30.5	27	27	30	32	37	40	50
33.0	28	28	32	34	39	43	53
35.6	30	30	34	36	41	45	56
38.1	32	32	36	38	44	48	60
40.6	33	33	38	40	46	50	63
43.2	35	35	39	42	48	53	66
45.7	37	37	41	44	50	55	69
48.3	38	38	43	46	53	58	72
50.8	40	40	45	48	55	60	75
53.3	42	42	47	49	57	62	78
55.9	43	43	49	51	60	65	81
58.4	45	45	51	53	62	67	84
61.0	47	47	52	55	64	70	87
63.5	48	48	54	57	66	72	90

[a] Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

[b] If transverse specimens of $^1/_2$-size cannot be taken, refer to 9.7.1.

[c] For wall thicknesses not listed, the manufacturer has the option to utilize applicable formula in accordance with 6.5.2 and 6.5.3 or the next higher wall in this table.

[d] For all Grades except L80 13 Cr, wall thickness greater than 63.5 mm, refer to 4.2.1 or 4.3.1 or 4.4.3.

[e] For Grade L80 13 Cr, wall thickness greater than 35.6 mm, refer to 4.2.1 or 4.3.1 or 4.4.3.

Table C.15—Minimum Absorbed Energy for Pipe—Longitudinal Orientation (Joules)

L80	N80	C90	R95/T95	P110	C110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*
40	40	40	40	52	54	54

NOTE 1 Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

NOTE 2 Longitudinal testing is required only if transverse testing is not possible. Pipe tested in the transverse direction does not need to be tested or demonstrate conformance to these values.

Table C.16—Frequency of Charpy V-notch Testing—Pipe, Coupling Stock, Coupling Material, Coupling Blanks, Couplings, and Accessory Material

Grade	Label 1	Number of Tests per Lot			
		Pipe	Coupling Stock/ Material	Coupling Blanks/ Couplings	Accessory Material
1	*2*	*3*	*4*	*5*	*6*
H40	All sizes	[d]	[d]	[d]	[d]
K55, J55	All sizes	N/A	1	1	1 [b]
N80, R95	All sizes	1 [a]	1	1	1 [b]
L80	All sizes	1 [a]	1	1	1 [b]
C90, T95	All sizes	1 [a]	1	1	1 [b]
C110	All sizes	1	1	1	1
P110	All sizes	1 [a]	1	1	1 [b]
Q125 [c]	All sizes	3 [c]	Each length [c]	1	Each length [c]

[a] Testing is not mandatory when qualified by a documented procedure; see 6.5.5 for mandatory requirements.

[b] When required in 6.6.

[c] Refer to 9.7.10 for requirements.

[d] See A.9 (SR 16) when specified.

Table C.17—Distance between Plates for Electric-weld Flattening Tests

Grade	D/t Ratio	Distance between Plates mm
H40	≥ 16	$0.5 \times D$
	< 16	$D \times (0.830 - 0.0206\ D/t)$
J55 and K55	≥ 16	$0.65 \times D$
	3.93 to 16	$D \times (0.980 - 0.0206\ D/t)$
	< 3.93	$D \times (1.104 - 0.0518\ D/t)$
N80 [a]	9 to 28	$D \times (1.074 - 0.0194\ D/t)$
L80 Type 1	9 to 28	$D \times (1.074 - 0.0194\ D/t)$
R95 [a]	9 to 28	$D \times (1.080 - 0.0178\ D/t)$
P110 [b]	All	$D \times (1.086 - 0.0163\ D/t)$
Q125 [b]	All	$D \times (1.092 - 0.0140\ D/t)$

NOTE

D is the specified outside diameter of pipe, in millimeters.

t is the specified wall thickness of the pipe, in millimeters.

[a] If the flattening test fails at 12 o'clock or 6 o'clock, the flattening shall continue until the remaining portion of the specimen fails at the 3 o'clock or 9 o'clock position; premature failure at 12 o'clock or 6 o'clock shall not be considered basis for rejection.

[b] See A.6 (SR 11); flattening shall be conducted until this distance or until $0.85 \times D$, whichever is less, without cracking at any location.

Table C.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b,c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
								Round Thread		Buttress Thread	
		D mm	kg/m	t mm	d mm	mm	w_{pe} kg/m	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
4 1/2	9.50	114.30	14.38	5.21	103.88	100.70	14.02	3.64	—	—	—
4 1/2	10.50	114.30	15.73	5.69	102.92	99.74	15.24	3.33	—	4.53	1.12
4 1/2	11.60	114.30	17.38	6.35	101.60	98.42	16.91	3.18	3.61	4.32	0.91
4 1/2	13.50	114.30	19.87	7.37	99.56	96.38	19.44	—	3.35	4.07	0.60
4 1/2	15.10	114.30	22.69	8.56	97.18	94.00	22.32	—	3.53	3.64	0.24
5	11.50	127.00	17.19	5.59	115.82	112.64	16.74	4.32	—	—	—
5	13.00	127.00	19.69	6.43	114.14	110.96	19.12	4.00	4.85	5.38	1.24
5	15.00	127.00	22.69	7.52	111.96	108.78	22.16	3.71	4.51	4.99	0.61
5	18.00	127.00	27.19	9.19	108.62	105.44	26.70	—	4.52	4.40	0.22
5	21.40	127.00	32.13	11.10	104.80	101.62	31.73	—	3.45	3.76	–0.62
5	23.20	127.00	34.76	12.14	102.72	99.54	34.39	—	3.15	3.42	–0.96
5	24.10	127.00	36.15	12.70	101.60	98.42	35.82	—	2.99	3.23	–1.14
5 1/2	14.00	139.70	20.91	6.20	127.30	124.12	20.41	4.60	—	—	—
5 1/2	15.50	139.70	23.48	6.98	125.74	122.56	22.85	4.36	5.26	5.71	0.87
5 1/2	17.00	139.70	25.72	7.72	124.26	121.08	25.13	4.14	5.31	5.41	0.58
5 1/2	20.00	139.70	30.05	9.17	121.36	118.18	29.52	—	4.50	4.84	0.45
5 1/2	23.00	139.70	34.05	10.54	118.62	115.44	33.57	—	4.37	4.31	−0.52
5 1/2	26.80	139.70	40.15	12.70	114.30	111.12	39.78	—	—	—	—
5 1/2	29.70	139.70	44.47	14.27	111.16	107.98	44.14	—	—	—	—
5 1/2	32.60	139.70	48.74	15.88	107.94	104.76	48.49	—	—	—	—
5 1/2	35.30	139.70	52.80	17.45	104.80	101.62	52.61	—	—	—	—
5 1/2	38.00	139.70	56.82	19.05	101.60	98.42	56.68	—	—	—	—
5 1/2	40.50	139.70	60.64	20.62	98.46	95.28	60.55	—	—	—	—
5 1/2	43.10	139.70	64.41	22.22	95.26	92.08	64.38	—	—	—	—
6 5/8	20.00	168.28	29.76	7.32	153.64	150.46	29.06	5.58	6.23	6.35	0.89
6 5/8	24.00	168.28	35.72	8.94	150.40	147.22	35.13	4.42	5.48	5.52	0.68
6 5/8	28.00	168.28	41.67	10.59	147.10	143.92	41.18	—	4.73	4.71	–0.75
6 5/8	32.00	168.28	47.62	12.06	144.16	140.98	46.46	—	4.73	4.00	–1.46

Table C.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
								Round Thread		Buttress Thread	
		D mm	kg/m	t mm	d mm	mm	w_{pe} kg/m	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
7	17.00	177.80	25.60	5.87	166.06	162.88	24.89	7.61	—	—	—
7	20.00	177.80	29.91	6.91	163.98	160.80	29.12	6.74	—	—	—
7	23.00	177.80	34.67	8.05	161.70	158.75 [e]	33.70	6.26	7.94	8.28	0.58
7	23.00	177.80	34.67	8.05	161.70	158.52	33.70	6.26	7.94	8.28	0.58
7	26.00	177.80	39.14	9.19	159.42	156.24	38.21	5.79	7.37	7.65	–0.54
7	29.00	177.80	43.60	10.36	157.08	153.90	42.78	—	6.79	7.13	–0.69
7	32.00	177.80	47.92	11.51	154.78	152.40 [e]	47.20	—	6.23	6.40	–1.31
7	32.00	177.80	47.92	11.51	154.78	151.60	47.20	—	6.23	6.40	–1.31
7	35.00	177.80	52.09	12.65	152.50	149.32	51.52	—	5.68	5.79	–1.91
7	38.00	177.80	56.10	13.72	150.36	147.18	55.52	—	5.18	5.24	–2.47
7	42.70	177.80	63.84	15.88	146.04	142.86	63.41	—	—	—	—
7	46.40	177.80	69.35	17.45	142.90	139.72	69.01	—	—	—	—
7	50.10	177.80	74.85	19.05	139.70	136.52	74.58	—	—	—	—
7	53.60	177.80	80.21	20.62	136.56	133.38	79.93	—	—	—	—
7	57.10	177.80	85.42	22.22	133.36	130.18	85.25	—	—	—	—
7 5/8	24.00	193.68	35.72	7.62	178.44	175.26	34.96	7.11	—	—	—
7 5/8	26.40	193.68	39.29	8.33	177.02	173.84	38.08	6.78	8.58	9.12	2.59
7 5/8	29.70	193.68	44.20	9.52	174.64	171.46	43.24	—	7.91	8.38	1.84
7 5/8	33.70	193.68	50.15	10.92	171.84	168.66	49.22	—	7.13	7.51	0.98
7 5/8	39.00	193.68	58.04	12.70	168.28	165.10	56.68	—	6.16	6.44	– 0.10
7 5/8	42.80	193.68	63.69	14.27	165.14	161.96	63.14	—	5.32	5.50	–1.03
7 5/8	45.30	193.68	67.41	15.11	163.46	160.28	66.54	—	4.87	5.01	–1.52
7 5/8	47.10	193.68	70.09	15.88	161.92	158.74	69.63	—	4.48	4.57	–1.96
7 5/8	51.20	193.68	76.19	17.45	158.78	155.60	75.84	—	—	—	—
7 5/8	55.30	193.68	82.30	19.05	155.58	152.40	82.04	—	—	—	—
7 3/4	46.10	196.85	68.60	15.11	166.63	165.10 [e]	67.72	—	—	—	—
7 3/4	46.10	196.85	68.60	15.11	166.63	163.45	67.72	—	—	—	—

Table C.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
								Round Thread		Buttress Thread	
		D mm	kg/m	t mm	d mm	mm	w_{pe} kg/m	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
8 5/8	24.00	219.08	35.72	6.71	205.66	202.48	35.14	10.93	—	—	—
8 5/8	28.00	219.08	41.67	7.72	203.64	200.46	40.24	10.07	—	—	—
8 5/8	32.00	219.08	47.62	8.94	201.20	200.02 [e]	46.33	9.39	12.44	12.5	2.51
8 5/8	32.00	219.08	47.62	8.94	201.20	198.02	46.33	9.39	12.44	7	2.51
8 5/8	36.00	219.08	53.57	10.16	198.76	195.58	52.35	8.72	11.60	12.57	1.62
8 5/8	40.00	219.08	59.53	11.43	196.22	193.68 [e]	58.53	—	10.73	11.68	0.71
8 5/8	40.00	219.08	59.53	11.43	196.22	193.04	58.53	—	10.73	10.77	0.71
8 5/8	44.00	219.08	65.48	12.70	193.68	190.50	64.64	—	9.88	10.77	–0.20
8 5/8	49.00	219.08	72.92	14.15	190.78	187.60	71.51	—	8.88	9.87	–1.21
9 5/8	32.30	244.48	48.07	7.92	228.60	224.66	46.20	11.00	—	—	—
9 5/8	36.00	244.48	53.57	8.94	226.60	222.63	51.93	10.36	14.48	13.87	2.74
9 5/8	40.00	244.48	59.53	10.03	224.40	222.25 [e]	57.99	9.69	13.59	12.97	1.84
9 5/8	40.00	244.48	59.53	10.03	224.40	220.45	57.99	9.69	13.59	12.97	1.84
9 5/8	43.50	244.48	64.74	11.05	222.40	218.41	63.61	—	12.78	12.15	1.01
9 5/8	43.50	244.48	64.74	11.05	222.40	218.41	63.61	—	12.84 [f]	12.15	1.01
9 5/8	47.00	244.48	69.94	11.99	220.50	216.54	68.75	—	12.03	11.39	0.25
9 5/8	47.00	244.48	69.94	11.99	222.50	216.54	68.75	—	12.09 [f]	11.39	0.25
9 5/8	53.50	244.48	79.62	13.84	216.80	215.90 [e]	78.72	—	10.57	9.92	–1.22
9 5/8	53.50	244.48	79.62	13.84	216.80	215.90 [e]	78.72	—	10.63 [f]	9.92	–1.22
9 5/8	53.50	244.48	79.62	13.84	216.80	212.83	78.72	—	10.57	9.92	–1.22
9 5/8	53.50	244.48	79.62	13.84	216.80	212.83	78.72	—	10.63 [f]	9.92	–1.22
9 5/8	58.40	244.48	86.91	15.11	214.25	212.72 [e]	85.47	—	9.58	8.92	–2.22
9 5/8	58.40	244.48	86.91	15.11	214.25	212.72 [e]	85.47	—	9.65 [f]	8.92	–2.22
9 5/8	58.40	244.48	86.91	15.11	214.25	210.29	85.47	—	9.58	8.92	–2.22
9 5/8	58.40	244.48	86.91	15.11	214.25	210.29	85.47	—	9.65 [f]	8.92	–2.22
9 5/8	59.40	244.48	88.40	15.47	213.50	209.58	87.37	—	—	—	—
9 5/8	64.90	244.48	96.58	17.07	210.30	206.38	95.73	—	—	—	—
9 5/8	70.30	244.48	104.62	18.64	207.20	203.23	103.82	—	—	—	—
9 5/8	75.60	244.48	112.51	20.24	204.00	200.02	111.93	—	—	—	—

Table C.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thick-ness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
								Round Thread		Buttress Thread	
		D mm	kg/m	t mm	d mm	mm	w_{pe} kg/m	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
10 3/4	32.75	273.05	48.74	7.09	258.90	254.91	46.50	13.94	—	—	—
10 3/4	40.50	273.05	60.27	8.89	255.30	251.31	57.91	11.91	—	15.38	3.03
10 3/4	45.50	273.05	67.71	10.16	252.70	250.82 [e]	65.87	11.00	—	14.21	1.86
10 3/4	45.50	273.05	67.71	10.16	252.70	248.77	65.87	11.00	—	14.21	1.86
10 3/4	51.00	273.05	75.90	11.43	250.20	246.23	73.75	10.11	—	13.05	0.70
10 3/4	51.00	273.05	75.90	11.43	250.20	246.33	73.75	10.16 [f]	—	13.05	0.70
10 3/4	55.50	273.05	82.59	12.57	247.90	244.48 [e]	80.75	9.30	—	12.25	–0.09
10 3/4	55.50	273.05	82.59	12.57	247.90	244.48 [e]	80.75	9.35 [f]	—	12.01	–0.34
10 3/4	55.50	273.05	82.59	12.57	247.90	243.94	80.75	9.30	—	12.25	–0.09
10 3/4	55.50	273.05	82.59	12.57	247.90	243.94	80.75	9.35 [f]	—	12.01	–0.34
10 3/4	60.70	273.05	90.33	13.84	245.40	241.40	88.47	8.42	—	11.07	—
10 3/4	60.70	273.05	90.33	13.84	245.40	241.40	88.47	8.47 [f]	—	10.87	—
10 3/4	65.70	273.05	97.77	15.11	242.80	238.86	96.12	7.54	—	9.98	—
10 3/4	65.70	273.05	97.77	15.11	242.80	238.86	96.12	7.60 [f]	—	9.74	—
10 3/4	73.20	273.05	108.93	17.07	238.90	234.95	107.76	—	—	—	—
10 3/4	79.20	273.05	117.86	18.64	235.80	231.80	116.95	—	—	—	—
10 3/4	85.30	273.05	126.94	20.24	232.60	228.60	126.19	—	—	—	—
11 3/4	42.00	298.45	62.50	8.46	281.50	279.40 [e]	62.56	13.27	—	—	—
11 3/4	42.00	298.45	62.50	8.46	281.50	277.50	62.56	13.27	—	—	—
11 3/4	47.00	298.45	69.94	9.52	279.41	275.44	67.83	12.42	—	16.04	—
11 3/4	54.00	298.45	80.36	11.05	276.40	272.39	78.32	11.23	—	14.50	—
11 3/4	60.00	298.45	89.29	12.42	273.60	269.88 [e]	87.61	10.17	—	13.12	—
11 3/4	60.00	298.45	89.29	12.42	273.60	269.88 [e]	87.61	9.77 [f]	—	13.12	—
11 3/4	60.00	298.45	89.29	12.42	273.60	269.65	87.61	10.17	—	13.12	—
11 3/4	60.00	298.45	89.29	12.42	273.60	269.65 [e]	87.61	9.77 [f]	—	13.12	—
11 3/4	65.00	298.45	96.73	13.56	271.30	269.88 [e]	95.27	—	—	—	—
11 3/4	65.00	298.45	96.73	13.56	271.30	267.36	95.27	—	—	—	—
11 3/4	71.00	298.45	105.66	14.78	268.90	264.92	103.40	—	—	—	—

Table C.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
								Round Thread		Buttress Thread	
		D mm	kg/m	t mm	d mm	mm	w_{pe} kg/m	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
13 3/8	48.00	339.72	71.43	8.38	322.96	318.99	68.48	15.04	—	—	—
13 3/8	54.50	339.72	81.10	9.65	320.42	316.45	78.55	13.88	—	17.91	—
13 3/8	61.00	339.72	90.78	10.92	317.88	313.91	88.55	12.74	—	16.44	—
13 3/8	68.00	339.72	101.19	12.19	315.34	311.37	98.46	11.61	—	14.97	—
13 3/8	68.00	339.72	101.19	12.19	315.34	311.37	98.46	11.67 [f]	—	14.97	—
13 3/8	72.00	339.72	107.15	13.06	313.60	311.15 [e]	105.21	10.98	—	14.33	—
13 3/8	72.00	339.72	107.15	13.06	313.60	311.15 [e]	105.21	10.91 [f]	—	13.98	—
13 3/8	72.00	339.72	107.15	13.06	313.60	309.63	105.21	10.98	—	14.33	—
13 3/8	72.00	339.72	107.15	13.06	313.60	309.63	105.21	10.91 [e]	—	13.98	—
16	65.00	406.40	96.73	9.53	387.40	382.57	96.73	18.59	—	—	—
16	75.00	406.40	111.61	11.13	384.10	379.37	108.49	16.66	—	20.13	—
16	84.00	406.40	125.01	12.57	381.30	376.48	122.09	14.92	—	18.11	—
16	109.00	406.40	162.21	16.66	373.10	368.30	160.13	—	—	—	—
18 5/8	87.50	473.08	130.21	11.05	450.98	446.22	125.91	33.60	—	39.25	—
20	94.00	508.00	139.89	11.13	485.70	480.97	136.38	20.50	27.11	24.78	—
20	94.00	508.00	139.89	11.13	485.70	480.97	136.38	20.61	27.26 [g]	24.78	—
20	106.50	508.00	158.49	12.70	482.60	477.82	155.13	18.22	24.27	22.00	—
20	133.00	508.00	197.93	16.13	475.70	470.97	195.66	13.03	17.84	16.02	—

NOTE See also Figures D.1, D.2, and D.3.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses, threaded and coupled (column 4) are shown for information only.

[c] The densities of martensitic chromium steels (L80 Types 9Cr and 13Cr) are less than those of carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 shall be used.

[d] Mass gain or loss due to end-finishing; see 7.5.

[e] Drift diameter for most common bit size; this drift diameter shall be specified in the purchase agreement and marked on the pipe; see 7.10 for drift requirements.

[f] Based on 758 MPa minimum yield strength or greater.

[g] Based on 379 MPa minimum yield strength.

Table C.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
1	2			D mm	Non-upset T&C kg/m	External Upset T&C kg/m	Integral Joint kg/m	t mm	d mm	w_{pe} kg/m	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1.050	1.14	1.20	—	26.67	1.70	1.79	—	2.87	20.93	1.68	0.09	0.64	—	—
1.050	1.48	1.54	—	26.67	2.20	2.29	—	3.91	18.85	2.19	—	0.60	—	—
1.315	1.70	1.80	1.72	33.40	2.53	2.68	2.56	3.38	26.64	2.50	0.18	0.64	0.09	0.09
1.315	2.19	2.24	—	33.40	3.26	3.33	—	4.55	24.30	3.24	—	0.61	—	—
1.660	2.09	—	2.10	42.16	—	—	3.13	3.18	35.80	3.06	—	—	—	0.09
1.660	2.30	2.40	2.33	42.16	3.42	3.57	3.47	3.56	35.04	3.39	0.36	0.73	—	0.09
1.660	3.03	3.07	—	42.16	4.51	4.57	—	4.85	32.46	4.46	—	0.68	—	—
1.900	2.40	—	2.40	48.26	—	—	3.57	3.18	41.90	3.54	—	—	—	0.09
1.900	2.75	2.90	2.76	48.26	4.09	4.32	4.11	3.68	40.90	4.05	0.27	0.91	—	0.09
1.900	3.65	3.73	—	48.26	5.43	5.55	—	5.08	38.10	5.41	—	0.92	—	—
1.900	4.42	—	—	48.26	6.58	—	—	6.35	35.56	6.56	—	—	—	—
1.900	5.15	—	—	48.26	7.66	—	—	7.62	33.02	7.64	—	—	—	—
2.063	3.24	—	3.25	52.40	—	—	4.84	3.96	44.48	4.73	—	—	—	0.09
2.063	4.50	—	—	52.40	—	—	—	5.72	40.96	6.58	—	—	—	—
2 3/8	4.00	—	—	60.32	5.95	—	—	4.24	51.84	5.86	0.73	—	—	—
2 3/8	4.60	4.70	—	60.32	6.85	6.99	—	4.83	50.66	6.61	0.73	1.81	1.34	—
2 3/8	5.80	5.95	—	60.32	8.63	8.85	—	6.45	47.42	8.57	0.64	1.63	1.16	—
2 3/8	6.60	—	—	60.32	9.82	—	—	7.49	45.34	9.76	—	—	—	—
2 3/8	7.35	7.45	—	60.32	10.94	11.09	—	8.53	43.26	10.89	—	—	—	—

Table C.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections *(continued)*

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
1	2			D mm	Non-upset T&C kg/m	External Upset T&C kg/m	Integral Joint kg/m	t mm	d mm	w_{pe} kg/m	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
2 7/8	6.40	6.50	—	73.02	9.52	9.67	—	5.51	62.00	9.17	1.45	2.54	1.71	—
2 7/8	7.80	7.90	—	73.02	11.61	11.76	—	7.01	59.00	11.41	1.27	2.63	1.78	—
2 7/8	8.60	8.70	—	73.02	12.80	12.95	—	7.82	57.78	12.57	1.18	2.27	1.43	—
2 7/8	9.35	9.45	—	73.02	13.91	14.06	—	8.64	54.74	13.72	—	—	—	—
2 7/8	10.50	—	—	7302	15.67	—	—	9.96	53.10	15.49	—	—	—	—
2 7/8	11.50	—	—	73.02	17.11	—	—	11.18	50.66	17.05	—	—	—	—
3 1/2	7.70	—	—	88.90	11.46	—	—	5.49	77.92	11.29	2.45	—	—	—
3 1/2	9.20	9.30	—	88.90	13.69	13.84	—	6.45	76.00	13.12	2.27	4.17	2.45	—
3 1/2	10.20	—	—	88.90	15.18	—	—	7.34	74.22	14.76	2.18	—	—	—
3 1/2	12.70	—	—	88.90	18.90	19.27	—	9.52	69.86	18.64	1.81	3.72	2.00	—
3 1/2	14.30	—	—	88.90	21.28	—	—	10.92	67.06	21.00	—	—	—	—
3 1/2	15.50	—	—	88.90	27.07	—	—	12.09	64.72	22.90	—	—	—	—
3 1/2	17.00	—	—	88.90	25.70	—	—	13.46	61.98	25.04	—	—	—	—
4	9.50	—	—	101.60	14.14	—	—	5.74	90.12	13.57	2.81	—	—	—
4	10.70	11.00	—	101.60	—	16.37	—	6.65	88.30	15.57	—	4.81	—	—
4	13.20	—	—	101.60	19.64	—	—	8.38	84.84	19.27	—	—	—	—
4	16.10	—	—	101.60	23.96	—	—	10.54	80.52	23.67	—	—	—	—
4	18.90	—	—	101.60	28.13	—	—	12.70	76.20	27.84	—	—	—	—
4	22.20	—	—	101.60	33.04	—	—	15.49	70.62	32.89	—	—	—	—

Table C.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections *(continued)*

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] kg			
1	2			D mm	Non-upset T&C kg/m	External Upset T&C kg/m	Integral Joint kg/m	t mm	d mm	w_{pe} kg/m	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
4 1/2	12.60	12.75	—	114.30	18.75	18.97	—	6.88	100.54	18.23	2.72	5.99	—	—
4 1/2	15.20	—	—	114.30	22.62	—	—	8.56	97.18	22.32	—	—	—	—
4 1/2	17.00	—	—	114.30	25.30	—	—	9.65	95.00	24.90	—	—	—	—
4 1/2	18.90	—	—	114.30	28.13	—	—	10.92	92.46	27.84	—	—	—	—
4 1/2	21.50	—	—	114.30	32.00	—	—	12.70	88.90	31.82	—	—	—	—
4 1/2	23.70	—	—	114.30	35.27	—	—	14.22	85.86	35.10	—	—	—	—
4 1/2	26.10	—	—	114.30	38.84	—	—	16.00	82.30	38.79	—	—	—	—

NOTE See also Figures D.4, D.5, and D.7.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses (columns 6, 7, and 8) are shown for information only.

[c] The densities of martensitic chromium (L80 Types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 shall be used.

[d] Mass gain or loss due to end-finishing; see 7.5.

[e] The length of the upset may alter the mass gain or loss due to end-finishing.

Table C.20—External Upset Tubing Dimensions for API Connections for Grades H40, J55, L80, R95, N80, C90, T95, and P110

Labels [a]		Outside Diameter D	Nominal Linear Mass Threaded and Coupled [b]	Upset			
				Outside Diameter [c] D_4	Length from End of Pipe to Start of Taper [d, e] L_{eu}	Length from End of Pipe to End of Taper [e] L_a	Length from End of Pipe to Start of Pipe Body [e] L_b
1	**2**	mm	kg/m	mm +1.59 0	mm +0 –25.4	mm	mm **max**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	1.20	26.67	1.79	33.40	60.32	—	—
1.050	1.54	26.67	2.29	33.40	60.32	—	—
1.315	1.80	33.40	2.68	37.31	63.50	—	—
1.315	2.24	33.40	3.33	37.31	63.50	—	—
1.660	2.40	42.16	3.57	46.02	66.68	—	—
1.660	3.07	42.16	4.57	46.02	66.68	—	—
1.900	2.90	48.26	4.32	53.19	68.26	—	—
1.900	3.73	48.26	5.55	53.19	68.26	—	—
2 3/8	4.70	60.32	6.99	65.89	101.60	152.40	254.00
2 3/8	5.95	60.32	8.85	65.89	101.60	152.40	254.00
2 3/8	7.45	60.32	11.09	65.89	101.60	152.40	254.00
2 7/8	6.50	73.02	9.67	78.59	107.95	158.75	260.35
2 7/8	7.90	73.02	11.76	78.59	107.95	158.75	260.35
2 7/8	8.70	73.02	12.95	78.59	107.95	158.75	260.35
2 7/8	9.45	73.02	14.06	78.59	107.95	158.75	260.35
3 1/2	9.30	88.90	13.84	95.25	114.30	165.10	266.70
3 1/2	12.95	88.90	19.27	95.25	114.30	165.10	266.70
4	11.00	101.60	16.37	107.95	114.30	165.10	266.70
4 1/2	12.75	114.30	18.97	120.65	120.65	171.45	273.05

NOTE 1 See also Figures D.5 and D.6.

NOTE 2 Nominal linear masses are shown for information only.

[a] Labels are for information and assistance in ordering.

[b] The densities of martensitic chromium steels (L80 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for chromium steels. A mass correction factor of 0.989 shall be used.

[c] The minimum outside diameter of upset D_4 is limited by the minimum length of full-crest threads; see API 5B.

[d] For pup joints only, the length tolerance on L_{eu} is +101.6 mm to –25.4 mm. The length on L_b may be 101.6 mm longer than specified.

[e] For extended-length upsets on external upset tubing, add 25.4 mm to the dimensions in columns 6, 7, and 8.

Table C.21—Integral Tubing Connection Dimensions for API Connections for Grades H40, J55, L80, R95, N80, C90, and T95

Labels		Outside Diameter D	Nominal Linear Mass [a]	Upset Dimensions								
				Pin				Box				
				Outside Diameter [b] D_4	Inside Diameter [c] d_{iu}	Length L_{iu}	Length of Taper m_{iu}	Outside Diameter W_b	Length L_{eu}	Length of Taper m_{eu}	Diameter of Recess Q	Width of Face b
1	**2**	mm	kg/m	mm +1.59 0	mm +0.38 0	mm **min**	mm **min**	mm +0.13 –0.64	mm **min**	mm	mm	mm **min**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1.315	1.72	33.40	2.56	—	24.64	34.92	6.35	39.37	44.45	25.40	35.00	0.79
1.660	2.10	42.16	3.13	—	33.05	38.10	6.35	47.75	47.62	25.40	43.76	0.79
1.660	2.33	42.16	3.47	—	33.05	38.10	6.35	47.75	47.62	25.40	43.76	0.79
1.900	2.40	48.26	3.57	—	38.89	38.89	6.35	53.59	50.80	25.40	49.86	0.79
1.900	2.76	48.26	4.11	—	38.89	38.89	6.35	53.59	50.80	25.40	49.86	0.79
2.063	3.25	52.40	4.84	53.19	42.47	42.47	6.35	59.06	53.98	25.40	54.76	0.79

NOTE See also Figure D.7.

[a] Nominal linear masses, upset and threaded, are shown for information only.

[b] The minimum outside diameter D_4 is limited by the minimum length of full-crest threads; see API 5B.

[c] The minimum diameter d_{iu} is limited by the drift test.

Table C.22—Range Lengths

Dimensions in meters

	Range 1 [b]	Range 2 [b]	Range 3 [b]
Casing (PE/T and C/SF)			
Total range length, inclusive	4.88 to 7.62	7.62 to 10.36	10.36 to 14.63
Permissible variation, max [a]	1.83	1.52	1.83
Tubing and casing used as tubing (PE/T and C/SF)			
Total range length, inclusive	6.10 to 7.32	8.53 to 9.75	11.58 to 12.80
Permissible variation, max [a]	0.61	0.61	0.61
Integral tubing connections (including IJ/PE and IJ/SF)			
Total range length, inclusive	6.10 to 7.92	8.53 to 10.36	11.58 to 13.72
Permissible variation, max [a]	0.61	0.61	0.61
Pup joints [b]	Lengths: 0.61; 0.91; 1.22; 1.83; 2.44; 3.05; and 3.66 Tolerance: ±0.076		

[a] Length variation applies to rail car shipment to the point of use and does not apply to order items of less than 18,144 kg of pipe.

[b] Lengths other than those listed may be furnished by agreement between the purchaser and the manufacturer.

Table C.23—Standard Drift Size

Dimensions in millimeters

Product and Label 1	Standard Drift Mandrel Size min	
	Length	Diameter
Casing		
< 9 5/8	152	d – 3.18
≥ 9 5/8 to ≤ 13 3/8	305	d – 3.97
> 13 3/8	305	d – 4.76
Tubing [a, b]		
≤ 2 7/8	1067	d – 2.38
> 2 7/8 to ≤ 8 5/8	1067	d – 3.18
> 8 5/8 to < 10 3/4	1067	d – 3.97

[a] Integral-joint tubing shall be tested before upsetting with a drift mandrel as shown and shall also be drift-tested at the pin end, after upsetting, with a cylindrical drift mandrel 1067 mm in length and d_{iu} – 0.38 mm in diameter (see Table C.21, column 6 for d_{iu}).

[b] Casing sizes larger than Label 1: 4 1/2 but smaller than Label 1: 10 3/4 specified by the purchaser to be used in tubing service shall be marked as specified in Section 10.

Table C.24—Alternative Drift Size

Labels		Pipe Outside Diameter D mm	Nominal Linear Mass, T&C kg/m	Alternative Drift Mandrel Size mm min	
1	2			Length	Diameter
1	*2*	*3*	*4*	*5*	*6*
7	23.00	177.80	34.67	152	158.75
7	32.00	177.80	47.92	152	152.40
7 3/4	46.10	196.85	68.60	152	165.10
8 5/8	32.00	219.08	47.62	152	200.02
8 5/8	40.00	219.08	59.53	152	193.68
9 5/8	40.00	244.48	59.53	305	222.25
9 5/8	53.50	244.48	79.62	305	215.90
9 5/8	58.40	244.48	86.91	305	212.72
10 3/4	45.50	273.05	67.71	305	250.82
10 3/4	55.50	273.05	82.59	305	244.48
11 3/4	42.00	298.45	62.50	305	279.40
11 3/4	60.00	298.45	89.29	305	269.88
11 3/4	65.00	298.45	96.73	305	269.88
13 3/8	72.00	339.72	107.15	305	311.15

NOTE 1 Subsection 7.10 allows other dimensions when specified in the purchase agreement.

NOTE 2 See footnote [b] to Table C.23 for casing used as tubing.

Table C.25—Maximum Permissible Depth of Linear Imperfections

Grade	Depth as % of Specified Wall Thickness	
	External Imperfections	Internal Imperfections
H40 – J55 – K55 – N80Q – L80 – R95 [P110 to A.9 (SR 16)]	12.5 %	12.5 %
N80 Type 1	10 %	10 %
C90 – T95 – C110 – P110 – Q125	5 %	5 %
[P110 to A.9 (SR 16) and A.3 (SR 2)]	5 %	5 %

Table C.26—Upset Products—Maximum Permissible Depth of Imperfections

Surface		Depth	Measurement Notes
A Integral-joint and External Upset Tubing (see Figure D.5 and Figure D.7)			
A.1	All surfaces of upset and upset run-out interval, except as stated below	12.5 % t	Percentage of specified pipe body wall thickness t; for nonlinear imperfections; for all Grades of pipe.
		12.5 % t	Percentage of specified pipe body wall thickness t; for linear imperfections; for Grades H40, J55, K55, L80, N80, and R95.
		5 % t	Percentage of specified pipe body wall thickness t; for linear imperfections; for Grades C90, T95, and P110 pipe.
A.2	The minimum wall thickness in the upset run-out interval, and the maximum combined effect of coincident internal and external imperfections in all areas, shall not total less than 87.5 % of the specified wall thickness.		
B Integral Tubing Connections (see Figure D.7)			
B.1	Box end and external surface	0.25 mm	From end of pipe to a plane at a distance equal to the specified minimum dimension L_{eu} (see Figure D.7) from end of pipe.
B.2	Pin end internal surface	0.38 mm	From end of pipe to a plane at a distance equal to the specified minimum dimension L_{iu} (see Figure D.7) from end of pipe.
			For Grades C90 and T95, the maximum permissible depth for linear imperfections shall be 5 % of the specified pipe body wall thickness.
B.3	Upset underfill in the upset run-out intervals shall not be considered a defect unless the remaining wall thickness (at the upset underfill) is less than 87.5 % of the specified pipe body wall thickness.		

Table C.27—API Round Thread Casing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter W [b, c] mm	Minimum Length mm		Diameter of Recess Q [d] mm	Width of Bearing Face b mm	Mass kg	
	Outside Diameter D mm		Short N_L	Long N_L			Short	Long
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
4 1/2	114.30	133.35	158.75	177.80	116.68	7.14	5.24	5.96
5	127.00	147.32	165.10	196.85	129.38	7.14	6.43	7.86
5 1/2	139.70	160.02	171.45	203.20	142.08	6.35	7.34	8.92
6 5/8	168.28	187.71	184.15	222.25	170.66	6.35	9.12	11.34
7	177.80	200.03	184.15	228.60	180.18	7.94	10.88	13.92
7 5/8	193.70	215.90	190.50	234.95	197.64	5.56	12.16	15.63
8 5/8	219.08	244.48	196.85	254.00	223.04	6.35	15.62	21.67
9 5/8	244.48	269.88	196.85	266.70	248.44	6.35	17.85	25.45
10 3/4	273.05	298.45	203.20	—	277.02	6.35	20.58	—
11 3/4	298.45	323.85	203.20	—	302.42	6.35	22.43	—
13 3/8	339.72	365.12	203.20	—	343.69	5.56	25.42	—
16	406.40	431.80	228.60	—	411.96	5.56	34.33	—
18 5/8	473.08	508.00	228.60	—	478.63	5.56	53.33	—
20	508.00	533.40	228.60	292.10	513.56	5.56	42.81	56.98

NOTE See also Figure D.1 and Figure D.2.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] All Grades except Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than ±3.18 mm.

[c] Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than $\frac{+3.18}{-1.59}$ mm.

[d] Tolerance on diameter of recess, Q, for all Grades: $\frac{+0.79}{0}$ mm.

Table C.28—API Buttress Thread Casing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter		Minimum Length	Diameter of Counterbore	Width of Bearing Face	Mass kg	
	Outside Diameter D mm	Regular W [b, c] mm	Special Clearance [d] W_c mm	N_L mm	Q mm	b mm	Regular	Special Clearance
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
4 1/2	114.30	133.35	123.82	225.42	117.86	6.35	6.89	3.48
5	127.00	147.32	136.52	231.78	130.56	7.14	8.38	4.00
5 1/2	139.70	160.02	149.22	234.95	143.26	7.14	9.30	4.47
6 5/8	168.28	187.71	177.80	244.48	171.83	6.35	11.01	5.65
7	177.80	200.03	187.32	254.00	181.36	7.94	13.98	6.28
7 5/8	193.68	215.90	206.38	263.52	197.23	7.94	15.82	9.29
8 5/8	219.08	244.48	231.78	269.88	222.63	9.52	20.86	10.80
9 5/8	244.48	269.88	257.18	269.88	248.03	9.52	23.16	12.02
10 3/4	273.05	298.45	285.75	269.88	276.61	9.52	25.74	13.39
11 3/4	298.45	323.85	—	269.88	302.01	9.52	28.03	—
13 3/8	339.72	365.12	—	269.88	343.28	9.52	31.77	—
16	406.40	431.80	—	269.88	410.31	9.52	40.28	—
18 5/8	473.08	508.00	—	269.88	476.99	9.52	62.68	—
20	508.00	533.40	—	269.88	511.91	9.52	50.10	—

NOTE See also Figure D.3.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] All Grades except Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than ±3.18 mm.

[c] Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than $\frac{+3.18}{-1.59}$ mm.

[d] All Grades except Grade Q125—Tolerance on outside diameter W_c: $\frac{+0.79}{-0.40}$ mm.

Table C.29—API Non-upset Tubing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter W [b] mm	Minimum Length N_L mm	Diameter of Recess Q mm	Width of Bearing Face b mm	Maximum Bearing Face Diameter, Special Bevel B_f mm	Mass kg
	Outside Diameter D mm						
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	26.67	33.35	80.96	28.27	1.59	30.00	0.23
1.315	33.40	42.16	82.55	35.00	2.38	37.80	0.38
1.660	42.16	52.17	88.90	43.76	3.18	47.17	0.59
1.900	48.26	55.88	95.25	49.86	1.59	52.07	0.56
2 3/8	60.32	73.02	107.95	61.93	4.76	66.68	1.28
2 7/8	73.02	88.90	130.18	74.63	4.76	80.98	2.34
3 1/2	88.90	107.95	142.88	90.50	4.76	98.42	3.71
4	101.60	120.65	146.05	103.20	4.76	111.12	4.35
4 1/2	114.30	132.08	155.58	115.90	4.76	123.19	4.89

NOTE See also Figure D.4.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] Tolerance on outside diameter W: ±1 %.

Table C.30—API External Upset Tubing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a] Outside Diameter D mm	Outside Diameter		Minimum Length N_L mm	Diameter of Recess Q mm	Width of Bearing Face, Regular b mm	Maximum Bearing Face Diameter B_f		Mass kg	
		Regular W [b] mm	Special Clearance W_c [c] mm				Regular with Special Bevel mm	Special Clearance mm	Regular	Special Clearance
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1.050	26.67	42.16	—	82.55	35.00	2.38	37.80	—	0.38	—
1.315	33.40	48.26	—	88.90	38.89	2.38	42.77	—	0.57	—
1.660	42.16	55.88	—	95.25	47.63	3.18	50.95	—	0.68	—
1.900	48.26	63.50	—	98.42	54.76	3.18	58.34	—	0.84	—
2 3/8	60.32	77.80	73.91	123.82	67.46	3.97	71.83	69.90	1.55	1.07
2 7/8	73.02	93.17	87.88	133.35	80.16	5.56	85.88	83.24	2.40	1.55
3 1/2	88.90	114.30	106.17	146.05	96.85	6.35	104.78	100.71	4.10	2.38
4	101.60	127.00	—	152.40	109.55	6.35	117.48	—	4.82	—
4 1/2	114.30	141.30	—	158.75	122.25	6.35	130.96	—	6.05	—

NOTE See also Figure D.5.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] Tolerance on outside diameter W: ±1 %.

[c] Tolerance on outside diameter W_c: ±0.38 mm.

Table C.31—Permissible Depth of External Imperfections on Coupling

Coupling for Label 1		Grades H40, J55, K55, N80, R95, L80, and P110		Grades C90, T95, C110, and Q125
		Pits and Round-bottom Gouges mm	Grip Marks and Sharp-bottom Gouges mm	Pits, Round-bottom Gouges, Sharp-bottom Gouges, Grip Marks mm
1	*2*	*3*	*4*	*5*
Tubing	< 3 1/2	0.76	0.64	0.76
	≥ 3 1/2 to ≤ 4 1/2	1.14	0.76	0.89
Casing [a]	< 6 5/8	0.89	0.76	0.76
	≥ 6 5/8 to ≤ 7 5/8	1.14	1.02	0.89
	> 7 5/8	1.52	1.02	0.89

[a] Includes casing used as tubing.

Table C.32—Frequency of Tensile Tests—Casing and Tubing

Grade [e]	Label 1	Maximum Number of Pieces in a Lot	Number of Tests	
			Per Lot	Per Heat
1	*2*	*3*	*4*	*5*
H40, K55, J55, N80	< 6 5/8	400 [a, b]	1	1
	≥ 6 5/8	200 [a, b]	1	1
R95	≤ 4 1/2	200 [a, b]	2 [c]	1
	>4 1/2	100 [a, b]	2 [c]	1
L80 Type 1, L80 3Cr	≤ 4 1/2	200 [a, b]	2 [c]	1
L80 9Cr, L80 13Cr	≤ 4 1/2	200 [b, d]	2 [c]	—
C90, T95	≤ 4 1/2	200 [b, d]	1	—
L80 Type 1, L80 3Cr	> 4 1/2	100 [a, b]	2 [c]	1
L80 9Cr, L80 13Cr	> 4 1/2	100 [b, d]	2 [c]	—
C90, T95	> 4 1/2	100 [b, d]	1	—
C110	All sizes	100 [b, d]	1	—
P110	< 6 5/8	200 [a, b]	1	1
	≥ 6 5/8	100 [a, b]	1	1
Q125	All sizes	— [d]	3 [c]	—

NOTE Table includes casing used as tubing.

[a] See 9.2.1.

[b] See 9.4.2.

[c] See 9.4.3.

[d] See 9.2.2.

[e] For all Grades, except Grade Q125 multiple-length seamless pipe, a length shall be considered as all of the sections cut from a particular multiple length, provided the pipe receives no additional heat treatment after being cut into individual lengths.

Table C.33—Frequency of Tensile Tests—Coupling Stock, Coupling Material, and Coupling Blanks

Grade	Material	Condition When Heat-treated	Maximum Number of Pieces in a Lot	Number of Tests	
				Per Lot	Per Heat
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80, and P110	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [a]	1	1 [b]
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [a]	1	1 [b]
		Coupling blank	400 [c]	1	—
	Hot forging	Coupling blank	400 [c]	1	—
R95, L80 Type 1, L80 3Cr	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [a]	2 [d, e]	2 [d, e]
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [a]	2 [d, e]	2 [d, e]
		Coupling blank	400 [c]	2 [e]	—
	Hot forging	Coupling blank	400 [c]	2 [e]	—
L80 9Cr and L80 13Cr	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [d]	2 [d, e]	—
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [d]	2 [d, e]	—
		Coupling blank	400 [c]	2 [e]	—
	Hot forging	Coupling blank	400 [c]	2 [e]	—
C90 and T95	Coupling stock and coupling material	Coupling stock and coupling material for pipe Label 1: All sizes	1 [b]	1	—
		Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
	Hot forging	Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
C110 and Q125	Coupling stock and coupling material	Coupling stock and coupling material for pipe Label 1: All sizes	1 [b]	1	—
		Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		

[a] See 9.2.1.

[b] Approximately 50 % from each end.

[c] See 9.2.3.

[d] See 9.2.2.

[e] When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

Table C.34—Frequency of Tensile Testing—Pup Joints and Accessory Material

Grade	Material and Heat Treatment Conditions [a]		Maximum Number of Pieces in a Lot	Number of Tests	
				Per Lot	Per Heat
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80	Full-length standard tubing or casing from one or more heats		Label 1: < 6 5/8: 400	1	1
			Label 1: ≥ 6 5/8: 200		
P110	Full-length standard tubing or casing from one or more heats		Label 1: < 6 5/8: 200	1	1
			Label 1: ≥ 6 5/8: 100		
H40, J55, K55, N80, P110	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	1	1
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	1	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	1	—
R95, L80 Type 1, L80 3Cr	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	2 [a, b]	2 [a, b]
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	2 [a, b]	2 [a, b]
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	2 [b]	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	2 [b]	—
L80 9Cr, L80 13Cr	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	2 [a, b]	—
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	2 [a, b]	—
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	2 [b]	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	2 [b]	—
C90 and T95	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	1	—
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		1	1 [a]	—
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
		Heat-treated in sequential loads or continuous heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
C110 and Q125	Full-length standard tubing or casing from one or more heats		In accordance with 9.2.3	3 [a, b]	—
	Thick-wall mechanical tube or bar stock from a single heat		1	1 [a]	—
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
		Heat-treated in sequential loads or continuous heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		

[a] Approximately 50 % from each end.

[b] When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

[c] Each lot shall be from the same heat of steel for Grades L80 9Cr, L80 13Cr, C90, T95, C110, and Q125; see 9.2.3.

Table C.35—Frequency of Hardness Testing

Grade	Material		Number of Tests per Lot	Maximum Number of Pieces in a Lot	Type of Test	Location
1	*2*		*3*	*4*	*5*	*6*
L80	Pipe, coupling stock, coupling material	Label 1: ≤ 4 1/2	2 [a]	200 [b, c]	Through-wall, 1 quadrant	Body tensile test
		Label 1: > 4 1/2	2 [a]	100 [b, c]	Through-wall, 1 quadrant	Body tensile test
	Coupling blanks or hot forgings		2 [a]	Heat-treat lot or 400 coupling blanks [b, c]	Through-wall, 1 quadrant	Coupling blank tensile test
	Pup joints and accessory material (heat-treated in individual lengths)	Batch heat treatment (method a, 9.2.3)	2 [a]	100 pup joints or 400 accessory material [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
		Heat-treated in sequential loads (method b, 9.2.3)	2 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
		Continuous heat treatment (method c, 9.2.3)	2 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
C90, T95	As-quenched product		1	Each production run or heat treatment practice	Through-wall, 4 quadrants	Design area of greatest thickness
	Non-upset pipe		1	Each length	Through-wall, 1 quadrant	Approximately 50 % from each end
	Upset pipe		1	Each length	Surface—HRC or HBW	Pipe body and one upset [d]
			1	20 [c]	Through-wall, 4 quadrants	One upset
			1	Label 1: ≤ 4 1/2: 200	Through-wall, 4 quadrants	Pipe body tensile test
				Label 1: > 4 1/2: 100		
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube-length heat treatment	2 [a]	Each length	Through-wall, 4 quadrants	One from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 5/8: 50 [c]	Through-wall, 4 quadrants	From a piece with the highest surface hardness number in the lot
				Label 1: ≥ 9 5/8: 30 [c]		

Table C.35—Frequency of Hardness Testing *(continued)*

Grade	Material		Number of Tests per Lot	Maximum Number of Pieces in a Lot	Type of Test	Location
1	*2*		*3*	*4*	*5*	*6*
C110	As-quenched product		1	Each production run or heat treatment practice	Through-wall, 4 quadrants	Design area of greatest thickness
	Non-upset pipe		2	One from each end	Through-wall, 1 quadrant	Each end of each piece
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube length heat treatment	2 [a]	Each length	Through-wall, 4 quadrants	One from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 $^{5}/_{8}$: 50 [c]	Through-wall, 4 quadrants	From a piece with the highest surface hardness number in the lot
				Label 1: ≥ 9 $^{5}/_{8}$: 30 [c]		
Q125	Casing		3 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pipe body
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube length heat treatment	1	Each length	Through-wall, 1 quadrant	Approximately 50 % from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 $^{5}/_{8}$: 50 [c]	Through-wall, 1 quadrant	Randomly selected piece
				Label 1: ≥ 9 $^{5}/_{8}$: 30 [c]		

[a] When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

[b] The lengths tested shall be selected randomly and represent the start and end of the heat treatment cycle.

[c] Each lot shall be from the same heat of steel for Grades L80 9Cr, L80 13Cr, C90, T95, and Q125.

[d] One upset approximately 50 % from each end if both ends are upset.

Table C.36—Frequency of Flattening Tests

Casing and Tubing					
Grade	**Type of Heat Treatment**		**Number of Tests**		
1	*2*	*3*	*4*		
H40, J55, K55, N80, L80 Type 1, R95, P110	Non-full-body		As described in footnote [a]		
	Full-body, full-length	≤ Label 1: 4 1/2	Same as non-full-body heat-treated or 1 per lot of 100 lengths or less		
		> Label 1: 4 1/2 [b]	Same as non-full-body heat-treated or 1 per lot of 20 lengths or less		
Q125	All		1 on each end of each length of pipe [see A.6 (SR 11)]		
Pup Joints					
Grade	**Type of Heat Treatment**		**Maximum Number of Pieces in a Lot**	**Number of Tests**	
				Per Lot	**Per Heat**
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80, L80 Type 1, R95, P110	Treated after cutting to length	Batch heat-treated	100 pup joints	1	1
		Continuously heat-treated	—		
	Treated before cutting to length	≤ Label 1: 4 1/2	200 lengths		
		> Label 1: 4 1/2 [b]	100 lengths		
Q125	All			1 on each end of each length of pipe	

[a] The leading end of the first pipe of each coil shall have two test specimens flattened: one in the 90° position and one in the 0° position. Two test specimens shall be flattened from an intermediate pipe of each coil: one in the 90° position and one in the 0° position. The trailing end of the last pipe of each coil shall have two test specimens flattened: one in the 90° position and one in the 0° position.

When a weld stop condition occurs during production of a multiple length, flattening tests with the weld at the 90° position and 0° position shall be made from the crop end resulting from each side of the weld stop, and may be substituted for the intermediate flattening tests.

90° position: the weld is positioned at 3 o'clock or at 9 o'clock; 0° position: the weld is positioned at 6 o'clock or at 12 o'clock.

[b] Includes casing used as tubing.

Table C.37—Summary of NDE Methods for Seamless Pipe, Coupling Stock, Body of Welded Pipe, and Accessory Material (in Accordance with 9.15.9 and 9.15.11)

Product	Grade	Visual Inspection (see 9.14)	Wall Thickness Verification	Ultrasonic Inspection	Flux Leakage Inspection	Eddy Current Inspection	Magnetic Particle Inspection [a]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Pipe and accessory material	H40, J55, K55	R	N	N	N	N	N
	N80, L80, R95	R	R	A	A	A	A
	P110	R	R	A	A	A	NA
	Q125	R	R	C	B	B	B
Pipe	C90, T95, C110	R	R	C (A) [b]	B (A) [b]	B (A) [b]	B (NA) [b]
Accessory material	C90, T95, C110	R	R	C (A) [b]	B (A) [b]	B (A) [b]	B (A) [b]
Coupling stock	H40, J55, K55	R	NA	N	N	N	N
	N80, L80, R95, P110, C90, T95, C110, Q125	R	R	A	A	A	A

A = one method or any combination of methods shall be used; B = at least one method shall be used in addition to ultrasonic inspection to inspect on the outside surface; C = ultrasonic inspection shall be used to inspect the outside and inside surface; N = not required; NA = not applicable; R = required.

[a] MPI is permitted for end-area inspection. MPI is permitted for pipe-body outside-surface inspection in combination with other methods of pipe body inspection. MPI is permitted for coupling stock outside surface inspection and coupling stock oblique inspection. Coupling stock receiving full-length MPI does not require full-length wall thickness verification; however, mechanical wall thickness measurement of each end is required. MPI is permitted for the pipe OD and ID when inspected on the ends of the pipe uninspected area.

[b] Values in parenthesis () are specigic to oblique angled defects.

Table C.38—Acceptance (Inspection) Levels

Material	Grade		External Imperfections			Internal Imperfections		
			Longitudinal	Transverse	Oblique	Longitudinal	Transverse	Oblique
1	*2*		*3*	*4*	*5*	*6*	*7*	*8*
Pipe body [a]	N80 Type 1		L3	—	—	L3	—	—
	N80Q, L80, R95		L4	—	—	L4	—	—
	[P110 to A.9 (SR 16)]		L4	L4	—	L4	L4	—
	P110		L2	L2	—	L2	L2	—
	[P110 to A.9 (SR 16) and A.3 (SR 2)]		L2	L2	—	L2	L2	—
	Q125	UT	L2	L2	—	L2	L2	—
		Second method	L2	L2	—	—	—	—
	C90, T95, C110	UT	L2	L2	L2 [b]	L2	L2	L2 [b]
		Second method	L2	L2	—	—	—	—
Coupling stock	All grades except L80 13Cr, C90, T95, C110, and Q125		L2	L2	—	N	N	—
	L80 13Cr, Q125		L2	L2	—	L3	L3	—
	C90, T95, C110		L2	L2	L2 [b]	L3	L3	L3 [b]
Weld seam	P110, Q125		L2	N	—	L2	N	—
	All other grades		L3	N	—	L3	N	—
	All other grades to A.3 (SR 2)		L2	N	—	L2	N	—

L*x* = acceptance (inspection) level; N = not required; UT = ultrasonic testing.

[a] Accessory material shall be treated as pipe body.

[b] Flux leakage inspection or eddy current inspection may be used as alternative NDE methods for oblique inspection for pipe body; flux leakage inspection, eddy current inspection, or magnetic particle inspection may be used as alternative NDE methods for oblique inspection for accessory material.

Table C.39—Artificial Reference Indicators

Acceptance (Inspection) Level	Notch Depth [a] Maximum %	Notch Length Maximum for Eddy Current mm	Notch Length Maximum at Full Depth (Methods Other Than Eddy Current) mm	Notch Width Maximum mm	Radially Drilled Hole Diameter [b] mm
1	*2*	*3*	*4*	*5*	*6*
L2	5	38	50	1	1.6
L3	10	38	50	1	3.2
L4	12.5	38	50	1	3.2

NOTE See Figure D.18.

[a] Depth as a percent of specified wall thickness; the depth tolerance shall be ±15 % of the calculated notch depth with a minimum notch depth of 0.3 mm ± 0.05 mm.

[b] Drilled hole diameter (through the pipe wall) shall be based on the drill bit size.

Table C.40—Size of Stamp Markings

Product	Label 1	Marking Height mm
Pipe	< 4 $^1/_2$	4.8
	≥ 4 $^1/_2$	6.4
Coupling	For pipe sizes < 4 $^1/_2$	6.4
	For pipe sizes ≥ 4 $^1/_2$ to < 7 $^5/_8$	9.5
	For pipe sizes ≥ 7 $^5/_8$	12.7

Table C.41—Grade Color Codes

Grade	Grade Type	Number and Color of Bands for Product [a] with Length ≥ 1.8 m	Color(s) for Couplings	
			Entire Coupling	Band(s) [b, c]
1	*2*	*3*	*4*	*5*
H40	—	None or black band at the manufacturer's option	None	Same as for pipe
J55 Tubing	—	One bright green	Bright green	None
J55 Casing	—	One bright green	Bright green	One white
K55	—	Two bright green	Bright green	None
N80	1	One red	Red	None
N80	Q	One red, one bright green	Red	Green
R95	—	One brown	Brown	None
L80	1	One red, one brown	Red	One brown
L80	3Cr	One red, one white	Red [d]	One white
L80	9Cr	One red, one brown, two yellow	None	Two yellow
L80	13Cr	One red, one brown, one yellow	None	One yellow
C90	—	One purple	Purple	None
T95	—	One silver	Silver	None
C110	—	One white, two brown	White	Two brown
P110	—	One white	White	None
Q125	—	One orange	Orange	None

[a] In the case of coupling material, unless otherwise specified in the purchase agreement, the manufacturer's internal requirements shall govern.

[b] Special clearance couplings shall also have a black band.

[c] Seal-ring couplings shall also have a blue band.

[d] The painting of the entire coupling surface may be waived; see 10.4.

Table C.42—Thread Type Markings

Thread Type	Marked Symbol
Short round	SC
Long round	LC
Buttress	BC
Non-upset	NU
External upset	EU
Integral joint	IJ

Table C.43—Marking Requirements and Sequence

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Manufacturer's name or mark	«....»	D or P	D or P	P	P	P
2	API 5CT	5CT [c]	D or P	D or P	P	P	P
	Manufacturer's option: licensed/registered industry mark	«....»	D or P	D or P	P	P	P
	Date of manufacture as in 10.1.8 or 10.1.9	«....»	D or P	D or P	P	P	P
3	Unthreaded pipe or SF, if applicable (place symbol after specification marking):						
	— Unthreaded pipe either upset or non-upset	PE	D or P		P		
	— Pipe with SF threaded by the pipe mill or processor	SF	D or P		P		
	— Couplings threaded with SF	SF		D or P		P	
	— Coupling stock	CS					P
4	Size designation (fill in Label 1 designation from column 1 of Table C.1 or Table C.2)	«....»	P		P		
	Specified diameter for coupling stock and other products with no mass designation						P
5	Mass designation (fill in Label 2 designation from Table C.1 or Table C.2)	«....»	D or P		P		
	Specified wall thickness for coupling stock and other products with no mass designation						P
6	Grade of product:						
	— H40	H					
	— J55	J					
	— K55	K					

Table C.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
6	— N80 Type 1	N1					
	— N80Q	NQ					
	— R95	R					
	— L80 Type 1	L					
	— L80 3Cr	L3CR					
	— L80 9Cr	L9					
	— L80 13Cr	L13					
	— C90	C90T					
	— T95	C110					
	— C110	P					
	— P110	Q					
	— Q125						
	All Grade designations		D or P	D or P	P	P	P
7	Sulfide cracking test [f] — C90	A, AH [g], B, or D					
	— T95	A, AH [g], B, or D					
	— C110	A, D					
	All test method designations				P	P	P
8	Reduced alternative impact test temperature, if applicable. Fill in specified test temperature for full-size specimens, including ± symbol and °C	«....»C	P	P	P	P	
9	Heat treatment, if applicable: — J55 or K55 normalized	Z	P	P			P
	— J55 or K55 normalized and tempered (N&T)	N&T	P	P			P
10	Process of manufacture: — Seamless	S					
	— Electric-welded	E					
	All designations		D or P		P		

Table C.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
11	Supplementary requirements, if applicable:						
	— A.2 (SR 1)	S1	P		P		
	— A.3 (SR 2)	S2	P		P		
	— A.4 (SR 9) (fill in type)	S9Q«....»				P	
	— A.8 (SR 13)	S13		D or P		P	
	— A.9 (SR 16) (fill in minimum full-size energy absorption requirement, in joules, and test temperature including ± symbol and °C)	S16«....»C	P		P		
	— A.13 (SR 41)	S41.1	P		P		
		S41.2	P		P		
	— A.14 (SR 42)	S42	P				
	— A.15 (SR 43)	S43			P	D [d] or P	
	— A.16 (SR 44)	S44			P	D [d] or P	
	— A.17 (SR 45)	S45			P	D [d] or P	
	— A.18 (SR 46)	S46	D or P	D or P	P		
	— A.19 (SR 47)	S47	P	D	P	D [d] or P	
	— A.20 (SR 48)	S48	P		P	D [d] or P	
	— A.21 (SR 49)	S49					
12	Hydrostatic test pressure [e] (fill in the actual test pressure, in MPa)						
	All designations	P«....»	P		P		
13	Type of thread, if applicable	«....» [h]	P	P	P	P	

Table C.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
14	Full-length drift test, if applicable: — Standard (casing or tubing)	D					
	— Alternative (casing or tubing) where « » is the size of the alternative drift	DA«....»					
	— For casing specified for tubing service and drift-tested in accordance with 7.10	DT42					
	All designations		P		P		
15	Serialization of Grades C90, T95, C110, and Q125				D [d] or P	D [d] or P	P
16	Tin plating of couplings, if applicable	T		P		P	
17	Couplings H40, J55, and K55 only visually inspected	V		P			
18	Additional markings (see 10.1.10)		D or P	D or P	D or P	P	P

NOTE See 10.4 for mandatory color code requirements.

[a] D = optional (die) stamping (for location, see 10.2.3); P = requirement for (paint) stenciling (for location, see 10.3).

[b] A blank space, «....», indicates information to be filled in.

[c] The manufacturer may include “API” before “5CT.”

[d] Stamp marking shall conform to the requirements of 10.2.

[e] Pipe can be identified as manufactured to SI units by the marked hydro-test pressure that will be less than 100 (MPa), whereas the pressure marked for pipe manufactured to USC units will be over 1000 (psi). This information is used to clearly identify the units used for CVN markings, which shall be in the same unit system as the pressure markings.

[f] “A” when tested using Method A (smooth tensile), “B” when tested using Method B (bent beam), “D” when tested using Method D (DCB). If more than one test method is required, then state the combination of the test method designations as above, in alphabetical order. For example, if purchaser requires Method A and D, then mark “AD.”

[g] For Grades C90 and T95, “AH” when tested at 90 % Ys_{min}.

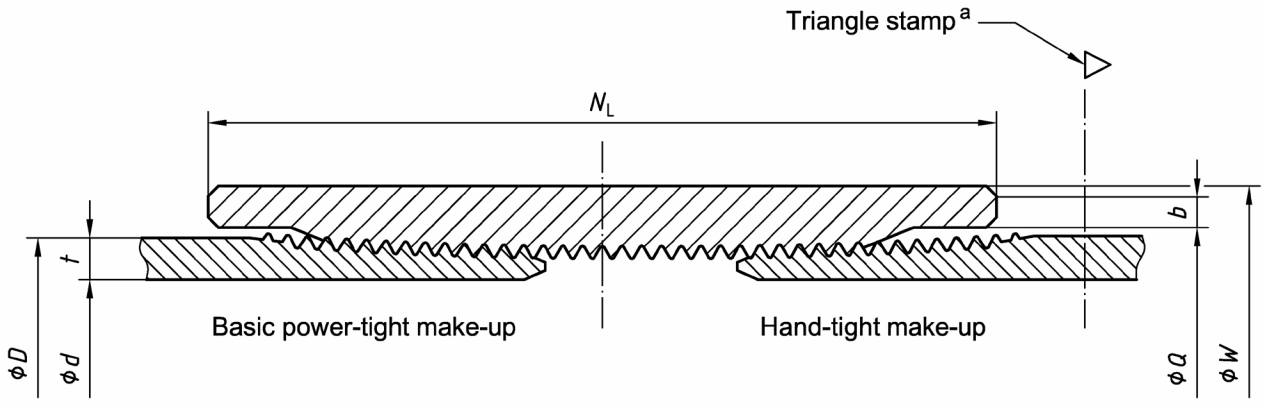
[h] See Table C.42 for thread type markings.

Table C.44—Retention of Records

Requirement	Subsection Reference
Chemical Properties	
Heat analysis	9.3.1
Product analysis	9.3.2
Mechanical Properties	
Heat control tensile tests	9.4.2
Tensile tests on products	6.2, 9.4.7
Impact tests on products	6.4, 6.5, 6.6, 9.7
Hardness tests	6.7, 6.8, 6.9, 9.6
Hardenability tests	6.10, 9.9
Grain size (Grades C90, T95, and C110)	6.11, 9.8
Coupling tests	8.3
Hydrostatic Tests	
Tester recorder charts	9.12.1
Testing	9.12.1
Supplemental inspection when hydrostatic test pressure is limited, if applicable	A.13.1 (SR 41.1), A.13.2 (SR 41.2)
Manufacturer Certification	
Results of all required tests	12.3
Sulfide stress cracking test (Grades C90, T95, and C110)	6.14, 9.10
Calibration	Various

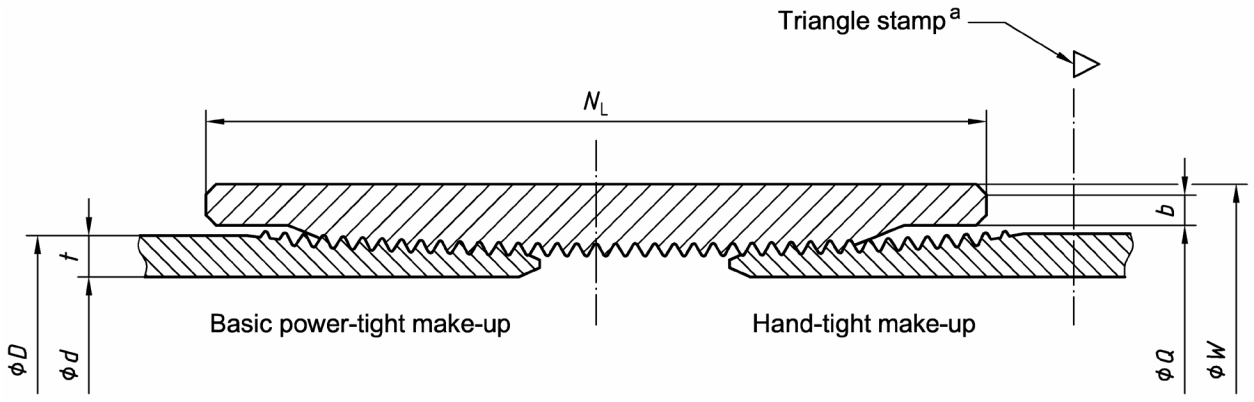
Annex D
(normative)

Figures in SI (USC) Units



[a] A 9.52 mm ($^3/_8$ in.) high, equilateral triangle die stamp shall be placed at a distance of $L_4 + 1.59$ mm ($+ \, ^1/_{16}$ in.) from each end of Label 1: 16, 18 $^5/_8$, and 20 short round thread casing in Grades H40, J55, and K55; see Table C.18 or Table E.18 for pipe dimensions, Table C.27 or Table E.27 for coupling dimensions, and API 5B for L_4.

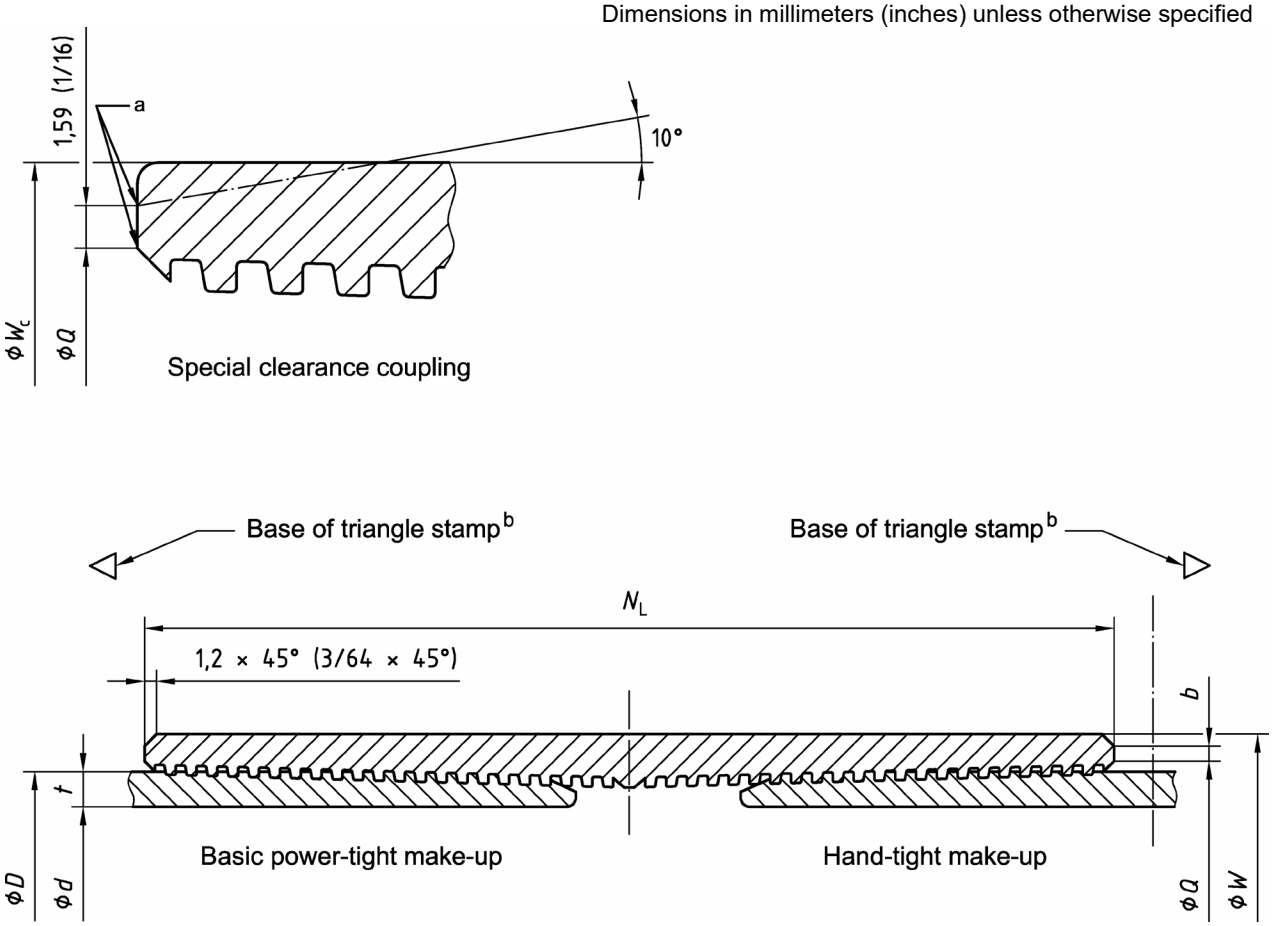
Figure D.1—Short Round Thread Casing and Coupling



[a] A 9.52 mm ($^3/_8$ in.) high, equilateral triangle die stamp shall be placed at a distance of $L_4 + 1.59$ mm ($+^1/_{16}$ in.) from each end of Label 1: 20 long round thread casing in Grades H40, J55, and K55; see Table C.18 or Table E.18 for pipe dimensions, Table C.27 or Table E.27 for coupling dimensions, and API 5B for L_4.

Figure D.2—Long Round Thread Casing and Coupling

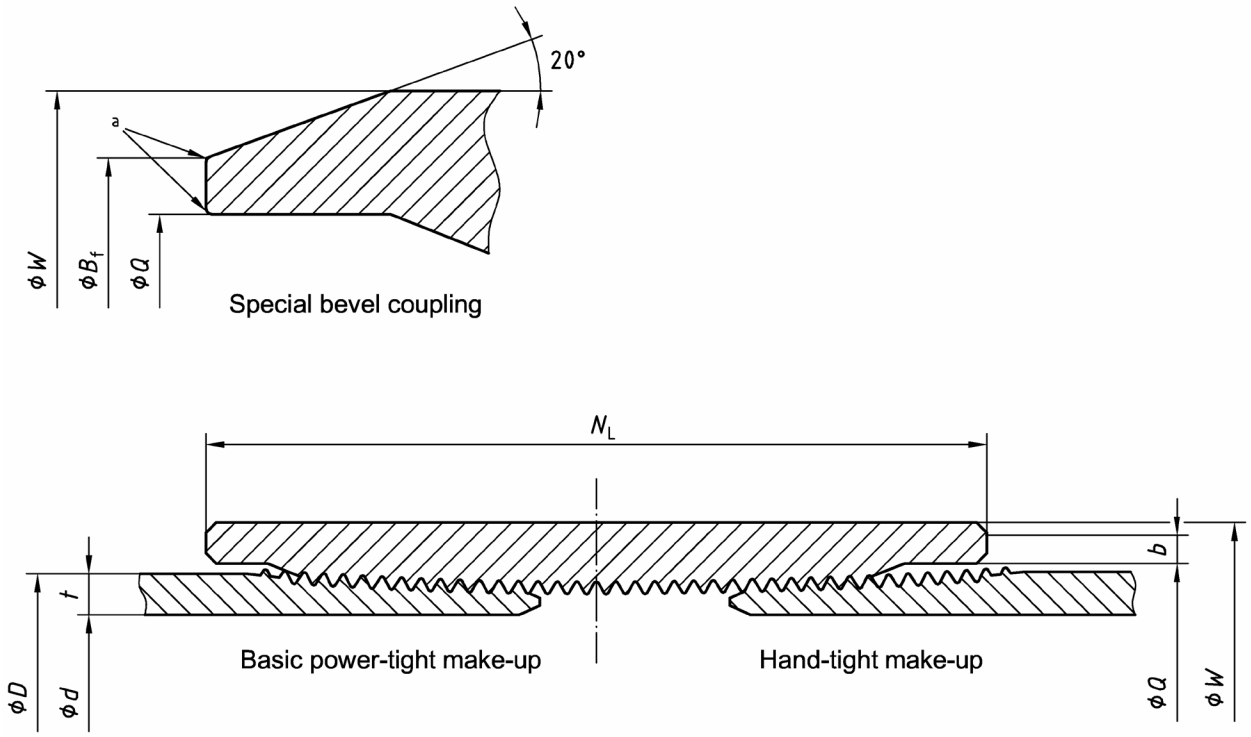
Dimensions in millimeters (inches) unless otherwise specified



[a] On special clearance couplings, the inside and outside edges of the bearing face shall be broken or rounded; a 10° bevel (both ends) shall be furnished only when specified in the purchase order.

[b] A 9.52 mm ($^3/_8$ in.) high, equilateral triangle die-stamp or paint band shall be placed at a distance of A_1 from each end of buttress casing; see Table C.18 or Table E.18 for pipe dimensions, Table C.27 or Table E.27 for coupling dimensions, and API 5B for A_1.

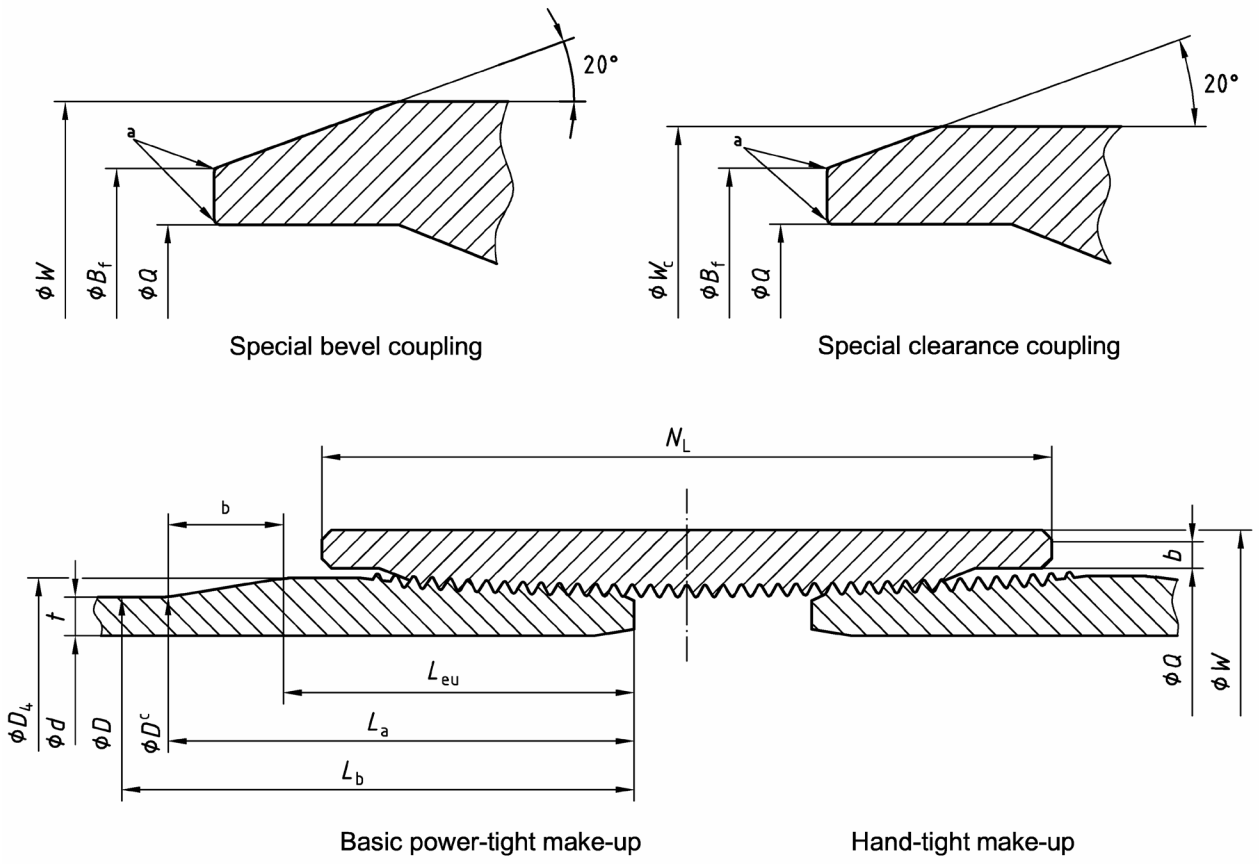
Figure D.3—Buttress Thread Casing and Coupling



NOTE See Table C.19 or Table E.19 for pipe dimensions, Table C.29 or Table E.29 for coupling dimensions, and API 5B for thread details.

[a] On special bevel couplings, the inside and outside edges of the bearing face shall be broken or rounded.

Figure D.4—Non-upset Tubing and Coupling



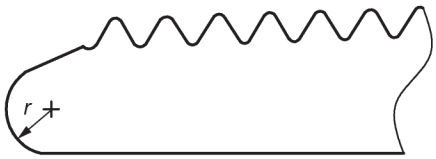
NOTE See Tables C.19 and C.20 or Tables E.19 and E.20 for pipe dimensions, Table C.30 or Table E.30 for coupling dimensions, and API 5B for thread details.

[a] On special bevel couplings and special clearance couplings, the inside and outside edges of the bearing face shall be broken or rounded.

[b] Upset run-out interval, not to be confused with b on the right-hand side of the figure that indicates the coupling bearing face dimension.

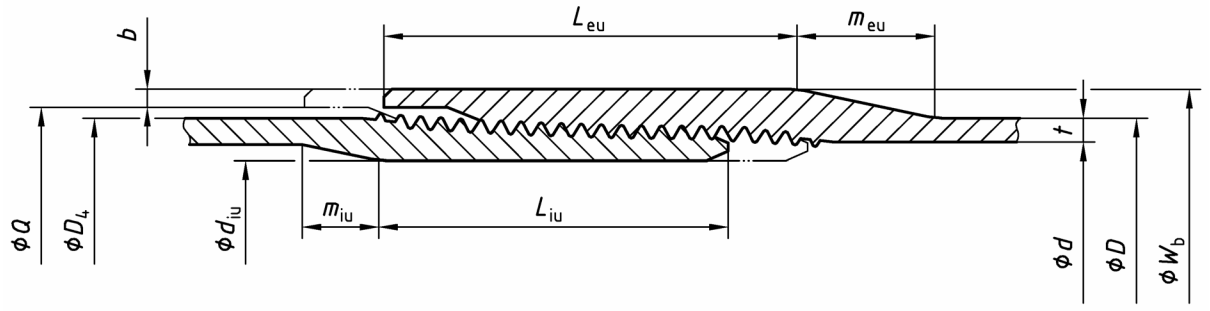
[c] See 7.11.1 for tolerance on outside diameter at a distance L_a from end of pipe.

Figure D.5—External Upset Tubing and Coupling



Label 1	Radius [a] r mm (in.)
1	*2*
2 3/8	2.4 (3/32)
2 7/8	2.4 (3/32)
3 1/2	3.2 (1/8)
4 1/2	3.2 (1/8)
NOTE See API 5B for product acceptance.	
[a] These dimensions are for reference only and are not subject to measurement for determining product acceptance.	

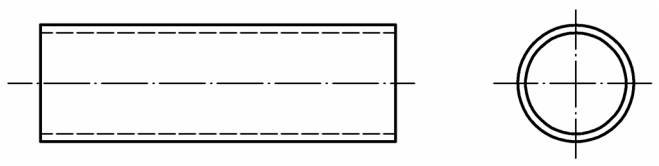
Figure D.6—Rounded Nose for External Upset Tubing



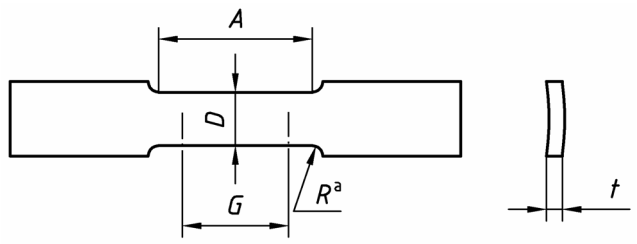
NOTE 1 Dashed lines indicate power-tight make-up.

NOTE 2 See Tables C.19 and C.21 or Tables E.19 and E.21 for pipe dimensions, and API 5B for thread details.

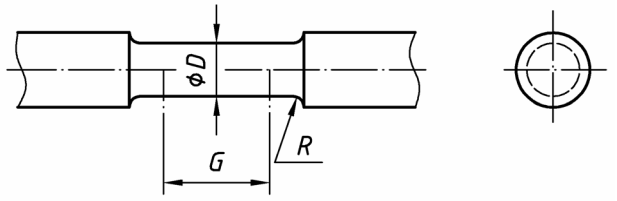
Figure D.7—Integral-joint Tubing



a) Full-section specimen



b) Strip specimen [a]

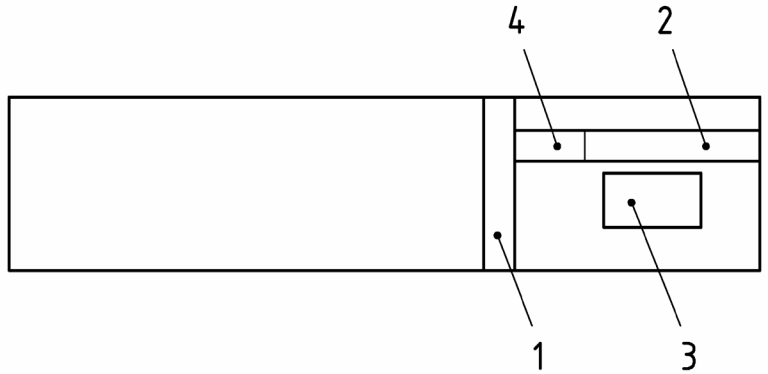


c) Round bar specimen

Dimension	**Strip Specimen** mm (in.)	**Round Bar Specimen** mm (in.)	
		D = 12.7 (0.500)	D = 8.9 (0.350)
Gauge length, G	50.8 ± 0.13 (2.000 ± 0.005)	50.8 ± 0.13 (2.000 ± 0.005)	35.6 ± 0.13 (1.400 ± 0.005)
Diameter or width, D	38.1 (1.500) approximately	12.7 ± 0.25 (0.500 ± 0.010)	8.9 ± 0.18 (0.350 ± 0.007)
Radius of fillet, min, R	25.4 (1.000)	9.5 (0.375)	6.4 (0.250)
Length of reduced section, min, A	57.2 (2.250)	57.2 (2.250)	44.5 (1.750)

[a] See 9.4.5 for testing without use of suitable curved-face testing grips.

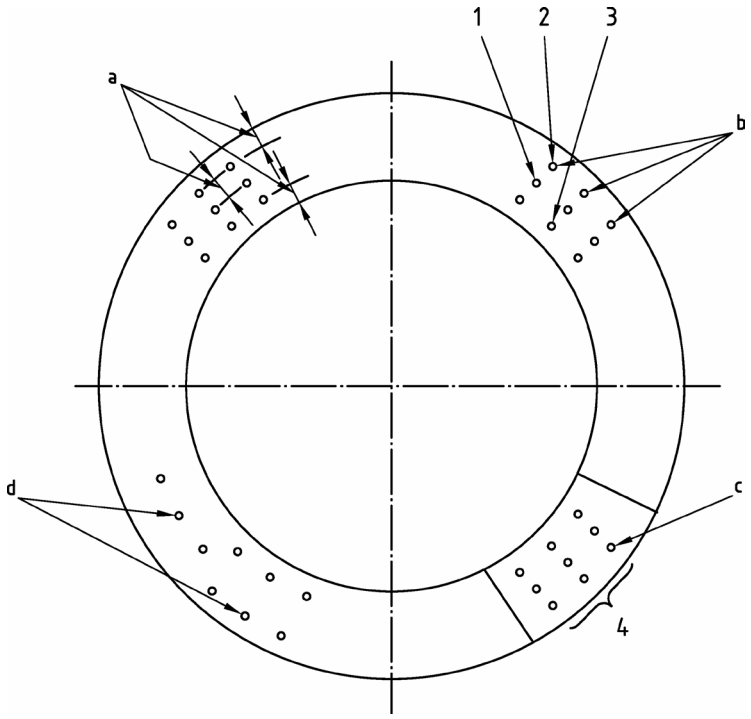
Figure D.8—Tensile Test Specimens



Key

1 hardness test ring [see Figure D.10 for detail, 6.4 mm (0.25 in.) minimum thickness]
2 tensile test specimen
3 impact test samples (see Figure D.11 for detail)
4 hardness test sample [6.4 mm (0.25 in.) minimum thickness], to be removed from tensile test sample prior to tensile test piece preparation

Figure D.9—Example Location of Test Samples Removed from Product



Key

1 indentation at mid-wall location
2 indentation at outside-wall location
3 indentation at inside-wall location
4 product test block

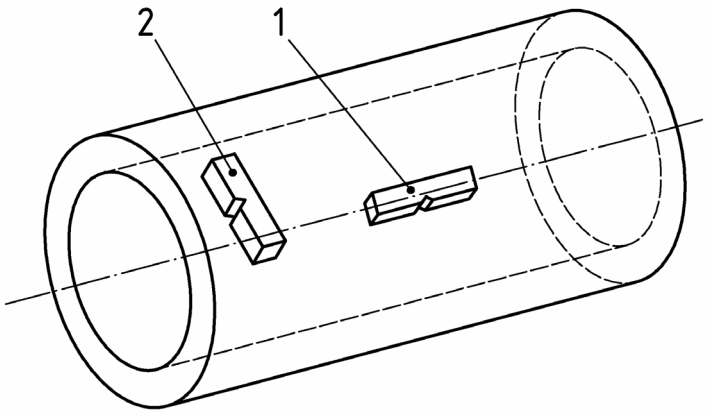
[a] Take the outside-wall and inside-wall tests between 2.54 mm (0.10 in.) and 3.81 mm (0.15 in.) from the applicable surface (see 9.6.9). An error may result if an indentation is spaced closer than 2 $^{1}/_{2}$ diameters from its center to the edge of the specimen or three diameters from another indentation measured center to center.

[b] The mean hardness number is the average of three Rockwell hardness numbers in the same location.

[c] Rockwell hardness indentation data are called Rockwell hardness numbers.

[d] Alternate spacing of rows permitted for thin-wall product.

Figure D.10—Through-wall Hardness Test

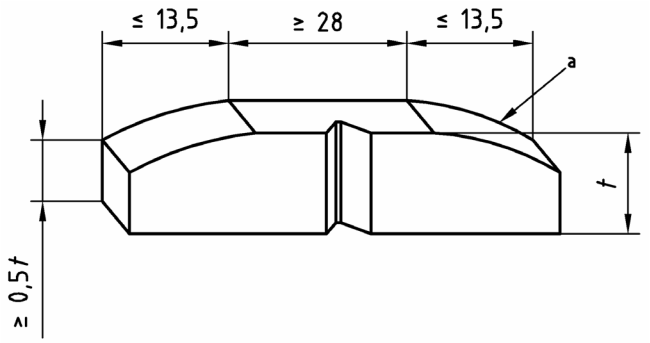


Key

1 longitudinal specimen
2 transverse specimen

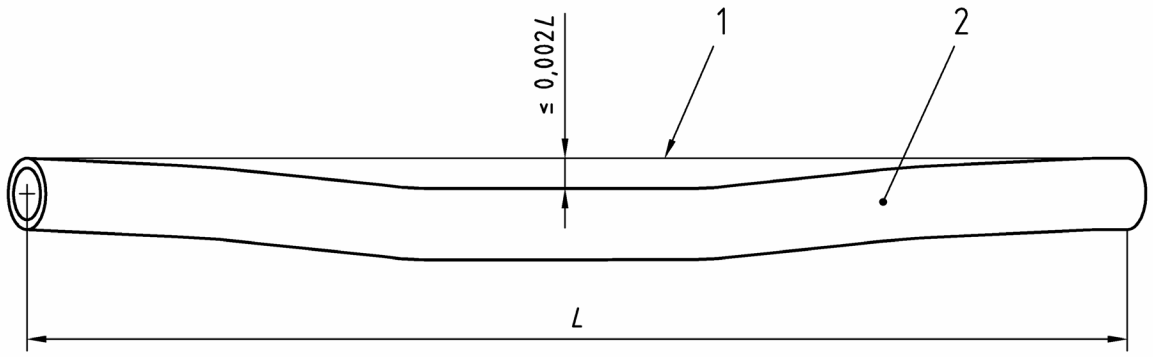
Figure D.11—Impact Test Specimen Orientation

Dimensions in millimeters



[a] Outside diameter curvature.

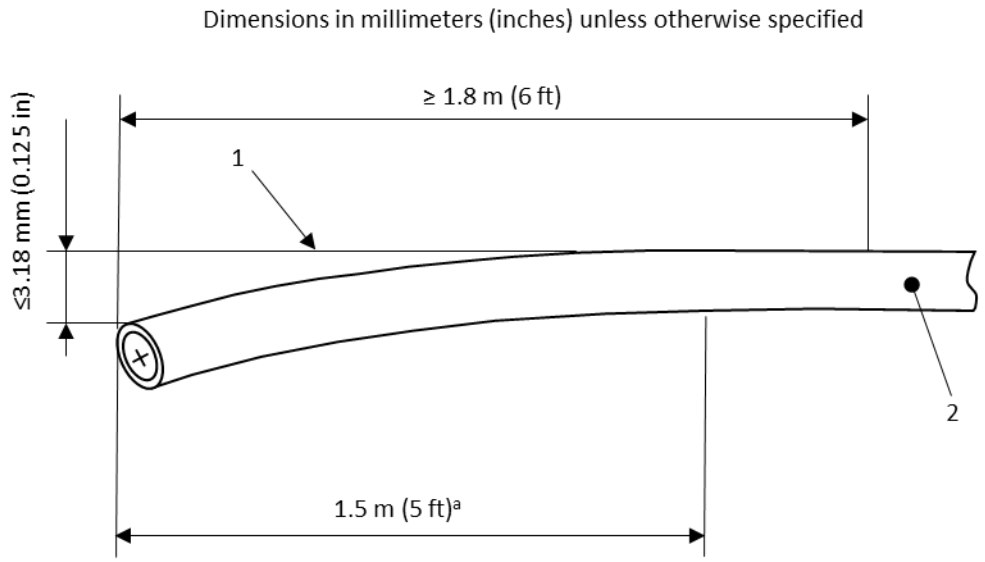
Figure D.12—Charpy Specimen Dimensions



Key

1 taut string or wire
2 pipe

Figure D.13—Measuring Full-length Straightness



Key

1 straight line
2 pipe

[a] Hooked end.

Figure D.14—Measuring End Straightness

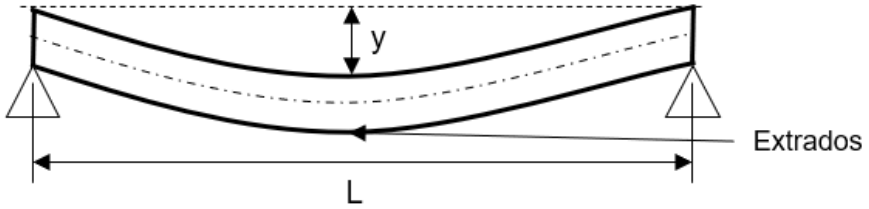
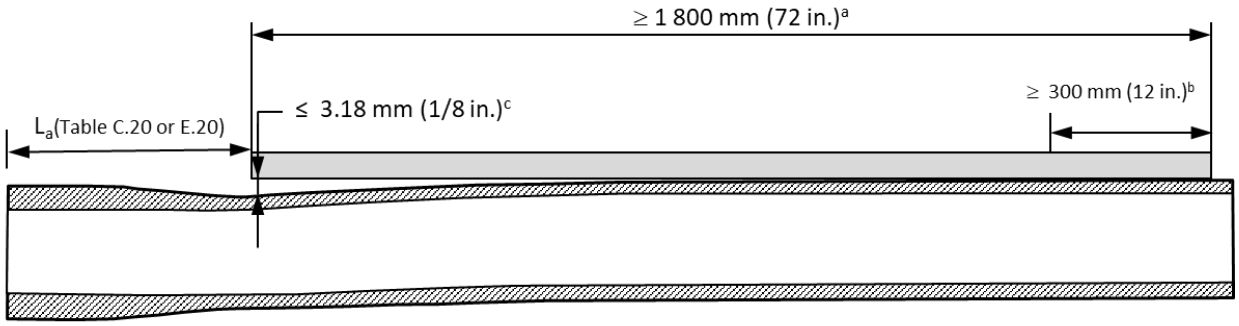
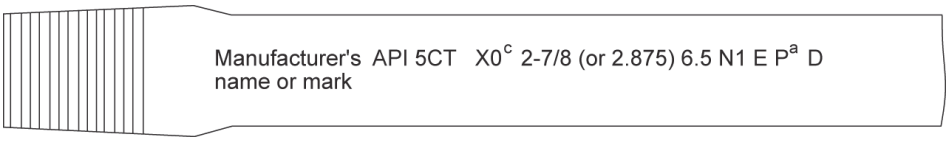


Figure D.15—Gag Straightening Fiber Strain Factors



Key
[a] Minimum straight edge.
[b] Minimum contact.
[c] Maximum drop.

Figure D.16—Upset-end Hook Measurement

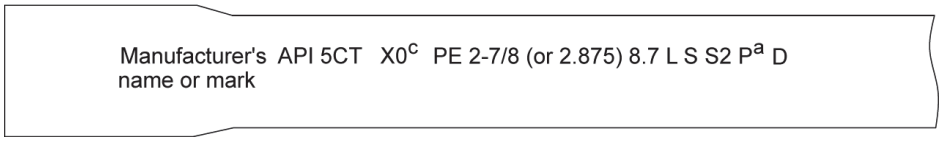


Stencil Marking [beginning at least 0.6 m (2 ft) from either externally threaded end]



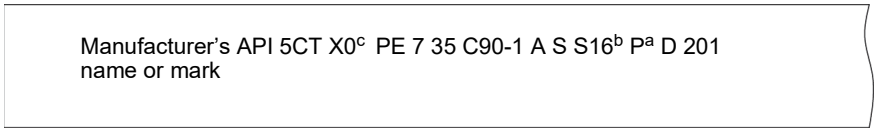
Stamp Marking—Optional [within approximately 0.3 m (1 ft) of either externally threaded end]

a) EXAMPLE 1 Tubing Label 1: 2 $^{7}/_{8}$, Label 2: 6.5, Grade N80 Type 1, electric-weld, external upset, threaded (by the manufacturer) pin-by-pin without couplings.



Stencil Marking [beginning at least 0.6 m (2 ft) from either end]

b) EXAMPLE 2 Tubing Label 1: 2 $^{7}/_{8}$, Label 2: 8.7, Grade L80 Type 1, seamless, external upset, plain-end. Additional requirements include hydrostatic testing to 94.5 MPa (13,700 psi) and inspection to SR 2.



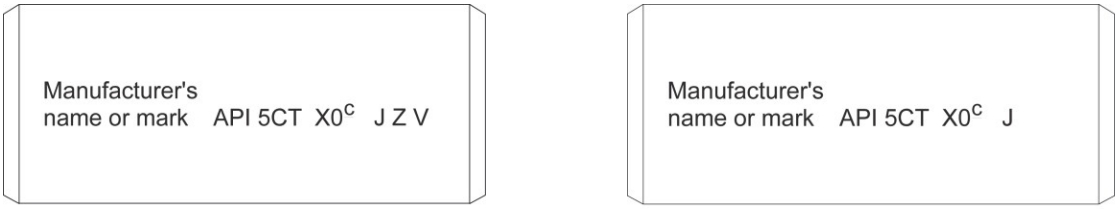
Stencil Marking [beginning at least 0.6 m (2 ft) from either end]



Stamp Marking—Optional [within approximately 0.3 m (1 ft) from either end]

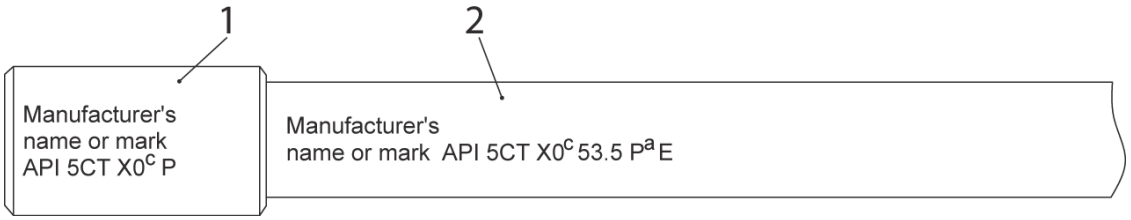
c) EXAMPLE 3 Casing Label 1: 7, Label 2: 35, Grade C90 Type 1, seamless, plain-end, serial number 201. Supplementary requirement 16 (SR 16) for test at −10 °C (+14 °F). The pipe was pressure-tested to 69 MPa (10,000 psi).

Figure D.17—Examples of Marking Requirements and Sequence for Manufacturers and Threaders Using Section 10 and Table C.43 or Table E.43

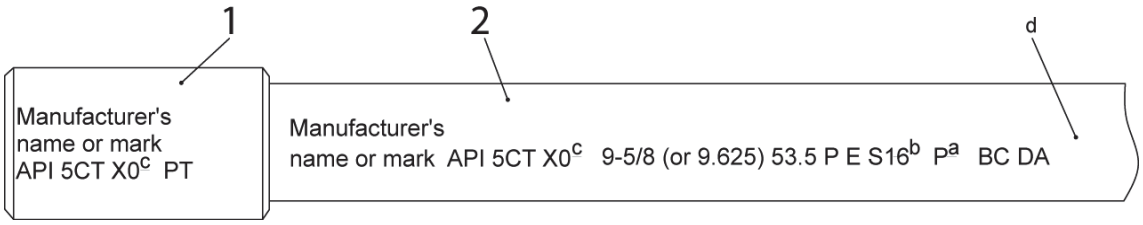


Stencil Marking **Stamp Marking—Optional**

d) EXAMPLE 4 [e] Tubing coupling for Label 1; 2 $^{7}/_{8}$, Grade J55, normalized upset (or non-upset) tubing, only visual inspection required.



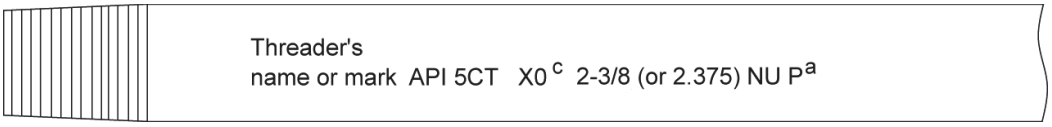
Stamp Marking—Optional [within approximately 0.3 m (1 ft) from the coupling]



Stencil Marking [beginning not less than 0.6 m (2 ft) from the coupling]

e) EXAMPLE 5 [e] Buttress casing with coupling: Label 1: 9 $^{5}/_{8}$, Label 2: 53.5, Grade P110, electric-weld; supplementary requirements are SR 11 and SR 16 for test at −18 °C (0 °F) and 215.9 mm (8.500 in.) drift test. Coupling is tin-plated.

Figure D.17—Examples of Marking Requirements and Sequence for Manufacturers and Threaders Using Section 10 and Table C.43 or Table E.43 *(continued)*



Stencil Marking (adjacent to the threads)

f) EXAMPLE 6 [f] Threader: Label 1: 2 3/8, Label 2: 4, Grade J55 non-upset thread, and hydrostatically tested to alternative test pressure of 43.5 MPa (6300 psi).

Key

1 coupling
2 pipe

[a] Express pressure in megapascals for pipe manufactured to SI units and in pounds per square inch for pipe manufactured to USC units.

[b] Express the CVN requirements in joules and the temperature in degrees Celsius for pipe manufactured to SI units, and in foot-pounds and degrees Fahrenheit for pipe manufactured to USC units.

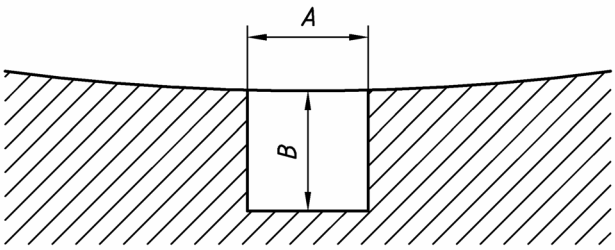
[c] Date of manufacture—This example is for product manufactured in accordance with the current edition of API 5CT during the period of overlap with application (see 10.1.9) of the previous edition. Note that "X" is used for the last digit of the year of manufacture so that it is a generic example and will not change with subsequent editions of this standard.

[d] Express alternative drift diameter in millimeters for pipe manufactured to SI units and in inches for pipe manufactured to USC units.

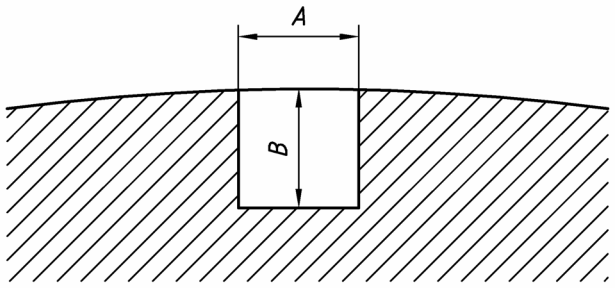
[e] Marking in the center of the coupling may be in either the longitudinal or transverse direction.

[f] Threader stencil marking shall be placed adjacent to the threads and is in addition to marking applied by other pipe manufacturers.

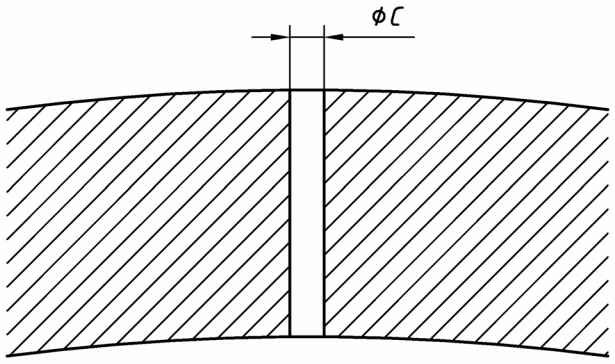
Figure D.17—Examples of Marking Requirements and Sequence for Manufacturers and Threaders Using Section 10 and Table C.43 or Table E.43 *(continued)*



a) Notch—Inner surface [a]

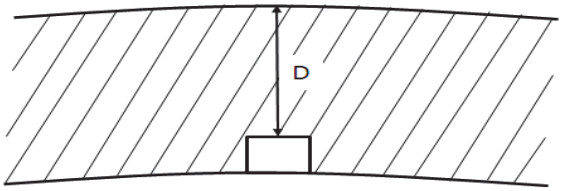


b) Notch—Outer surface [a]



c) Drilled hole

Figure D.18—Reference Indicators



d) Flat-bottomed Hole

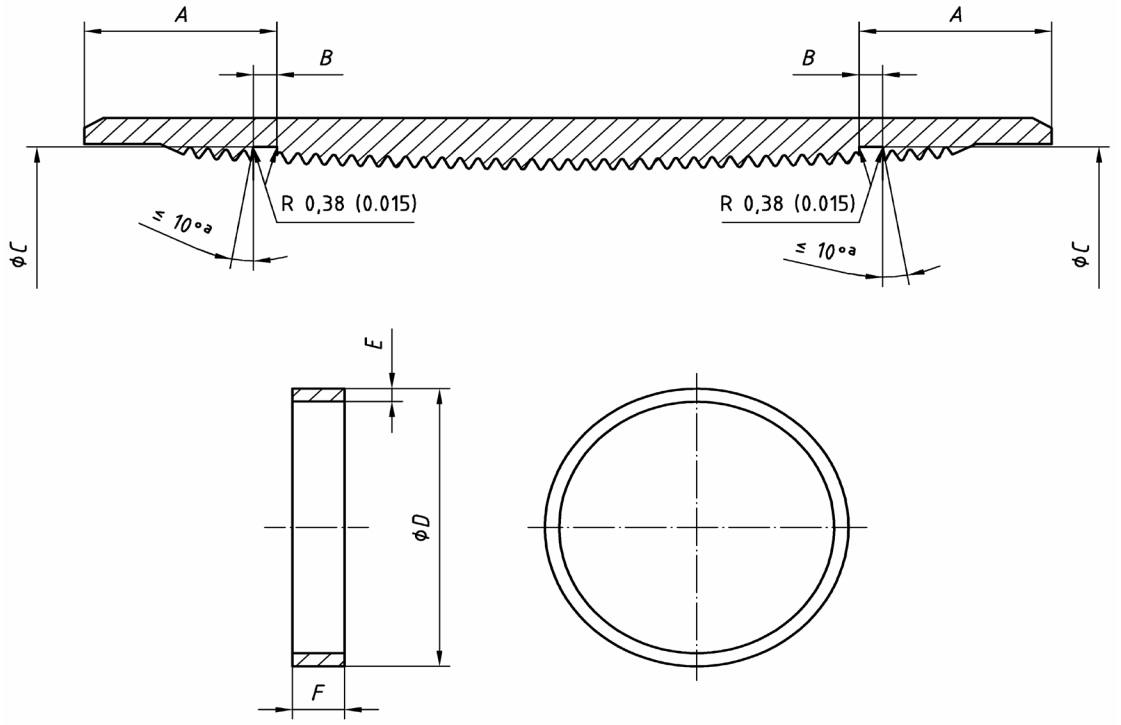
Key

A notch width
B notch depth
C hole diameter
D 90 % ± 1.5 % of the specified minimum wall thickness

[a] Notch length: See Table C.39 or Table E.39.

Figure D.18—Reference Indicators *(continued)*

Dimensions in millimeters (inches)

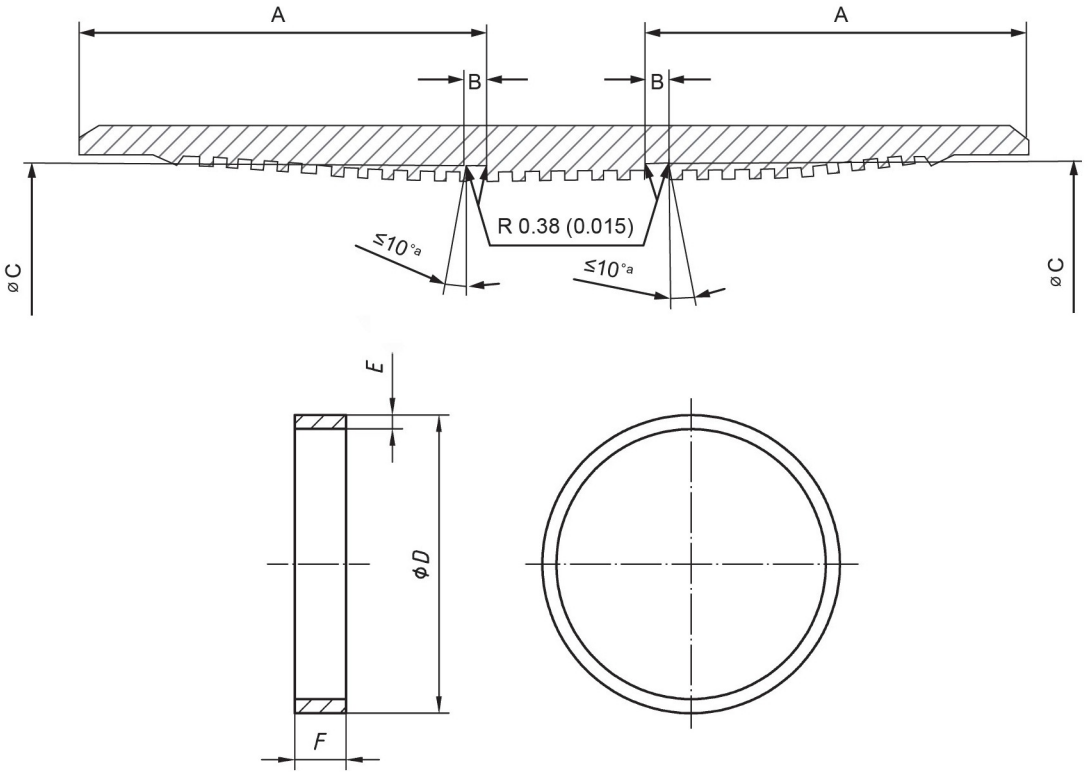


[a] Angle optional; seal-ring groove and thread pitch diameter shall be concentric within 0.51 mm (0.020 in.) of indicated thread run-out.

8 Round Casing Label 1	Outside Diameter	Coupling Dimensions mm (in.)			Ring Dimensions mm (in.)		
		A ±3.2 (±0.125)	*B* ±0.13 (±0.005)	*C* ±0.25 (±0.010)	*D* ±0.38 (±0.015)	*E* +0.25 0 (+0.010 0)	*F* +0.38 0 (+0.015 0)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
4 1/2	114.30	34.9 (1.375)	4.78 (0.188)	114.63 (4.513)	115.27 (4.538)	2.54 (0.100)	3.96 (0.156)
5	127.00	38.1 (1.500)	4.78 (0.188)	127.13 (5.005)	127.76 (5.030)	2.54 (0.100)	3.96 (0.156)
5 1/2	139.70	38.1 (1.500)	4.78 (0.188)	139.83 (5.505)	140.46 (5.530)	2.54 (0.100)	3.96 (0.156)
6 5/8	168.28	44.5 (1.750)	4.78 (0.188)	168.00 (6.614)	168.63 (6.639)	2.54 (0.100)	3.96 (0.156)
7	177.80	44.5 (1.750)	4.78 (0.188)	177.52 (6.989)	178.16 (7.014)	2.54 (0.100)	3.96 (0.156)
7 5/8	193.68	44.5 (1.750)	4.78 (0.188)	193.29 (7.610)	193.93 (7.635)	2.54 (0.100)	3.96 (0.156)
8 5/8	219.09	47.6 (1.875)	4.78 (0.188)	218.52 (8.603)	219.15 (8.628)	2.54 (0.100)	3.96 (0.156)
9 5/8	244.48	47.6 (1.875)	4.78 (0.188)	243.92 (9.603)	244.55 (9.628)	2.54 (0.100)	3.96 (0.156)
10 3/4	273.05	44.5 (1.750)	4.78 (0.188)	272.67 (10.735)	273.30 (10.760)	2.54 (0.100)	3.96 (0.156)
11 3/4	298.45	47.6 (1.875)	4.78 (0.188)	297.89 (11.728)	298.53 (11.753)	2.54 (0.100)	3.96 (0.156)
13 3/8	339.72	57.2 (2.250)	4.78 (0.188)	338.56 (13.329)	339.19 (13.354)	2.54 (0.100)	3.96 (0.156)
16	406.40	69.9 (2.750)	4.78 (0.188)	404.44 (15.923)	405.08 (15.948)	2.54 (0.100)	3.96 (0.156)
18 5/8	473.08	69.9 (2.750)	4.78 (0.188)	471.12 (18.548)	471.75 (18.573)	2.54 (0.100)	3.96 (0.156)
20	508.00	69.9 (2.750)	4.78 (0.188)	506.04 (19.923)	506.68 (19.948)	2.54 (0.100)	3.96 (0.156)

Figure D.19—SR 13.1 Seal-ring Coupling and Nonmetallic Ring for Round Thread Casing

Dimensions in millimeters (inches)



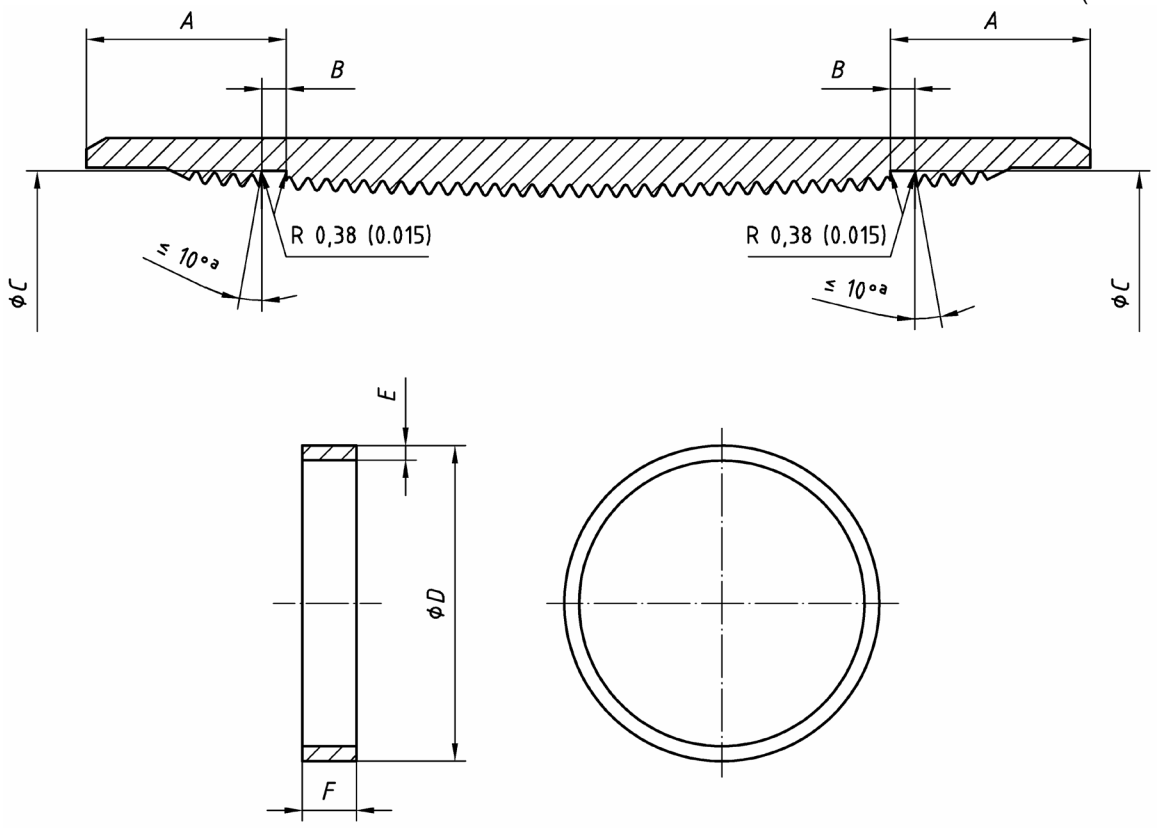
a Angle optional.

b Seal-ring groove and thread pitch diameter shall be concentric within 0.51 mm (0.020 in.) of indicated thread run-out.

Buttress Casing Label 1	Outside Diameter	Coupling Dimensions [b] mm (in.)			Ring Dimensions mm (in.)		
		A ±3.2 (±0.125)	*B* ±0.13 (±0.005)	*C* ±0.25 (±0.010)	*D* ±0.38 (±0.015)	*E* +0.25 0 (+0.010 0)	*F* +0.38 0 (+0.015 0)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
4 1/2	114.30	76.2 (3.000)	4.78 (0.188)	115.21 (4.536)	115.21 (4.536)	2.54 (0.100)	3.96 (0.156)
5	127.00	81.0 (3.188)	4.78 (0.188)	127.46 (5.018)	127.46 (5.043)	2.54 (0.100)	3.96 (0.156)
5 1/2	139.70	81.0 (3.188)	4.78 (0.188)	140.16 (5.518)	140.79 (5.543)	2.54 (0.100)	3.96 (0.156)
6 5/8	168.28	81.0 (3.188)	4.78 (0.188)	168.73 (6.643)	168.37 (6.668)	2.54 (0.100)	3.96 (0.156)
7	177.80	82.6 (3.250)	4.78 (0.188)	178.16 (7.014)	178.79 (7.039)	2.54 (0.100)	3.96 (0.156)
7 5/8	193.68	85.7 (3.375)	4.78 (0.188)	193.85 (7.632)	193.85 (7.657)	2.54 (0.100)	3.96 (0.156)
8 5/8	219.09	85.7 (3.375)	4.78 (0.188)	219.25 (8.632)	219.25 (8.632)	2.54 (0.100)	3.96 (0.156)
9 5/8	244.48	85.7 (3.375)	4.78 (0.188)	244.65 (9.632)	245.295 (9.657)	2.54 (0.100)	3.96 (0.156)
10 3/4	273.05	85.7 (3.375)	4.78 (0.188)	273.23 (10.757)	273.86 (10.782)	2.54 (0.100)	3.96 (0.156)
11 3/4	298.45	88.9 (3.500)	4.78 (0.188)	298.42 (11.749)	299.06 (11.774)	2.54 (0.100)	3.96 (0.156)
13 3/8	339.72	95.3 (3.750)	4.78 (0.188)	339.29 (13.358)	339.93 (13.383)	2.54 (0.100)	3.96 (0.156)

Figure D.20—SR 13.2 Seal-ring Coupling and Nonmetallic Ring for Buttress Thread Casing

Dimensions in millimeters (inches)



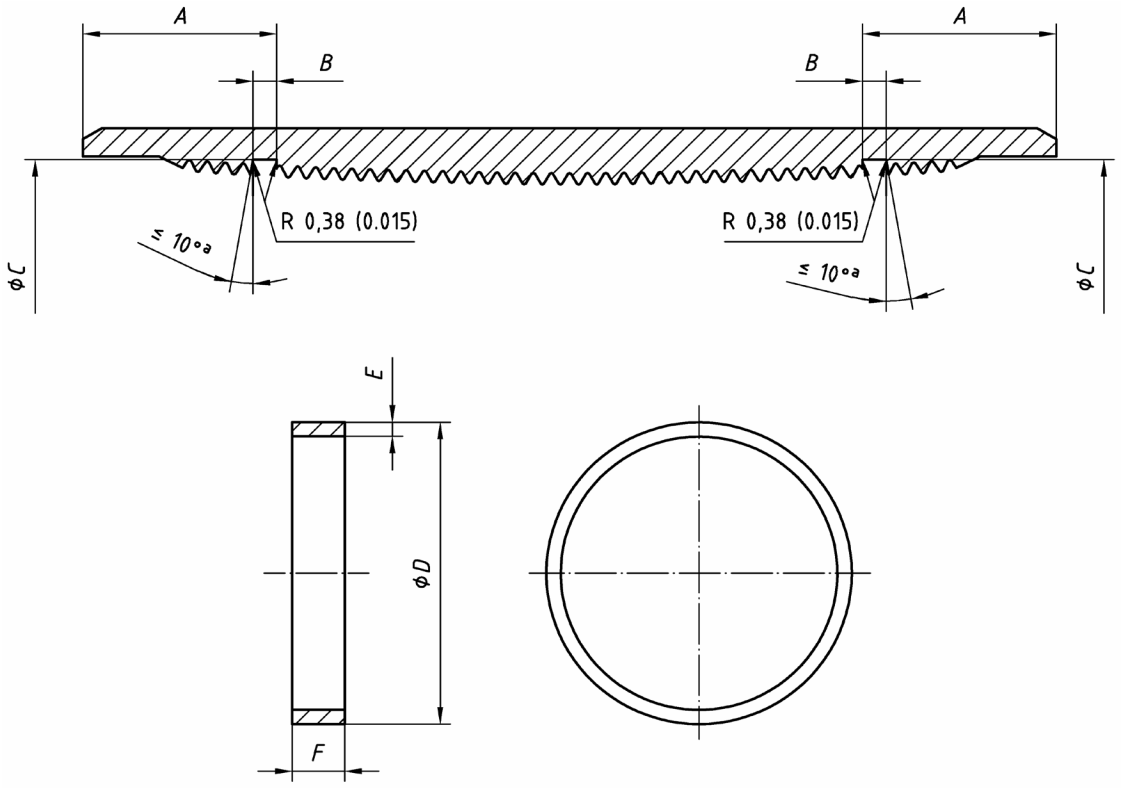
[a] Angle optional.

[b] Seal-ring groove and thread pitch diameter shall be concentric within 0.51 mm (0.020 in.) of indicated thread run-out.

Non-upset Tubing Size Label 1	Outside Diameter	Coupling Dimensions [b] mm (in.)			Ring Dimensions mm (in.)		
		A ±3.2 (±0.125)	*B* ±0.13 (±0.005)	*C* ±0.25 (±0.010)	*D* ±0.19 (±0.008)	*E* +0.13 0 (+0.005 -0)	*F* +0.38 0 (+0.015 -0)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	26.67	20.7 (0.813)	3.96 (0.156)	27.46 (1.081)	27.89 (1.098)	2.03 (0.080)	3.18 (0.125)
1.315	33.40	20.7 (0.813)	3.96 (0.156)	34.19 (1.346)	34.62 (1.363)	2.03 (0.080)	3.18 (0.125)
1.660	42.16	20.7 (0.813)	3.96 (0.156)	42.95 (1.691)	43.38 (1.708)	2.03 (0.080)	3.18 (0.125)
1.900	48.26	25.4 (1.000)	4.78 (0.188)	48.74 (1.919)	49.20 (1.937)	2.03 (0.080)	3.96 (0.156)
2 3/8	60.32	25.4 (1.000)	4.78 (0.188)	60.81 (2.394)	61.26 (2.412)	2.03 (0.080)	3.96 (0.156)
2 7/8	73.02	25.4 (1.000)	4.78 (0.188)	73.51 (2.894)	73.96 (2.912)	2.03 (0.080)	3.96 (0.156)
3 1/2	88.90	25.4 (1.000)	4.78 (0.188)	89.38 (3.519)	89.84 (3.537)	2.03 (0.080)	3.96 (0.156)
4	101.60	28.6 (1.125)	4.78 (0.188)	102.31 (4.028)	102.77 (4.046)	2.54 (0.100)	3.96 (0.156)
4 1/2	114.30	28.6 (1.125)	4.78 (0.188)	115.01 (4.528)	115.47 (4.546)	2.54 (0.100)	3.96 (0.156)

Figure D.21—SR 13.3 Seal-ring Coupling and Nonmetallic Ring for Non-upset Tubing

Dimensions in millimeters (inches)



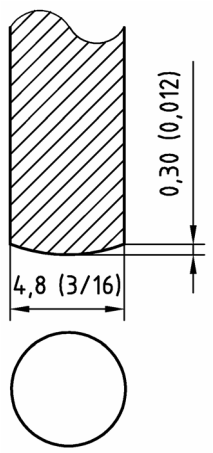
[a] Angle optional.

[b] Seal-ring groove and thread pitch diameter shall be concentric within 0.51 mm (0.020 in.) of indicated thread run-out.

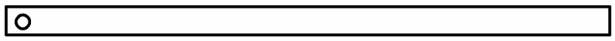
EU Tubing Size Label 1	Outside Diameter	Coupling Dimensions [b] mm (in.)			Ring Dimensions mm (in.)		
		A ±3.2 (±0.125)	*B* ±0.13 (±0.005)	*C* ±0.25 (±0.010)	*D* ±0.19 (±0.008)	*E* +0.13 -0 (+0.005 -0)	*F* +0.38 -0 (+0.015 -0)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	26.67	22.2 (0.875)	3.96 (0.156)	34.09 (1.342)	34.54 (1.360)	2.03 (0.080)	3.18 (0.125)
1.315	33.40	22.2 (0.875)	3.96 (0.156)	38.00 (1.496)	38.43 (1.513)	2.03 (0.080)	3.18 (0.125)
1.660	42.16	22.2 (0.875)	4.78 (0.188)	46.74 (1.840)	47.17 (1.857)	2.03 (0.080)	3.96 (0.156)
1.900	48.26	22.2 (0.875)	4.78 (0.188)	53.87 (2.121)	54.31 (2.138)	2.03 (0.080)	3.96 (0.156)
2 3/8	60.32	28.6 (1.125)	4.78 (0.188)	66.60 (2.622)	67.06 (2.640)	2.54 (0.100)	3.96 (0.156)
2 7/8	73.02	28.6 (1.125)	4.78 (0.188)	79.30 (3.122)	79.76 (3.140)	2.54 (0.100)	3.96 (0.156)
3 1/2	88.90	28.6 (1.125)	4.78 (0.188)	95.96 (3.778)	96.42 (3.796)	2.54 (0.100)	3.96 (0.156)
4	101.60	28.6 (1.125)	4.78 (0.188)	108.66 (4.278)	109.12 (4.296)	2.54 (0.100)	3.96 (0.156)
4 1/2	114.30	28.6 (1.125)	4.78 (0.188)	121.36 (4.778)	121.82 (4.796)	2.54 (0.100)	3.96 (0.156)

Figure D.22—SR 13.4-Seal-ring Coupling and Nonmetallic Ring for Upset Tubing

Dimensions in millimeters (inches)



a) Rounded contact point



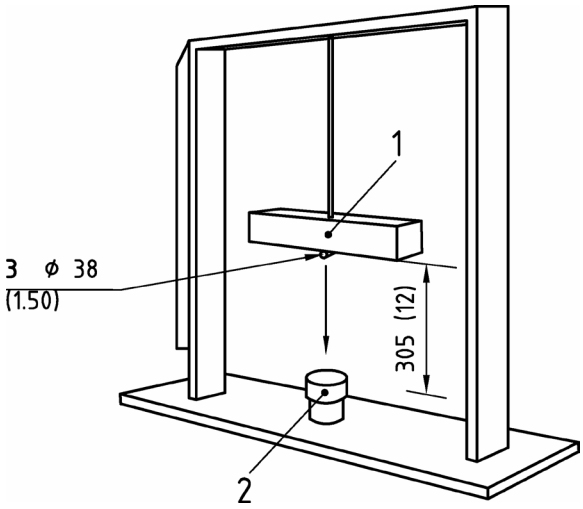
b) Top view



c) Side view

Figure D.23—Example of a 90° Hook-type Tool

Dimensions in millimeters (inches)

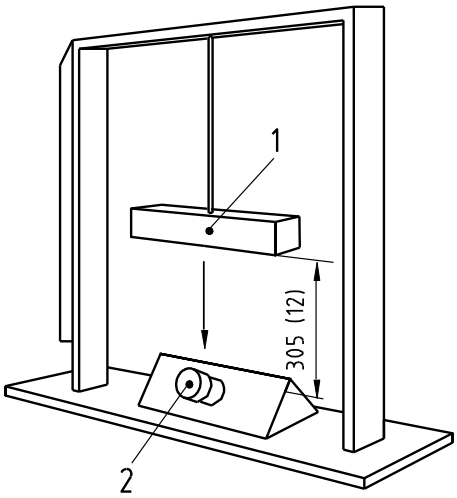


Key

1 flat steel plate
2 test assembly
3 round steel bar

Figure D.24—Axial Impact Test Apparatus

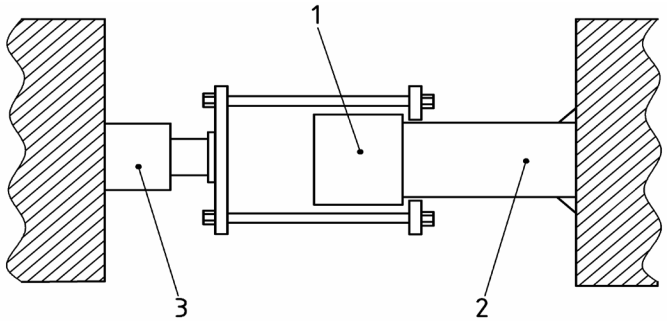
Dimensions in millimeters (inches)



Key

1 flat steel plate
2 test assembly

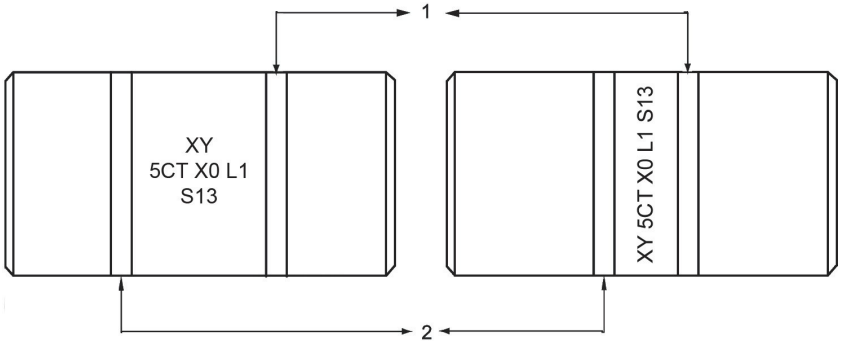
Figure D.25—45° Impact Test Apparatus



Key

1 thread protector
2 pipe section
3 hydraulic cylinder

Figure D.26—Stripping Test Apparatus



Key

1 blue seal-ring paint band
2 Grade or other paint band(s)

Figure D.27—Seal-ring Paint Band Example

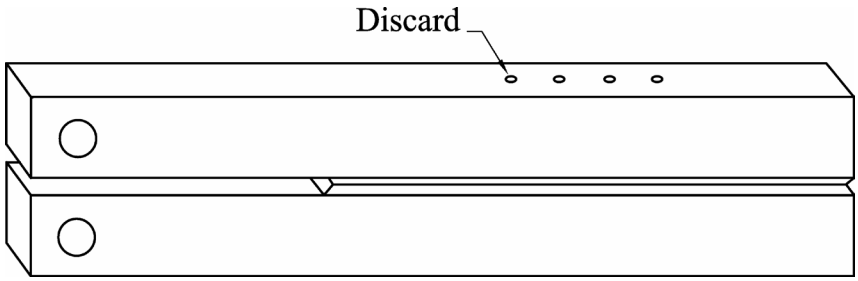


Figure D.28—Location of Hardness Impressions on DCB Specimen

Annex E
(normative)

Tables in USC Units

Table E.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	2	D in.	lb/ft	t in.	H40	J55 K55	L80 R95	N80	C90 T95	C110	P110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
4 1/2	9.50	4.500	9.70	0.205	PS	PS	—	—	—	—	—	—
4 1/2	10.50	4.500	10.60	0.224	—	PSB	—	—	—	—	—	—
4 1/2	11.60	4.500	11.70	0.250	—	PSLB	PLB	PLB	PLB	P	PLB	—
4 1/2	13.50	4.500	13.30	0.290	—	—	PLB	PLB	PLB	P	PLB	—
4 1/2	15.10	4.500	15.30	0.337	—	—	—	—	—	—	PLB	PLB
5	11.50	5.000	11.60	0.220	—	PS	—	—	—	—	—	—
5	13.00	5.000	13.20	0.253	—	PSLB	—	—	—	—	—	—
5	15.00	5.000	15.30	0.296	—	PSLB	PLB	PLB	PLB	P	PLB	—
5	18.00	5.000	18.30	0.362	—	—	PLB	PLB	PLB	P	PLB	PLB
5	21.40	5.000	21.60	0.437	—	—	PLB	PLB	PLB	P	PLB	PLB
5	23.20	5.000	23.40	0.478	—	—	PLB	PLB	PLB	P	PLB	PLB
5	24.10	5.000	24.30	0.500	—	—	PLB	PLB	PLB	P	PLB	PLB
5 1/2	14.00	5.500	14.00	0.244	PS	PS	—	—	—	—	—	—
5 1/2	15.50	5.500	15.80	0.275	—	PSLB	—	—	—	—	—	—
5 1/2	17.00	5.500	17.30	0.304	—	PSLB	PLB	PLB	PLB	P	PLB	—
5 1/2	20.00	5.500	20.20	0.361	—	—	PLB	PLB	PLB	P	PLB	—
5 1/2	23.00	5.500	22.90	0.415	—	—	PLB	PLB	PLB	P	PLB	PLB
5 1/2	26.80	5.500	27.00	0.500	—	—	—	—	P	P	—	—
5 1/2	29.70	5.500	29.90	0.562	—	—	—	—	P	P	—	—
5 1/2	32.60	5.500	32.70	0.625	—	—	—	—	P	P	—	—
5 1/2	35.30	5.500	35.50	0.687	—	—	—	—	P	P	—	—
5 1/2	38.00	5.500	38.20	0.750	—	—	—	—	P	P	—	—
5 1/2	40.50	5.500	40.80	0.812	—	—	—	—	P	P	—	—
5 1/2	43.10	5.500	43.30	0.875	—	—	—	—	P	P	—	—
6 5/8	20.00	6.625	20.00	0.288	PS	PSLB	—	—	—	—	—	—
6 5/8	24.00	6.625	24.00	0.352	—	PSLB	PLB	PLB	PLB	P	PLB	—
6 5/8	28.00	6.625	28.00	0.417	—	—	PLB	PLB	PLB	P	PLB	—
6 5/8	32.00	6.625	32.00	0.475	—	—	PLB	PLB	PLB	P	PLB	PLB
7	17.00	7.000	17.20	0.231	PS	—	—	—	—	—	—	—
7	20.00	7.000	20.10	0.272	PS	PS	—	—	—	—	—	—
7	23.00	7.000	23.30	0.317	—	PSLB	PLB	PLB	PLB	P	—	—
7	26.00	7.000	26.30	0.362	—	PSLB	PLB	PLB	PLB	P	PLB	—
7	29.00	7.000	29.30	0.408	—	—	PLB	PLB	PLB	P	PLB	—
7	32.00	7.000	32.20	0.453	—	—	PLB	PLB	PLB	P	PLB	—
7	35.00	7.000	35.00	0.498	—	—	PLB	PLB	PLB	P	PLB	PLB
7	38.00	7.000	37.70	0.540	—	—	PLB	PLB	PLB	P	PLB	PLB
7	42.70	7.000	42.90	0.625	—	—	—	—	P	P	—	—
7	46.40	7.000	46.60	0.687	—	—	—	—	P	P	—	—
7	50.10	7.000	50.30	0.750	—	—	—	—	P	P	—	—
7	53.60	7.000	53.90	0.812	—	—	—	—	P	P	—	—
7	57.10	7.000	57.40	0.875	—	—	—	—	P	P	—	—

Table E.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)
(continued)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	2	D in.	lb/ft	t in.	H40	J55 K55	L80 R95	N80	C90 T95	C110	P110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
7 5/8	24.00	7.625	24.00	0.300	PS	—	—	—	—	—	—	—
7 5/8	26.40	7.625	26.40	0.328	—	PSLB	PLB	PLB	PLB	P	—	—
7 5/8	29.70	7.625	29.70	0.375	—	—	PLB	PLB	PLB	P	PLB	—
7 5/8	33.70	7.625	33.70	0.430	—	—	PLB	PLB	PLB	P	PLB	—
7 5/8	39.00	7.625	39.00	0.500	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	42.80	7.625	42.80	0.562	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	45.30	7.625	45.30	0.595	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	47.10	7.625	47.10	0.625	—	—	PLB	PLB	PLB	P	PLB	PLB
7 5/8	51.20	7.625	51.20	0.687	—	—	—	—	P	P	—	—
7 5/8	55.30	7.625	55.30	0.750	—	—	—	—	P	P	—	—
7 3/4	46.10	7.750	46.10	0.595	—	—	P	P	P	P	P	P
8 5/8	24.00	8.625	24.00	0.264	—	PS	—	—	—	—	—	—
8 5/8	28.00	8.625	28.00	0.304	PS	—	—	—	—	—	—	—
8 5/8	32.00	8.625	32.00	0.352	PS	PSLB	—	—	—	—	—	—
8 5/8	36.00	8.625	36.00	0.400	—	PSLB	PLB	PLB	PLB	P	—	—
8 5/8	40.00	8.625	40.00	0.450	—	—	PLB	PLB	PLB	P	PLB	—
8 5/8	44.00	8.625	44.00	0.500	—	—	PLB	PLB	PLB	P	PLB	—
8 5/8	49.00	8.625	49.00	0.557	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	32.30	9.625	32.30	0.312	PS	—	—	—	—	—	—	—
9 5/8	36.00	9.625	36.00	0.352	PS	PSLB	—	—	—	—	—	—
9 5/8	40.00	9.625	40.00	0.395	—	PSLB	PLB	PLB	PLB	P	—	—
9 5/8	43.50	9.625	43.50	0.435	—	—	PLB	PLB	PLB	P	PLB	—
9 5/8	47.00	9.625	47.00	0.472	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	53.50	9.625	53.50	0.545	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	58.40	9.625	58.40	0.595	—	—	PLB	PLB	PLB	P	PLB	PLB
9 5/8	59.40	9.625	59.40	0.609	—	—	—	—	P	P	—	—
9 5/8	64.90	9.625	64.90	0.672	—	—	—	—	P	P	—	—
9 5/8	70.30	9.625	70.30	0.734	—	—	—	—	P	P	—	—
9 5/8	75.60	9.625	75.60	0.797	—	—	—	—	P	P	—	—
10 3/4	32.75	10.750	32.75	0.279	PS	—	—	—	—	—	—	—
10 3/4	40.50	10.750	40.50	0.350	PS	PSB	—	—	—	—	—	—
10 3/4	45.50	10.750	45.50	0.400	—	PSB	—	—	—	—	—	—
10 3/4	51.00	10.750	51.00	0.450	—	PSB	PSB	PSB	PSB	P	PSB	—
10 3/4	55.50	10.750	55.50	0.495	—	—	PSB	PSB	PSB	P	PSB	—
10 3/4	60.70	10.750	60.70	0.545	—	—	—	—	PSB	P	PSB	PSB
10 3/4	65.70	10.750	65.70	0.595	—	—	—	—	PSB	P	PSB	PSB
10 3/4	73.20	10.750	73.20	0.672	—	—	—	—	P	P	—	—
10 3/4	79.20	10.750	79.20	0.734	—	—	—	—	P	P	—	—
10 3/4	85.30	10.750	85.30	0.797	—	—	—	—	P	P	—	—
11 3/4	42.00	11.750	42.00	0.333	PS	—	—	—	—	—	—	—
11 3/4	47.00	11.750	47.00	0.375	—	PSB	—	—	—	—	—	—
11 3/4	54.00	11.750	54.00	0.435	—	PSB	—	—	—	—	—	—
11 3/4	60.00	11.750	60.00	0.489	—	PSB	PSB	PSB	PSB	P	PSB	PSB
11 3/4	65.00	11.750	65.00	0.534	—	—	P	P	P	P	P	P
11 3/4	71.00	11.750	71.00	0.582	—	—	P	P	P	P	P	P

Table E.1—API Casing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)
(continued)

Labels [a]		Outside Diameter	Nominal Linear Mass [b, c] T&C	Wall Thickness	Type of End-finish [d, e]							
1	**2**	D in.	lb/ft	t in.	**H40**	**J55 K55**	**L80 R95**	**N80**	**C90 T95**	**C110**	**P110**	**Q125**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
13 3/8	48.00	13.375	48.00	0.330	PS	—	—	—	—	—	—	—
13 3/8	54.50	13.375	54.50	0.380	—	PSB	—	—	—	—	—	—
13 3/8	61.00	13.375	61.00	0.430	—	PSB	—	—	—	—	—	—
13 3/8	68.00	13.375	68.00	0.480	—	PSB	PSB	PSB	PSB	P	PSB	—
13 3/8	72.00	13.375	72.00	0.514	—	—	PSB	PSB	PSB	P	PSB	PSB
16	65.00	16.000	65.00	0.375	PS	—	—	—	—	—	—	—
16	75.00	16.000	75.00	0.438	—	PSB	—	—	—	—	—	—
16	84.00	16.000	84.00	0.495	—	PSB	—	—	—	—	—	—
16	109.00	16.000	109.00	0.656	—	P	P	P	—	—	P	P
18 5/8	87.50	18.625	87.50	0.435	PS	PSB	—	—	—	—	—	—
20	94.00	20.000	94.00	0.438	PSL	PSLB	—	—	—	—	—	—
20	106.50	20.000	106.50	0.500	—	PSLB	—	—	—	—	—	—
20	133.00	20.000	133.00	0.635	—	PSLB	—	—	—	—	—	—

NOTE B = buttress thread; L = Long round thread; P = plain-end; S = short round thread; T&C = threaded and coupled.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses (column 4) are shown for information only.

[c] The densities of martensitic chromium steels (L80 Types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 may be used.

[d] Buttress casing is available with regular, special clearance couplings or special clearance couplings with special bevel.

[e] For casing with S, L, and B connections, intermediate wall thicknesses are allowed in accordance with 4.2.3 and 7.2 and API 5B.

Table E.2—API Tubing List (Sizes, Masses, Wall Thickness, Grade, and Applicable End-finish)

Labels				Outside Diameter	Nominal Linear Masses [a, b]			Wall Thick-ness	Type of End-finish						
1	2				Non-upset T&C	Ext. Upset T&C	Integ. Joint								
	NU T&C	EU T&C	IJ	D in.	lb/ft	lb/ft	lb/ft	t in.	H40	J55	L80 R95	N80	C90	T95	P110
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1.050	1.14	1.20	—	1.050	1.14	1.20	—	0.113	PNU	PNU	PNU	PNU	PNU	PNU	—
1.050	1.48	1.54	—	1.050	1.48	1.54	—	0.154	PU	PU	PU	PU	PU	PU	PU
1.315	1.70	1.80	1.72	1.315	1.70	1.80	1.72	0.133	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	—
1.315	2.19	2.24	—	1.315	2.19	2.24	—	0.179	PU	PU	PU	PU	PU	PU	PU
1.660	2.09	—	2.10	1.660	—	—	2.10	0.125	PI	PI	—	—	—	—	—
1.660	2.30	2.40	2.33	1.660	2.30	2.40	2.33	0.140	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	—
1.660	3.03	3.07	—	1.660	3.03	3.07	—	0.191	PU	PU	PU	PU	PU	PU	PU
1.900	2.40	—	2.40	1.900	—	—	2.40	0.125	PI	PI	—	—	—	—	—
1.900	2.75	2.90	2.76	1.900	2.75	2.90	2.76	0.145	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	—
1.900	3.65	3.73	—	1.900	3.65	3.73	—	0.200	PU	PU	PU	PU	PU	PU	PU
1.900	4.42	—	—	1.900	4.42	—	—	0.250	—	—	P	—	P	P	—
1.900	5.15	—	—	1.900	5.15	—	—	0.300	—	—	P	—	P	P	—
2.063	3.24	—	3.25	2.063	—	—	3.25	0.156	PI	PI	PI	PI	PI	PI	—
2.063	4.50	—	—	2.063	4.50	—	—	0.225	P	P	P	P	P	P	P
2 3/8	4.00	—	—	2.375	4.00	—	—	0.167	PN	PN	PN	PN	PN	PN	—
2 3/8	4.60	4.70	—	2.375	4.60	4.70	—	0.190	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2 3/8	5.80	5.95	—	2.375	5.80	5.95	—	0.254	—	—	PNU	PNU	PNU	PNU	PNU
2 3/8	6.60	—	—	2.375	6.60	—	—	0.295	—	—	P	—	P	P	—
2 3/8	7.35	7.45	—	2.375	7.35	7.45	—	0.336	—	—	PU	—	PU	PU	—
2 7/8	6.40	6.50	—	2.875	6.40	6.50	—	0.217	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2 7/8	7.80	7.90	—	2.875	7.80	7.90	—	0.276	—	—	PNU	PNU	PNU	PNU	PNU
2 7/8	8.60	8.70	—	2.875	8.60	8.70	—	0.308	—	—	PNU	PNU	PNU	PNU	PNU
2 7/8	9.35	9.45	—	2.875	9.35	9.45	—	0.340	—	—	PU	—	PU	PU	—
2 7/8	10.50	—	—	2.875	10.50	—	—	0.392	—	—	P	—	P	P	—
2 7/8	11.50	—	—	2.875	11.50	—	—	0.440	—	—	P	—	P	P	—
3 1/2	7.70	—	—	3.500	7.70	—	—	0.216	PN	PN	PN	PN	PN	PN	—
3 1/2	9.20	9.30	—	3.500	9.20	9.30	—	0.254	PNU	PNU	PNU	PNU	PNU	PNU	PNU
3 1/2	10.20	—	—	3.500	10.20	—	—	0.289	PN	PN	PN	PN	PN	PN	—
3 1/2	12.70	12.95	—	3.500	12.70	12.95	—	0.375	—	—	PNU	PNU	PNU	PNU	PNU
3 1/2	14.30	—	—	3.500	14.30	—	—	0.430	—	—	P	—	P	P	—
3 1/2	15.50	—	—	3.500	15.50	—	—	0.476	—	—	P	—	P	P	—
3 1/2	17.00	—	—	3.500	17.00	—	—	0.530	—	—	P	—	P	P	—
4	9.50	—	—	4.000	9.50	—	—	0.226	PN	PN	PN	PN	PN	PN	—
4	10.70	11.00	—	4.000	—	11.00	—	0.262	PU	PU	PU	PU	PU	PU	—
4	13.20	—	—	4.000	13.20	—	—	0.330	—	—	P	—	P	P	—
4	16.10	—	—	4.000	16.10	—	—	0.415	—	—	P	—	P	P	—
4	18.90	—	—	4.000	18.90	—	—	0.500	—	—	P	—	P	P	—
4	22.20	—	—	4.000	22.20	—	—	0.610	—	—	P	—	P	P	—
4 1/2	12.60	12.75	—	4.500	12.60	12.75	—	0.271	PNU	PNU	PNU	PNU	PNU	PNU	—
4 1/2	15.20	—	—	4.500	15.20	—	—	0.337	—	—	P	—	P	P	—
4 1/2	17.00	—	—	4.500	17.00	—	—	0.380	—	—	P	—	P	P	—
4 1/2	18.90	—	—	4.500	18.90	—	—	0.430	—	—	P	—	P	P	—
4 1/2	21.50	—	—	4.500	21.50	—	—	0.500	—	—	P	—	P	P	—
4 1/2	23.70	—	—	4.500	23.70	—	—	0.560	—	—	P	—	P	P	—
4 1/2	26.10	—	—	4.500	26.10	—	—	0.630	—	—	P	—	P	P	—

NOTE I = integral joint; N = non-upset threaded and coupled; P = plain-end; T&C = threaded and coupled; U = external upset threaded and coupled.

[a] Nominal linear masses (columns 6, 7, and 8) are shown for information only.

[b] The densities of martensitic chromium steels (L80 types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 may be used.

Table E.3—Process of Manufacture and Heat Treatment

Grade	Type	Manufacturing Process [a]	Heat Treatment [e]	Tempering Temperature °F min
1	*2*	*3*	*4*	*5*
H40	—	S or EW	—	—
J55 [i]	—	S or EW	— [b]	—
K55	—	S or EW	— [b]	—
N80	1 [i]	S or EW	[c]	—
N80	Q	S or EW	Q [d]	—
R95 [i]	—	S or EW	Q	1000
L80	1	S or EW	Q	1050
L80	3Cr	S	Q	1050
L80	9Cr [i]	S	Q [f]	1100
L80	13Cr	S	Q [f]	1100 [j]
C90	—	S	Q	1150
T95	—	S	Q	1200
C110	—	S	Q	1200
P110	—	S or EW [g, h]	Q	—
Q125	—	S or EW [h]	Q	—

[a] EW = electric-welded process; S = seamless process.

[b] Full-body, full-length normalized, normalized and tempered or quenched and tempered at the manufacturer's option, or as specified in the purchase agreement (see 5.2.2).

[c] Full-body, full-length heat treatment is mandatory; at the manufacturer's option, normalized or normalized and tempered.

[d] Includes the method of interrupted quenching followed by controlled cooling.

[e] Q = quenched and tempered.

[f] Types 9Cr and 13Cr may be air-quenched.

[g] Special chemical requirements for electric-welded P110 pipe are specified in Table E.4.

[h] Products shall be heat-treated full-body, full-length; special requirements unique to electric-welded P110 and Q125 are specified in A.6 (SR 11).

[i] Quenched and tempered product in large D/t ratio combinations and nonquenched and tempered product may exhibit ductile rupture values lower than internal yield values. See API 5C3/ISO 10400 calculated performance values in columns 15 and 18 in Table K.1 and Table L.1.

[j] See 5.2.3.

Table E.4—Chemical Composition, Mass Fraction (%)

Grade	Type	C		Mn		Mo		Cr		Nb	Ni	Cu	P	S	Si
		min	max	min	max	min	max	min	max	max	max	max	max	max	max
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
H40	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
J55	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
K55	—	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
N80	1	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
N80	Q	—	—	—	—	—	—	—	—	—	—	—	0.030	0.030	—
R95	—	—	0.45 [c]	—	1.90	—	—	—	—	—	—	—	0.030	0.030	0.45
L80	1	—	0.43 [a]	—	1.90	—	—	—	1.50	—	0.25	0.35	0.030	0.030	0.45
L80	3Cr	—	0.30	—	1.20	—	—	2.50	3.90	0.30	0.25	0.35	0.020	0.010	0.45
L80	9Cr	—	0.15	0.30	0.60	0.90	1.10	8.00	10.0	—	0.50	0.25	0.020	0.010	1.00
L80	13Cr	0.15	0.22	0.25	1.00	—	—	12.0	14.0	—	0.50	0.25	0.020	0.010	1.00
C90	—	—	0.35	—	1.20	0.25 [b]	0.85	—	1.50	—	0.99	—	0.020	0.010	—
T95	—	—	0.35	—	1.20	0.25 [d]	0.85	0.40	1.50	—	0.99	—	0.020	0.010	—
C110	—	—	0.35	—	1.20	0.25	1.00	0.40	1.50	—	0.99	—	0.020	0.005	—
P110	—	—	—	—	—	—	—	—	—	—	—	—	0.030 [e]	0.030 [e]	—
Q125	—	—	0.35	—	1.35	—	0.85	—	1.50	—	—	—	0.020	0.010	—

NOTE Elements shown shall be reported in product analysis.

[a] The carbon content for L80 may be increased up to 0.50 % max if the product is oil-quenched or polymer-quenched.

[b] The molybdenum content for Grade C90 Type 1 has no minimum tolerance if the wall thickness is less than 0.700 in.

[c] The carbon content for R95 may be increased up to 0.55 % max if the product is oil-quenched.

[d] The molybdenum content for T95 Type 1 may be decreased to 0.15 % min if the wall thickness is less than 0.700 in.

[e] For EW Grade P110, the phosphorus content shall be 0.020 % max and the sulfur content 0.010 % max.

Table E.5—Tensile and Hardness Requirements

Grade	Type	Total Elongation Under Load %	Yield Strength ksi		Tensile Strength min ksi	Hardness [a, c] max		Specified Wall Thickness	Allowable Hardness Variation [b]
			min	max		HRC	HBW	in.	HRC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
H40	—	0.5	40	80	60	—	—	—	—
J55	—	0.5	55	80	75	—	—	—	—
K55	—	0.5	55	80	95	—	—	—	—
N80	1	0.5	80	110	100	—	—	—	—
N80	Q	0.5	80	110	100	—	—	—	—
R95	—	0.5	95	110	105	—	—	—	—
L80	1	0.5	80	95	95	23.0	241	—	—
L80	3Cr	0.5	80	95	95	23.0	241	—	—
L80	9Cr	0.5	80	95	95	23.0	241	—	—
L80	13Cr	0.5	80	95	95	23.0	241	—	—
C90	—	0.5	90	105	100	25.4	255	≤ 0.500	3.0
								0.501 to 0.749	4.0
								0.750 to 0.999	5.0
								≥ 1.000	6.0
T95	—	0.5	95	110	105	25.4	255	≤ 0.500	3.0
								0.501 to 0.749	4.0
								0.750 to 0.999	5.0
								≥ 1.000	6.0
C110	—	0.7	110	120	115	29.0	279	≤ 0.500	3.0
								0.501 to 0.749	4.0
								0.750 to 0.999	5.0
								≥ 1.000	6.0
P110	—	0.6	110	140	125	—	—	—	—
Q125	—	0.65	125	150	135	[b]	—	≤ 0.500	3.0
								0.501 to 0.749	4.0
								≥ 0.750	5.0

[a] In case of dispute, laboratory Rockwell C hardness testing shall be used as the referee method.

[b] No hardness limits are specified, but the maximum variation is restricted as a manufacturing control in accordance with 6.8 and 6.9.

[c] For through-wall hardness tests of Grades L80, C90, T95, and C110, the requirements stated in HRC scale are for maximum mean hardness number.

Table E.6—Elongation Table

Tensile Test Specimen				Minimum Elongation in 2.0 in. %							
				Grade							
				H40	J55	K55 L80	N80 C90	R95 T95	C110	P110	Q125
Specimen Area	Specified Wall Thickness in.			Specified Minimum Tensile Strength ksi							
in.^{2}	Specimen Width $^3/_4$ in.	Specimen Width 1 in.	Specimen Width 1 $^1/_2$ in.	60	75	95	100	105	115	125	135
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.750	≥ 0.994	≥ 0.746	≥ 0.497	30	24	20	19	18	16	15	14
0.740	0.980–0.993	0.735–0.745	0.490–0.496	29	24	19	19	18	16	15	14
0.730	0.967–0.979	0.726–0.734	0.484–0.489	29	24	19	19	18	16	15	14
0.720	0.954–0.966	0.715–0.725	0.477–0.483	29	24	19	19	18	16	15	14
0.710	0.941–0.953	0.706–0.714	0.471–0.476	29	24	19	18	18	16	15	14
0.700	0.927–0.940	0.695–0.705	0.464–0.470	29	24	19	18	18	16	15	14
0.690	0.914–0.926	0.686–0.694	0.457–0.463	29	24	19	18	18	16	15	14
0.680	0.900–0.913	0.675–0.685	0.450–0.456	29	24	19	18	18	16	15	14
0.670	0.887–0.899	0.666–0.674	0.444–0.449	29	24	19	18	17	16	15	14
0.660	0.861–0.873	0.646–0.654	0.431–0.436	29	24	19	18	17	16	15	14
0.650	0.847–0.860	0.635–0.645	0.424–0.430	29	23	19	18	17	16	15	14
0.640	0.847–0.860	0.635–0.645	0.424–0.430	29	23	19	18	17	16	15	14
0.630	0.834–0.846	0.626–0.634	0.417–0.423	29	23	19	18	17	16	15	14
0.620	0.820–0.833	0.615–0.625	0.410–0.416	28	23	19	18	17	16	15	14
0.610	0.807–0.819	0.606–0.614	0.404–0.409	28	23	19	18	17	16	15	14
0.600	0.794–0.806	0.595–0.605	0.397–0.403	28	23	19	18	17	16	15	14
0.590	0.781–0.793	0.586–0.594	0.391–0.396	28	23	19	18	17	16	15	14
0.580	0.767–0.780	0.575–0.585	0.384–0.390	28	23	19	18	17	16	15	14
0.570	0.754–0.766	0.566–0.574	0.377–0.383	28	23	18	18	17	16	14	13
0.560	0.740–0.753	0.555–0.565	0.370–0.376	28	23	18	18	17	16	14	13
0.550	0.727–0.739	0.546–0.554	0.364–0.369	28	23	18	18	17	15	14	13
0.540	0.714–0.726	0.535–0.545	0.357–0.363	28	23	18	17	17	15	14	13
0.530	0.701–0.713	0.526–0.534	0.351–0.356	28	23	18	17	17	15	14	13
0.520	0.687–0.700	0.515–0.525	0.344–0.350	27	22	18	17	17	15	14	13
0.510	0.674–0.686	0.506–0.514	0.337–0.343	27	22	18	17	17	15	14	13
0.500	0.660–0.673	0.495–0.505	0.330–0.336	27	22	18	17	16	15	14	13
0.490	0.647–0.659	0.486–0.494	0.324–0.329	27	22	18	17	16	15	14	13
0.480	0.634–0.646	0.475–0.485	0.317–0.323	27	22	18	17	16	15	14	13
0.470	0.621–0.633	0.466–0.474	0.311–0.316	27	22	18	17	16	15	14	13
0.460	0.607–0.620	0.455–0.465	0.304–0.310	27	22	18	17	16	15	14	13
0.450	0.594–0.606	0.446–0.454	0.297–0.303	27	22	18	17	16	15	14	13
0.440	0.580–0.593	0.435–0.445	0.290–0.296	27	22	18	17	16	15	14	13
0.430	0.567–0.579	0.426–0.434	0.284–0.289	26	22	17	17	16	15	14	13

Table E.6—Elongation Table *(continued)*

Tensile Test Specimen				Minimum Elongation in 2.0 in. %							
				Grade							
				H40	J55	K55 L80	N80 C90	R95 T95	C110	P110	Q125
Specimen Area	Specified Wall Thickness in.			Specified Minimum Tensile Strength ksi							
in.^{2}	Specimen Width $^3/_4$ in.	Specimen Width 1 in.	Specimen Width 1 $^1/_2$ in.	60	75	95	100	105	115	125	135
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.420	0.554–0.566	0.415–0.425	0.277–0.283	26	22	17	17	16	15	14	13
0.410	0.541–0.553	0.406–0.414	0.271–0.276	26	21	17	17	16	15	14	13
0.400	0.527–0.540	0.395–0.405	0.264–0.270	26	21	17	16	16	15	13	13
0.390	0.514–0.526	0.386–0.394	0.257–0.263	26	21	17	16	16	14	13	12
0.380	0.500–0.513	0.375–0.385	0.250–0.256	26	21	17	16	16	14	13	12
0.370	0.487–0.499	0.366–0.374	0.244–0.249	26	21	17	16	16	14	13	12
0.360	0.474–0.486	0.355–0.365	0.237–0.243	26	21	17	16	15	14	13	12
0.350	0.461–0.473	0.346–0.354	0.231–0.236	25	21	17	16	15	14	13	12
0.340	0.447–0.460	0.335–0.345	0.224–0.230	25	21	17	16	15	14	13	12
0.330	0.420–0.433	0.315–0.325	0.210–0.216	25	21	17	16	15	14	13	12
0.320	0.420–0.433	0.315–0.325	0.210–0.216	25	20	16	16	15	14	13	12
0.310	0.407–0.419	0.306–0.314	0.204–0.209	25	20	16	16	15	14	13	12
0.300	0.394–0.406	0.295–0.305	0.197–0.203	25	20	16	16	15	14	13	12
0.290	0.381–0.393	0.286–0.294	0.191–0.196	24	20	16	15	15	14	13	12
0.280	0.367–0.380	0.275–0.285	0.184–0.190	24	20	16	15	15	14	13	12
0.270	0.354–0.366	0.266–0.274	0.177–0.183	24	20	16	15	15	13	12	12
0.260	0.340–0.353	0.255–0.265	0.170–0.176	24	20	16	15	14	13	12	12
0.250	0.327–0.339	0.246–0.254	0.164–0.169	24	19	16	15	14	13	12	11
0.240	0.314–0.326	0.235–0.245	0.157–0.163	24	19	16	15	14	13	12	11
0.230	0.301–0.313	0.226–0.234	0.151–0.156	23	19	15	15	14	13	12	11
0.220	0.287–0.300	0.215–0.225	0.144–0.150	23	19	15	15	14	13	12	11
0.210	0.274–0.286	0.206–0.214	0.137–0.143	23	19	15	14	14	13	12	11
0.200	0.260–0.273	0.195–0.205	0.130–0.136	23	19	15	14	14	13	12	11
0.190	0.247–0.259	0.186–0.194	0.124–0.129	22	18	15	14	14	13	12	11
0.180	0.234–0.246	0.175–0.185	0.117–0.123	22	18	15	14	13	12	11	11
0.170	0.221–0.233	0.166–0.174	0.111–0.116	22	18	15	14	13	12	11	11

Table E.6—Elongation Table *(continued)*

Tensile Test Specimen				Minimum Elongation in 2.0 in. %							
				Grade							
				H40	J55	K55 L80	N80 C90	R95 T95	C110	P110	Q125
Specimen Area in.^{2}	Specified Wall Thickness in.			Specified Minimum Tensile Strength ksi							
	Specimen Width $^3/_4$ in.	Specimen Width 1 in.	Specimen Width 1 $^1/_2$ in.	60	75	95	100	105	115	125	135
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
0.160	0.207–0.220	0.155–0.165	0.104–0.110	22	18	14	14	13	12	11	10
0.150	0.194–0.206	0.146–0.154	0.097–0.103	21	18	14	14	13	12	11	10
0.140	0.180–0.193	0.135–0.145	0.090–0.096	21	17	14	13	13	12	11	10
0.130	0.167–0.179	0.126–0.134	0.084–0.089	21	17	14	13	13	12	11	10
0.120	0.154–0.166	0.115–0.125	0.077–0.083	20	17	14	13	12	11	11	10
0.110	0.141–0.153	0.106–0.114	0.071–0.076	20	16	13	13	12	11	10	9.5
0.100	0.127–0.140	0.095–0.105	0.064–0.070	20	16	13	12	12	11	10	9.5
0.090	0.114–0.126	0.086–0.094	0.057–0.063	19	16	13	12	12	11	10	9.5
0.080	0.100–0.113	0.075–0.085	0.050–0.056	19	15	12	12	11	11	10	9

NOTE The calculations of the elongation requirements are based on the cross-sectional area in column 1, which is shown rounded to two significant figures. The applicable wall thickness ranges shown in columns 2, 3, and 4 were calculated based on the specified specimen width (shown above the column numbers 2, 3, and 4) taking into account the rounding rules for the specimen area (i.e. to two significant figures) but with the wall thickness rounded down to two significant figures for SI units. When making these wall thickness ranges for USC units, 3 significant figures are used.

Table E.7—Critical Thickness for Couplings with API Threads

Dimensions in inches

Label 1	Critical Thickness for Couplings						
	NU	EU	Special Clearance		BC	LC	SC
			EU	BC			
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	0.169	0.211	—	—	—	—	—
1.315	0.211	0.258	—	—	—	—	—
1.660	0.239	0.240	—	—	—	—	—
1.900	0.196	0.251	—	—	—	—	—
2 3/8	0.304	0.300	0.224	—	—	—	—
2 7/8	0.380	0.358	0.254	—	—	—	—
3 1/2	0.451	0.454	0.294	—	—	—	—
4	0.454	0.458	—	—	—	—	—
4 1/2	0.435	0.493	—	0.259	0.447	0.474	0.462
5	—	—	—	0.266	0.479	0.511	0.491
5 1/2	—	—	—	0.268	0.481	0.514	0.495
6 5/8	—	—	—	0.274	0.469	0.508	0.485
7	—	—	—	0.280	0.530	0.568	0.540
7 5/8	—	—	—	0.348	0.536	0.573	0.546
8 5/8	—	—	—	0.352	0.602	0.647	0.612
9 5/8	—	—	—	0.352	0.602	0.657	0.614
10 3/4	—	—	—	0.352	0.602	—	0.618
11 3/4	—	—	—	—	0.602	—	0.618
13 3/8	—	—	—	—	0.602	—	0.618
16	—	—	—	—	0.667	—	0.632
18 5/8	—	—	—	—	0.854	—	0.819
20	—	—	—	—	0.667	0.673	0.634

NOTE The coupling blank thickness is greater than those indicated above due to thread height and manufacturing allowance to avoid black crest threads.

Table E.8—Acceptable Size Impact Specimens and Absorbed Energy Reduction Factor

Test Specimen Size	Specimen Dimensions mm	Reduction Factor
Full-size	10.0 × 10.0	1.00
3/4-size	10.0 × 7.5	0.80
1/2-size	10.0 × 5.0	0.55

Table E.9—Hierarchy of Test Specimen Orientation and Size

Choice	Orientation	Size
1st	Transverse	Full-size
2nd	Transverse	3/4-size
3rd	Transverse	1/2-size
4th	Longitudinal	Full-size
5th	Longitudinal	3/4-size
6th	Longitudinal	1/2-size

Table E.10—Transverse Impact Specimen Size Required

Label 1	Calculated Wall Thickness Required to Machine Transverse Charpy Impact Specimens in.		
	Full-size	3/4-size	1/2-size
1	*2*	*3*	*4*
3 1/2	0.809	0.711	0.612
4	0.752	0.654	0.555
4 1/2	0.712	0.614	0.515
5	0.681	0.583	0.484
5 1/2	0.656	0.558	0.459
6 5/8	0.616	0.518	0.419
7	0.606	0.508	0.409
7 5/8	0.591	0.493	0.394
7 3/4	0.588	0.490	0.391
8 5/8	0.572	0.474	0.375
9 5/8	0.557	0.459	0.360
10 3/4	0.544	0.446	0.347
11 3/4	0.535	0.437	0.338
13 3/8	0.522	0.424	0.325
16	0.508	0.410	0.311
18 5/8	0.497	0.399	0.300
20	0.493	0.395	0.296

NOTE The wall thicknesses in columns 2, 3, and 4 that are in excess of the maximum wall thicknesses for API pipe are for information only. The information in this table provides a 0.020 in. inside-wall and a 0.020 in. outside-wall machining allowance.

Table E.11—Longitudinal Impact Specimen Size Required

Label 1	Calculated Wall Thickness Required to Machine Longitudinal Charpy Impact Specimens in.		
	Full-size	3/4-size	1/2-size
1	*2*	*3*	*4*
1.050	0.472	0.374	0.275
1.315	0.464	0.366	0.267
1.660	0.458	0.360	0.261
1.900	0.455	0.357	0.258
2.063	0.453	0.355	0.256
2 3/8	0.450	0.352	0.253
2 7/8	0.448	0.350	0.251
3 1/2	0.445	0.347	0.248
4	0.444	0.346	0.247
4 1/2	0.443	0.345	0.246
5	0.442	0.344	0.245
5 1/2	0.441	0.343	0.244
6 5/8	0.440	0.342	0.243
7	0.440	0.342	0.243
7 5/8	0.439	0.341	0.242
7 3/4	0.439	0.341	0.242
8 5/8	0.439	0.341	0.242
9 5/8	0.438	0.340	0.241
10 3/4	0.438	0.340	0.241
11 3/4	0.437	0.339	0.240
13 3/8	0.437	0.339	0.240
16	0.436	0.338	0.239
18 5/8	0.436	0.338	0.239
20	0.436	0.338	0.239

NOTE The wall thicknesses in columns 2, 3, and 4 that are in excess of the maximum wall thicknesses for API pipe are for information only. The above provides a 0.020 in. inside-wall and a 0.020 in. outside-wall machining allowance.

Table E.12—Minimum Absorbed Energy for Couplings, Coupling Stock, Coupling Material, and Coupling Blanks—Transverse Orientation (ft·lb)

Critical Thickness in.	L80 [a, b, c, d, e]	N80 [a, b, c, d]	C90 [a, b, c, d]	R95/T95 [a, b, c, d]	P110 [a, b, c, d]	C110 [a, b, c, d]	Q125 [a, b, c, d]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
≤ 0.5	20	15	20	20	20	20	25
0.6	20	17	20	20	22	20	25
0.7	20	19	20	20	24	20	26
0.8	20	20	20	20	26	22	28
0.9	20	22	21	22	28	24	30
1.0	21	24	23	24	30	26	32
1.1	22	25	24	25	32	28	35
1.2	23	27	26	27	34	30	37
1.3	25	29	27	29	37	31	39
1.4	26	30	29	30	39	33	42
1.5	28	32	31	32	41	35	44
1.6	29	34	32	34	43	37	46
1.7	31	35	34	35	45	39	48
1.8	32	37	35	37	47	41	51
1.9	34	39	37	39	49	42	53
2.0	35	40	39	40	52	44	55
2.1	36	42	40	42	54	46	57
2.2	38	44	42	44	56	48	60
2.3	39	45	43	45	58	50	62
2.4	41	47	45	47	60	51	64
2.5	42	49	47	49	62	53	67

[a] Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

[b] If transverse specimens of $^1/_2$-size cannot be taken, refer to 9.7.1.

[c] For wall thicknesses not listed, the manufacturer has the option to utilize the applicable formula in accordance with 6.4.4 or the next higher wall in this table.

[d] For all Grades except L80 13 Cr, wall thickness greater than 2.5 in., refer to 4.2.1 or 4.3.1 or 4.4.3.

[e] For Grade L80 13 Cr, wall thickness greater than 1.4 in., refer to 4.2.1 or 4.3.1 or 4.4.3.

Table E.13—Minimum Absorbed Energy for Couplings, Coupling Stock, Coupling Material, and Coupling Blanks—Longitudinal Orientation (ft·lb)

L80	N80	C90	R95/T95	P110	C110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*
40	30	40	40	40	40	50

NOTE 1 Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

NOTE 2 Longitudinal testing is required only if transverse testing is not possible. Coupling, coupling stock tested in the transverse direction does not need to be tested or demonstrate compliance to these values.

Table E.14—Minimum Absorbed Energy for Pipe—Transverse Orientation (ft·lb)

Wall Thickness in.	L80 [a, b, c, d, e]	N80 [a, b, c, d]	C90 [a, b, c, d]	R95/T95 [a, b, c, d]	P110 [a, b, c, d]	C110 [a, b, c, d]	Q125 [a, b, c, d]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
≤ 0.7	15	15	15	15	20	20	25
0.8	15	15	17	18	20	22	28
0.9	16	16	18	19	22	24	30
1.0	17	17	19	21	24	26	32
1.1	18	18	21	22	25	28	35
1.2	20	20	22	23	27	30	37
1.3	21	21	24	25	29	31	39
1.4	22	22	25	26	30	33	42
1.5	23	23	26	28	32	35	44
1.6	25	25	28	29	34	37	46
1.7	26	26	29	31	35	39	48
1.8	27	27	30	32	37	41	51
1.9	28	28	32	34	39	42	53
2.0	29	29	33	35	40	44	55
2.1	31	31	34	36	42	46	57
2.2	32	32	36	38	44	48	60
2.3	33	33	37	39	45	50	62
2.4	34	34	39	41	47	51	64
2.5	36	36	40	42	49	53	67

[a] Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

[b] If transverse specimens of $^1/_2$-size cannot be taken, refer to 9.7.1.

[c] For wall thicknesses not listed, the manufacturer has the option to utilize applicable formula in accordance with 6.5.2 and 6.5.3 or the next higher wall in this table.

[d] For all Grades except L80 13 Cr, wall thickness greater than 2.5 in., refer to 4.2.1 or 4.3.1 or 4.4.3.

[e] For Grade L80 13 Cr, wall thickness greater than 1.4 in., refer to 4.2.1 or 4.3.1 or 4.4.3.

Table E.15—Minimum Absorbed Energy for Pipe—Longitudinal Orientation (ft·lb)

L80	N80	C90	R95/T95	P110	C110	Q125
1	*2*	*3*	*4*	*5*	*6*	*7*
30	30	30	30	38	40	40

NOTE 1 Values given are full-size, average minimums; refer to 6.3.1 for individual minimum values.

NOTE 2 Longitudinal testing is required only if transverse testing is not possible. Pipe tested in the transverse direction does not need to be tested or demonstrate conformance to these values.

Table E.16—Frequency of Charpy V-notch Testing—Pipe, Coupling Stock, Coupling Material, Coupling Blanks, Couplings, and Accessory Material

Grade	Label 1	Number of Tests per Lot			
		Pipe	Coupling Stock/Material	Coupling Blanks/Couplings	Accessory Material
1	*2*	*3*	*4*	*5*	*6*
H40	All sizes	d	d	d	d
K55, J55	All sizes	N/A	1	1	1 [b]
N80, R95	All sizes	1 [a]	1	1	1 [b]
L80	All sizes	1 [a]	1	1	1 [b]
C90, T95	All sizes	1 [a]	1	1	1 [b]
C110	All sizes	1	1	1	1
P110	All sizes	1 [a]	1	1	1 [b]
Q125 [c]	All sizes	3 [c]	Each length [c]	1	Each length [c]

[a] Testing is not mandatory when qualified by a documented procedure; see 6.5.5 for mandatory requirements.

[b] When required in 6.6.

[c] Refer to 9.7.10 for requirements.

[d] See A.9 (SR 16) when specified.

Table E.17—Distance between Plates for Electric-weld Flattening Tests

Grade	D/t Ratio	Distance between Plates in.
H40	≥ 16	$0.5 \times D$
	< 16	$D \times (0.830 - 0.0206\ D/t)$
J55 and K55	≥ 16	$0.65 \times D$
	3.93 to 16	$D \times (0.980 - 0.0206\ D/t)$
	< 3.93	$D \times (1.104 - 0.0518\ D/t)$
N80 [a]	9 to 28	$D \times (1.074 - 0.0194\ D/t)$
L80 Type 1	9 to 28	$D \times (1.074 - 0.0194\ D/t)$
R95 [a]	9 to 28	$D \times (1.080 - 0.0178\ D/t)$
P110 [b]	All	$D \times (1.086 - 0.0163\ D/t)$
Q125 [b]	All	$D \times (1.092 - 0.0140\ D/t)$

NOTE

D is the specified outside diameter of pipe, in inches.

t is the specified wall thickness of the pipe, in inches.

[a] If the flattening test fails at 12 o'clock or 6 o'clock, the flattening shall continue until the remaining portion of the specimen fails at the 3 o'clock or 9 o'clock position; premature failure at 12 o'clock or 6 o'clock shall not be considered basis for rejection.

[b] See A.6 (SR 11); flattening shall be conducted until this distance or until $0.85 \times D$, whichever is less, without cracking at any location.

Table E.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thick-ness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
								Round Thread		Buttress Thread	
		D in.	lb/ft	t in.	d in.	in.	w_{pe} lb/ft	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
4 1/2	9.50	4.500	9.70	0.205	4.090	3.965	9.41	8.02	—	—	—
4 1/2	10.50	4.500	10.60	0.224	4.052	3.927	10.24	7.34	—	9.98	2.47
4 1/2	11.60	4.500	11.70	0.250	4.000	3.875	11.36	7.00	7.95	9.52	2.01
4 1/2	13.50	4.500	13.30	0.290	3.920	3.795	13.05	—	7.38	8.82	1.32
4 1/2	15.10	4.500	15.30	0.337	3.826	3.701	15.00	—	6.73	8.02	0.52
5	11.50	5.000	11.30	0.220	4.560	4.435	11.24	9.52	—	—	—
5	13.00	5.000	13.20	0.253	4.494	4.369	12.84	8.81	10.69	11.86	2.21
5	15.00	5.000	15.30	0.296	4.408	4.283	14.88	8.17	9.95	11.00	1.35
5	18.00	5.000	18.30	0.362	4.276	4.151	17.95	—	8.83	9.71	0.05
5	21.40	5.000	21.60	0.437	4.126	4.001	21.32	—	7.60	8.28	–1.37
5	23.20	5.000	23.40	0.478	4.044	3.919	23.11	—	6.95	7.53	–2.12
5	24.10	5.000	24.30	0.500	4.000	3.875	24.05	—	6.60	7.13	–2.52
5 1/2	14.00	5.500	14.00	0.244	5.012	4.887	13.71	10.14	—	—	—
5 1/2	15.50	5.500	15.80	0.275	4.950	4.825	15.36	9.61	11.60	12.58	1.92
5 1/2	17.00	5.500	17.30	0.304	4.892	4.767	16.89	9.12	11.03	11.93	1.27
5 1/2	20.00	5.500	20.20	0.361	4.778	4.653	19.83	—	9.92	10.67	0.01
5 1/2	23.00	5.500	22.90	0.415	4.670	4.545	22.56	—	8.90	9.51	–1.15
5 1/2	26.80	5.500	27.00	0.500	4.500	4.375	26.72	—	—	—	—
5 1/2	29.70	5.500	29.90	0.562	4.376	4.251	29.67	—	—	—	—
5 1/2	32.60	5.500	32.70	0.625	4.250	4.125	32.57	—	—	—	—
5 1/2	35.30	5.500	35.50	0.687	4.126	4.001	35.35	—	—	—	—
5 1/2	38.00	5.500	38.20	0.750	4.000	3.875	38.08	—	—	—	—
5 1/2	40.50	5.500	40.80	0.812	3.876	3.751	40.69	—	—	—	—
5 1/2	43.10	5.500	43.30	0.875	3.750	3.625	43.26	—	—	—	—
6 5/8	20.00	6.625	20.00	0.288	6.049	5.924	19.51	11.15	13.74	14.00	1.97
6 5/8	24.00	6.625	24.00	0.352	5.921	5.796	23.60	9.74	12.08	12.18	0.15
6 5/8	28.00	6.625	28.00	0.417	5.791	5.666	27.67	—	10.42	10.38	–1.65
6 5/8	32.00	6.625	32.00	0.475	5.675	5.550	31.23	—	8.98	8.81	–3.22

Table E.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
								Round Thread		Buttress Thread	
		D in.	lb/ft	t in.	d in.	in.	w_{pe} lb/ft	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
7	17.00	7.00	17.20	0.231	6.538	6.413	16.72	16.77	—	—	—
7	20.00	7.00	20.10	0.272	6.456	6.331	19.56	14.68	—	—	—
7	23.00	7.00	23.30	0.317	6.366	6.250 [e]	22.65	13.80	17.51	18.26	1.27
7	23.00	7.00	23.30	0.317	6.366	6.241	22.65	13.80	17.51	18.26	1.27
7	26.00	7.00	26.30	0.362	6.276	6.151	25.69	12.76	16.25	16.86	–0.12
7	29.00	7.00	29.30	0.408	6.184	6.059	28.75	—	14.97	15.46	–1.52
7	32.00	7.00	32.20	0.453	6.094	6.000 [e]	31.70	—	13.74	14.11	–2.88
7	32.00	7.00	32.20	0.453	6.094	5.969	31.70	—	13.74	14.11	–2.88
7	35.00	7.00	35.00	0.498	6.004	5.879	34.61	—	12.53	12.77	–4.21
7	38.00	7.00	37.70	0.540	5.920	5.795	37.29	—	11.41	11.55	–5.44
7	42.70	7.00	42.90	0.625	5.750	5.625	42.59	—	—	—	—
7	46.40	7.00	46.60	0.687	5.626	5.501	46.36	—	—	—	—
7	50.10	7.00	50.30	0.750	5.500	5.375	50.11	—	—	—	—
7	53.60	7.00	53.90	0.812	5.376	5.251	53.71	—	—	—	—
7	57.10	7.00	57.40	0.875	5.250	5.125	57.29	—	—	—	—
7 5/8	24.00	7.625	24.00	0.300	7.025	6.900	23.49	15.68	—	—	—
7 5/8	26.40	7.625	26.40	0.328	6.969	6.844	25.59	14.94	18.91	20.11	5.71
7 5/8	29.70	7.625	29.70	0.375	6.875	6.750	29.06	—	17.43	18.47	4.06
7 5/8	33.70	7.625	33.70	0.430	6.765	6.640	33.07	—	15.71	16.56	2.16
7 5/8	39.00	7.625	39.00	0.500	6.625	6.500	38.08	—	13.57	14.19	–0.22
7 5/8	42.80	7.625	42.80	0.562	6.501	6.376	42.43	—	11.72	12.13	–2.28
7 5/8	45.30	7.625	45.30	0.595	6.435	6.310	44.71	—	10.74	11.05	–3.36
7 5/8	47.10	7.625	47.10	0.625	6.375	6.250	46.77	—	9.87	10.07	–4.33
7 5/8	51.20	7.625	51.20	0.687	6.251	6.126	50.95	—	—	—	—
7 5/8	55.30	7.625	55.30	0.750	6.125	6.000	55.12	—	—	—	—
7 3/4	46.10	7.750	46.10	0.595	6.560	6.500 [e]	45.51	—	—	—	—
7 3/4	46.10	7.750	46.10	0.595	6.560	6.435	45.51	—	—	—	—

Table E.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
								Round Thread		Buttress Thread	
		D in.	lb/ft	t in.	d in.	in.	w_{pe} lb/ft	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
8 5/8	24.00	8.625	24.00	0.264	8.097	7.972	23.60	24.10	—	—	—
8 5/8	28.00	8.625	28.00	0.304	8.017	7.892	27.04	22.20	—	—	—
8 5/8	32.00	8.625	32.00	0.352	7.921	7.875 [e]	31.13	20.70	27.42	27.71	5.53
8 5/8	32.00	8.625	32.00	0.352	7.921	7.796	31.13	20.70	27.42	27.71	5.53
8 5/8	36.00	8.625	36.00	0.400	7.825	7.700	35.17	19.23	25.57	25.76	3.57
8 5/8	40.00	8.625	40.00	0.450	7.725	7.625 [e]	39.33	—	23.66	23.74	1.56
8 5/8	40.00	8.625	40.00	0.450	7.725	7.600	39.33	—	23.66	23.74	1.56
8 5/8	44.00	8.625	44.00	0.500	7.625	7.500	43.43	—	21.78	21.76	–0.43
8 5/8	49.00	8.625	49.00	0.557	7.511	7.386	48.04	—	19.67	19.52	–2.66
9 5/8	32.30	9.625	32.30	0.312	9.001	8.845	31.06	24.25	—	—	—
9 5/8	36.00	9.625	36.00	0.352	8.921	8.765	34.89	22.85	31.93	30.58	6.03
9 5/8	40.00	9.625	40.00	0.395	8.835	8.750 [e]	38.97	21.37	29.97	28.60	4.05
9 5/8	40.00	9.625	40.00	0.395	8.835	8.679	38.97	21.37	29.97	28.60	4.05
9 5/8	43.50	9.625	43.50	0.435	8.755	8.599	42.73	—	28.17	26.78	2.23
9 5/8	43.50	9.625	43.50	0.435	8.755	8.599	42.73	—	28.31 [f]	26.78	2.23
9 5/8	47.00	9.625	47.00	0.472	8.681	8.525	46.18	—	26.52	25.11	0.56
9 5/8	47.00	9.625	47.00	0.472	8.681	8.525	46.18	—	26.66 [f]	25.11	0.56
9 5/8	53.50	9.625	53.50	0.545	8.535	8.500 [e]	52.90	—	23.30	21.86	–2.70
9 5/8	53.50	9.625	53.50	0.545	8.535	8.500 [e]	52.90	—	23.44 [f]	21.86	–2.70
9 5/8	53.50	9.625	53.50	0.545	8.535	8.379	52.90	—	23.30	21.86	–2.70
9 5/8	53.50	9.625	53.50	0.545	8.535	8.379	52.90	—	23.44 [f]	21.86	–2.70
9 5/8	58.40	9.625	58.40	0.595	8.435	8.375 [e]	57.44	—	21.13	19.66	–4.89
9 5/8	58.40	9.625	58.40	0.595	8.435	8.375 [e]	57.44	—	21.27 [f]	19.66	–4.89
9 5/8	58.40	9.625	58.40	0.595	8.435	8.279	57.44	—	21.13	19.66	–4.89
9 5/8	58.40	9.625	58.40	0.595	8.435	8.279	57.44	—	21.27 [f]	19.66	–4.89
9 5/8	59.40	9.625	59.40	0.609	8.407	8.251	58.70	—	—	—	—
9 5/8	64.90	9.625	64.90	0.672	8.281	8.125	64.32	—	—	—	—
9 5/8	70.30	9.625	70.30	0.734	8.157	8.001	69.76	—	—	—	—
9 5/8	75.60	9.625	75.60	0.797	8.031	7.875	75.21	—	—	—	—

Table E.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thickness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
								Round Thread		Buttress Thread	
		D in.	lb/ft	t in.	d in.	in.	w_{pe} lb/ft	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
10 3/4	32.75	10.750	32.75	0.279	10.192	10.036	31.23	30.74	—	—	—
10 3/4	40.50	10.750	40.50	0.350	10.050	9.894	38.91	26.26	—	33.91	6.69
10 3/4	45.50	10.750	45.50	0.400	9.950	9.875 [e]	44.26	24.26	—	31.32	4.10
10 3/4	45.50	10.750	45.50	0.400	9.950	9.794	44.26	24.26	—	31.32	4.10
10 3/4	51.00	10.750	51.00	0.450	9.850	9.694	49.55	22.28	—	28.76	1.54
10 3/4	51.00	10.750	51.00	0.450	9.850	9.684	49.55	22.39 [f]	—	28.76	1.54
10 3/4	55.50	10.750	55.50	0.495	9.760	9.625 [e]	54.26	20.51	—	26.47	–0.74
10 3/4	55.50	10.750	55.50	0.495	9.760	9.625 [e]	54.26	20.62 [f]	—	26.47	–0.74
10 3/4	55.50	10.750	55.50	0.495	9.760	9.604	54.26	20.51	—	26.47	–0.74
10 3/4	55.50	10.750	55.50	0.495	9.760	9.604	54.26	20.62 [f]	—	26.47	–0.74
10 3/4	60.70	10.750	60.70	0.545	9.660	9.504	59.45	18.56	—	23.96	—
10 3/4	60.70	10.750	60.70	0.545	9.660	9.504	59.45	18.67 [f]	—	23.96	—
10 3/4	65.70	10.750	65.70	0.595	9.560	9.404	64.59	16.63	—	21.47	—
10 3/4	65.70	10.750	65.70	0.595	9.560	9.404	64.59	16.75 [f]	—	21.47	—
10 3/4	73.20	10.750	73.20	0.672	9.406	9.250	72.40	—	—	—	—
10 3/4	79.20	10.750	79.20	0.734	9.282	9.126	78.59	—	—	—	—
10 3/4	85.30	10.750	85.30	0.797	9.156	9.000	84.80	—	—	—	—
11 3/4	42.00	11.750	42.00	0.333	11.084	11.000 [e]	40.64	29.25	—	—	—
11 3/4	42.00	11.750	42.00	0.333	11.084	10.928	40.64	29.25	—	—	—
11 3/4	47.00	11.750	47.00	0.375	11.000	10.844	45.60	27.39	—	35.36	—
11 3/4	54.00	11.750	54.00	0.435	10.880	10.724	52.62	24.76	—	31.96	—
11 3/4	60.00	11.750	60.00	0.489	10.772	10.625 [e]	58.87	22.42	—	28.93	—
11 3/4	60.00	11.750	60.00	0.489	10.772	10.625 [e]	58.87	21.54 [f]	—	28.93	—
11 3/4	60.00	11.750	60.00	0.489	10.772	10.616	58.87	22.42	—	28.93	—
11 3/4	60.00	11.750	60.00	0.489	10.772	10.616	58.87	21.54 [f]	—	28.93	—
11 3/4	65.00	11.750	65.00	0.534	10.682	10.625 [e]	64.03	—	—	—	—
11 3/4	65.00	11.750	65.00	0.534	10.682	10.526	64.03	—	—	—	—
11 3/4	71.00	11.750	71.00	0.582	10.586	10.430	69.48	—	—	—	—

Table E.18—Dimensions and Masses for Standard Casing and for Casing Threaded with API Round Thread and Buttress Thread *(continued)*

Labels [a]		Outside Diameter	Nominal Linear Mass T&C [b, c]	Wall Thick-ness	Inside Diameter	Drift Diameter	Calculated Mass [c]				
							Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
								Round Thread		Buttress Thread	
		D in.	lb/ft	t in.	d in.	in.	w_{pe} lb/ft	Short	Long	RC	SCC
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
13 3/8	48.00	13.375	48.00	0.330	12.715	12.559	46.02	33.15	—	—	—
13 3/8	54.50	13.375	54.50	0.380	12.615	12.459	52.79	30.61	—	39.49	—
13 3/8	61.00	13.375	61.00	0.430	12.515	12.359	59.50	28.09	—	36.24	—
13 3/8	68.00	13.375	68.00	0.480	12.415	12.259	66.17	25.59	—	33.01	—
13 3/8	68.00	13.375	68.00	0.480	12.415	12.259	66.17	25.73 [f]	—	33.01	—
13 3/8	72.00	13.375	72.00	0.514	12.347	12.250 [e]	70.67	23.91	—	30.83	—
13 3/8	72.00	13.375	72.00	0.514	12.347	12.250 [e]	70.67	24.05 [f]	—	30.83	—
13 3/8	72.00	13.375	72.00	0.514	12.347	12.191	70.67	23.91	—	30.83	—
13 3/8	72.00	13.375	72.00	0.514	12.347	12.191	70.67	24.05 [f]	—	30.83	—
16	65.00	16.000	65.00	0.375	15.250	15.062	62.64	40.98	—	—	—
16	75.00	16.000	75.00	0.438	15.124	14.936	72.86	36.72	—	44.37	—
16	84.00	16.000	84.00	0.495	15.010	14.822	82.05	32.89	—	39.92	—
16	109.00	16.000	109.00	0.656	14.688	14.500	107.60	—	—	—	—
18 5/8	87.50	18.625	87.50	0.435	17.755	17.567	84.59	72.31	—	86.54	—
20	94.00	20.000	94.00	0.438	19.124	18.936	91.59	45.20	59.77	54.62	—
20	94.00	20.000	94.00	0.438	19.124	18.936	91.59	45.44	60.09 [g]	54.62	—
20	106.50	20.000	106.50	0.500	19.000	18.812	104.23	40.17	53.51	48.50	—
20	133.00	20.000	133.00	0.635	18.730	18.542	131.45	28.83	39.33	35.32	—

NOTE See also Figures D.1, D.2, and D.3.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses, threaded and coupled (column 4) are shown for information only.

[c] The densities of martensitic chromium steels (L80 Types 9Cr and 13Cr) are less than those of carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 shall be used.

[d] Mass gain or loss due to end-finishing; see 7.5.

[e] Drift diameter for most common bit size; this drift diameter shall be specified in the purchase agreement and marked on the pipe; see 7.10 for drift requirements.

[f] Based on 110,000 psi minimum yield strength or greater.

[g] Based on 55,000 psi minimum yield strength.

Table E.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
1	2			D in.	Non-upset T&C lb/ft	External Upset T&C lb/ft	Integral Joint lb/ft	t in.	d in.	w_{pe} lb/ft	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1.050	1.14	1.20	—	1.050	1.14	1.20	—	0.113	0.824	1.13	0.20	1.40	—	—
1.050	1.48	1.54	—	1.050	1.48	1.54	—	0.154	0.742	1.48	—	1.32	—	—
1.315	1.70	1.80	1.72	1.315	1.70	1.80	1.72	0.133	1.049	1.68	0.40	1.40	—	0.20
1.315	2.19	2.24	—	1.315	2.19	2.24	—	0.179	0.957	2.17	—	1.35	—	—
1.660	2.09	—	2.10	1.660	—	—	2.10	0.125	1.410	2.05	—	—	—	0.20
1.660	2.30	2.40	2.33	1.660	2.30	2.40	2.33	0.140	1.380	2.27	0.80	1.60	—	0.20
1.660	3.03	3.07	—	1.660	3.03	3.07	—	0.191	1.278	3.00	—	1.50	0.20	—
1.900	2.40	—	2.40	1.900	—	—	2.40	0.125	1.650	2.37	—	—	—	0.20
1.900	2.75	2.90	2.76	1.900	2.75	2.90	2.76	0.145	1.610	2.72	0.60	2.00	—	0.20
1.900	3.65	3.73	—	1.900	3.65	3.73	—	0.200	1.500	3.63	—	2.03	—	—
1.900	4.42	—	—	1.900	4.42	—	—	0.250	1.400	4.41	—	—	—	—
1.900	5.15	—	—	1.900	5.15	—	—	0.300	1.300	5.13	—	—	—	—
2.063	3.24	—	3.25	2.063	—	—	3.25	0.156	1.751	3.18	—	—	—	0.20
2.063	4.50	—	—	2.063	—	—	—	0.225	1.613	4.42	—	—	—	—
2 3/8	4.00	—	—	2.375	4.00	—	—	0.167	2.041	3.94	1.60	—	—	—
2 3/8	4.60	4.70	—	2.375	4.60	4.70	—	0.190	1.995	4.44	1.60	4.00	2.96	—
2 3/8	5.80	5.95	—	2.375	5.80	5.95	—	0.254	1.867	5.76	1.40	3.60	2.56	—
2 3/8	6.60	—	—	2.375	6.60	—	—	0.295	1.785	6.56	—	—	—	—
2 3/8	7.35	7.45	—	2.375	7.35	7.45	—	0.336	1.703	7.32	—	—	—	—

Table E.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections *(continued)*

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
1	2			D in.	Non-upset T&C lb/ft	External Upset T&C lb/ft	Integral Joint lb/ft	t in.	d in.	w_{pe} lb/ft	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
2 7/8	6.40	6.50	—	2.875	6.40	6.50	—	0.217	2.441	6.17	3.20	5.60	3.76	—
2 7/8	7.80	7.90	—	2.875	7.80	7.90	—	0.276	2.323	7.67	2.80	5.80	3.92	—
2 7/8	8.60	8.70	—	2.875	8.60	8.70	—	0.308	2.259	8.45	2.60	5.00	3.16	—
2 7/8	9.35	9.45	—	2.875	9.35	9.45	—	0.340	2.195	9.21	—	—	—	—
2 7/8	10.50	—	—	2.875	10.50	—	—	0.392	2.091	10.40	—	—	—	—
2 7/8	11.50	—	—	2.875	11.50	—	—	0.440	1.995	11.45	—	—	—	—
3 1/2	7.70	—	—	3.500	7.70	—	—	0.216	3.068	7.58	5.40	—	—	—
3 1/2	9.20	9.30	—	3.500	9.20	9.30	—	0.254	2.992	8.81	5.00	9.20	5.40	—
3 1/2	10.20	—	—	3.500	10.20	—	—	0.289	2.922	9.92	4.80	—	—	—
3 1/2	12.70	12.95	—	3.500	12.70	12.95	—	0.375	2.750	12.53	4.00	8.20	4.40	—
3 1/2	14.30	—	—	3.500	14.30	—	—	0.430	2.640	14.11	—	—	—	—
3 1/2	15.50	—	—	3.500	15.50	—	—	0.476	2.548	15.39	—	—	—	—
3 1/2	17.00	—	—	3.500	17.00	—	—	0.530	2.440	16.83	—	—	—	—
4	9.50	—	—	4.000	9.50	—	—	0.226	3.548	9.12	6.20	—	—	—
4	10.70	11.00	—	4.000	—	11.00	—	0.262	3.476	10.47	—	10.60	—	—
4	13.20	—	—	4.000	13.20	—	—	0.330	3.340	12.95	—	—	—	—
4	16.10	—	—	4.000	16.10	—	—	0.415	3.170	15.90	—	—	—	—
4	18.90	—	—	4.000	18.90	—	—	0.500	3.000	18.71	—	—	—	—
4	22.20	—	—	4.000	22.20	—	—	0.610	2.780	22.11	—	—	—	—

Table E.19—Dimensions and Masses for Standard Tubing and for Tubing Threaded with API Non-upset, External Upset, and Integral Tubing Connections *(continued)*

Labels [a]				Outside Diameter	Nominal Linear Masses [b, c]			Wall Thickness	Inside Diameter	Calculated Mass [c]				
										Plain-end	e_m, Mass Gain or Loss Due to End-finishing [d] lb			
1	2			D in.	Non-upset T&C lb/ft	External Upset T&C lb/ft	Integral Joint lb/ft	t in.	d in.	w_{pe} lb/ft	Non-upset	External Upset [e]		Integral Joint
	NU T&C	EU T&C	IJ									Regular	Special Clearance	
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
4 1/2	12.60	12.75	—	4.500	12.60	12.75	—	0.271	3.958	12.25	6.00	13.20	—	—
4 1/2	15.20	—	—	4.500	15.20	—	—	0.337	3.826	15.00	—	—	—	—
4 1/2	17.00	—	—	4.500	17.00	—	—	0.380	3.740	16.77	—	—	—	—
4 1/2	18.90	—	—	4.500	18.90	—	—	0.430	3.640	18.71	—	—	—	—
4 1/2	21.50	—	—	4.500	21.50	—	—	0.500	3.500	21.38	—	—	—	—
4 1/2	23.70	—	—	4.500	23.70	—	—	0.560	3.380	23.59	—	—	—	—
4 1/2	26.10	—	—	4.500	26.10	—	—	0.630	3.240	26.06	—	—	—	—

NOTE See also Figures D.4, D.5, and D.7.

[a] Labels are for information and assistance in ordering.

[b] Nominal linear masses (columns 6, 7, and 8) are shown for information only.

[c] The densities of martensitic chromium (L80 Types 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for martensitic chromium steels. A mass correction factor of 0.989 shall be used.

[d] Mass gain or loss due to end-finishing; see 7.5.

[e] The length of the upset may alter the mass gain or loss due to end-finishing.

Table E.20—External Upset Tubing Dimensions for API Connections for Grades H40, J55, L80, R95, N80, C90, T95, and P110

Labels [a]		Size Outside Diameter D	Nominal Linear Mass Threaded and Coupled [b]	Upset			
				Outside Diameter [c] D_4	Length from End of Pipe to Start of Taper [d, e] L_{eu}	Length from End of Pipe to End of Taper [e] L_a	Length from End of Pipe to Start of Pipe Body [e] L_b
1	**2**	in.	lb/ft	in. +0.0625 0	in. 0 –1	in.	in. **max**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	1.20	1.050	1.20	1.315	2 3/8	—	—
1.050	1.54	1.050	1.54	1.315	2 3/8	—	—
1.315	1.80	1.315	1.80	1.469	2 1/2	—	—
1.315	2.24	1.315	2.24	1.469	2 1/2	—	—
1.660	2.40	1.660	2.40	1.812	2 5/8	—	—
1.660	3.07	1.660	3.07	1.812	2 5/8	—	—
1.900	2.90	1.900	2.90	2.094	2 11/16	—	—
1.900	3.73	1.900	3.73	2.094	2 11/16	—	—
2 3/8	4.70	2.375	4.70	2.594	4.00	6.00	10.00
2 3/8	5.95	2.375	5.95	2.594	4.00	6.00	10.00
2 3/8	7.45	2.375	7.45	2.594	4.00	6.00	10.00
2 7/8	6.50	2.875	6.50	3.094	4 1/4	6 1/4	10 1/4
2 7/8	7.90	2.875	7.90	3.094	4 1/4	6 1/4	10 1/4
2 7/8	8.70	2.875	8.70	3.094	4 1/4	6 1/4	10 1/4
2 7/8	9.45	2.875	9.45	3.094	4 1/4	6 1/4	10 1/4
3 1/2	9.30	3.500	9.30	3.750	4 1/2	6 1/2	10 1/2
3 1/2	12.95	3.500	12.95	3.750	4 1/2	6 1/2	10 1/2
4	11.00	4.000	11.00	4.250	4 1/2	6 1/2	10 1/2
4 1/2	12.75	4.500	12.75	4.750	4 3/4	6 3/4	10 3/4

NOTE 1 See also Figures D.5 and D.6.

NOTE 2 Nominal linear masses are shown for information only.

[a] Labels are for information and assistance in ordering.

[b] The densities of martensitic chromium steels (L80 9Cr and 13Cr) are different from carbon steels. The masses shown are therefore not accurate for chromium steels. A mass correction factor of 0.989 shall be used.

[c] The minimum outside diameter of upset D_4 is limited by the minimum length of full-crest threads; see API 5B.

[d] For pup joints only, the length tolerance on L_{eu} is +4 in. to -1 in. The length on L_b may be 4 in. longer than specified.

[e] For extended-length upsets on external upset tubing, add 1 in. to the dimensions in columns 6, 7, and 8.

Table E.21—Integral Tubing Connection Dimensions for API Connections for Grades H40, J55, L80, R95, N80, C90, and T95

Labels		Outside Diameter D	Nominal Linear Mass [a]	Upset Dimensions								
				Pin				Box				
				Outside Diameter [b] D_4	Inside Diameter [c] d_{iu}	Length L_{iu}	Length of Taper m_{iu}	Outside Diameter W_b	Length L_{eu}	Length of Taper m_{eu}	Diameter of Recess Q	Width of Face b
1	**2**	in.	lb/ft	in. +0.0625 -0	in. +0.015 -0	in. **min**	in. **min**	in. +0.005 –0.025	in. **min**	in.	in.	in. **min**
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1.315	1.72	1.315	1.72	—	0.970	1 3/8	1/4	1.550	1.750	1	1.378	1/32
1.660	2.10	1.660	2.10	—	1.301	1 1/2	1/4	1.880	1.875	1	1.723	1/32
1.660	2.33	1.660	2.33	—	1.301	1 1/2	1/4	1.880	1.875		1.723	1/32
1.900	2.40	1.900	2.40	—	1.531	1 5/8	1/4	2.110	2.000	1	1.963	1/32
1.900	2.76	1.900	2.76	—	1.531	1 5/8	1/4	2.110	2.000		1.963	1/32
2.063	3.25	2.063	3.25	2.094	1.672	1 11/16	1/4	2.325	2.125	1	2.156	1/32

NOTE See also Figure D.7.

[a] Nominal linear masses, upset and threaded, are shown for information only.

[b] The minimum outside diameter D_4 is limited by the minimum length of full-crest threads; see API 5B.

[c] The minimum diameter d_{iu} is limited by the drift test.

Table E.22—Range Lengths

Dimensions in feet

	Range 1 [b]	Range 2 [b]	Range 3 [b]
Casing (PE/T and C/SF)			
Total range length, inclusive	16.0 to 25.0	25.0 to 34.0	34.0 to 48.0
Permissible variation, max [a]	6.0	5.0	6.0
Tubing and casing used as tubing (PE/T and C/SF)			
Total range length, inclusive	20.0 to 24.0	28.0 to 32.0	38.0 to 42.0
Permissible variation, max [a]	2.0	2.0	2.0
Integral tubing connections (including IJ/PE and IJ/SF)			
Total range length, inclusive	20.0 to 26.0	28.0 to 34.0	38.0 to 45.0
Permissible variation, max [a]	2.0	2.0	2.0
Pup joints [b]	Lengths: 2; 3; 4; 6; 8; 10; and 12 Tolerance: ±3 in.		

[a] Length variation applies to rail car shipment to the point of use and does not apply to order items less than 40,000 lb of pipe.

[b] Lengths other than those listed may be furnished by agreement between the purchaser and the manufacturer.

Table E.23—Standard Drift Size

Dimensions in inches

Product and Label 1	Standard Drift Mandrel Size min	
	Length	Diameter
Casing		
< 9 5/8	6	$d - 1/8$
≥ 9 5/8 to ≤ 13 3/8	12	$d - 5/32$
> 13 3/8	12	$d - 3/16$
Tubing [a, b]		
≤ 2 7/8	42	$d - 3/32$
> 2 7/8 to ≤ 8 5/8	42	$d - 1/8$
> 8 5/8 to < 10 3/4	42	$d - 5/32$

[a] Integral-joint tubing shall be tested before upsetting with a drift mandrel as shown and shall also be drift-tested at the pin end, after upsetting, with a cylindrical drift mandrel 42 in. in length and $d_{iu} - 0.015$ in diameter (see Table E.21, column 6 for d_{iu}).

[b] Casing sizes larger than Label 1: 4 1/2 but smaller than Label 1: 10 3/4 specified by the purchaser to be used in tubing service shall be marked as specified in Section 10.

Table E.24—Alternative Drift Size

Labels		Pipe Outside Diameter *D* mm	Nominal Linear Mass, T&C lb/ft	Alternative Drift Mandrel Size in. min	
1	2			Length	Diameter
1	*2*	*3*	*4*	*5*	*6*
7	23.00	7.000	23.3	6	6.250
7	32.00	7.000	32.2	6	6.000
7 3/4	46.10	7.750	46.1	6	6.500
8 5/8	32.00	8.625	32.0	6	7.875
8 5/8	40.00	8.625	40.0	6	7.625
9 5/8	40.00	9.625	40.0	12	8.750
9 5/8	53.50	9.625	53.5	12	8.500
9 5/8	58.40	9.625	58.4	12	8.375
10 3/4	45.50	10.750	45.5	12	9.875
10 3/4	55.50	10.750	55.5	12	9.625
11 3/4	42.00	11.750	42.0	12	11.000
11 3/4	60.00	11.750	60.0	12	10.625
11 3/4	65.00	11.750	65.0	12	10.625
13 3/8	72.00	13.375	72.0	12	12.250

NOTE 1 Subsection 7.10 allows other dimensions when specified in the purchase agreement.

NOTE 2 See footnote [b] to Table E. 23 for casing used as tubing.

Table E.25—Maximum Permissible Depth of Linear Imperfections

Grade	Depth as % of Specified Wall Thickness	
	External Imperfections	Internal Imperfections
H40 – J55 – K55 – N80Q – L80 – R95 [P110 to A.9 (SR 16)]	12.5 %	12.5 %
N80 Type 1	10 %	10 %
C90 – T95 – C110 – P110 – Q125	5 %	5 %
[P110 to A.9 (SR 16) and A.3 (SR 2)]	5 %	5 %

Table E.26—Upset Products—Maximum Permissible Depth of Imperfections

	Surface	Depth	Measurement Notes
A Integral-joint and External Upset Tubing (see Figure D.5 and Figure D.7)			
A.1	All surfaces of upset and upset run- out interval, except as stated below	12.5 % t	Percentage of specified pipe body wall thickness t; for nonlinear imperfections; for all Grades of pipe.
		12.5 % t	Percentage of specified pipe body wall thickness t; for linear imperfections; for Grades H40, J55, K55, L80, N80, and R95.
		5 % t	Percentage of specified pipe body wall thickness t; for linear imperfections; for Grades C90, T95, and P110 pipe.
A.2	The minimum wall thickness in the upset run-out interval, and the maximum combined effect of coincident internal and external imperfections in all areas, shall not total less than 87.5 % of the specified wall thickness.		
B Integral Tubing Connections (see Figure D.7)			
B.1	Box end and external surface	0.010 in.	From end of pipe to a plane at a distance equal to the specified minimum dimension L_{eu} (see Figure D.7) from end of pipe.
B.2	Pin end internal surface	0.015 in.	From end of pipe to a plane at a distance equal to the specified minimum dimension L_{iu} (see Figure D.7) from end of pipe.
			For Grades C90 and T95, the maximum permissible depth for linear imperfections shall be 5 % of the specified pipe body wall thickness.
B.3	Upset underfill in the upset run-out intervals shall not be considered a defect unless the remaining wall thickness (at the upset underfill) is less than 87.5 % of the specified pipe body wall thickness.		

Table E.27—API Round Thread Casing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter W [b, c] in.	Minimum Length in.		Diameter of Recess Q [d] in.	Width of Bearing Face b in.	Mass lb	
	Outside Diameter D in.		Short N_L	Long N_L			Short	Long
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
4 1/2	4.500	5.250	6 1/4	7	4 19/32	9/32	11.55	13.15
5	5.000	5.800	6 1/2	7 3/4	5 3/32	9/32	14.17	17.32
5 1/2	5.500	6.300	6 3/4	8	5 19/32	1/4	16.18	19.66
6 5/8	6.625	7.390	7 1/4	8 3/4	6 23/32	1/4	20.11	25.00
7	7.000	7.875	7 1/4	9	7 3/32	5/16	23.98	30.69
7 5/8	7.625	8.500	7 1/2	9 1/4	7 25/32	7/32	26.80	34.15
8 5/8	8.625	9.625	7 3/4	10	8 25/32	1/4	34.44	47.42
9 5/8	9.625	10.625	7 3/4	10 1/2	9 25/32	1/4	39.36	55.72
10 3/4	10.750	11.750	8	—	10 25/32	1/4	45.38	—
11 3/4	11.750	12.750	8	—	11 29/32	1/4	49.44	—
13 3/8	13.375	14.375	8	—	13 17/32	7/32	56.04	—
16	16.000	17.000	9	—	16 7/32	7/32	75.69	—
18 5/8	18.625	20.000	9	—	18 27/32	7/32	117.58	—
20	20.000	21.000	9	11 1/2	20 7/32	7/32	94.38	125.61

NOTE See also Figure D.1 and Figure D.2.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] All Grades except Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than ±1/8 in.

[c] Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than $\frac{+1/8}{-1/16}$ in.

[d] Tolerance on diameter of recess, Q, for all Grades: $\frac{+0.331}{0}$ in.

Table E.28—API Buttress Thread Casing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter		Minimum Length	Diameter of Counterbore	Width of Bearing Face	Mass lb	
	Outside Diameter D in.	Regular W [b, c] in.	Special Clearance [d] W_c in.	N_L in.	Q in.	b in.	Regular	Special Clearance
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
4 1/2	4.500	5.250	4.875	8 7/8	4.640	1/4	15.19	7.68
5	5.000	5.800	5.375	9 1/8	5.140	9/32	18.46	8.82
5 1/2	5.500	6.300	5.875	9 1/4	5.640	9/32	20.50	9.85
6 5/8	6.625	7.390	7.000	9 5/8	6.765	1/4	24.49	12.46
7	7.000	7.875	7.375	10	7.140	5/16	30.82	13.84
7 5/8	7.625	8.500	8.125	10 3/8	7.765	5/16	34.88	20.47
8 5/8	8.625	9.625	9.125	10 5/8	8.765	3/8	45.99	23.80
9 5/8	9.625	10.625	10.125	10 5/8	9.765	3/8	51.05	26.49
10 3/4	10.750	11.750	11.250	10 5/8	10.890	3/8	56.74	29.52
11 3/4	11.750	12.750	—	10 5/8	11.890	3/8	61.80	—
13 3/8	13.375	14.375	—	10 5/8	13.515	3/8	70.03	—
16	16.000	17.000	—	10 5/8	16.154	3/8	88.81	—
18 5/8	18.625	20.000	—	10 5/8	18.779	3/8	138.18	—
20	20.000	21.000	—	10 5/8	20.154	3/8	110.45	—

NOTE See also Figure D.3.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] All Grades except Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than ±1/8 in.

[c] Grade Q125—Tolerance on outside diameter W: ±1 % but not greater than $\frac{+1/8}{-1/16}$ in.

[d] All Grades except Grade Q125—Tolerance on outside diameter W_c: $\frac{-1/64}{+1/32}$ in.

Table E.29—API Non-upset Tubing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter W [b] in.	Minimum Length N_L in.	Diameter of Recess Q in.	Width of Bearing Face b in.	Maximum Bearing Face Diameter, Special Bevel B_f in.	Mass lb
	Outside Diameter D in.						
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1.050	1.050	1.313	3 3/16	1.113	1/16	1.181	0.51
1.315	1.315	1.660	3 1/4	1.378	3/32	1.488	0.84
1.660	1.660	2.054	3 1/2	1.723	1/8	1.857	1.29
1.900	1.900	2.200	3 3/4	1.963	1/16	2.050	1.23
2 3/8	2.375	2.875	4 1/4	2.438	3/16	2.625	2.82
2 7/8	2.875	3.500	5 1/8	2.938	3/16	3.188	5.15
3 1/2	3.500	4.250	5 5/8	3.563	3/16	3.875	8.17
4	4.000	4.750	5 3/4	4.063	3/16	4.375	9.58
4 1/2	4.500	5.200	6 1/8	4.563	3/16	4.850	10.77

NOTE See also Figure D.4.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] Tolerance on outside diameter W: ±1 %.

Table E.30—API External Upset Tubing Coupling—Dimensions, Tolerances, and Masses

Label 1	Size [a]	Outside Diameter		Minimum Length N_L in.	Diameter of Recess Q in.	Width of Bearing Face, Regular b in.	Maximum Bearing Face Diameter B_f		Mass lb	
	Outside Diameter D in.	Regular W [b] in.	Special Clearance W_c [c] in.				Regular with Special Bevel in.	Special Clearance in.	Regular	Special Clearance
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1.050	1.050	1.660	—	3 1/4	1.378	3/32	1.488	—	0.84	—
1.315	1.315	1.900	—	3 1/2	1.531	3/32	1.684	—	1.26	—
1.660	1.660	2.200	—	3 3/4	1.875	1/8	2.006	—	1.49	—
1.900	1.900	2.500	—	3 7/8	2.156	1/8	2.297	—	1.85	—
2 3/8	2.375	3.063	2.910	4 7/8	2.656	5/32	2.828	2.752	3.43	2.35
2 7/8	2.875	3.668	3.460	5 1/4	3.156	7/32	3.381	3.277	5.30	3.42
3 1/2	3.500	4.500	4.180	5 3/4	3.813	1/4	4.125	3.965	9.03	5.24
4	4.000	5.000	—	6	4.313	1/4	4.625	—	10.63	—
4 1/2	4.500	5.563	—	6 1/4	4.813	1/4	5.156	—	13.33	—

NOTE See also Figure D.5.

[a] The size designation for the coupling is the same as the size designation for the pipe on which the coupling is used.

[b] Tolerance on outside diameter W: ±1 %.

[c] Tolerance on outside diameter W_c: ±0.015 in.

Table E.31—Permissible Depth of External Imperfections on Coupling

Dimensions in inches

Coupling for Label 1		Grades H40, J55, K55, N80, R95, L80, and P110		Grades C90, T95, C110, and Q125
		Pits and Round-bottom Gouges	Grip Marks and Sharp-bottom Gouges	Pits, Round-bottom Gouges, Sharp-bottom Gouges, Grip Marks
1	*2*	*3*	*4*	*5*
Tubing	< 3 1/2	0.030	0.025	0.030
	≥ 3 1/2 to ≤ 4 1/2	0.045	0.030	0.035
Casing [a]	< 6 5/8	0.035	0.030	0.030
	≥ 6 5/8 to ≤ 7 5/8	0.045	0.040	0.035
	> 7 5/8	0.060	0.040	0.035

[a] Includes casing used as tubing.

Table E.32—Frequency of Tensile Tests—Casing and Tubing

Grade [e]	Label 1	Maximum Number of Pieces in a Lot	Number of Tests	
			Per Lot	Per Heat
1	*2*	*3*	*4*	*5*
H40, K55, J55, N80	< 6 5/8	400 [a, b]	1	1
	≥ 6 5/8	200 [a, b]	1	1
R95	≤ 4 1/2	200 [a, b]	2 [c]	1
	> 4 1/2	100 [a, b]	2 [c]	1
L80 Type 1, L80 3Cr	≤ 4 1/2	200 [a, b]	2 [c]	1
L80 9Cr, L80 13Cr	≤ 4 1/2	200 [b, d]	2 [c]	—
C90, T95	≤ 4 1/2	200 [b, d]	1	—
L80 Type 1, L80 3Cr	> 4 1/2	100 [a, b]	2 [c]	1
L80 9Cr, L80 13Cr	> 4 1/2	100 [b, d]	2 [c]	—
C90, T95	> 4 1/2	100 [b, d]	1	—
C110	All sizes	100 [b, d]	1	—
P110	< 6 5/8	200 [a, b]	1	1
	≥ 6 5/8	100 [a, b]	1	1
Q125	All sizes	— [d]	3 [c]	—

NOTE Table includes casing used as tubing.

[a] See 9.2.1.

[b] See 9.4.2.

[c] See 9.4.3.

[d] See 9.2.2.

[e] For all Grades except Grade Q125 multiple-length seamless pipe, a length shall be considered as all of the sections cut from a particular multiple length, provided the pipe receives no additional heat treatment after being cut into individual lengths.

Table E.33—Frequency of Tensile Tests—Coupling Stock, Coupling Material, and Coupling Blanks

Grade	Material	Condition When Heat-treated	Maximum Number of Pieces in a Lot	Number of Tests	
				Per Lot	Per Heat
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80, and P110	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [a]	1	1 [b]
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [a]	1	1 [b]
		Coupling blank	400 [c]	1	—
	Hot forging	Coupling blank	400 [c]	1	—
R95, L80 Type 1, L80 3Cr	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [a]	2 [d, e]	2 [d, e]
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [a]	2 [d, e]	2 [d, e]
		Coupling blank	400 [c]	2 [e]	—
	Hot forging	Coupling blank	400 [c]	2 [e]	—
L80 9Cr and L80 13Cr	Coupling stock and coupling material	Coupling stock and coupling material for pipe ≤ Label 1: 4 1/2	200 [d]	2 [d, e]	—
		Coupling stock and coupling material for pipe > Label 1: 4 1/2	100 [d]	2 [d, e]	—
		Coupling blank	400 [c]	2 [e]	—
	Hot forging	Coupling blank	400 [c]	2 [e]	—
C90 and T95	Coupling stock and coupling material	Coupling stock and coupling material for pipe Label 1: All sizes	1 [b]	1	—
		Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
	Hot forging	Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
C110 and Q125	Coupling stock and coupling material	Coupling stock and coupling material for pipe Label 1: All sizes	1 [b]	1	—
		Coupling blank	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		

[a] See 9.2.1.

[b] Approximately 50 % from each end.

[c] See 9.2.3.

[d] See 9.2.2.

[e] When more than one test is required, the test specimens shall be from different lengths. except for a single piece lot where the test specimens may be taken from both ends of the length.

Table E.34—Frequency of Tensile Testing—Pup Joints and Accessory Material

Grade	Material and Heat Treatment Conditions [a]		Maximum Number of Pieces in a Lot	Number of Tests	
				Per Lot	Per Heat
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80	Full-length standard tubing or casing from one or more heats		Label 1: < 6 5/8: 400	1	1
			Label 1: ≥ 6 5/8: 200		
P110	Full-length standard tubing or casing from one or more heats		Label 1: < 6 5/8: 200	1	1
			Label 1: ≥ 6 5/8: 100		
H40, J55, K55, N80, P110	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	1	1
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	1	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	1	—
R95, L80 Type 1, L80 3Cr	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	2 [a, b]	2 [a, b]
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	2 [a, b]	2 [a, b]
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	2 [b]	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	2 [b]	—
L80 9Cr, L80 13Cr	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	2 [a, b]	—
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		Label 1: ≤ 4 1/2: 200	2 [a, b]	—
			Label 1: > 4 1/2: 100		
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	100 pup joints or 400 accessory material	2 [b]	—
		Heat-treated in sequential loads or continuous heat treatment	In accordance with 9.2.3	2 [b]	—
C90 and T95	Full-length standard tubing or casing from one or more heats		Label 1: ≤ 4 1/2: 200	1	—
			Label 1: > 4 1/2: 100		
	Thick-wall mechanical tube or bar stock from a single heat		1	1 [a]	—
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
		Heat-treated in sequential loads or continuous heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
C110 and Q125	Full-length standard tubing or casing from one or more heats		In accordance with 9.2.3	3 [a, b]	—
	Thick-wall mechanical tube or bar stock from a single heat		1	1 [a]	—
	Heat-treated in individual lengths or hot forgings	Batch heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		
		Heat-treated in sequential loads or continuous heat treatment	Label 1: < 9 5/8: 50 [c]	1	—
			Label 1: ≥ 9 5/8: 30 [c]		

[a] Approximately 50 % from each end.

[b] When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

[c] Each lot shall be from the same heat of steel for Grades L80 9Cr, L80 13Cr, C90, T95, C110, and Q125; see 9.2.3.

Table E.35—Frequency of Hardness Testing

Grade	Material		Number of Tests per Lot	Maximum Number of Pieces in a Lot	Type of Test	Location
1	*2*		*3*	*4*	*5*	*6*
L80	Pipe, coupling stock, coupling material	Label 1: ≤ 4 1/2	2 [a]	200 [b, c]	Through-wall, 1 quadrant	Body tensile test
		Label 1: > 4 1/2	2 [a]	100 [b, c]	Through-wall, 1 quadrant	Body tensile test
	Coupling blanks or hot forgings		2 [a]	Heat-treat lot or 400 coupling blanks [b, c]	Through-wall, 1 quadrant	Coupling blank tensile test
	Pup joints and accessory material (heat-treated in individual lengths)	Batch heat treatment (method a, 9.2.3)	2 [a]	100 pup joints or 400 accessory material [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
		Heat-treated in sequential loads (method b, 9.2.3)	2 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
		Continuous heat treatment (method c, 9.2.3)	2 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pup joint or accessory tensile test
C90, T95	As-quenched product		1	Each production run or heat treatment practice	Through-wall, 4 quadrants	Design area of greatest thickness
	Non-upset pipe		1	Each length	Through-wall, 1 quadrant	Approximately 50 % from each end
	Upset pipe		1	Each length	Surface—HRC or HBW	Pipe body and one upset [d]
			1	20 [c]	Through-wall, 4 quadrants	One upset
			1	Label 1: ≤ 4 1/2: 200	Through-wall, 4 quadrants	Pipe body tensile test
				Label 1: > 4 1/2: 100		
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube-length heat treatment	2 [a]	Each length	Through-wall, 4 quadrants	One from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 5/8: 50 [c]	Through-wall, 4 quadrants	From a piece with the highest surface hardness number in the lot
				Label 1: ≥ 9 5/8: 30 [c]		

Table E.35—Frequency of Hardness Testing *(continued)*

Grade	Material		Number of Tests per Lot	Maximum Number of Pieces in a Lot	Type of Test	Location
1	*2*		*3*	*4*	*5*	*6*
C110	As-quenched product		1	Each production run or heat treatment practice	Through-wall, 4 quadrants	Design area of greatest thickness
	Non-upset pipe		2	One from each end	Through-wall, 1 quadrant	Each end of each piece
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube length heat treatment	2 [a]	Each length	Through-wall, 4 quadrants	One from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 $^{5}/_{8}$: 50 [c]	Through-wall, 4 quadrants	From a piece with the highest surface hardness number in the lot
				Label 1: ≥ 9 $^{5}/_{8}$: 30 [c]		
Q125	Casing		3 [a]	Lot (see 9.2) [b, c]	Through-wall, 1 quadrant	Pipe body
	Coupling blanks, coupling stock, coupling material, pup joints, and accessory material	Tube length heat treatment	1	Each length	Through-wall, 1 quadrant	Approximately 50 % from each end
		Individual heat treatment	1	Each piece	Surface—HRC or HBW	Each piece
			1	Label 1: < 9 $^{5}/_{8}$: 50 [c]	Through-wall, 1 quadrant	Randomly selected piece
				Label 1: ≥ 9 $^{5}/_{8}$: 30 [c]		

[a] When more than one test is required, the test specimens shall be from different lengths, except for a single piece lot where the test specimens may be taken from both ends of one length.

[b] The lengths tested shall be selected randomly and represent the start and end of the heat treatment cycle.

[c] Each lot shall be from the same heat of steel for Grades L80 9Cr, L80 13Cr, C90, T95, and Q125.

[d] One upset approximately 50 % from each end if both ends are upset.

Table E.36—Frequency of Flattening Tests

Casing and Tubing			
Grade	**Type of Heat Treatment**		**Number of Tests**
1	*2*	*3*	*4*
H40, J55, K55, N80, L80 Type 1, R95, P110	Non-full-body		As described in footnote [a]
	Full-body, full-length	≤ Label 1: 4 1/2	Same as non-full-body heat-treated or 1 per lot of 100 lengths or less
		> Label 1: 4 1/2 [b]	Same as non-full-body heat-treated or 1 per lot of 20 lengths or less
Q125	All		1 on each end of each length of pipe [see A.6 (SR 11)]

Pup Joints					
Grade	**Type of Heat Treatment**		**Maximum Number of Pieces in a Lot**	**Number of Tests**	
				Per Lot	**Per Heat**
1	*2*	*3*	*4*	*5*	*6*
H40, J55, K55, N80, L80 Type 1, R95, P110	Treated after cutting to length	Batch heat-treated	100 pup joints	1	1
		Continuously heat-treated	—		
	Treated before cutting to length	≤ Label 1: 4 1/2	200 lengths		
		> Label 1: 4 1/2 [b]	100 lengths		
Q125	All			1 on each end of each length of pipe	

[a] The leading end of the first pipe of each coil shall have two test specimens flattened: one in the 90° position and one in the 0° position. Two test specimens shall be flattened from an intermediate pipe of each coil: one in the 90° position and one in the 0° position. The trailing end of the last pipe of each coil shall have two test specimens flattened: one in the 90° position and one in the 0° position.

When a weld stop condition occurs during production of a multiple length, flattening tests with the weld at the 90° position and 0° position shall be made from the crop end resulting from each side of the weld stop, and may be substituted for the intermediate flattening tests.

90° position: the weld is positioned at 3 o'clock or at 9 o'clock; 0° position: the weld is positioned at 6 o'clock or at 12 o'clock.

[b] Includes casing used as tubing.

Table E.37—Summary of NDE Methods for Seamless Pipe, Coupling Stock, Body of Welded Pipe, and Accessory Material (in Accordance with 9.15.9 and 9.15.11)

Product	Grade	Visual Inspection (see 9.14)	Wall Thickness Verification	Ultrasonic Inspection	Flux Leakage Inspection	Eddy Current Inspection	Magnetic Particle Inspection [a]
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Pipe and accessory material	H40, J55, K55	R	N	N	N	N	N
	N80, L80, R95	R	R	A	A	A	A
	P110	R	R	A	A	A	NA
	Q125	R	R	C	B	B	B
Pipe	C90, T95, C110	R	R	C (A) [b]	B (A) [b]	B (A) [b]	B (NA) [b]
Accessory material	C90, T95, C110	R	R	C (A) [b]	B (A) [b]	B (A) [b]	B (A) [b]
Coupling stock	H40, J55, K55	R	NA	N	N	N	N
	N80, L80, R95, P110, C90, T95, C110, Q125	R	R	A	A	A	A

A = one method or any combination of methods shall be used; B = at least one method shall be used in addition to ultrasonic inspection to inspect on the outside surface; C = ultrasonic inspection shall be used to inspect the outside and inside surface; N = not required; NA = not applicable; R = required.

[a] MPI is permitted for end-area inspection. MPI is permitted for pipe-body outside-surface inspection in combination with other methods of pipe body inspection. MPI is permitted for coupling stock outside surface inspection and coupling stock oblique inspection. Coupling stock receiving full-length MPI does not require full-length wall thickness verification; however, mechanical wall thickness measurement of each end is required. MPI is permitted for the pipe OD and ID when inspected on the ends of the pipe uninspected area.

[b] Values in parenthesis () are specific to oblique angled defects.

Table E.38—Acceptance (Inspection) Levels

Material	Grade		External Imperfections			Internal Imperfections		
			Longitudinal	Transverse	Oblique	Longitudinal	Transverse	Oblique
1	*2*		*3*	*4*	*5*	*6*	*7*	*8*
Pipe body [a]	N80 Type 1		L3	—	—	L3	—	—
	N80Q, L80, R95		L4	—	—	L4	—	—
	[P110 to A.9 (SR 16)]		L4	L4	—	L4	L4	—
	P110		L2	L2	—	L2	L2	—
	[P110 to A.9 (SR 16) and A.3 (SR 2)]		L2	L2	—	L2	L2	—
	Q125	UT	L2	L2	—	L2	L2	—
		Second method	L2	L2	—	—	—	—
	C90, T95, C110	UT	L2	L2	L2 [b]	L2	L2	L2 [b]
		Second method	L2	L2	—	—	—	—
Coupling stock	All grades except L80 13Cr, C90, T95, C110, and Q125		L2	L2	—	N	N	—
	L80 13Cr, Q125		L2	L2	—	L3	L3	—
	C90, T95, C110		L2	L2	L2 [b]	L3	L3	L3 [b]
Weld seam	P110, Q125		L2	N	—	L2	N	—
	All other grades		L3	N	—	L3	N	—
	All other grades to A.3 (SR 2)		L2	N	—	L2	N	—

L*x* = acceptance (inspection) level; N = not required; UT = ultrasonic testing.

[a] Accessory material shall be treated as pipe body.

[b] Flux leakage inspection or eddy current inspection may be used as alternative NDE methods for oblique inspection for pipe body; flux leakage inspection, eddy current inspection, or magnetic particle inspection may be used as alternative NDE methods for oblique inspection for accessory material.

Table E.39—Artificial Reference Indicators

Acceptance (Inspection) Level	Notch Depth [a] Maximum %	Notch Length Maximum for Eddy Current in.	Notch Length Maximum at Full Depth (Methods Other Than Eddy Current) in.	Notch Width Maximum in.	Radially Drilled Hole Diameter [b] in.
1	*2*	*3*	*4*	*5*	*6*
L2	5	1.5	2.0	0.040	1/16
L3	10	1.5	2.0	0.040	1/8
L4	12.5	1.5	2.0	0.040	1/8

NOTE See Figure D.18.

[a] Depth as a percent of specified wall thickness; the depth tolerance shall be ±15 % of the calculated notch depth with a minimum notch depth of 0.3 mm ± 0.05 mm.

[b] Drilled hole diameter (through the pipe wall) shall be based on the drill bit size.

Table E.40—Size of Stamp Markings

Product	Label 1	Marking Height in.
Pipe	< 4 1/2	3/16
	≥ 4 1/2	1/4
Coupling	For pipe sizes < 4 1/2	1/4
	For pipe sizes ≥ 4 1/2 to < 7 5/8	3/8
	For pipe sizes ≥ 7 5/8	1/2

Table E.41—Grade Color Codes

Grade	Grade Type	Number and Color of Bands for Product [a] with Length ≥ 6.0 ft	Color(s) for Couplings	
			Entire Coupling	Band(s) [b, c]
1	*2*	*3*	*4*	*5*
H40	—	None or black band at the manufacturer's option	None	Same as for pipe
J55 Tubing	—	One bright green	Bright green	None
J55 Casing	—	One bright green	Bright green	One white
K55	—	Two bright green	Bright green	None
N80	1	One red	Red	None
N80	Q	One red, one bright green	Red	Green
R95	—	One brown	Brown	None
L80	1	One red, one brown	Red	One brown
L80	3Cr	One red, one white	Red [d]	One white
L80	9Cr	One red, one brown, two yellow	None	Two yellow
L80	13Cr	One red, one brown, one yellow	None	One yellow
C90	—	One purple	Purple	None
T95	—	One silver	Silver	None
C110	—	One white, two brown	White	Two brown
P110	—	One white	White	None
Q125	—	One orange	Orange	None

[a] In the case of coupling material, unless otherwise specified in the purchase agreement, the manufacturer's internal requirements shall govern.

[b] Special clearance couplings shall also have a black band.

[c] Seal-ring couplings shall also have a blue band.

[d] The painting of the entire coupling surface may be waived; see 10.4.

Table E.42—Thread Type Markings

Thread Type	Marked Symbol
Short round	SC
Long round	LC
Buttress	BC
Non-upset	NU
External upset	EU
Integral joint	IJ

Table E.43—Marking Requirements and Sequence

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Manufacturer's name or mark	«....»	D or P	D or P	P	P	P
2	API 5CT	5CT [c]	D or P	D or P	P	P	P
	Manufacturer's option: licensed/registered industry mark	«....»	D or P	D or P	P	P	P
	Date of manufacture as in 10.1.8 or 10.1.9.	«....»	D or P	D or P	P	P	P
3	Unthreaded pipe or SF, if applicable (place symbol after specification marking): — Unthreaded pipe either upset or non-upset	PE	D or P		P		
	— Pipe with SF threaded by the pipe mill or processor	SF	D or P		P		
	— Couplings threaded with SF	SF		D or P		P	
	— Coupling stock	CS					P
4	Size designation (fill in Label 1 designation from column 1 of Table E.1 or Table E.2)	«....»	P		P		
	Specified diameter for coupling stock and other products with no mass designation						P
5	Mass designation (fill in Label 2 designation from Table E.1 or Table E.2)	«....»	D or P		P		
	Specified wall thickness for coupling stock and other products with no mass designation						P
6	Grade of product: — H40	H					
	— J55	J					

Table E.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
6	— N80 Type 1	N1					
	— N80Q	NQ					
	— R95	R					
	— L80 Type 1	L					
	— L80 3Cr	L3Cr					
	— L80 9Cr	L9					
	— L80 13Cr	L13					
	— C90	C90T					
	— T95	C110					
	— C110	P					
	— P110	Q					
	— Q125						
	All Grade designations		D or P	D or P	P	P	P
7	Sulfide cracking test [f]						
	— C90	A, AH [g], B, or D					
	— T95	A, AH [g], B, or D					
	— C110	A, D					
	All test method designations				P	P	P
8	Reduced alternative impact test temperature, if applicable. Fill in specified test temperature for full-size specimens, including ± symbol and °F	«....»F	P	P	P	P	
9	Heat treatment, if applicable:						
	— J55 or K55 normalized	Z	P	P			P
	— J55 or K55 normalized and tempered (N&T)	N&T	P	P			P
10	Process of manufacture:						
	— Seamless	S					
	— Electric-welded	E					
	All designations		D or P		P		

Table E.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
11	Supplementary requirements, if applicable: — A.2 (SR 1)	S1	P		P		
	— A.3 (SR 2)	S2	P		P		
	— A.4 (SR 9) (fill in type)	S9Q«....»				P	
	— A.8 (SR 13)	S13		D or P		P	
	— A.9 (SR 16) (fill in minimum full-size energy absorption requirement, in ft·lb, and test temperature including ± symbol and °F)	S16«....»F	P		P		
	— A.13 (SR 41)	S41.1 S41.2	P P		P P		
	— A.14 (SR 42)	S42					
	— A.15 (SR 43)	S43			P	D [d] or P	
	— A.16 (SR 44)	S44			P	D [d] or P	
	— A.17 (SR 45)	S45			P	D [d] or P	
	— A.18 (SR 46)	S46	D or P	D or P	P		
	— A.19 (SR 47)	S47	P	D	P	D [d] or P	
	— A.20 (SR 48)	S48	P		P	D [d] or P	
	— A.21 (SR 49)	S49					
12	Hydrostatic test pressure [e] (fill in the actual test pressure, in psi) All designations	P«....»	P		P		
13	Type of thread, if applicable	«....»	P	P	P	P	

Table E.43—Marking Requirements and Sequence *(continued)*

Marking Sequence		Mark or Symbol [b]	Stencil and/or Stamp Marking Requirements [a]				
			Grades H40, J55, K55, N80, R95, and P110		Grades L80, C90, T95, C110, and Q125		All Grades
			Pipe	Couplings and Accessories	Pipe	Couplings and Accessories	Coupling Stock and Accessory Materials
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
14	Full-length drift test, if applicable: — Standard (casing or tubing)	D					
	— Alternative (casing or tubing) where « » is the size of the alternative drift	DA«....»					
	— For casing specified for tubing service and drift-tested in accordance with 7.10	DT42					
	All designations		P		P		
15	Serialization of Grades C90, T95, C110, and Q125				D [d] or P	D [d] or P	P
16	Tin plating of couplings, if applicable	T		P		P	
17	Couplings H40, J55, and K55 only visually inspected	V		P			
18	Additional markings (see 10.1.10)		D or P	D or P	D or P	P	P

NOTE See 10.4 for mandatory color code requirements.

[a] D = optional (die) stamping; P = requirement for (paint) stenciling.

[b] A blank space, «....», indicates information to be filled in.

[c] The manufacturer may include “API” before “5CT.”

[d] Stamp marking shall conform to the requirements of 10.2.

[e] Pipe can be identified as manufactured to SI units by the marked hydro-test pressure that will be less than 100 (MPa), whereas the pressure marked for pipe manufactured to USC units will be over 1000 (psi). This information is used to clearly identify the units used for CVN markings, which shall be in the same unit system as the pressure markings.

[f] “A” when tested using Method A (smooth tensile), “B” when tested using Method B (bent beam), “D” when tested using Method D (DCB). If more than one Test Method is required, then state the combination of the test method designations as above, in alphabetical order. For example, if purchaser requires Method D and A, then state and mark “AD.”

[g] For Grades C90 and T95, “AH” when tested at 90 % Ys_{min}.

[h] See Table E.42 for thread type markings.

Table E.44—Retention of Records

Requirement	Subsection Reference
Chemical Properties	
Heat analysis	9.3.1
Product analysis	9.3.2
Mechanical Properties	
Heat control tensile tests	9.4.2
Tensile tests on products	6.2, 9.4.7
Impact tests on products	6.4, 6.5, 6.6, 9.7
Hardness tests	6.7, 6.8, 6.9, 9.6
Hardenability tests	6.10, 9.9
Grain size (Grades C90, T95, and C110)	6.11, 9.8
Coupling tests	8.3
Hydrostatic Tests	
Tester recorder charts	9.12.1
Testing	9.12.1
Supplemental inspection when hydrostatic test pressure is limited, if applicable	A.13.1 (SR 41.1), A.13.2 (SR 41.2)
Manufacturer Certification	
Results of all required tests	12.3
Sulfide stress cracking test (Grades C90, T95, and C110)	6.14, 9.10
Calibration	Various

Annex F
(normative)

Requirements for Thread Protector Design and Validation

F.1 General

F.1.1 The design validation requirements in this annex pertain to thread protectors that are required by 11.2 for tubular products with API or SF threaded connections, in sizes Label 1: 2 3/8 and larger. These protectors are typically composite-type metal-plastic, composite-type plastic, or all-plastic construction; they have a plastic-type thread profile to prevent galling and a reinforced outer shell to resist impact loads. The thread protector shall be designed to meet the design and testing requirements of 11.2 and this annex.

F.1.2 The thread-protector manufacturer shall document the design criteria, evaluation data, and installation procedures to demonstrate conformance with these requirements. This information shall be available upon request to the protector purchaser or the tubular user.

F.1.3 The thread-protector manufacturer shall design the protector to be used in conjunction with API or SF thread forms. Thread-protector design shall assist in minimizing corrosion that can result from moisture intrusion or entrapment. The protectors shall be capable of a snug-up fit with the face of the pin or coupling as applicable (no gap). The use of a gasket-type insert in the pin-end protector is acceptable by agreement between the thread-protector manufacturer and the purchaser.

F.1.4 The protector shall be designed to operate in the temperature range of –46 °C (–50 °F) to 66 °C (150 °F). The tolerance for all test temperatures shall be ±6 °C (±10 °F).

F.1.5 The thread profile shall be made of a material that will prevent galling of both the pin and box threads. It shall have sufficient thread contact to ensure performance. There shall be no metal-to-metal contact on the connection thread form and no metal-to-metal or plastic-to-metal contact with radial, steel, seal surfaces.

F.1.6 All plastic shall be either compounded or protected against deterioration from ultraviolet light for not less than 1 year. This may be accomplished by either chemical additions to the plastic or mechanical methods that limit exposure to this type of radiation.

F.1.7 The protector shall not be affected by solvents (such as diesel fuel, acetone, varsol, and trichloroethylene), storage, or assembly-thread compounds.

F.1.8 Air entrapment in the plastic material during molding shall be minimized. This should be controlled by the manufacturing process. At least 90 % of any one thread shall remain where air entrapment voids do occur, and no continuous line of broken threads shall cross the seal area or perfect-thread area.

F.1.9 If hookable/liftable thread protectors are specified, the protectors shall be made in such a way to preclude contact between lift hooks and pipe ends or the threaded portion of the box.

F.1.10 Friction in the impact test device shall be limited to ensure transfer of specified energy to the test assembly. The impact test device shall be rigid enough that any deflection is so minor as to have no bearing on the test results.

F.1.11 During testing, each test assembly shall be identified with a unique sample identifier.

F.2 Validation Procedures

The validation procedures in Sections F.3 to F.10 determine the suitability for service of thread protectors. The thread-protector manufacturer shall test a minimum of two sizes of tubing and two sizes of casing that

define the size range for each of the design-types offered by the thread-protector manufacturer. The thread-protector manufacturer shall also provide objective evidence that pipe sizes tested are the worst case for design. Justification for extrapolation to nontested sizes shall be provided. The grade of the pipe used for validation testing shall be documented for information only.

F.3 Dimensional Stability Tests

F.3.1 The intent of the dimensional stability test is to ensure that changes in thread protector dimensions do not result in thread protector failure by disengagement. Thread protectors that do not meet their design criteria shall be rejected.

F.3.2 The thread diameters and seal diameters shall be measured and recorded (where applicable) on the thread protector at 21 °C (70 °F). The exact location of diameter measurements and their associated tolerances shall be defined in the thread-protector manufacturer's design criteria.

F.3.3 Using appropriate temperature media, thread protectors shall be soaked at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F). Soak time shall be sufficient to ensure that thread protectors achieve uniform temperature such that it can be demonstrated that no part of the thread protector is outside the temperature tolerance listed in F.1.4 at the time of test. Immediately upon removing protectors from the temperature medium, their thread and seal diameters shall be measured and recorded (where applicable). Diameters shall be within the tolerance defined in the thread-protector manufacturer's design criteria.

F.3.4 The thread protectors from F.3.3 shall be restabilized at 21 °C (70 °F). The thread diameters and the seal diameters shall be measured and recorded (where applicable) of the thread protectors in accordance with the thread-protector manufacturer's design criteria to detect permanent plastic deformation of the diameters. The preceding thermal cycle shall not result in thread protector disengagement.

F.4 Torque Tests

F.4.1 The pin and box-thread protector shall be self-locking and able to withstand vibrations encountered during transportation. Refer to the thread-protector manufacturer's procedures for torque requirements to seat and remove protectors.

F.4.2 The test assemblies shall be made up (with storage compound or thread compound, or both, applied to machined threaded area of a connection) by applying the protectors to the connections using the thread-protector manufacturer's recommended practice, and the make-up torque shall be recorded.

F.4.3 Protectors that are incapable of meeting the thread-protector manufacturer's required installation torque (or with stripping, disengaging, and not shouldering the threads of the protector) shall not be considered acceptable for service.

F.4.4 The test assemblies shall be made up at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F). The protector shall be broken-out from the connection, and the torque shall be recorded. The thread-protector manufacturer shall provide guidance on alternative methods for removal. Recorded torque values for the break-out of the protectors are for information only.

F.5 Vibration Test

F.5.1 Test assemblies shall be made up to the thread-protector manufacturer's installation procedure and vibration testing shall be performed as described herein.

F.5.2 The test shall be performed on a vertically oscillating vibration unit. The test assemblies shall initially be stabilized at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F) but allowed to return to ambient during the test. The test shall be conducted at a minimum of 900 cycles/min with a minimum vertical displacement of 8.4 mm (0.33 in.) and a minimum acceleration of four times gravitational acceleration.

F.5.3 Test assemblies shall be positioned horizontally on the unit and shall be fastened to the unit by the pipe body only. The thread protector shall not be in contact with anything other than its test piece.

F.5.4 The protector shall not fall off or out during a one-million-cycle test.

F.6 Axial Impact Tests

F.6.1 The test assemblies shall be made up (with appropriate storage compound or thread compound, or both) by applying the protectors to the connections using the thread-protector manufacturer's recommended practice, and the torque shall be recorded.

F.6.2 Test assemblies shall be stabilized at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F).

F.6.3 The test assemblies shall be subjected to the axial impact test (see Figure D.24) at the stabilized temperatures using a steel bar of 38 mm (1.5 in.) diameter and a minimum free fall height of 0.3 m (12 in.). The thread protectors (pin and box) shall be capable of sustaining the axial impact loads in Table F.1 for Class A protectors or Table F.2 for Class B protectors without damage as defined in 11.2.1. Location of impact on protector shall be such that the end result is an impact that is perpendicular to the pipe axis and centered on the diameter of the protector.

Table F.1—Class A: Axial Impact Test Using 38 mm (1.5 in.) Diameter Steel Bar

Test Temperature °C (°F)	**Minimum Impact Energy** Joules (foot-pounds)				
	Label 1: 2 3/8 to ≤ 4 1/2	**Label 1:** > 4 1/2 to ≤ 6 5/8	**Label 1:** > 6 5/8 to ≤ 8 5/8	**Label 1:** > 8 5/8 to < 16	**Label 1:** ≥ 16 to 20
1	*2*	*3*	*4*	*5*	*6*
66 (150)	130 (96)	383 (282)	599 (442)	911 (672)	1014 (748)
21 (70)	315 (232)	1026 (757)	1360 (1003)	2032 (1498)	2108 (1555)
−46 (−50)	195 (144)	574 (424)	899 (663)	1366 (1008)	1521 (1122)

Table F.2—Class B: Axial Impact Test Using 38 mm (1.5 in.) Diameter Steel Bar

Test Temperature °C (°F)	**Minimum Impact Energy** Joules (foot-pounds)				
	Label 1: 2 3/8 to ≤ 4 1/2	**Label 1:** > 4 1/2 to ≤ 6 5/8	**Label 1:** > 6 5/8 to ≤ 8 5/8	**Label 1:** > 8 5/8 to < 16	**Label 1:** ≥ 16 to 20
1	*2*	*3*	*4*	*5*	*6*
66 (150)	60 (44)	177 (130)	277 (204)	421 (310)	556 (410)
21 (70)	145 (107)	474 (350)	628 (463)	939 (692)	1156 (853)
−46 (−50)	90 (67)	265 (196)	415 (306)	631 (466)	835 (616)

F.7 Angular Impact Test

F.7.1 The test assemblies shall be made up (with storage compound or thread compound, or both) by applying the protectors to the connections using the protector manufacturer's recommended practice, and the make-up torque shall be recorded.

F.7.2 The made-up test assemblies shall be stabilized at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F).

F.7.3 A 45° angular impact load shall be applied (see Figure D.25) to the test assembly at the stabilized temperatures using a flat steel plate and a minimum free fall height of 0.3 m (12 in.). The thread protectors (pin and box) shall be capable of sustaining angular impact loads in Table F.3 for Class A protectors or Table F.4 for Class B protectors without damage as defined in 11.2.1. The flat steel plate impact shall be centered on the outermost rim of the thread protector, such that initial contact occurs at a single point. The plate dimensions shall exceed the protector dimensions of the test assembly below it. The plate shall be thick enough to ensure that impact does not result in permanent deformation of the plate.

Table F.3—Class A: Angular (45°) Impact Test Using a Flat Steel Plate

Test Temperature °C (°F)	**Minimum Impact Energy** Joules (foot-pounds)				
	Label 1: 2 3/8 to ≤ 4 1/2	**Label 1:** > 4 1/2 to ≤ 6 5/8	**Label 1:** > 6 5/8 to ≤ 8 5/8	**Label 1:** > 8 5/8 to < 16	**Label 1:** ≥ 16 to 20
1	*2*	*3*	*4*	*5*	*6*
66 (150)	65 (48)	191 (141)	299 (220)	454 (335)	494 (364)
21 (70)	157 (116)	512 (378)	678 (500)	1013 (747)	1026 (756)
−46 (−50)	97 (72)	286 (211)	448 (331)	681 (503)	740 (546)

Table F.4—Class B: Angular (45°) Impact Test Using a Flat Steel Plate

Test Temperature °C (°F)	**Minimum Impact Energy** Joules (foot-pounds)				
	Label 1: 2 3/8 to ≤ 4 1/2	**Label 1:** > 4 1/2 to ≤ 6 5/8	**Label 1:** > 6 5/8 to ≤ 8 5/8	**Label 1:** > 8 5/8 to < 16	**Label 1:** ≥ 16 to 20
1	*2*	*3*	*4*	*5*	*6*
66 (150)	19 (14)	56 (41)	87 (64)	132 (98)	193 (142)
21 (70)	46 (34)	149 (110)	197 (146)	295 (218)	401 (295)
−46 (−50)	28 (21)	83 (62)	130 (96)	198 (146)	289 (213)

F.8 Corrosion Test

F.8.1 The protector shall assist in the prevention of corrosion of the thread and sealing surfaces. Proper sealing, venting, and use of corrosion-inhibiting compounds are essential to minimize corrosion. The normal storage period shall be 1 year, as described in 11.2.2.

F.8.2 The salt spray (fog) test shall be in accordance with ASTM B117 to determine corrosion resistance for comparison purposes. The salt spray (fog) test may not duplicate actual field use due to factors other than thread-protector performance.

F.8.3 The test assembly shall be made up (with storage compound or thread compound, or both) by applying protectors to the connection using the thread-protector manufacturer's recommended practice, and the make-up torque shall be recorded.

F.8.4 The cut-off end of the connector shall be sealed and vented with a hole to allow chamber atmosphere circulation.

F.8.5 A salt spray (fog) test shall be conducted in accordance with ASTM B117 for a minimum of 1000 h at a temperature of 35 °C (95 °F).

F.8.6 The test assembly shall be oriented horizontally in the test chamber to simulate pipe rack storage. If there is any directionality to the flow of fog through the chamber, its principal direction should be parallel to the pipe axial direction.

F.8.7 The protectors shall be deemed to have passed the test if there is:

a) no or slight corrosion damage in the perfect thread area;

b) no corrosion on any (applicable non-threaded) sealing surface;

c) less than 10 % corrosion damage of the overall thread surface.

F.9 Stripping Test (Pin-end Protector Only)

F.9.1 The test assembly shall be made up (with storage compound or thread compound, or both) by applying protectors to the connector using the thread-protector manufacturer's recommended practice, and the make-up torque shall be recorded.

F.9.2 The test assembly shall be stabilized at –46 °C (–50 °F), 66 °C (150 °F), and 21 °C (70 °F).

F.9.3 A stripping test shall be conducted in accordance with IADC/SPE 11396 on the pin protector (see Figure D.26) at the required stabilized temperatures and with an axial load equal to or greater than F_{ax} calculated using Equation (F.1) (SI units) or Equation (F.2) (USC units):

$$F_{ax} = 0.18 \times w_{pe} \tag{F.1}$$

where

F_{ax} is the force, in kilonewtons;

w_{pe} is the plain end linear mass of the pipe, in kilograms per meter.

Or

$$F_{ax} = 60 \times w_{pe} \tag{F.2}$$

where

F_{ax} is the force, in pounds force;

w_{pe} is the plain-end linear mass of the pipe, in pounds per foot.

F.9.4 The load shall be applied uniformly around the base of the protector but shall not be applied in such a manner as to compress the protector onto the connector.

F.9.5 The protectors shall be removed and inspected for torn threads. Protector threads may show signs of stress but shall not be torn away.

F.10 Hookability (Liftability) Test

F.10.1 When a hookable (liftable) thread protector is required, the thread-protector manufacturer shall demonstrate the hookability (liftability) of the design by testing the matched set of two protectors to not lower than 150 % of the load (75 % of the load for single protector testing) based on the plain-end mass for the maximum anticipated wall thickness of a specified diameter pipe.

F.10.2 The hookability (liftability) shall be evaluated on the basis of no damage, as defined in 11.2.2, by applying the testing load at 90° and 60° to pipe axis for not less than 5 minutes.

F.10.3 The type of hook used for the test shall be documented.

Annex G
(informative)

Procedures Used to Convert from USC Units to SI Units

G.1 Background

The following procedures were adopted in this standard for converting units from the United States customary (USC) system into the International System of Units (SI).

G.2 General

G.2.1 Rounding

The last retained digit in a number was unchanged when the next digit was less than 5 or raised when it was greater than 5.

When the digit following the last retained digit was exactly 5 followed by zeros, the last retained digit was unchanged if it was even, or was raised if it was odd.

G.2.2 Fractions

Fractions or numbers with fractions in USC units were converted to the full decimal equivalents in USC units without rounding. The full decimal equivalents in USC units were then converted to SI values using Equation (G.1):

$$N_{\mathrm{m}} = 25.4 \times N \tag{G.1}$$

where

N_{m} is the SI equivalent, expressed in millimeters, of a USC fraction or USC number with fractions (in inches);

N is the full decimal equivalent, expressed in inches, of a USC fraction or number with fractions that has not been rounded.

The converted SI values, in millimeters, for the equivalent of USC fractions or numbers with fractions were rounded to the appropriate number of places for the application.

G.2.3 Tolerances

Equation (G.1) was used. The USC values for tolerances, except angular misalignment, were converted to SI values based on the appropriate conversion factor.

The converted SI values for the tolerances, except angular misalignment, were rounded to the same number of decimal places as the SI value to which they were applicable.

G.3 Pipe Dimensions

G.3.1 Outside Diameter

The USC values for outside diameters of pipe and couplings were converted to SI values using Equation (G.2):

$$D_m = 25.4 \times D \quad \text{(G.2)}$$

where

D_m is the outside diameter, expressed in millimeters;

D is the outside diameter, expressed in inches.

The converted SI values for the outside diameters of pipe and couplings were rounded to the nearest 0.01 mm.

G.3.2 Wall Thickness

The USC values for wall thickness were converted to SI values using Equation (G.3):

$$t_m = 25.4 \times t \quad \text{(G.3)}$$

where

t_m is the wall thickness, expressed in millimeters;

t is the wall thickness, expressed in inches.

The converted SI values for wall thickness were rounded to the nearest 0.01 mm.

G.3.3 Inside Diameter

The SI values for the inside diameters of pipe were calculated (not converted) using Equation (G.4):

$$d_m = D_m - (2 \times t_m) \quad \text{(G.4)}$$

where

d_m is the inside diameter, expressed in millimeters;

D_m is the outside diameter, expressed in millimeters;

t_m is the wall thickness, expressed in millimeters.

The calculated SI values for inside diameters of pipe were rounded to the nearest 0.01 mm.

G.3.4 Diameters and Lengths of Upsets

The USC values for the diameters and lengths of upsets were converted to SI values using Equation (G.5):

$$U_m = 25.4 \times U \quad \text{(G.5)}$$

where

U_m is the upset dimension, expressed in millimeters;

U is the upset dimension, expressed in inches.

The converted SI values for the diameters and lengths of upsets were rounded to the nearest 0.01 mm.

G.4 Drift Diameters

G.4.1 Drift Diameter, Standard Drift Size (Table C.23)

The SI values for standard drift diameters of pipe were calculated (not converted) using Equation (G.6):

$$dd_{\mathrm{m}} = d_{\mathrm{m}} - dc_{\mathrm{m}} \tag{G.6}$$

where

dd_{m} is the drift diameter, expressed in millimeters;

d_{m} is the inside diameter, expressed in millimeters;

dc_{m} is the drift constant, expressed in millimeters.

The drift constants used are given in Table G.1.

Table G.1—Drift Constants

Product	Label 1	dc_{m} mm
Casing	< 9 5/8	3.18
	9 5/8 to 13 3/8	3.97
	> 13 3/8	4.76
Tubing	≤ 2 7/8	2.38
	> 2 7/8	3.18
Casing specified by the purchaser to be used in tubing service where Label 1 is larger than 4 1/2 but smaller than 10 3/4	> 4 1/2 to 8 5/8	3.18
	> 8 5/8 to 10 3/4	3.97

The calculated SI values for standard drift diameters were rounded to the nearest 0.01 mm.

G.4.2 Drift Diameter, Alternative Drift Size (Table C.24)

The USC values for alternative drift diameters were converted to SI values using Equation (G.7):

$$dd_{\mathrm{a,m}} = 25.4 \times dd_{\mathrm{a}} \tag{G.7}$$

where

$dd_{\mathrm{a,m}}$ is the alternative drift diameter, expressed in millimeters;

dd_{a} is the alternative drift diameter, expressed in inches.

The converted SI values for alternative drift diameters were rounded to the nearest 0.01 mm.

G.5 Coupling Dimensions

G.5.1 Length of Couplings

The USC values for the lengths of couplings in inches and fractions of inches were converted to decimal

equivalents in USC units without rounding. The full decimal equivalent of the lengths of the couplings in USC units were then converted to SI units using Equation (G.8):

$$N_{L,m} = 25.4 \times N_L \quad \text{(G.8)}$$

where

$N_{L,m}$ is the length of couplings, expressed in millimeters;

N_L is the length of couplings, expressed in inches, without rounding.

The converted SI values for the lengths of couplings were rounded to the nearest 0.01 mm.

G.5.2 Diameter of Coupling Recess

The USC values for diameters of the coupling recess were converted to SI values using Equation (G.9):

$$Q_m = 25.4 \times Q \quad \text{(G.9)}$$

where

Q_m is the diameter of the coupling recess, expressed in millimeters;

Q is the diameter of the coupling recess, expressed in inches.

The converted SI values for the diameters of the coupling recess were rounded to the nearest 0.01 mm.

G.5.3 Width of the Coupling Bearing Face

The USC values for the widths of the bearing face of couplings were converted to SI values using Equation (G.10):

$$b_m = 25.4 \times b \quad \text{(G.10)}$$

where

b_m is the width of the coupling bearing face, expressed in millimeters;

b is the width of the coupling bearing face, expressed in inches.

The converted SI values for the widths of the coupling bearing faces were rounded to the nearest 0.01 mm.

G.5.4 Diameter at the Root of the Coupling Thread at the End of the Pipe in the Power-tight Position

The USC values for the diameter at the root of the coupling thread at the end of the pipe in the power-tight position were calculated without rounding and were then converted to SI values using Equation (G.11):

$$D_{1m} = 25.4 \times d_1 \quad \text{(G.11)}$$

where

D_{1m} is the diameter, expressed in millimeters, at the root of the coupling thread at the end of the pipe in the power-tight position;

d_1 is the unrounded diameter, expressed in inches, at the root of the coupling thread at the end of the pipe in the power-tight position.

The converted SI values for the diameter at the root of the coupling thread at the end of the pipe in the power-tight position were rounded to the nearest 0.01 mm.

G.6 Linear Mass

G.6.1 Nominal Threaded and Coupled Linear Mass

The USC values for nominal threaded and coupled linear mass were converted to SI units using Equation (G.12):

$$w_{\mathrm{m}} = 1.48816 \times w \tag{G.12}$$

where

w_{m} is the linear mass, expressed in kilograms per meter;

w is the linear mass, expressed in pounds per foot.

The converted SI values for nominal threaded and coupled linear mass were rounded to the nearest 0.01 kg/m.

G.6.2 Plain-end Linear Mass

The plain-end linear masses expressed in SI units were calculated (not converted) using Equation (G.13):

$$w_{\mathrm{pe,m}} = 0.0246615 \times (D_{\mathrm{m}} - t_{\mathrm{m}}) \times t_{\mathrm{m}} \tag{G.13}$$

where

$w_{\mathrm{pe,m}}$ is the plain-end linear mass, expressed in kilograms per meter;

D_{m} is the outside diameter, expressed in millimeters;

t_{m} is the wall thickness, expressed in millimeters.

The calculated SI values for plain-end linear masses were rounded to the nearest 0.01 kg/m.

G.6.3 Coupling Masses

The USC values for the calculated masses of couplings were converted to SI values using Equation (G.14):

$$w_{\mathrm{c,m}} = 0.453592 \times w_{\mathrm{c}} \tag{G.14}$$

where

$w_{\mathrm{c,m}}$ is the mass of the coupling, expressed in kilograms;

w_{c} is the mass of the coupling, expressed in pounds.

The converted SI values for calculated masses of couplings were rounded to the nearest 0.01 kg.

G.6.4 Mass Gain or Loss Due to End-finish

The USC values for mass gain or loss due to end-finish were converted to SI units using Equation (G.15):

$$e_{e,m} = 0.453592 \times e_e \quad \text{(G.15)}$$

where

$e_{e,m}$ is the mass gain or loss due to end-finish, expressed in kilograms;

e_e is the mass gain or loss due to end-finish, expressed in pounds.

The converted SI values for mass gain or loss due to end-finish were rounded to the nearest 0.01 kg.

G.7 Tensile and Flattening Tests

G.7.1 Yield Strength

The USC values for yield strength were converted to SI values using Equation (G.16):

$$Ys_m = 0.00689476 \times Ys \quad \text{(G.16)}$$

where

Ys_m is the yield strength, expressed in megapascals;

Ys is the yield strength, expressed in pounds per square inch.

The converted SI values for strengths were rounded to the nearest megapascal.

G.7.2 Tensile Strength

The USC values for tensile strength were converted to SI values using Equation (G.17):

$$Ts_m = 0.00689476 \times Ts \quad \text{(G.17)}$$

where

Ts_m is the tensile strength, expressed in megapascals;

Ts is the tensile strength, expressed in pounds per square inch.

The converted SI values for strengths were rounded to the nearest megapascal.

G.7.3 Elongation

The values for elongation, in SI units, were calculated (not converted) using Equation (G.18):

$$e_m = k \times (A_m^{0.2} / U_m^{0.9}) \quad \text{(G.18)}$$

where

e_m is the minimum elongation, expressed as a percentage;

k is a constant equal to 1944;

A_m is the cross-sectional area of the tensile specimen, expressed in square millimeters;

U_m is the specified minimum tensile strength, expressed in megapascals.

The calculated SI values for elongation were rounded to the nearest 1.0 % for values of 10.0 % and larger, and to the nearest 0.5 % for values less than 10.0 %.

G.7.4 Flattening Test Formula

The equation used to determine the maximum distance between the plates during a flattening test was Equation (G.19):

$$D_f = D \times [Z_1 - (Z_2 \times D / t)] \quad \text{(G.19)}$$

where

D_f is the maximum distance between the plates during a flattening test, expressed in inches or millimeters depending on the units of D and t;

Z_1 is a constant;

Z_2 is a constant;

D is the specified outside diameter of the pipe, expressed in inches or millimeters;

t is the specified wall thickness of the pipe, expressed in inches or millimeters.

The same values for the constants Z_1 and Z_2 were used regardless of whether the units for D and t were inches or millimeters, provided the units for both D and t were the same.

G.8 Charpy Impact Energy Requirements

G.8.1 Critical Thickness for Couplings with API Threads (Table C.7)

The USC values for the critical thickness for couplings with API threads were converted to SI values using Equation (G.20):

$$t_{c,m} = 25.4 \times t_c \quad \text{(G.20)}$$

where

$t_{c,m}$ is the critical thickness, expressed in millimeters;

t_c is the critical thickness, expressed in inches.

The calculated SI values were rounded to the nearest 0.01 mm.

G.8.2 Charpy Impact Energy

The USC values for standard CVN impact energy requirements that are not determined by an equation were converted to SI values using Equation (G.21):

$$C_m = 1.35582 \times C \quad \text{(G.21)}$$

where

C_m is the standard Charpy impact energy, expressed in joules;

C is the standard Charpy impact energy, expressed in foot-pounds (e.g. 8, 15, 20, 30 ft·lb).

The converted SI values for standard CVN impact energy were rounded to the nearest joule.

G.8.3 Minimum Absorbed Energy Requirements for Couplings

The SI values for the minimum absorbed energy requirements for couplings with API threads were calculated using Equations (G.22) and (G.23).

For Grades N80, L80, C90, R95, T95, P110, and Q125 transverse Charpy absorbed energy requirements for couplings:

$$C_{ctm} = f_c \times Ys_{max} \times [(0.00118 \times t_c) + 0.01259] \quad \text{(G.22)}$$

Longitudinal Charpy absorbed energy requirements for couplings:

$$C_{clm} = f_c \times Ys_{max} \times [(0.00236 \times t_c) + 0.02518] \quad \text{(G.23)}$$

where

C_{ctm} is the minimum transverse Charpy impact energy for couplings, expressed in joules;

C_{clm} is the minimum longitudinal Charpy impact energy for couplings, expressed in joules;

Ys_{max} is the specified maximum yield strength of the coupling, expressed in megapascals;

t_c is the critical thickness shown in Table C.7 for couplings with API threads, expressed in millimeters;

f_c is a factor depending on the size of the Charpy impact specimen:

— 1.00 for full-size specimens (10 mm × 10 mm);

— 0.80 for $^3/_4$-size specimens (10 mm × 7.5 mm);

— 0.55 for $^1/_2$-size specimens (10 mm × 5 mm).

The calculated SI values were rounded to the nearest joule.

NOTE 1 The maximum-size fully machined transverse and longitudinal Charpy impact specimens for couplings for API threads can be found in API 5C3. These sizes are included in Tables C.12 to C.13 and used in the calculation of the Charpy requirements shown in those tables.

NOTE 2 The absorbed energy requirements in Tables C.12 and C.13 are for full-size test specimens where the factor f is set to 1.00.

G.8.4 Minimum Absorbed Energy Requirements for Pipe

The SI values for the maximum specified wall thickness for various grades of pipe for minimum absorbed energy values from full-size test specimens were calculated using Equations (G.24) to (G.27).

The rounding procedures of ISO 80000-1 or ASTM E29 shall be followed. For example, when calculating the requirements for 27 J, 27.49999999 should be used for $C_{pt,m}$ or $C_{pl,m}$ (since it rounds to 27). Similarly, when calculating the requirements for 28 J, 28.50000000 should be used for $C_{pt,m}$ or $C_{pl,m}$ (since it rounds to 28). The wall thickness that results from the calculation shall be rounded down to two decimal places.

a) Grades N80Q, L80, C90, R95, T95, and P110:

Transverse Charpy absorbed energy requirements for pipe (Table C.14):

$$t = [(C_{pt,m} / Ys_{min}) - 0.01259] / 0.00118 \quad \text{(G.24)}$$

Longitudinal Charpy absorbed energy requirements for pipe (Table C.15):

$$t = [(C_{pl,m} / Ys_{min}) - 0.02518] / 0.00236 \quad \text{(G.25)}$$

b) Grades C110 and Q125:

Transverse Charpy absorbed energy requirements for pipe (Table C.14):

$$t = [(C_{pt,m} / Ys_{max}) - 0.01259] / 0.00118 \quad \text{(G.26)}$$

Longitudinal Charpy absorbed energy requirements for pipe (Table C.15):

$$t = [(C_{pl,m} / Ys_{max}) - 0.02518] / 0.00236 \quad \text{(G.27)}$$

where

$C_{pt,m}$ is the minimum transverse Charpy impact energy for pipe, expressed in joules;

$C_{pl,m}$ is the minimum longitudinal Charpy impact energy for pipe, expressed in joules;

Ys_{max} is the specified maximum yield strength of the pipe, expressed in megapascals;

Ys_{min} is the specified minimum yield strength of the pipe, expressed in megapascals.

G.8.5 Calculated Wall Thickness Required to Machine Transverse and Longitudinal Charpy Impact Specimens from Pipe and Couplings (Table C.10 and Table C.11)

The SI values for the wall thicknesses required to machine transverse and longitudinal Charpy impact test specimens from pipe and couplings were calculated using Equations (G.28) and (G.29):

Transverse Charpy impact specimens (Table C.10):

$$t_t = (D_m / 2) - [(D_m / 2)^2 - 756.25]^{0.5} + 1.00 + w_{Cs} \quad \text{(G.28)}$$

Longitudinal Charpy impact specimens (Table C.11):

$$t_l = (D_m / 2) - [(D_m / 2)^2 - 25]^{0.5} + 1.00 + w_{Cs} \quad \text{(G.29)}$$

where

t_t is the calculated value for the wall thickness, expressed in millimeters, required to machine transverse Charpy impact test specimens from pipe and couplings;

t_l is the calculated value for the wall thickness, expressed in millimeters, required to machine longitudinal Charpy impact test specimens from pipe and couplings;

D_m is the specified outside diameter of the pipe or coupling, expressed in millimeters;

w_{Cs} is the width of the Charpy impact test specimen, expressed in millimeters:

- 10.0 mm for full-size specimens;
- 7.5 mm for $^3/_4$-size specimens;
- 5.0 mm for $^1/_2$-size specimens.

In the above formulas, a machining allowance of 1.00 mm is included (USC formula allowed 0.020 in. on the inside pipe surface and 0.020 in. on the outside surface or 1.00 mm total for the purposes of this calculation).

The calculated SI values for the wall thicknesses required to machine transverse and longitudinal Charpy impact test specimens from pipe and couplings were rounded to the nearest 0.01 mm.

G.9 Other

G.9.1 Temperature

The temperatures in degrees Fahrenheit (USC) were converted to temperatures in degrees Celsius (SI) using Equation (G.33):

$$°C = (°F - 32) \times 5/9 \tag{G.33}$$

where

°C is the temperature, expressed in degrees Celsius;

°F is the temperature, expressed in degrees Fahrenheit.

The converted SI values for temperatures were rounded to the nearest degree.

When the temperature being converted was over 600 °F, the number was rounded to the most rational value rounded to the nearest 5 °C. For example, 750 °F converts to 399 °C, but the rational conversion is 400 °C.

G.9.2 Torque

The USC values for make-up torque may be converted to SI values using Equation (G.34):

$$T_{\mathrm{m}} = 1.35582 \times T \tag{G.34}$$

where

T_{m} is the torque, expressed in newton-meters;

T is the torque, expressed in foot-pounds.

The converted SI values for make-up torque may be rounded to the nearest newton-meter.

NOTE This standard does not include requirements for torque; however, as this standard is the primary casing and tubing standard, a conversion procedure for torque is included for convenience of the user.

G.9.3 Critical Stress Intensity Factor for SSC Requirements

The critical stress intensity factor, K_{Issc}, expressed in USC may be converted to SI values using Equation (G.35):

$$K_{\mathrm{Isscm}} = 1.099 \times K_{\mathrm{Issc}} \tag{G.35}$$

where

K_{Isscm} is the critical stress intensity factor for SSC, expressed in megapascals–square root of meters (MPa·√m);

K_{Issc} is the critical stress intensity factor for SSC, expressed in kilopounds–square root of inches (ksi·√in.).

The converted SI values for critical stress intensity factor K_{Isscm} for SSC may be rounded to the nearest 0.1 megapascals–square root of meters (MPa·√m).

The converted USC values for critical stress intensity factor K_{Issc} for SSC may be rounded to the nearest 0.1 kilopounds–square root of inches (ksi·√in.).

Bibliography

[1] API Bulletin 5A2, *Thread Compounds for Casing, Tubing, and Line Pipe*

[2] API Bulletin 5T1, *Imperfection and Defect Terminology*

[3] API Recommended Practice 5B1, *Gauging and Inspection of Casing, Tubing, and Line Pipe Threads*

[4] API Recommended Practice 5C1, *Care and Use of Casing and Tubing*

[5] API Recommended Practice 5C6, *Pipe with Welded Connectors*

[6] API Specification Q1, *Quality Management System Requirements for Organizations Providing Products for the Petroleum and Natural Gas Industry*

[7] ASNT Nondestructive Testing Handbook, Volume 9, *Visual Testing (VT)*

[8] ASTM A941, *Standard Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys*

[9] Failure Analysis and Prevention, *ASM Metals Handbook,* Volume 11, Ninth Edition, 1986

[10] Hodge J.M., Orehoski M.A., *Relationship between Hardenability and Percentage Martensite in Some Low Alloy Steels*, Trans. AIME, 167, pp. 627–642, 1946

[11] ISO/IEC [7] 17011, *Conformity assessment—Requirements for accreditation bodies accrediting conformity assessment bodies*

[12] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

[13] NACE MR0175/ISO 15156 (all parts), *Petroleum and natural gas industries—Materials for use in H_2S-containing environments in oil and gas production*

[14] National Bureau of Standards [8], *Handbook 91*, U.S. Department of Commerce, Experimental Statistics

[7] International Electrotechnical Commission, 3 Rue de Varembé, CH-1211 Geneva 20, Switzerland, www.iec.ch.

[8] National Bureau of Standards (now National Institute of Standards and Technology), 100 Bureau Drive, Gaithersburg, Maryland 20899, www.nist.gov.



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