

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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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.

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Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every 5 years.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 H₂S (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*

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*

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 H₂S 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
$Y_{s_{max}}$	specified maximum yield strength
$Y_{s_{min}}$	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, 5.3.5, 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
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)
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 C110 and Q125	9.4.6
Type and size of test specimen for tensile testing the upset	9.4.5
Additional hardness testing	9.6.1
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, and P110	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
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
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)
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
Type and size of test specimen for tensile testing the upset	9.4.5
Additional hardness testing	9.6.1
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 Coupling 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 Coupling 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
Wall thickness measurement for 100 % coverage	9.13.4, A.21 (SR 49)
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 (A_{r3}) 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):

$$\varepsilon = 6Dy / L^2 \quad (1)$$

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):

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

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 mm² (0.01 in.²), or 490 mm² (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 mm² (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

$Y_{s\max}$ 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	$Y_{s\max} \times (0.00118t + 0.01259)$ or Table C.12, whichever is greater up to the maximum thickness in Table C.12	$Y_{s\max} \times (0.00236t + 0.02518)$ or Table C.13, whichever is greater
USC units, foot-pounds	$Y_{s\max} \times (0.152t + 0.064)$ or Table E.12, whichever is greater up to the maximum thickness in Table E.12	$Y_{s\max} \times (0.304t + 0.128)$ 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

$Y_{s\min}$ 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	$Y_{s\min} \times (0.00118t + 0.01259)$ or Table C.14, whichever is greater	$Y_{s\min} \times (0.00236t + 0.02518)$ or Table C.15, whichever is greater
USC units, foot-pounds	$Y_{s\min} \times (0.152t + 0.064)$ or Table E.14, whichever is greater	$Y_{s\min} \times (0.304t + 0.128)$ 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

$Y_{s\max}$ 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	$Y_{s\max} \times (0.00118t + 0.01259)$ or Table C.14, whichever is greater up to the maximum thickness in Table C.14	$Y_{s\max} \times (0.00236t + 0.02518)$ or Table C.15 whichever is greater
USC units, foot-pounds	$Y_{s\max} \times (0.152t + 0.064)$ or Table E.14 whichever is greater up to the maximum thickness in Table E.14	$Y_{s\max} \times (0.304t + 0.128)$ 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):

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

or

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

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):

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

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):

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

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):

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

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 shall 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 $Y_{S_{min}}$	496 MPa (72,000 psi) for C90 524 MPa (76,000 psi) for T95
	85 % of $Y_{S_{min}}$	644 MPa (93,500 psi) for C110
	90 % of $Y_{S_{min}}$	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 $Y_{S_{min}}$	447 MPa (64,800 psi) for C90 472 MPa (68,400 psi) for T95
	76 % of $Y_{S_{min}}$	576 MPa (83,600 psi) for C110
	81 % of $Y_{S_{min}}$	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):

$$W_L = [(w_{pe})(L_{ef}) + (e_m)](k_m) \quad (8)$$

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 Joints

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 <i>t</i>

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”:

- 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;
- 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
$< 4 \frac{1}{2}$	$\pm 0.79 \text{ mm } (\pm 0.031 \text{ in.})$
$\geq 4 \frac{1}{2}$	$\frac{+1}{-0.5} \%$

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: $5 \frac{1}{2}$ and smaller, and a distance approximately equal to the outside diameter for sizes larger than Label 1: $5 \frac{1}{2}$. 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
$\leq 3 \frac{1}{2}$	$\frac{+2.38}{-0.79} \text{ mm } (\frac{+3/32}{-1/32} \text{ in.})$
$> 3 \frac{1}{2} \text{ to } \leq 5$	$+2.78 \text{ mm to } -0.75 \% D (+7/64 \text{ in. to } -0.75 \% D)$
$> 5 \text{ to } \leq 8 \frac{5}{8}$	$+3.18 \text{ mm to } -0.75 \% D (+1/8 \text{ in. to } -0.75 \% D)$
$> 8 \frac{5}{8}$	$+3.97 \text{ mm to } -0.75 \% D (+5/32 \text{ in. to } -0.75 \% D)$

For Label 1: $2 \frac{3}{8}$ 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
$\geq 2 \frac{3}{8}$ to $\leq 3 \frac{1}{2}$	$\frac{+2.38}{-0.79}$ mm ($\frac{+3/32}{-1/32}$ in.)
$> 3 \frac{1}{2}$ 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 mm² (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 hand-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.