Specification for Coiled Tubing

U.S. Customary and SI Units

API SPECIFICATION 5ST
FIRST EDITION, APRIL 2010

EFFECTIVE DATE: OCTOBER 1, 2010

REAFFIRMED, MAY 2015

AMERICAN PETROLEUM INSTITUTE

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Upstream Segment

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1 Scope

This specification covers the manufacturing, inspection, and testing of all carbon and low alloy steel coiled tubing in Grades CT70, CT80, CT90, CT100 and CT110, in the designations and wall thicknesses given in Table A.5, that can be used as work strings, completion strings, and static installations in oil and gas wells. Coiled tubing may be ordered to this specification.

Coiled tubing is manufactured using the continuously milled process. This specification does not cover the joining of seamless or welded tubing segments in lengths less than 200 ft (61 m).

Tubing of a higher grade is not be substituted for tubing ordered as a lower grade without purchaser approval.

In the dimensional tables herein, coiled tubing is designated by outside diameter, expressed to the thousandth of an inch (0.1 mm), with OD sizes ranging from 0.750 in. (19.1 mm) through 3 $^{1}/_{2}$ in. (88.9 mm).

Both U.S. Customary units and SI units are shown in this document. Annex H covers specific information about conversion factors and rounding procedures.

The suitability of the coiled tubular products made to this specification for use in environments containing hydrogen sulfide (H_2S) is outside of the scope of this document. It is the responsibility of the purchaser (and/or the user) of coiled tubing to determine the level of resistance to sour service damage mechanisms such as sulfide stress cracking necessary for the end use of the tubing.

2 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 amendments) applies.

Requirements of other standards included by reference in this specification are essential to the safety and interchangeability of the equipment produced.

Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this specification prior to their use as equivalent standards.

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

API Specification 5LCP, *Specification for Coiled Line Pipe*

API Recommended Practice 5SI, *Recommended Practice for Purchaser Representative Surveillance and/or Inspection at the Supplier*

API Standard 5T1, *Imperfection Technology*

API Standard 1104, *Welding of Pipelines and Related Facilities*

ASME *Boiler and Pressure Vessel Code* [1], *Section IX, Welding and Brazing Qualifications*

[1] ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.

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

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

ASTM A450, *Standard Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes*

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

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

ASTM E8, *Standard Test Methods for Tension Testing 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 E44, *Standard Definitions of Terms Relating to Heat Treatment of Metals*

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

ASTM E94, *Standard Guide for Radiographic Examination*

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

ASTM E140, *Standard Hardness Conversion Table for Metals*

ASTM E164, *Standard Practice for Contact Ultrasonic Testing of Weldments*

ASTM E165, *Standard Practice for Liquid Penetrant Examination*

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

ASTM E273, *Standard Practice for Ultrasonic Examination 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 E384, *Standard Test Method for Microindentation Hardness of Materials*

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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

ASTM E797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact method*

ASTM E1025, *Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators Used for Radiology*

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[2] American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, Ohio 43228, www.asnt.org.
[3] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM E1444, *Standard Practice for Magnetic Particle Testing*

ISO 1027[4], *Radiographic image quality indicators for nondestructive testing—Principles and identification*

3 Definitions

For the purposes of this specification, the following definitions apply.

3.1
as milled condition
Tubing that has completed all milling operations but has not been placed on a reel.

3.2
Bauschinger effect
A phenomenon that occurs in polycrystalline metals, including steel, that results in a decrease in the yield strength in one direction due to plastic deformation in another direction, such as caused by service loads, coiling, or straightening.

3.3
calibration
The comparison of an instrument with, or the adjustment to, a known reference(s) often traceable to a national metrology lab or institute.

3.4
coiled tubing
Continuously milled carbon or alloy steel tubular product manufactured to this specification.

3.5
completion string
Tubing string placed within a well to serve as an exhaust or delivery duct for produced or injected fluids.

3.6
continuously milled tubing
Coiled tubing manufactured in milled lengths greater than 200 ft (61 m).

3.7
defect
An imperfection of sufficient magnitude to warrant rejection of the product, or a section of the product, based on the criteria defined in this specification.

3.8
dent
A local change in surface contour caused by a mechanical impact, but not accompanied by the loss of metal.

3.9
electrodischarge machine
EDM
A machine that removes of a controlled amount of material by electric spark erosion.

3.10
grain size
The dimensions of the grains or crystals in polycrystalline metal exclusive of twinned regions and subgrains when present.

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

NOTE Grain size is usually estimated or measured on the cross-section of an aggregate of grains. Average size of grains in the metal usually expressed as an average diameter or grains per unit area or volume.

3.11
flash
A thin fin or web of metal formed at the joining edges of a weld when a small portion of metal is extruded during the high frequency induction seam-forming process. A flash extends above the plane of the OD surface or the plane of the ID surface.

3.12
flash-in
The condition in which the internal flash from the seam welding process is left inside the tubing.

3.13
gouge
Elongated grooves or cavities caused by mechanical removal of metal.

3.14
heat-affected zone
HAZ
The zone directly adjacent to the weld fusion zone in a longitudinal seam weld, circumferential tube-to-tube weld and skelp-end weld. The mechanical properties in the HAZ are affected by the heat produced during the welding process.

3.15
high frequency induction welding
HFI
A welding process used to form a longitudinal seam along the length of the milled tube. As the edges of the skelp are passed through a high-frequency induction coil, the edges of the skelp are heated through the resistance to flow of current.

3.16
imperfection
A discontinuity in the product wall or on the product surface that can be detected by the nondestructive evaluation (NDE) methods.

3.17
inclusion
Particles of nonmetallic impurities, usually oxides, sulfides, and silicates that are mechanically held within steel after solidification.

3.18
killed steel
Steel deoxidized with certain deoxidizing elements, such as aluminum, silicon, etc. The term “killed” is used because such additions cause the steel to lie quietly in the molds during solidification.

3.19
lamination
An internal metal separation creating layers generally parallel to the surface.

3.20
linear imperfection
Linear irregularities, which include, but are not limited to, seams, laps, cracks, cuts, and scores.

3.21
manufacturer
A firm, company, or corporation responsible for making and marking the product in accordance with this specification. The manufacturer is responsible for compliance with all of the applicable provisions of this specification.

3.22
master coil
The original wide coil of steel that is supplied by the steel manufacturer and is subsequently slit into several narrower coils of skelp of the appropriate width for the manufacture of coiled tubing.

3.23
mill stop
An interruption in the normal production of the seam welding of a string.

3.24
milled length
A single length of coiled tubing created during continuous operation of a mill.

NOTE A milled length can include tubing manufactured from a number of coils of skelp. The lengths of skelp can have a single specified wall thickness, or can have various specified wall thicknesses. A milled length does not include tube-to-tube welds.

3.25
normalize
A heat treatment of steel whereby the steel is heated to a temperature above the upper critical temperature to achieve transformation to austenite then allowed to cool in air to a temperature substantially below the lower critical temperature.

3.26
ovality
Defined herein as $2(D_{max} - D_{min})/(D_{max} + D_{min})$ where D_{max} and D_{min} are the measured diameters at a specific location along the tubing, and may be expressed as a percentage.

3.27
processes requiring validation
Certain operations performed during skelp joining and tube manufacturing that affect attribute compliance required in this document (except chemistry and dimensions) shall have their processes validated.

a) Welded without filler metal:

Manufacturing Condition	Processes requiring validation
Heat treated tubing	Friction-stir weld Heat treatment of friction stir skelp-end weld Seam weld and full body heat treatment Nondestructive evaluation

b) Welded with filler metal (skelp-end weld and tube-to-tube weld, and fitting welds):

Manufacturing Condition	Processes requiring validation
Heat treated tubing	Skelp-end weld Heat treatment of skelp-end weld Tube-to-tube weld Heat treatment of tube-to-tube weld Fitting weld Heat treatment of fitting weld Nondestructive evaluation

3.28
product analysis
A chemical analysis taken from master coils, skelp, or finished tubular product.

3.29
reference end
The end of the coiled tubing that is intended to be connected to the service reel. This end is used in reporting measured footage for the location of the skelp-end and tube-to-tube welds within the coiled tubing string.

3.30
service reel
A cylindrical-shaped core drum, typically fabricated from steel and bounded by parallel flanges mounted transverse to the core, for use in storing and transporting coiled tubular products.

NOTE The service reel is usually equipped with a self-contained hydraulic drive system to control rotation of the reel, an onboard hydraulic levelwind apparatus, and onboard high-pressure piping which connects to the coiled tubing through a high pressure rotating swivel. The diameters of the cylindrical core and boundary flanges will vary relative to the tube diameter and length to be spooled onto the reel.

3.31
service string
The construction of a specific length of coiled tubing for use in concentric well intervention operations.

3.32
shipping reel
A wooden or metal capstan-like device for transporting coiled tubing.

NOTE Also referred to as a transport reel.

3.33
skelp
Flat steel rolled to specified tolerances and slit to the appropriate width for the manufacture of coiled tubing.

3.34
soft metric conversion
A soft conversion is a direct mathematical conversion from a U.S. measurement to its metric equivalent.

3.35
spool
The total length of "as-manufactured" coiled tubing that is placed either on the service reel or shipping reel for storage and/or transport.

NOTE The tubing in a spool of tubing can contain one or more tube-to-tube welds. Can be used interchangeably with string or the capstan reel.

3.36
spooling radius ratio
The ratio of the diameter of the shipping reel core to the diameter of the coiled tube.

NOTE This ratio is used in determining the minimum recommended bending radius for spooling coiled tubular products onto the reel.

3.37
standardization
The adjustment of nondestructive test instruments to a known reference value.

3.38
stress relief
Heat treatment to a suitable temperature to reduce residual stresses, followed by cooling sufficiently slowly to minimize the development of new residual stresses.

3.39
string
The finished product manufactured at a coiled tubing facility.

NOTE Used interchangeably with spool.

3.40
strip
A single length of skelp, cut from a master coil.

3.41
tapered string
A complex string of coiled tubing manufactured with a constant outside diameter and variable wall thickness within the length of the spooled tube.

EXAMPLE A tapered string can be constructed as follows:

a) a continuously milled string incorporating single or multiple wall thickness segments joined using skelp-end welds, and

b) continuously milled coiled tubing segments of single wall thickness joined to other finished tube segments of increasing/decreasing wall thickness using the tube-to-tube welding process.

NOTE The tapering may occur within the original strip segments that are used to fabricate the string.

3.42
undercut
Undercuts in tube-to-tube welds are defined as the reduction of thickness of the tubing wall adjacent to the weld where it is fused to the surface of the tubing.

NOTE Undercutting on the outside surface can best be identified and measured visually. Undercutting on the inside surface can be identified using radiographic or ultrasonic means.

3.43
wall thickness (specified)
In untapered string segments, the specified wall thickness is given in tables in this Specification. In continuous tapered sections of strings, the specified thickness is the average of at least four measurements of the local wall thickness, taken by a suitably calibrated wall thickness measuring device.

4 Information to be Supplied by the Purchaser

4.1 Mandatory Purchaser Requirements

In placing orders for coiled steel tubing to be manufactured in accordance with API 5ST, the purchaser shall specify the following as applicable on the purchase agreement (see Note 1).

Information	Reference
Specification	API Specification 5ST
Grade	Tables A.1, A.2
Method for yield strength	6.2.1.3
Preliminary String Length Profile	7.2
Length(s)	7.2
Diameter	7.3, 7.4, Table A.5
Wall thickness(es)	7.4
Tubular Ends	7.8
Product Analysis	8.2.2
Drying procedure	8.4.6
Alternate Drift Ball Material	8.5.2
NDE Reference Indicators	10.8.2, 10.8.2.2
Certificate of compliance	15.2
Tensile retest	12.2
Documentation	15.2.1
Additional NDE	Annex D
Coiled Tubing Shipping Reels	Annex G
Delivery date and shipping instructions	

4.2 Optional Purchaser Requirements and Requirements Subject to Agreement

The purchaser should also state on the purchase agreement requirements concerning the following optional requirements. Requirements subject to agreement are shown with an asterisk (*).

Information	Reference
Chemical composition *	6.1
Additional Hardness Tests *	6.2.2
Fracture toughness tests	6.2.6
Final string length profile *	7.2.2
Ovality measurement	7.3.2
Minimum remaining wall thickness *	7.4.2.2
Tube-to-tube welds *	7.6, Annex B and Annex C
Trim of Inside Flash *	7.7.4
End finish and connection *	7.8
Tensile Test Sample Width *	8.3.1
Alternate Hydrostatic pressure *	8.4.4
Demonstration of NDE standard	10.2
Additional skelp end weld inspection *	10.5.2, 10.7
Additional tube-to-tube weld inspection *	10.5.4, 10.7
Alternate Image Quality Indicators (IQIs)*	10.6.2
NDE Reference Indicators *	10.8.2, 10.8.2.2
Grain size determination	9.4
Markings in SI units	13.1
External coatings	14.1, 14.2
Internal coatings	14.2.3
Documentation to be Supplied	15.2.2
Supplementary requirements *	Annex D
Purchaser inspection	Annex E
Marking requirements and Monogram * (see Note 2)	Annex F
Shipping reel dimensions *	Annex G

NOTE 1 Nothing in this specification is to be interpreted as indicating a preference by the committee for any material or process or as indicating equality between the various materials or processes. In the selection of materials and processes, the purchaser must be guided by his experience and by the service for which the tubing is intended.

NOTE 2 There is no requirement for marking a product with the API Monogram. The American Petroleum Institute continues to license use of the API Monogram on products covered by this specification, but it is administered by the staff of the Institute separately from the Specification. The policy describing use of the API Monogram is contained in Annex F. No other use of the API Monogram is permitted. Licensees mark products in conformance with Annex F and Section 9, and non-licensees mark products in conformance with Section 9.

5 Processes of Manufacture and Material

5.1 General

The various grades of steel used to manufacture coiled tubing furnished to this specification shall be made to a fine grain practice. A fine grain practice refers to the use of elements to deoxidize or “kill” the liquid steel, which results in a finer prior austenitic grain size upon solidification.

Coiled tubing furnished to this specification shall be manufactured by the high frequency induction (HFI) or laser weld processes as defined in 5.2.1 and 5.2.2 respectively. Cold drawn tubular products without appropriate heat treatment are not permitted.

The welds described in 5.2 (skelp-end weld, electric weld, laser weld, tube-to-tube weld) shall not be repair-welded.

5.2 Types of Welds

5.2.1 Electric Weld

An electric weld is a longitudinal seam weld produced by the HFI welding process defined in 5.3.1.1.

5.2.2 Laser Weld

A laser weld is a longitudinal seam weld produced by the laser welding process defined in 5.3.1.2.

5.2.3 Skelp End Weld

A skelp end weld is a butt weld that joins skelp ends together. Skelp end welds shall be made in accordance with a qualified welding procedure.

5.2.4 Tube-to-tube Weld

A tube-to-tube weld is a circumferential butt weld that joins two pieces of tubing together (see Annexes B and C).

5.3 Welding Processes

5.3.1 Without Filler Metal

5.3.1.1 HFI Welding

A process of forming a seam by electric induction welding wherein the edges to be welded are mechanically pressed together and the heat for welding is generated by resistance to flow of high frequency electric current. The welder frequency is 100 kHz or higher.

5.3.1.2 Laser Welding

A process of forming a seam by laser welding wherein the edges to be welded are mechanically pressed together and the heat for welding is generated by conversion of laser light energy to heat.

5.3.1.3 Friction Stir Welding

A solid state joining process utilizing a non-consumable rotating tool that generates heat through friction and deformation and simultaneously mechanically mixes the softened metals to form the metallurgical bond.

5.3.2 With Filler Metal

5.3.2.1 Gas Metal Arc Welding

A welding process that produces coalescence of metals by heating them with an arc or arcs between a continuous consumable electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture. Pressure is not used, and the filler metal is obtained from the electrode.

5.3.2.2 Plasma Arc Welding

A welding process that produces coalescence of metals by heating them with a constricted arc between an electrode and the work, or the electrode and a nozzle. Shielding is obtained from the hot ionized gas issuing from the torch, which may be supplemented by an auxiliary source of shielding gas. Shielding gas may be an inert gas or a mixture of gases. Pressure may or may not be used.

5.3.2.3 Gas Tungsten Arc Welding

A welding process that produces coalescence of the metals by heating them with an arc between a single tungsten electrode and the work. Shielding is obtained from a gas. Pressure is not used, and a filler metal may or may not be used.

5.4 Heat Treatment

The product shall be heat treated in accordance with a documented procedure. For all grades, the weld seam and the entire heat-affected zone shall be heat treated so as to simulate a normalizing heat treatment (see Note) followed by full body stress relief and/or temper, except that by agreement between the purchaser and the manufacturer, alternative heat treatments or combinations of heat treatment and chemical composition may be substituted. Where such substitutions are made, the manufacturer shall demonstrate the effectiveness of the method selected using a procedure that is agreed between the purchaser and the manufacturer. This procedure may include, but is not necessarily limited to, hardness testing, microstructural evaluation, and mechanical testing.

NOTE During the manufacture of electric-welded tubing, the product is in motion through the surrounding air. Normalizing is usually defined as “cooling in still air”, hence the phrase “to simulate a normalizing heat treatment” is used here.

5.5 Traceability

The manufacturer shall establish and follow procedures for maintaining heat and master-coil identity until all required heat and master-coil tests are performed and conformance with specification requirements has been shown.

6 Material Requirements

6.1 Chemical Requirements

For coiled tubing manufactured to this specification, all skelp segments manufactured within a continuously-milled string shall be of the same grade with the same nominal specified chemistry and mechanical properties.

The composition of tubing furnished to this specification shall conform to the chemical requirements given in Table A.1, except that other chemical compositions may be furnished by agreement between the purchaser and the manufacturer.

Niobium (columbium), vanadium, titanium, or combinations thereof may be used at the discretion of the manufacturer. For all grades, by agreement between the purchaser and the manufacturer, elements other than niobium (columbium) vanadium, and titanium may be used; however, caution should be exercised in determining the quantity that may be present for any particular size and thickness of tubing, because the addition of such otherwise desirable elements may alter the weldability of the tubing.

As a minimum, each required analysis shall include the determination of the following:

a) carbon, manganese, phosphorus, sulfur, and silicon;

b) chromium, molybdenum, niobium (columbium), vanadium, nickel, copper, titanium, and boron or combinations thereof, if added during steelmaking;

c) any other alloying element added during steelmaking for a reason other than for deoxidation purposes.

6.2 Mechanical Properties

6.2.1 Tensile Properties

6.2.1.1 General

All coiled tubing grades shall conform to the tensile requirements given in Table A.2. Tensile tests to determine conformance shall be conducted on samples taken prior to any spooling. Retests may be performed on as-milled or spooled product unless otherwise specified on the purchase agreement.

6.2.1.2 Elongation

The minimum elongation in a 2 in. (50.8 mm) sample shall be determined by the following Equation (1).

$$e = kA^{0.2}/U^{0.9} \tag{1}$$

where

e is the minimum elongation in 2 in. (50.8 mm) in %, reported to the nearest 0.5 %;

A is the cross-sectional area of the tensile test specimen in in.^{2} (mm^2);

U is the specified minimum ultimate tensile strength, psi (MPa);

k is a constant, 625,000 (1900).

See Table A.3 for minimum elongation values for various size tensile specimens and grades. These values are based upon specified outside diameters and specified wall thicknesses.

6.2.1.3 Yield Strength

The yield strength shall be determined by the 0.2 % offset method or the 0.5 % extension under load method by agreement between the purchaser and the manufacturer. Elongation shall be recorded and reported. The report shall show the nominal width of the test specimen when strip specimens are used, or state when full section specimens are used.

NOTE Spooling and unspooling of coiled tubing can result in a reduction of the yield strength of approximately 5 % to 10 % due to the Bauschinger Effect. For this reason, tubing grade is based on tests conducted before the first spooling step in the manufacturing process. Retests may be performed on as-milled or spooled product unless otherwise specified on the purchase agreement.

6.2.2 Hardness Test

For each tensile specimen required, a microhardness survey specimen (ring or block) shall be removed from the product at the location of the tensile samples. The hardness survey specimen shall be prepared and tested in accordance with the requirements of 8.7.3, and 8.9.5. The hardness values shall comply with the requirements given in Table A.2.

Surface macrohardness shall also be measured on the surfaces of skelp-end and tube-to-tube welds. The hardness values shall comply with the requirements given in Table A.2.

By agreement, and when specified on the purchase agreement, additional macro- or microhardness tests shall be taken at specified locations.

6.2.3 Grain Size

For all grades, the grain size shall be ASTM grain size 8 or finer.

6.2.4 Flattening Test

All coiled tubing products that are produced to this specification shall comply with the flattening requirements shown in Table A.4.

The acceptance criteria for flattening tests are as follows. No cracks or breaks exceeding 0.125 in. (3.2 mm) in any direction in the weld or the parent metal shall occur on the outside surface until the distance between the plates is less than the value calculated by the equations given in Table 4. Cracks that originate at the edge of the specimen and are less than 0.25 in. (6.4 mm) long shall not be cause for rejection. The minimum test frequency for milled lengths of coiled tubing shall be at least one flattening test from each end of each continuously milled length.

6.2.5 Flaring Test

All grades of coiled tubing shall be subjected to a flaring test as specified in 8.3.3. The acceptable criterion is no cracking in the weld seam region or base metal up to a minimum ID expansion of ID_f (defined in 8.3.3).

6.2.6 Fracture Toughness Test

Fracture toughness testing for Charpy V-Notch energy is required where requested on the purchase order, considering the limitations imposed by diameter and thickness of the tubing ordered. Full size transverse (to the tube direction) specimens should be used when possible based upon pipe geometry per ASTM A370. When full size transverse specimens are not possible, the largest sub size specimens shall be used ($^3/_4$, $^1/_2$). When transverse specimens are not possible, $^1/_2$ size longitudinal specimens shall be used. The test specimens shall be oriented circumferentially from a location 90° from the weld with the axis of the notch oriented through the pipe wall. All tests shall be conducted at 32 °F (0 °C). The minimum absorbed energy requirements for full size specimens shall be 20 ft-lb (27 J) average, 15 ft-lb (20 J) minimum individual for full size transverse specimens, 30 ft-lb (41 J) average, 20 ft-lb (27 J) minimum individual for full size longitudinal specimens. The minimum absorbed energy reduction factors for sub-size specimens are: 0.8 for $^3/_4$ size, and 0.55 for $^1/_2$ size. By agreement between the purchaser and manufacturer, alternate tests may be used if the above requirements can not be met due to pipe geometry.

6.2.7 Metallographic Examination

A metallographic examination of a weld cross section shall be performed on both ends of each milled length.

The specimen shall be ground, polished, and etched in such a way that the microstructure of the base metal and weld zone can be investigated. In the case of “flash-in” tubing, the profile of the weld root shall show that it is continuous, with smooth curves blending into the inside diameter of the tubing.

7 Dimensions, Masses per Unit Length, Lengths, Defects, and End Finishes

7.1 General

Coiled tubing shall be furnished in the sizes, wall thicknesses, and masses shown in Table A.5 as specified on the purchase agreement. (See Table A.6 for the SI unit equivalents of the U.S. customary values given in Table A.5).

7.2 Length of Strings and Sections of Strings

7.2.1 General

The minimum and maximum length of the tubing shall be specified on the purchase agreement.

The accuracy of length measuring devices shall be equal to or less than 1 %.

7.2.2 Coiled Tubing String Length Profile

The preliminary length profile of a tapered coiled tubing string shall be specified by the purchaser following established criteria for the proposed service, and attached to the purchase agreement form. The final coiled tubing string length profile shall be by agreement between the purchaser and the manufacturer.

7.3 Diameter

7.3.1 Outside Diameter

The outside diameter shall be within the tolerances shown in Table A.7 for product in the as-milled condition. Diameter measurements of coiled tubing shall be made with a caliper that measures actual diameter across a single plane, with the diameter of record representing the average of the maximum and minimum diameter readings. Diameter measurements shall be made on both ends of each spooled length of coiled tubing on segments that have not been subjected to plastic deformation from spooling.

7.3.2 Ovality

When agreed upon between the manufacturer and the purchaser the ovality of the tubing shall be measured within 150 ft (45.7 m) of the ends, as installed on the reel. Ovality is defined as $2(D_{max} - D_{min})/(D_{max} + D_{min})$ where D_{max} and D_{min} are the measured diameters at a specific location along the tubing, and may be expressed as a percentage.

7.4 Wall Thickness

7.4.1 Wall Thickness Changes between Skelp Segments

The changes in specified wall thickness (Δt) between the adjoining skelp segments shall not exceed the values specified as follows:

a) 0.008 in. (0.2 mm) where the specified wall thickness of the thicker of the adjoining segments is less than 0.110 in. (2.8 mm);

b) 0.011 in. (0.3 mm) where the specified wall thickness of the thicker of the adjoining segments is between 0.110 in. (2.8 mm) and 0.150 in. (3.8 mm);

c) 0.020 in. (0.5 mm) where the specified wall thickness of the thicker of the adjoining segments is between 0.151 in. (3.8 mm) and 0.204 in. (5.2 mm);

d) 0.031 in. (0.8 mm) where the specified wall thickness of the thicker of the adjoining segments is 0.205 in. (5.2 mm).

7.4.2 Wall Thickness Measurement

7.4.2.1 General

Both ends of each milled length of tubing shall be measured for conformance to the wall thickness requirements. The wall thickness at any location shall be within the tolerances specified in Table A.8, except that the seam weld area shall not be limited by the plus tolerance. Wall thickness measurements shall be made with a mechanical device or

with a properly calibrated nondestructive inspection device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical device shall govern.

7.4.2.2 Minimum Remaining Wall Thickness

The remaining wall at locations of complete imperfection removal shall be agreed between the manufacturer and the purchaser, and stated in the purchase agreement.

7.5 Mass per Unit Length

The mass per unit length, w_{pe}, shall be calculated in accordance with the following Equation (2).

$$w_{pe} = k(D - t)t \tag{2}$$

where

w_{pe} is the mass per unit length, rounded to the nearest 0.01 lb/ft (0.01 kg/m);

D is the specified outside diameter, in. (mm);

t is the specified wall thickness, in. (mm);

k is the constant 10.69 (USC) or 0.024 661 5 (SI).

7.6 Tube-to-tube Welds

By written agreement, and when specified on the purchase agreement, two or more lengths of the same grade of tubing may be welded together by the manufacturer. See Annex B.

7.7 Workmanship and Defects

7.7.1 General

Imperfections of the types described in 7.7.2 to 7.7.12 that exceed the specified criteria shall be considered defects.

7.7.2 Dents

The tubing shall contain no dents.

7.7.3 Offset Skelp Edges

The radial offset of the skelp edges of the longitudinal weld shall not exceed 0.010 in. (0.3 mm) or 0.05t, whichever is greater.

7.7.4 Height of Outside Seam Weld Flash

The outside seam weld flash shall be trimmed to be flush with the tube outer surface.

7.7.5 Height of Inside Seam Weld Flash Column

7.7.5.1 Flash Height

The inside seam weld of “flash-in” tubing shall not extend above the prolongation of the original inside surface of the tubing more than 0.090 in. (2.3 mm), or the specified wall thickness, t, whichever is less.

7.7.5.2 Trim of Inside Flash

By agreement between the manufacturer and the purchaser, and when specified on the purchase agreement, the inside seam weld flash shall be trimmed.

For “flash-trimmed” coiled tubing, the flash shall not extend above the prolongation of the original inside surface of the tubing more than 0.020 in. (0.5 mm).

The depth of the groove resulting from removal of the inside flash shall not be greater than that shown in Table A.9 for the specified wall thicknesses. Depth of groove is defined as the difference between the wall thickness measured approximately 0.5 in. (12.7 mm) from the seam weld line and the remaining wall under the groove.

7.7.6 Cracks and Leaks

All cracks and leaks shall be considered defects.

7.7.7 Laminations

Laminations shall be considered defects.

7.7.8 Nonmetallic Inclusions

Any inclusion whose NDT signal exceeds the specified NDT criteria shall be considered a defect.

7.7.9 Undercuts at Tube-to-Tube Welds

Undercut of tube-to-tube welds is not permitted.

7.7.10 Tube- to-Tube Radial Offset

For all tubing, the radial offset at tube-to-tube welds shall not exceed 0.010 in. (0.3 mm) or 0.05t, whichever is greater. (t = specified wall thickness).

7.7.11 Non Surface-Breaking Weld Seam Defects

Any weld seam imperfection within $^{1}/_{16}$ in. (1.6 mm) on either side of the weld seam, not on the inside or outside surface, that is proven to reduce the net effective wall thickness below 90 % of the specified wall thickness shall be considered a defect.

7.7.12 Other Defects

Any imperfection having a depth greater than 10 % of the specified wall thickness shall be considered a defect.

7.8 End Finishes

Tubing shall be furnished with unfinished or plain ends, unless otherwise specified on the purchase agreement. When a connection is required, the purchaser shall specify the connection.

8 Testing

8.1 Test Equipment—Accuracy of Measuring Instruments

All inspection and test equipment shall be maintained, calibrated and recalibrated according to the manufacturer’s written procedures.

The accuracy of all measuring instruments used for acceptance or rejection shall be verified at least every operating shift. Verifying the accuracy of measuring devices such as calipers and gauge balls shall consist of inspection for wear and conformance to specified dimensions. Verifying the accuracy of rulers, length measuring counters, length-measuring tapes, and other non-adjustable measuring devices shall consist of a visual check for legibility of markings and general wear of fixed reference points. The adjustable and non-adjustable designation of measuring devices used by the manufacturer shall be documented. If measuring equipment, whose calibration or verification is required under the provisions of this specification, is subject to unusual or severe conditions sufficient to make its accuracy questionable, recalibration or reverification shall be performed before using the instrument.

8.2 Testing of Chemical Composition—Chemical Analysis Sampling Frequency

8.2.1 Heat Analysis

The tubing manufacturer shall report the heat analysis representing each heat of steel used in the production of tubing under this specification.

8.2.2 Product Analysis

When specified on the purchase agreement, one product analysis representing each heat of steel used in the production of a tubing string under this specification shall be performed.

8.3.2 Sampling Methods

At the option of the manufacturer, samples used for product analyses shall be taken from either finished tubing, skelp, tensile test specimens, or flattening test specimens. The location of the samples shall be a minimum of 90° from the electric weld.

8.3 Testing of Mechanical Properties

8.3.1 Tensile Tests

At the option of the manufacturer, longitudinal tests may utilize a full section specimen (see Figure 1), or a strip specimen (see Figure 2 and Figure 3) taken from finished tubing. The strip specimen shall be tested without flattening.

For strip specimens, the width of the gauge section shall be as agreed between the manufacturer and the purchaser.

Figure 1—Full Section Specimen

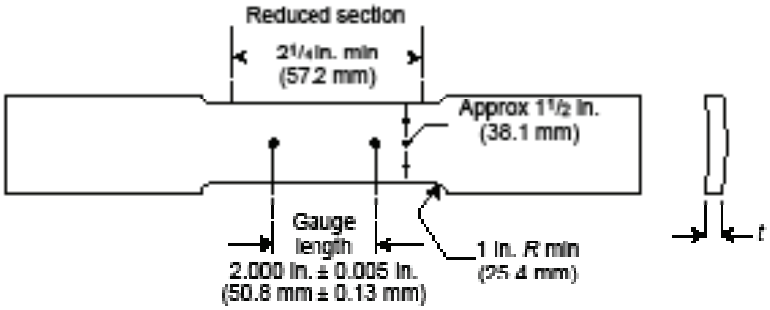

Figure 2—Strip Specimen

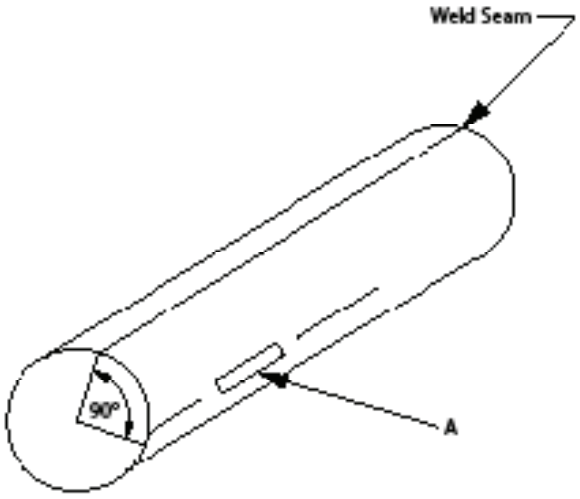

Figure 3—Orientation of Tensile Test Strip Specimen

Tensile test frequency shall be as follows.

a) A tensile test shall be performed on each end of each string.

b) Previously obtained tensile test results may be used for the contained tube sections that are not accessible so long as they are obtained from the same grade, heat, specified wall thickness, heat treatment and mill parameters.

8.3.2 Flattening Tests

One set of flattening tests consists of one test with the weld at the 0° position and one test with the weld at the 90° position.

Flattening test locations shall be as follows.

a) One set of flattening tests shall be made on specimens from each end of the milled length.

b) When a section of tubing has been removed because of a mill stop or defective longitudinal weld, a set of flattening tests shall be made on specimen(s) from the usable end(s).

8.3.3 Flaring Tests

8.3.3.1 General

Flaring test locations shall be as follows.

a) One flaring test shall be performed from each end of the continuously milled length in accordance with ASTM A450.

b) When a section of tubing has been removed because of a mill stop or defective longitudinal weld, a set of flaring tests shall be made on specimen(s) from the usable end(s).

8.3.3.2 Flaring Test Specimen

Specimens approximately 4 in. (101.6 mm) in length shall be flared over a mandrel having a 60° included angle. The *ID* flash may be ground flush prior to testing.

8.3.3.3 Flaring Test Inside Diameter Requirements

The required minimum inside diameter (ID_f) after flaring without cracking, is as follows in Equation (3) and Equation (4).

Grades CT90 and below $ID_f = 1.25 \times ID$ (3)

Grade CT100 and above $ID_f = 1.21 \times ID$ (4)

where

ID_f is the required minimum measured inside diameter of the tubing after flaring, in. (mm);

ID is the calculated inside diameter, in. (mm).

8.3.4 Hardness Test

Hardness tests shall be conducted as in 9.3.

8.3.5 Fracture Toughness Tests

Fracture toughness tests shall be conducted as in 6.2.6.

8.4 Hydrostatic Tests

8.4.1 General

Hydrostatic testing shall be performed on finished lengths of coiled tubing, spooled on the shipping or service reel, after all weld processes have been completed. The minimum test pressure shall be as specified in 8.4.2 to 8.4.4, and based upon the specified minimum wall thickness (t_{min}) in the coiled tubing string.

8.4.2 Hydrostatic Test Requirements

Each finished coiled length of tubing shall withstand, without leakage a hydrostatic test to at least the pressure specified in 8.4.4. Hydrostatic pressure tests shall be conducted after all air has been removed from the coiled tubing. Test pressures (see Table A.5) shall be held for not less than 15 minutes. Test pressures shall not drop more than 200 psig (1.4 MPa) in the last 15 minutes of the test.

8.4.3 Verification of Hydrostatic test

All hydrostatic tests shall be performed with a pressure measurement and recording system accurate to ±0.5 % of full scale.

Pressure sensors and recording devices shall be chosen such that the test pressure(s) fall between 25 % and 75 % of the full scale of the instrument.

Display units shall have sufficient scale to clearly show the test(s).

The data recording rate and time scale of displayed data shall be adjusted to clearly show the pressure trend for each test and provide evidence the test meets the acceptance criteria.

The test pressure-measuring device shall be standardized by means of a dead weight tester, or equivalent, within the six months prior to each use. Standardization records retention shall be as specified in 11.2.

Test records or charts shall be available for examination at the manufacturer's facility.

8.4.4 Test Pressures

8.4.4.1 Standard Test Pressures

The minimum test pressure for grades, outside diameters, and wall thicknesses shall be computed by the equation given below, and in Table A.5 or Table A.6. The hydrostatic test pressures herein are inspection test pressures, are not intended as a basis for design, and do not necessarily have any direct relationship to working pressures. The test pressures given in Table A.5 and Table A.6 were computed by Equation (5).

$$P = 1.60\ y_s\ t_{min}/D \tag{5}$$

where

P is the hydrostatic test pressure, psi (MPa);

y_s is the specified minimum yield strength, psi (MPa);

t_{min} is the specified minimum wall thickness, in. (mm);

D is the specified outside diameter, in. (mm).

Test pressures shall be rounded to the nearest 100 psig. (Table A.5, USC) or 0,1 MPa. (Table A.6, SI).

NOTE The test pressures are limited to 15,000 psig (103,4 MPa).

8.4.4.2 Alternate Test Pressures

An intermediate or higher pressure at the discretion of the manufacturer unless specifically limited by the purchaser, or a higher pressure as agreed between the purchaser and the manufacturer may be employed.

8.4.4.3 Test Pressure for Strings with Tapered Segments

When hydrostatic pressure testing is conducted on a tapered tubing string, the test pressure shall be limited to the pressure specified for the segment with the lowest specified wall thickness within the string.

8.4.5 Hydrostatic Test Fluid

The fluid for the hydrostatic pressure testing shall be treated with agents that limit its pH to a value between 7.0 and 9.0. A corrosion inhibitor may be added to the hydrostatic test fluid.

8.4.6 Removal of Test Fluid

After final hydrostatic testing, the manufacturer shall assure that the hydrostatic test fluid, gauging and fluid removal pig, and all other debris have been removed from the *ID* of the tubing. The manufacturer shall employ a documented fluid removal procedure to displace the test fluid after the hydrostatic test is completed. Where specified on the purchase agreement, special drying procedures for the *ID* surface shall be used.

8.5 Drift (Gauge Ball) Testing

8.5.1 General

Unless otherwise specified on the purchase agreement, each completed string of coiled tubing shall be drift tested using the appropriate gauge ball having the dimension indicated in Table A.10. The ball shall pass without obstruction through the entire length of the tubing.

8.5.2 Drift (Gauge Ball) Material

Unless otherwise agreed between the purchaser and the manufacturer, and stated on the purchaser agreement, the drift (gauge) ball shall be manufactured from nylon or steel.

8.5.3 Drift Testing Tapered Strings

If drift testing a tapered string, the gauge ball shall be sized for the smallest internal diameter section of tubing.

9 Test Methods

9.1 Chemical Analysis

Methods and practices relating to chemical analysis shall be performed in accordance with ASTM A751. Calibrations performed shall be traceable to established standards.

9.2 Tensile Test

The tensile testing procedure shall conform to the requirements of ASTM A370. All tensile tests shall include yield strength, tensile strength, and elongation determinations and shall be performed with the specimens at room temperature.

Tensile test machines shall have been calibrated within 12 months preceding any test in accordance with the procedures of ASTM E4. Where yield strength is determined by the use of extensometers, such extensometers shall have been calibrated within the preceding 12 months in accordance with the procedures of ASTM E83.

9.3 Microhardness Test

Microhardness tests shall be made in accordance with ASTM E384. The typical location of hardness readings is shown in Figure 4.

Conversions shall be made in accordance with ASTM E140. The use of the Rockwell B hardness (HRB) scale is permissible at hardness levels below HRC 20. Microhardness tests may be acquired using a Knoop or Vickers indenter and the readings converted to Rockwell B or C.

Microhardnesses shall be determined from samples obtained from the beginning and end of each continuously-milled length, and at any mill stop.

Calibration of the hardness tester shall be made, as follows, on a certified test block in the range 30 to 35 for CT110, 25 to 30 HRC for Grade CT100, and a range of 20 to 25 HRC for Grades CT90 and below.

a) Microhardness impressions shall be taken between 0.040 in. to 0.100 in. (1.0 mm to 2.5 mm) from the applicable surface;

b) as a minimum, microhardness surveys shall be made in the weld line, the HFI weld area, and the tube wall, as shown in Figure 4 (location 1);

c) three microhardness impressions taken at each position (*OD*, midwall, *ID*) shall be averaged to give one hardness value for each position;

d) when agreed between the manufacturer and the purchaser, microhardness readings shall be taken at a specified number of locations in the tube (typically locations such as 2 and 3 in Figure 4);

e) microhardness impressions shall be at least three diameters apart.

The first microhardness impression on each hardness block or ring quadrant may be disregarded.

Hardness values shall be reported (actual or converted) as HRB or HRC values, as appropriate. Rockwell hardness readings and values shall be reported to the nearest 0.5 of a Rockwell hardness point.

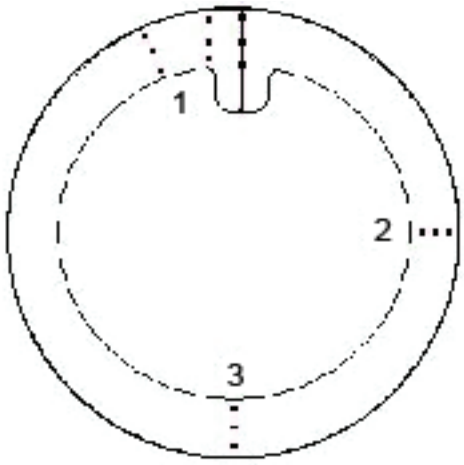

Figure 4—Through-wall Hardness Test Impression Locations

9.4 Grain Size Determination

When specified on the purchase agreement, the grain size shall be determined by metallographic evaluations on as-manufactured tube per requirements of ASTM E112. The method used to determine the grain size shall be reported.

9.5 Charpy V-Notch Test

When specified on the purchase agreement, and when possible for the OD and wall thickness of the tube, Charpy V-Notch fracture toughness tests shall be conducted to the requirements of ASTM A370 and ASTM E23 (see. 6.2.6).

10 Nondestructive Inspection

10.1 General

This section addresses in-line nondestructive inspections. Supplementary final nondestructive inspection after hydrostatic testing is addressed in Annex D.

10.2 NDE Reference Standards Demonstration

When specified on the purchase agreement, arrangements shall be made by the manufacturer to perform a demonstration for the purchaser or his representative during production. Such demonstration shall be based on material in progress or sample lengths of similar material retained by the manufacturer for that purpose that exhibit natural or artificially produced defects of the character stated in 10.7.1, 10.8.2, Table A.11, Table A.12, or Table A.13, and Annex D (SR 37). When inspection by the purchaser is stated on the purchase agreement, the provisions of Annex E shall apply.

10.3 Qualification of Personnel

As a minimum, ASNT Recommended Practice No. SNT-TC-1A, or equivalent, shall be the basis of qualification for NDT personnel. Personnel shall be requalified for any method previously qualified, if they have not performed NDT in that method for a period exceeding 12 months. Nondestructive testing shall be conducted by Level I, II, or III personnel.

Evaluation of indications shall be performed by Level I personnel, under the supervision of Level II or III personnel, or by Level II or III personnel.

10.4 Standard Practices for Inspection

For other than surface inspection (see 10.5.1) and wall thickness verification, the required inspections shall be performed in accordance with the applicable ASTM standards, or equivalent, as follows:

a) electromagnetic (flux leakage) ASTM E570;

b) electromagnetic (eddy-current) ASTM E309;

c) ultrasonic inspection ASTM E164, ASTM E213;

d) ultrasonic (weld seam) ASTM E273;

e) magnetic particle inspection ASTM E709;

f) radiographic inspection ASTM E94;

g) liquid penetrant inspection ASTM E165.

10.5 Methods of Nondestructive Inspection

10.5.1 Surface Inspection

The surfaces of the skelp or tubing shall be inspected to detect surface defects by a method that is equivalent to a visual inspection. Optical or electromagnetic methods that have a demonstrated capability of detecting surface defects may be used.

Where visual inspection is performed during the inspection of welds and imperfection prove-up, the visual inspection shall be conducted by personnel who are trained to detect and evaluate surface imperfections and have visual acuity that meets the applicable requirements of ASNT Recommended Practice No. SNT-TC-1A or equivalent.

10.5.2 Skelp End Welds

Skelp end welds shall be inspected in skelp form by radiographic inspection in accordance with 10.6. Other methods such as ultrasound, magnetic particle and liquid penetrant inspection shall be performed by agreement between the purchaser and the manufacturer, as stated on the purchase agreement.

10.5.3 Seam Welds

Seam welds shall be inspected full length (100 %) by ultrasonic or electromagnetic methods in accordance with 10.8.1 through 10.8.4. The location of equipment in the manufacturer's facility shall be at the discretion of the manufacturer.

10.5.4 Tube-to-Tube Welds

Tube-to-tube welds shall be inspected by radiographic or ultrasonic methods. Other methods such as magnetic particle inspection and liquid penetrant inspection, shall be performed by agreement between the purchaser and the manufacturer, as stated on the purchase agreement.

10.5.5 Full Body Inspection After Hydrostatic Test

By agreement between the purchaser and the manufacturer, and when specified on the purchase agreement, the tubing shall be nondestructively inspected in accordance with SR37 (see Annex D).

10.6 Radiographic Inspection of Skelp End Welds and Tube-to-tube Welds

10.6.1 Radiographic Inspection Equipment

The homogeneity of skelp-end welds and tube-to-tube welds examined by radiographic methods shall be determined by means of x-rays directed through the weld material onto a suitable radiographic film, or to a detector which will display onto a screen and be permanently recorded by a digital medium, provided adequate sensitivity can be obtained.

10.6.2 Radiography Reference Standards

10.6.2.1 General

Unless otherwise specified on the purchase agreement, the reference standard shall be the ASTM hole-type image quality indicator (IQI) described in Table A.11, the ASTM wire-type image quality indicator described in ASTM E747 and Table A.11, or the ISO wire-type image quality indicator described in ISO 1027, and Table A.12 and Table A.13. By agreement between the purchaser and the manufacturer, other standard image quality indicators may be used, provided that an equivalent or better sensitivity is achieved.

10.6.2.2 ISO Wire Image Quality Indicator

The ISO wire-type image quality indicator shall be Fe 6/12 or Fe 10/16 in accordance with ISO Standard 1027, and with Table A.12 and Table A.13 for the appropriate wall thickness. When the wire image quality indicator is placed in proximity to the weld, the diameter of the wire employed shall be based on the specified wall thickness plus the estimated thickness of the weld reinforcement (not to exceed the maximum allowed) at the image quality indicator location. When the image quality indicator is placed on the base metal, the diameter of the wire employed shall be based on the specified wall thickness.

10.6.2.3 ASTM Image Quality Indicator

The ASTM image quality indicator shall be in accordance with Table A.11 for the appropriate wall thickness. Either a wire type (in accordance with ASTM E747) or a hole type (in accordance with ASTM E1025) shall be used. The sensitivity may be modified by agreement between the purchaser and manufacturer, as stated on the purchase agreement.

10.6.3 Frequency of Use of Image Quality Indicator

The image quality indicator shall be used to check the sensitivity and adequacy of the radiographic technique on each skelp-end weld and each tube-to-tube weld.

The skelp or pipe shall be held in a stationary position during the adjustment of the sensitivity of radiographic technique by use of the image quality indicator. Proper definition and sensitivity is attained when the following is clearly discernible:

a) individual wires of the ISO image quality indicator, or

b) the 2T hole in the ASTM image quality indicator.

10.6.4 Acceptance Limits for Radiographic Inspection

Radiographic examination shall be capable of detecting weld imperfections and defects as described in 10.6.5.

10.6.5 Defects Observed During Radiographic Inspection

Cracks, porosity, lack of complete penetration, lack of complete fusion as indicated by radiographic examination, shall be considered defects.

10.6.6 Disposition of Defects Observed During Radiographic Inspection

There shall be no imperfections or defects. Any weld defect detected as a result of radiographic examination shall be rejected. Disposition of the tubing containing the defect shall be in accordance with 10.10.

10.7 Inspection of Welds by Other Nondestructive Test Methods

10.7.1 General

All welds shall be free from two-dimensional defects. Cracks or other two-dimensional defects found by any means, shall be rejected.

10.7.2 Ultrasonic Inspection of Skelp-end and Tube-to-tube Welds

When specified on the purchase agreement, skelp end welds and tube-to-tube welds may be inspected in strip or tube form using ultrasonic shear waves. Inspection shall be conducted in accordance with ASTM E164. The reference indicator shall be a parallel sided notch with a maximum depth of 5 % or 10 % of the specified wall thickness [minimum depth 0.015 in. (0.38 mm)]. with a width between 0.015 in. (0.38 mm) and 0.020 in. (0.51 mm), and a maximum length of 0.25 in. (6.4 mm) or 0.500 in. (12.7 mm). No repeatable volumetric or planar indications shall be permitted.

10.8 Ultrasonic and Electromagnetic Inspection of the Seam Weld

10.8.1 Equipment

Any equipment utilizing the ultrasonic or electromagnetic principles and capable of continuous and uninterrupted inspection of the entire thickness of the weld seam shall be utilized. The equipment shall be standardized with an

applicable reference standard as described in 8.6.8.2 immediately before and after each run of a milled length to demonstrate its effectiveness and the inspection procedures. The equipment shall be adjusted to produce well-defined indications when the reference standard is scanned by the inspection unit in a manner simulating the inspection of the product and shall be capable of inspecting 0.25 in. (6.4 mm) of tubing on either side of the weld line for the entire wall thickness.

10.8.2 Reference Standards for Electric Seam Welds

10.8.2.1 General

The following are minimum requirements for reference standards.

a) Reference standards shall have the same specified diameter as the product being inspected and may be of any convenient length as determined by the manufacturer.

b) Reference standards shall contain machined notches, one on the inside surface and one on the outside surface, or a drilled hole as shown in Figure 5. The reference indicators other than those specified in 10.8.2.2 shall be agreed between the manufacturer and the purchaser.

c) Reference standards shall be identified. The dimensions and type of reference indicators shall be verified by a documented procedure.

d) The manufacturer shall use a documented procedure to establish the reject threshold for ultrasonic or electromagnetic inspection. The applicable reference indicators shall be capable of being detected under normal operating conditions. Such capability shall be demonstrated dynamically, either on-line or off-line at the option of the manufacturer, using a speed of movement between the pipe and the transducer that simulates the inspection to be used for the production pipe.

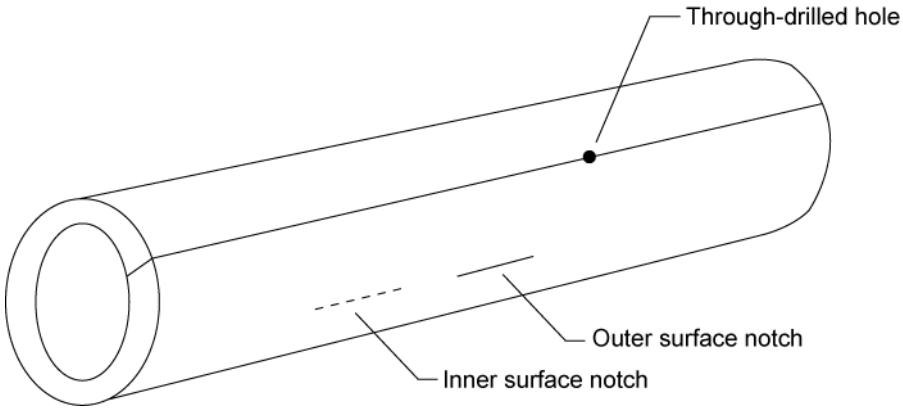

Figure 5—NDT Reference Indicators

10.8.2.2 Reference Notches and Holes

The following are minimum requirements for reference notches and holes.

a) The notches shall be separated by a distance sufficient to produce two separate and distinguishable signals.

b) Notches may be placed in or adjacent to the seam weld, or parallel to the seam weld.

c) The longitudinal notches shall have the following dimensions: depth 10 % of specified wall thickness, with a minimum 0.015 in. (0.38 mm), width 0.020 in. (0.5 mm) maximum, length 0.500 in. (12.7 mm) maximum. The tolerance on notch depth shall be ± 10 % of the calculated notch depth.

d) Reference holes shall be drilled cylindrical holes of diameter $^{1}/_{16}$ in. (1.6 mm) or $^{1}/_{32}$ in. (0.8 mm) and may be either partially or entirely through the wall, as stated on the purchase agreement.

NOTE The reference standards as defined above are convenient standards for standardization of NDT equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

10.8.3 Records Verifying System Ability

Inspection system records shall be maintained to document the verification of the system abilities in detecting reference indicators as stated in 10.8.2. These records shall include standardization and operating procedures, equipment description, personnel qualifications, equipment test settings, and dynamic test data demonstrating the system abilities for detecting the reference indicators.

10.8.4 Acceptance Limits

Table A.14 gives the height of acceptance limit signals produced by reference indicators. An imperfection that produces a signal greater than the acceptance limit signal given in Table A.14 shall be considered a defect unless it can be demonstrated by the manufacturer that the imperfection does not exceed the provision of 7.4.2.1 or 7.7 as appropriate.

10.8.5 Weld Repair

Defects in the longitudinal weld, found by any means, shall not be repaired.

10.9 Magnetic Particle and Liquid Penetrant Inspection

10.9.1 General

For pipe ends and for imperfection prove-up on the outer surface of welds and the pipe body, either magnetic particle inspection or liquid penetrant inspection, at the option of the manufacturer, shall be performed.

10.9.2 Equipment

The equipment used for magnetic particle inspection shall produce a magnetic field, transverse to the imperfection, of sufficient intensity to indicate imperfections of the following character in the external surface of the pipe: open welds, partial or incomplete welds, intermittent welds, cracks, seams, overlaps and slivers. Magnetic particle inspection shall be performed in accordance with ASTM E709.

The equipment used for liquid penetrant inspection shall also detect such imperfections. Liquid penetrant inspection shall be performed in accordance with ASTM E165.

10.9.3 Acceptance Limits

The manufacturer shall mark each magnetic particle or liquid penetrant indication, and subsequently explore each indication with respect to the depth of the imperfection. Imperfections that require metal removal to determine their depth shall be completely removed or cut out.

10.10 Disposition of Defects and Imperfections

10.10.1 Defects

Pipe and welds containing one or more defects shall be given one of the following dispositions.

a) The defect shall be completely removed provided that the remaining wall thickness is within the specified limits (90 % of specified wall thickness). Removal shall be performed in such a way that the dressed area blends in smoothly with the contour of the pipe.

b) The section of the tubing or weld containing the defect shall be cut out of the pipe and removed as a cylinder.

c) For skelp-end or pipe-to-pipe welds, the weld containing the defect and the complete heat-affected zone associated with the weld shall be cut out and removed.

10.10.2 Removal of Outer Surface Imperfections

Imperfections shall also be completely removed to a smooth finish (400 grit to 600 grit), provided that the remaining wall thickness is within specified limits (90 % of specified wall thickness). Removal shall be performed in such a way that the dressed area blends in smoothly with the contour of the pipe. After removal, the remaining wall thickness shall be verified through ultrasonic inspection.

10.10.3 Reinspection of Area

After removal of a repairable defect or imperfection, the affected area shall be reinspected by one or more of the nondestructive inspection methods specified in Section 10 in order to verify complete removal of the imperfection or defect. The manufacturer's documented prove-up procedures shall address the possibility that there may be other coincident defects in the affected area.

11 Invalidation of Tests

11.1 Defective Tensile Test Specimens

If any part of the fracture is outside the middle third of the gauge length as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. For full-section tubular specimens, failure occurring outside the middle third of the length between the crossheads or gripping fixtures shall be permitted to be retested.

11.2 Defective Mechanical Test Specimens

For any of the mechanical tests in Section 6, any test specimen that shows defective preparation or material imperfections unrelated to the intent of the particular mechanical test, whether observed before or after testing, may be discarded and replaced by another specimen from the same length of tubing.

12 Retests

12.1 Chemistry Recheck Analyses

If the product analysis representing the heat fails to conform to the specified requirements, at the manufacturer's option, either the heat shall be rejected or two recheck analyses shall be made using two additional samples from the heat. If both recheck analyses conform to the specified requirements, the heat shall be accepted, except for the master-coil from which the initial sample that failed was taken. If one or both recheck analyses fail to conform to the specified requirements, at the manufacturer's option either the heat shall be rejected or the remainder of the heat shall be tested individually for conformance to the specified requirements.

For such individual testing, analyses for only the rejecting element or elements need be determined. Samples for recheck analyses shall be taken in the same location as specified for product analysis samples.

12.2 Tensile Retest

If the tensile test specimen fails to conform to the specified requirements, the manufacturer may elect to retest two additional specimens from the same region of the same milled length. If both retested specimens conform to the requirements, the milled length shall be accepted. If one or both of the retested specimens fail to conform to the specified requirements, the manufacturer may elect to further retest two more samples within 50 ft (15.2 m) of the end of the milled length. The segment of the milled length cut out to obtain retest specimens shall be discarded. If one or

both of these tests fail, the milled length shall be rejected. Specimens for retest shall be taken in the same manner as the specimen that failed to meet the minimum requirements.

NOTE These specimens may have been bent during spooling.

Retests may be performed on as-milled or spooled product unless otherwise specified on the purchase agreement.

12.3 Flattening Retest

If the flattening test fails to conform to the specified requirements, the manufacturer may elect to retest two additional specimens from any failed end or regions adjacent to tube-to-tube welds. The retests shall be made with the weld alternately at 0° and 90°. If one or both of the retested specimens fails to conform to the specified requirements, the manufacturer may elect to further retest within 50 ft (15.2 m) of the end of the milled length or tubing-to-tubing region. Should this test fail, the milled length shall be rejected. Further strips within the spooled length shall be tested as per the requirements for the flattening test. Specimens for retest shall be taken in the same manner as the specimen that failed to meet the specified requirements.

12.4 Flaring Retest

If the flaring test fails to conform to the specified requirements, the manufacturer may elect to retest two additional specimens from the same region of the same milled length. If both retested specimens conform to the requirements, the milled length shall be accepted. If one or both of the retested specimens fails to conform to the specified requirements, the manufacturer may elect to further retest within 50 ft (15.2 m) of the end of the same milled length. If this test fails, the milled strip length shall be rejected. Further strips within the spooled length shall be inspected as per the requirements for flare testing. Specimens for retest shall be taken in the same manner as the specimen that failed to meet the specified requirements.

12.5 Hardness Retests

12.5.1 Grade CT90 and Below

If any hardness value falls above 22.0 HRC, one more hardness value shall be taken in the immediate area (three readings required). If the new hardness value does not exceed 22.0 HRC, the new hardness value will be accepted. If the new hardness value exceeds 22.0 HRC, the strip shall be rejected. Further re-testing is allowed with further cropping up to 50 ft (15.2 m) of from the end of the same milled length.

12.5.2 Grade CT100

If any hardness value falls above 28.0, one more hardness value shall be taken in the immediate area (three readings are required). If the new hardness value does not exceed 28.0 HRC, the new hardness value will be accepted. If the new hardness value exceeds 28.0 HRC, the strip shall be rejected. Further re-testing is allowed with further cropping up to 50 ft (15.2 m) of from the end of the same milled length.

12.5.3 Grade CT110

If any hardness value falls above 30.0, one more hardness value shall be taken in the immediate area (three readings are required). If the new hardness value does not exceed 30.0 HRC, the new hardness value will be accepted. If the new hardness value exceeds 30.0 HRC, the strip shall be rejected. Further re-testing is allowed with further cropping up to 50 ft (15.2 m) of from the end of the same milled length.

12.6 Fracture Toughness Test Retests

If the Charpy test fails to conform to the specified requirements (see 6.2.6), the manufacturer may elect to retest two additional specimens from the same region of the same milled length. If both retested specimens conform to the requirements, the milled length shall be accepted. If one or both of the retested specimens fails to conform to the specified requirements, the manufacturer may elect to further retest within 50 ft (15.2 m) of the end of the same milled

length. If this test fails, the milled strip length shall be rejected. Further strips within the spooled length shall be inspected as per the requirements for Charpy test. Specimens for retest shall be taken in the same manner as the specimen that failed to meet the specified requirements.

13 Marking

13.1 General

Coiled tubing manufactured in conformance with this specification shall be marked legibly and durably by the manufacturer on a tag attached to the tubing or a plate attached to the shipping reel as specified herein.

Length and hydrostatic test pressure markings should be in U.S. customary units. The markings may be in SI units, or both USC and SI units when specified on the purchase agreement.

Additional markings, including those for compatible standards, following the specification marking are allowed and may be applied as desired by the manufacturer or as requested by the purchaser.

13.2 Sequence of Markings

The sequence of identification markings shall be as follows.

a) Manufacturer—Manufacturer's name or mark shall be the first identifying mark, followed by manufacturer's spool number.

b) Specification—Spec 5ST" shall be marked when the product is in complete compliance with this specification.

c) Compatible Standards—Products in compliance with multiple compatible standards may be marked with the name of each standard.

d) Designation—The OD size shall be marked.

e) Grade—The symbols to be used are as follows:

Grade	Symbol
Grade CT70	CT70
Grade CT80	CT80
Grade CT90	CT90
Grade CT100	CT100
Grade CT110	CT110

f) Test Pressure—The actual hydrostatic test pressure applied shall be marked, preceded by the word "TESTED".

g) Supplementary Requirements—Where Annex D (SR 37) nondestructive inspection is performed, the following shall be added: NDE SR37.

13.3 Length

For all tubing sizes, the length as measured on the finished coiled tubing, shall be paint-stencilled on the outside surface of the shipping reel.

14 Coating and Protection

14.1 Coatings

Coiled tubing strings shall be given an external protective film to protect them from corrosion during transit, unless specified otherwise in the purchase agreement.

Coatings should be smooth and should not drain or evaporate from the tubing surface. Also, the coating shall be designed so that it does not bind the coiled tubing together restricting uncoiling operations.

If bare tubing or specially coated tubing is desired, the purchase agreement shall so state. For special coatings, the purchase agreement shall state further whether it is to be applied to the full length, or whether a certain specified distance from the end is to be left uncoated.

NOTE Unless otherwise specified, such bare ends are commonly given a coating for protection in transit.

14.2 Protection from Corrosion

14.2.1 Protection of Outer Diameter of Uncoated Tubing

Coiled tubing that has not been given a corrosion-resistant external coating shall be protected from exposure to liquid water by one of the following methods:

a) wrapping the shipping reel holding the tubing with plastic,

b) covering the tubing with an appropriate tarpaulin system to protect the outside surface,

c) placing the coiled reels in a container designed to protect the tubing from liquid water, and

d) placing the coiled reels in a dry warehouse.

14.2.2 Coiled Tubing Preshipment Preparation

As agreed between the manufacturer and the purchaser, after all manufacturing steps are complete and the coiled tubing is ready to be shipped or transferred to storage, the coiled tubing shall be filled with a dry nonreactive gas and the ends sealed. For coiled tubing that has been in storage prior to shipment, the end seals shall be inspected prior to shipment. If the end seals are broken, the manufacturer shall restore the protective environment, refill the tubing with nonreactive gas, and reseal the tube ends.

14.2.3 Internal Surface Protective Coating

When specified on the purchase agreement the manufacturer shall protect the internal surface of the coiled tubing. The internal corrosion inhibitor and application method shall be specified or approved by the purchaser.

15 Document Control and Retention

15.1 General

The manufacturer shall establish procedures for maintaining traceability of heat, master coil, and skelp identity of all finished tubing with regard to all applicable chemical and mechanical test results, and nondestructive testing.

15.2 Certification

15.2.1 General

The manufacturer shall furnish to the purchaser a certificate of compliance stating that the material has been manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements as stated on the purchase agreement.

15.2.2 Spool Documentation

The manufacturer shall maintain at least the following information for each finished string supplied to the customer. When specified on the purchase agreement, any of items a) through l) shall be provided to the customer:

a) the manufacturer's certificate shall state the API Specification and date of revision to which the tubing was manufactured;

b) specified diameter, wall thickness, and grade;

c) chemical analyses (heat, product, if required) showing the mass in percent of all elements whose limits or reporting requirements are set in this specification (see 8.2);

d) test data for all tensile tests required by this specification including yield strength, tensile strength, elongation, and hardness (where required);

e) the location of any skelp-end welds, and any tube-to-tube welds, measured from the reference end of the finished product;

f) hydrostatic test pressure and duration at specified test pressure;

g) the method of nondestructive inspection employed for the weld seam (e.g. ultrasonic, electromagnetic) and the nondestructive test reference indicators used;

h) the type and size of all image quality indicators and other reference standards used during the inspection of skelp-end and tube-to-tube welds;

i) fracture-toughness test results (including test type and criteria and the size, location, and, orientation of the specimen) where such testing is specified by the purchaser;

j) results of any supplemental testing required by the purchaser;

k) the number of times that the tubing has been spooled, and spool dimensions;

l) certification of the coiled tubing drying procedure.

15.3 Retention of Records

Manufacturing and quality records requiring retention are shown in Table A.15. Such records shall be retained by the manufacturer and shall be made available to the purchaser upon request for a 5-year period after the date of purchase from the manufacturer.

Annex A
(normative)

Tables

Table A.1—Chemical Requirements (mass percent)

Grade	Carbon Max.	Manganese Max.	Phosphorus Max.	Sulfur Max.	Silicon Max.
CT70	0.16	1.20	0.025	0.005	0.50
CT80	0.16	1.20	0.020	0.005	0.50
CT90	0.16	1.20	0.020	0.005	0.50
CT100	0.16	1.65	0.025	0.005	0.50
CT110	0.16	1.65	0.025	0.005	0.50

Table A.2—Tensile Requirements

Grade	Yield Strength (min.)		Yield Strength (max.)		Tensile Strength (min.)		Hardness Maximum
	psi	MPa	psi	MPa	psi	MPa	Body and Weld, HRC
CT70	70,000	(483)	80,000	(552)	80,000	(552)	22
CT80	80,000	(551)	90,000	(620)	88,000	(607)	22
CT90	90,000	(620)	100,000	(689)	97,000	(669)	22
CT100	100,000	(689)			108,000	(758)	28
CT110	110,000	(758)			115,000	(793)	30

Table A.3—Elongation Table—Normative

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)
Designation			Cross Sectional Area, A		Elongation in 2.00 in., minimum (%)				
Size	Wall Thickness				Coiled tubing grades				
	in.	Mm	in^2	mm^2	CT70	CT80	CT90	CT100	CT110
0.750	0.080	2.0	0.1684	108.6	17.0	15.5	14.0	13.0	12.0
0.750	0.083	2.1	0.1739	112.2	17.0	15.5	14.5	13.0	12.5
0.750	0.087	2.2	0.1812	116.9	17.0	16.0	14.5	13.0	12.5
0.750	0.095	2.4	0.1955	126.1	17.5	16.0	14.5	13.5	12.5
0.750	0.102	2.6	0.2076	134.0	17.5	16.0	15.0	13.5	12.5
1.000	0.075	1.9	0.2179	140.6	18.0	16.5	15.0	13.5	13.0
1.000	0.080	2.0	0.2312	149.2	18.0	16.5	15.0	14.0	13.0
1.000	0.083	2.1	0.2391	154.3	18.0	16.5	15.5	14.0	13.0
1.000	0.087	2.2	0.2495	161.0	18.8	17.0	15.5	14.0	13.0
1.000	0.095	2.4	0.2701	174.3	18.5	17.0	15.5	14.0	13.5
1.000	0.102	2.6	0.2878	185.6	19.0	17.5	16.0	14.5	13.5
1.000	0.109	2.8	0.3051	196.8	19.0	17.5	16.0	14.5	13.5
1.000	0.118	3.0	0.3270	210.9	19.5	17.5	16.0	14.5	14.0
1.000	0.125	3.2	0.3436	221.7	19.5	18.0	16.5	15.0	14.0
1.000	0.134	3.4	0.3646	235.2	19.5	18.0	16.5	15.0	14.0
1.250	0.075	1.9	0.2769	178.6	18.5	17.0	15.5	14.5	13.5
1.250	0.080	2.0	0.2941	189.7	19.0	17.5	16.0	14.5	13.5
1.250	0.087	2.2	0.3179	205.1	19.0	17.5	16.0	14.5	14.0
1.250	0.095	2.4	0.3447	222.4	19.5	18.0	16.5	15.0	14.0
1.250	0.102	2.6	0.3679	237.3	20.0	18.0	16.5	15.0	14.5
1.250	0.109	2.8	0.3907	252.1	20.0	18.5	17.0	15.5	14.5
1.250	0.118	3.0	0.4196	270.7	20.5	18.5	17.0	15.5	14.5
1.250	0.125	3.2	0.4418	285.0	20.5	19.0	17.5	15.5	15.0
1.250	0.134	3.4	0.4698	303.1	21.0	19.0	17.5	16.0	15.0
1.250	0.145	3.7	0.5034	324.7	21.0	19.5	17.5	16.0	15.0
1.250	0.156	4.0	0.5362	345.9	21.5	19.5	18.0	16.5	15.5
1.250	0.175	4.4	0.5910	381.3	21.5	20.0	18.5	16.5	15.5
1.500	0.087	2.2	0.3862	249.2	20.0	18.5	17.0	15.0	14.5
1.500	0.095	2.4	0.4193	270.5	20.5	18.5	17.0	15.5	14.5
1.500	0.102	2.6	0.4480	289.0	20.5	19.0	17.5	15.5	15.0
1.500	0.109	2.8	0.4763	307.3	21.0	19.0	17.5	16.0	15.0
1.500	0.118	3.0	0.5123	330.5	21.0	19.5	18.0	16.0	15.0
1.500	0.125	3.2	0.5400	348.4	21.5	19.5	18.0	16.5	15.5
1.500	0.134	3.4	0.5751	371.0	21.5	20.0	18.0	16.5	15.5
1.500	0.145	3.7	0.6172	398.2	22.0	20.0	18.5	16.5	16.0
1.500	0.156	4.0	0.6587	425.0	22.0	20.5	18.5	17.0	16.0
1.500	0.175	4.4	0.7285	470.0	22.5	21.0	19.0	17.5	16.5
1.500	0.188	4.8	0.7749	499.9	23.0	21.0	19.5	17.5	16.5

Table A.3—Elongation Table—Normative (Continued)

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)
Designation			Cross Sectional Area, A		Elongation in 2.00 in., minimum (%)				
Size	Wall Thickness				Coiled tubing grades				
	in.	Mm	in^2	mm^2	CT70	CT80	CT90	CT100	CT110
1.500	0.204	5.2	0.8306	535.9	23.5	21.0	18.5	18.0	17.0
1.750	0.095	2.4	0.4939	318.7	21.0	19.5	17.5	16.0	15.0
1.750	0.102	2.6	0.5281	340.7	21.5	19.5	18.0	16.0	15.5
1.750	0.109	2.8	0.5619	362.5	21.5	20.0	18.0	16.5	15.5
1.750	0.118	3.0	0.6050	390.3	22.0	20.0	18.5	16.5	16.0
1.750	0.125	3.2	0.6381	411.7	22.0	20.5	18.5	17.0	16.0
1.750	0.134	3.4	0.6803	438.9	22.5	20.5	19.0	17.0	16.0
1.750	0.145	3.7	0.7311	471.7	22.5	21.0	19.0	17.5	16.5
1.750	0.156	4.0	0.7812	504.0	23.0	21.0	19.5	17.5	16.5
1.750	0.175	4.4	0.8659	558.6	23.5	21.5	19.5	18.0	17.0
1.750	0.188	4.8	0.9225	595.2	24.0	22.0	20.0	18.0	17.0
1.750	0.204	5.2	0.9908	639.2	24.0	22.0	20.5	18.5	17.5
1.750	0.224	5.7	1.0739	692.8	24.5	22.5	20.5	18.5	17.5
1.750	0.250	6.4	1.1781	760.1	25.0	23.0	21.0	19.0	18.0
2.000	0.109	2.8	0.6475	417.8	22.0	20.5	18.5	17.0	16.0
2.000	0.118	3.0	0.6977	450.1	22.5	20.5	19.0	17.0	16.0
2.000	0.125	3.2	0.7363	475.0	22.5	21.0	19.0	17.5	16.5
2.000	0.134	3.4	0.7855	506.8	23.0	21.0	19.5	17.5	16.5
2.000	0.145	3.7	0.8450	545.2	23.5	21.5	19.5	18.0	17.0
2.000	0.156	4.0	0.9037	583.0	23.5	21.5	20.0	18.0	17.0
2.000	0.175	4.4	1.0033	647.3	24.0	22.0	20.5	18.5	17.5
2.000	0.188	4.8	1.0702	690.5	24.5	22.5	20.5	18.5	17.5
2.000	0.204	5.2	1.1510	742.6	25.0	23.0	21.0	19.0	18.0
2.000	0.224	5.7	1.2498	806.3	25.5	23.0	21.5	19.5	18.0
2.000	0.250	6.4	1.3745	886.7	25.5	23.5	21.5	19.5	18.5
2.000	0.276	7.0	1.4948	964.4	26.0	24.0	22.0	20.0	19.0
2.000	0.281	7.1	1.5175	979.0	26.5	24.0	22.0	20.0	19.0
2 3/8	0.109	2.8	0.7760	500.6	23.0	21.0	19.5	17.5	16.5
2 3/8	0.118	3.0	0.8367	539.8	23.5	21.5	19.5	18.0	17.0
2 3/8	0.125	3.2	0.8836	570.0	23.5	21.5	20.0	18.0	17.0
2 3/8	0.134	3.4	0.9434	608.6	24.0	22.0	20.0	18.0	17.0
2 3/8	0.145	3.7	1.0158	655.4	24.0	22.0	20.5	18.5	17.5
2 3/8	0.156	4.0	1.0875	701.6	24.5	22.5	20.5	18.5	17.5
2 3/8	0.175	4.4	1.2095	780.3	25.0	23.0	21.0	19.0	18.0
2 3/8	0.188	4.8	1.2917	833.3	25.5	23.5	21.5	19.5	18.5
2 3/8	0.204	5.2	1.3914	897.7	26.0	23.5	21.5	19.5	18.5
2 3/8	0.224	5.7	1.5137	976.6	26.0	24.0	22.0	20.0	19.0
2 3/8	0.250	6.4	1.6690	1076.8	26.5	24.5	22.5	20.5	19.5
2 3/8	0.276	7.0	1.8200	1174.2	27.0	25.0	23.0	21.0	19.5

Table A.3—Elongation Table—Normative (Continued)

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)
Designation			Cross Sectional Area, A		Elongation in 2.00 in., minimum (%)				
Size	Wall Thickness				Coiled tubing grades				
	in.	Mm	in^2	mm^2	CT70	CT80	CT90	CT100	CT110
2 3/8	0.281	7.1	1.8486	1192.6	27.5	25.0	23.0	21.0	19.5
2 3/8	0.300	7.6	1.9556	1261.7	27.5	25.5	23.0	21.0	20.0
2 5/8	0.145	3.7	1.1297	728.8	25.0	22.5	21.0	19.0	18.0
2 5/8	0.156	4.0	1.2100	780.7	25.0	23.0	21.0	19.0	18.0
2 5/8	0.175	4.4	1.3470	869.0	25.5	23.5	21.5	19.5	18.5
2 5/8	0.188	4.8	1.4393	928.6	26.0	24.0	22.0	20.0	18.5
2 5/8	0.204	5.2	1.5516	1001.0	26.5	24.0	22.0	20.0	19.0
2 5/8	0.224	5.7	1.6896	1090.1	27.0	24.5	22.5	20.5	19.5
2 5/8	0.250	6.4	1.8653	1203.4	27.5	25.0	23.0	21.0	19.5
2 5/8	0.276	7.0	2.0368	1314.0	28.0	25.5	23.5	21.5	20.0
2 5/8	0.281	7.1	2.0693	1335.0	28.0	25.5	23.5	21.5	20.0
2 5/8	0.300	7.6	2.1913	1413.7	28.5	26.0	24.0	21.5	20.5
2 7/8	0.134	3.4	1.1539	744.4	25.0	23.0	21.0	19.0	18.0
2 7/8	0.145	3.7	1.2436	802.3	25.0	23.0	21.0	19.5	18.0
2 7/8	0.156	4.0	1.3326	859.7	25.8	23.5	21.5	19.5	18.5
2 7/8	0.175	4.4	1.4844	957.7	26.0	24.0	22.0	20.0	19.0
2 7/8	0.188	4.8	1.5870	1023.9	26.5	24.5	22.5	20.0	19.0
2 7/8	0.204	5.2	1.7118	1104.4	27.0	24.5	22.5	20.5	19.5
2 7/8	0.224	5.7	1.8656	1203.6	27.5	25.0	23.0	21.0	19.5
2 7/8	0.250	6.4	2.0617	1330.1	28.0	25.5	23.5	21.5	20.0
2 7/8	0.276	7.0	2.2535	1453.9	28.5	26.0	24.0	21.5	20.5
2 7/8	0.281	7.1	2.2900	1477.4	28.5	26.0	24.0	22.0	20.5
2 7/8	0.300	7.6	2.4269	1565.7	29.0	26.5	24.5	22.0	21.0
3 1/4	0.145	3.7	1.4144	912.5	26.0	24.0	22.0	20.0	18.5
3 1/4	0.156	4.0	1.5163	978.3	26.5	24.0	22.0	20.0	19.0
3 1/4	0.175	4.4	1.6906	1090.7	27.0	24.5	22.5	20.5	19.5
3 1/4	0.188	4.8	1.8085	1166.8	27.0	25.0	23.0	21.0	19.5
3 1/4	0.204	5.2	1.9521	1259.4	27.5	25.5	23.0	21.0	20.0
3 1/4	0.224	5.7	2.1295	1373.8	28.0	26.0	23.5	21.5	20.5
3 1/4	0.250	6.4	2.3562	1520.1	28.5	26.5	24.0	22.0	20.5
3 1/4	0.276	7.0	2.5787	1663.7	29.0	27.0	24.5	22.5	21.0
3 1/4	0.281	7.1	2.6210	1691.0	29.5	27.0	24.5	22.5	21.0
3 1/4	0.300	7.6	2.7803	1793.7	29.5	27.0	25.0	22.5	21.5
3 1/2	0.156	4.0	1.6389	1057.3	26.5	24.5	22.5	20.5	19.0
3 1/2	0.175	4.4	1.8280	1179.4	27.5	25.0	23.0	21.0	19.5
3 1/2	0.188	4.8	1.9561	1262.0	27.5	25.5	23.0	21.0	20.0
3 1/2	0.204	5.2	2.1124	1362.8	28.0	26.0	23.5	21.5	20.0
3 1/2	0.224	5.7	2.3054	1487.3	28.5	26.0	24.0	22.0	20.5

Table A.3—Elongation Table—Normative (Continued)

(1)			(2)	(3)	(4)	(5)	(6)	(7)	(8)
Designation			Cross Sectional Area, A		Elongation in 2.00 in., minimum (%)				
Size	Wall Thickness				Coiled tubing grades				
	in.	Mm	in^2	mm^2	CT70	CT80	CT90	CT100	CT110
3 1/2	0.250	6.4	2.5526	1646.8	29.0	26.5	24.5	22.0	21.0
3 1/2	0.276	7.0	2.7955	1803.5	29.5	27.0	25.0	22.5	21.5
3 1/2	0.281	7.1	2.8417	1833.4	30.0	27.5	25.0	22.5	21.5
3 1/2	0.300	7.6	3.0159	1945.8	30.0	27.5	25.5	23.0	21.5
NOTE Table based upon elongation calculations in 2.00 in. (50.8 mm) gauge length section.									

Table A.4—Flattening Requirements

Grade	D/t ratio [a]	Maximum Distance Between Plates (in. or mm.)
CT70	7-23	$D(1.074 – 0.0194\ D/t)$
CT80 [b]	7-23	$D(1.074 – 0.0194\ D/t)$
CT90 [b]	7-23	$D(1.080 – 0.0178\ D/t)$
CT100 [b]	7-23	$D(1.080 – 0.0178\ D/t)$
CT110 [c]	All	$D(1.086 – 0.0163\ D/t)$

a D = Specified outside diameter of the tubing.
t = Specified wall thickness of the tubing.

b If the flattening test fails at 0° or 180°, the flattening shall continue until the remaining portion of the specimen fails at the 90° or 270° position. Premature failure at 12 o'clock or 6 o'clock position shall not be considered basis for rejection (see Retest 12.3).

c Flattening shall be at least $0.85D$.

Table A.5—Coiled Tubing Dimensions, Masses per Unit Length and Test Pressures (U.S. Customary Units)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure				
		D	Specified	Minimum								
			t	t_{min}	w_{pe}		d	CT70	CT80	CT90	CT100	CT110
Size	Wall	in.	in.	in.	lb/ft		in.	psig	psig	psig	psig	psig
0.750	0.080	0.750	0.080	0.075	0.57	9.375	0.590	11200	12800	14400	15000	15000
0.750	0.083	0.750	0.083	0.078	0.59	9.036	0.584	11600	13300	15000	15000	15000
0.750	0.087	0.750	0.087	0.082	0.62	8.621	0.576	12200	14000	15000	15000	15000
0.750	0.095	0.750	0.095	0.090	0.67	7.895	0.560	13400	15000	15000	15000	15000
0.750	0.102	0.750	0.102	0.097	0.71	7.353	0.546	14500	15000	15000	15000	15000
1.000	0.075	1.000	0.075	0.070	0.74	13.333	0.850	7800	9000	10100	11200	12300
1.000	0.080	1.000	0.080	0.075	0.79	12.500	0.840	8400	9600	10800	12000	13200
1.000	0.083	1.000	0.083	0.078	0.81	12.048	0.834	8700	10000	11200	12500	13700
1.000	0.087	1.000	0.087	0.082	0.85	11.494	0.826	9200	10500	11800	13100	14400
1.000	0.095	1.000	0.095	0.090	0.92	10.526	0.810	10100	11500	13000	14400	15000
1.000	0.102	1.000	0.102	0.097	0.98	9.804	0.796	10900	12400	14000	15000	15000
1.000	0.109	1.000	0.109	0.104	1.04	9.174	0.782	11600	13300	15000	15000	15000
1.000	0.118	1.000	0.118	0.110	1.11	8.475	0.764	12300	14100	15000	15000	15000
1.000	0.125	1.000	0.125	0.117	1.17	8.000	0.750	13100	15000	15000	15000	15000
1.000	0.134	1.000	0.134	0.126	1.24	7.463	0.732	14100	15000	15000	15000	15000
1.250	0.075	1.250	0.075	0.070	0.94	16.667	1.100	6300	7200	8100	9000	9900
1.250	0.080	1.250	0.080	0.075	1.00	15.625	1.090	6700	7700	8600	9600	10600
1.250	0.087	1.250	0.087	0.082	1.08	14.368	1.076	7300	8400	9400	10500	11500
1.250	0.095	1.250	0.095	0.090	1.17	13.158	1.060	8100	9200	10400	11500	12700
1.250	0.102	1.250	0.102	0.097	1.25	12.255	1.046	8700	9900	11200	12400	13700
1.250	0.109	1.250	0.109	0.104	1.33	11.468	1.032	9300	10600	12000	13300	14600
1.250	0.118	1.250	0.118	0.110	1.43	10.593	1.014	9900	11300	12700	14100	15000
1.250	0.125	1.250	0.125	0.117	1.50	10.000	1.000	10500	12000	13500	15000	15000
1.250	0.134	1.250	0.134	0.126	1.60	9.328	0.982	11300	12900	14500	15000	15000
1.250	0.145	1.250	0.145	0.137	1.71	8.621	0.960	12300	14000	15000	15000	15000
1.250	0.156	1.250	0.156	0.148	1.82	8.013	0.938	13300	15000	15000	15000	15000
1.250	0.175	1.250	0.175	0.167	2.01	7.143	0.900	15000	15000	15000	15000	15000
1.500	0.087	1.500	0.087	0.082	1.31	17.241	1.326	6100	7000	7900	8700	9600
1.500	0.095	1.500	0.095	0.090	1.43	15.789	1.310	6700	7700	8600	9600	10600
1.500	0.102	1.500	0.102	0.097	1.52	14.706	1.296	7200	8300	9300	10300	11400
1.500	0.109	1.500	0.109	0.104	1.62	13.761	1.282	7800	8900	10000	11100	12200
1.500	0.118	1.500	0.118	0.110	1.74	12.712	1.264	8200	9400	10600	11700	12900
1.500	0.125	1.500	0.125	0.117	1.84	12.000	1.250	8700	10000	11200	12500	13700
1.500	0.134	1.500	0.134	0.126	1.96	11.194	1.232	9400	10800	12100	13400	14800
1.500	0.145	1.500	0.145	0.137	2.10	10.345	1.210	10200	11700	13200	14600	15000
1.500	0.156	1.500	0.156	0.148	2.24	9.615	1.188	11100	12600	14200	15000	15000

Table A.5—Coiled Tubing Dimensions, Masses per Unit Length and Test Pressures (U.S. Customary Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure				
		D	Specified	Minimum								
			t	t_{min}	w_{pe}		d	CT70	CT80	CT90	CT100	CT110
Size	Wall	in.	in.	in.	lb/ft		in.	psig	psig	psig	psig	psig
1.500	0.175	1.500	0.175	0.167	2.48	8.571	1.150	12500	14300	15000	15000	15000
1.500	0.188	1.500	0.188	0.180	2.64	7.979	1.124	13400	15000	15000	15000	15000
1.500	0.204	1.500	0.204	0.196	2.83	7.353	1.092	14600	15000	15000	15000	15000
1.750	0.095	1.750	0.095	0.090	1.68	18.421	1.560	5800	6600	7400	8200	9100
1.750	0.102	1.750	0.102	0.097	1.80	17.157	1.546	6200	7100	8000	8900	9800
1.750	0.109	1.750	0.109	0.104	1.91	16.055	1.532	6700	7600	8600	9500	10500
1.750	0.118	1.750	0.118	0.110	2.06	14.831	1.514	7000	8000	9100	10100	11100
1.750	0.125	1.750	0.125	0.117	2.17	14.000	1.500	7500	8600	9600	10700	11800
1.750	0.134	1.750	0.134	0.126	2.31	13.060	1.482	8100	9200	10400	11500	12700
1.750	0.145	1.750	0.145	0.137	2.49	12.069	1.460	8800	10000	11300	12500	13800
1.750	0.156	1.750	0.156	0.148	2.66	11.218	1.438	9500	10800	12200	13500	14900
1.750	0.175	1.750	0.175	0.167	2.95	10.000	1.400	10700	12200	13700	15000	15000
1.750	0.188	1.750	0.188	0.180	3.14	9.309	1.374	11500	13200	14800	15000	15000
1.750	0.204	1.750	0.204	0.196	3.37	8.578	1.342	12500	14300	15000	15000	15000
1.750	0.224	1.750	0.224	0.216	3.65	7.813	1.302	13800	15000	15000	15000	15000
1.750	0.250	1.750	0.250	0.242	4.01	7.000	1.250	15000	15000	15000	15000	15000
2.000	0.109	2.000	0.109	0.104	2.20	18.349	1.782	5800	6700	7500	8300	9200
2.000	0.118	2.000	0.118	0.110	2.37	16.949	1.764	6200	7000	7900	8800	9700
2.000	0.125	2.000	0.125	0.117	2.51	16.000	1.750	6600	7500	8400	9400	10300
2.000	0.134	2.000	0.134	0.126	2.67	14.925	1.732	7100	8100	9100	10100	11100
2.000	0.145	2.000	0.145	0.137	2.88	13.793	1.710	7700	8800	9900	11000	12100
2.000	0.156	2.000	0.156	0.148	3.08	12.821	1.688	8300	9500	10700	11800	13000
2.000	0.175	2.000	0.175	0.167	3.41	11.429	1.650	9400	10700	12000	13400	14700
2.000	0.188	2.000	0.188	0.176	3.64	10.638	1.624	9900	11300	12700	14100	15000
2.000	0.204	2.000	0.204	0.192	3.92	9.804	1.592	10800	12300	13800	15000	15000
2.000	0.224	2.000	0.224	0.212	4.25	8.929	1.552	11900	13600	15000	15000	15000
2.000	0.250	2.000	0.250	0.238	4.68	8.000	1.500	13300	15000	15000	15000	15000
2.000	0.276	2.000	0.276	0.261	5.09	7.246	1.448	14600	15000	15000	15000	15000
2.000	0.281	2.000	0.281	0.266	5.16	7.117	1.438	14900	15000	15000	15000	15000
2 3/8	0.109	2.375	0.109	0.104	2.64	21.789	2.157	4900	5600	6300	7000	7700
2 3/8	0.118	2.375	0.118	0.110	2.85	20.127	2.139	5200	5900	6700	7400	8200
2 3/8	0.125	2.375	0.125	0.117	3.01	19.000	2.125	5500	6300	7100	7900	8700
2 3/8	0.134	2.375	0.134	0.126	3.21	17.724	2.107	5900	6800	7600	8500	9300
2 3/8	0.145	2.375	0.145	0.137	3.46	16.379	2.085	6500	7400	8300	9200	10200
2 3/8	0.156	2.375	0.156	0.148	3.70	15.224	2.063	7000	8000	9000	10000	11000

Table A.5—Coiled Tubing Dimensions, Masses per Unit Length and Test Pressures (U.S. Customary Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure				
		D	Specified	Minimum								
			t	t_{min}	w_{pe}		d	CT70	CT80	CT90	CT100	CT110
Size	Wall	in.	in.	in.	lb/ft		in.	psig	psig	psig	psig	psig
2 3/8	0.175	2.375	0.175	0.167	4.12	13.571	2.025	7900	9000	10100	11300	12400
2 3/8	0.188	2.375	0.188	0.176	4.40	12.633	1.999	8300	9500	10700	11900	13000
2 3/8	0.204	2.375	0.204	0.192	4.73	11.642	1.967	9100	10300	11600	12900	14200
2 3/8	0.224	2.375	0.224	0.212	5.15	10.603	1.927	10000	11400	12900	14300	15000
2 3/8	0.250	2.375	0.250	0.238	5.68	9.500	1.875	11200	12800	14400	15000	15000
2 3/8	0.276	2.375	0.276	0.261	6.19	8.605	1.823	12300	14100	15000	15000	15000
2 3/8	0.281	2.375	0.281	0.266	6.29	8.452	1.813	12500	14300	15000	15000	15000
2 3/8	0.300	2.375	0.300	0.285	6.65	7.917	1.775	13400	15000	15000	15000	15000
2 5/8	0.145	2.625	0.145	0.137	3.84	18.103	2.335	5800	6700	7500	8400	9200
2 5/8	0.156	2.625	0.156	0.148	4.12	16.827	2.313	6300	7200	8100	9000	9900
2 5/8	0.175	2.625	0.175	0.167	4.58	15.000	2.275	7100	8100	9200	10200	11200
2 5/8	0.188	2.625	0.188	0.176	4.90	13.963	2.249	7500	8600	9700	10700	11800
2 5/8	0.204	2.625	0.204	0.192	5.28	12.868	2.217	8200	9400	10500	11700	12900
2 5/8	0.224	2.625	0.224	0.212	5.75	11.719	2.177	9000	10300	11600	12900	14200
2 5/8	0.250	2.625	0.250	0.238	6.35	10.500	2.125	10200	11600	13100	14500	15000
2 5/8	0.276	2.625	0.276	0.261	6.93	9.511	2.073	11100	12700	14300	15000	15000
2 5/8	0.281	2.625	0.281	0.266	7.04	9.342	2.063	11300	13000	14600	15000	15000
2 5/8	0.300	2.625	0.300	0.285	7.46	8.750	2.025	12200	13900	15000	15000	15000
2 7/8	0.134	2.875	0.134	0.126	3.93	21.455	2.607	4900	5600	6300	7000	7700
2 7/8	0.145	2.875	0.145	0.137	4.23	19.828	2.585	5300	6100	6900	7600	8400
2 7/8	0.156	2.875	0.156	0.148	4.53	18.429	2.563	5800	6600	7400	8200	9100
2 7/8	0.175	2.875	0.175	0.167	5.05	16.429	2.525	6500	7400	8400	9300	10200
2 7/8	0.188	2.875	0.188	0.176	5.40	15.293	2.499	6900	7800	8800	9800	10800
2 7/8	0.204	2.875	0.204	0.192	5.82	14.093	2.467	7500	8500	9600	10700	11800
2 7/8	0.224	2.875	0.224	0.212	6.35	12.835	2.427	8300	9400	10600	11800	13000
2 7/8	0.250	2.875	0.250	0.238	7.02	11.500	2.375	9300	10600	11900	13200	14600
2 7/8	0.276	2.875	0.276	0.261	7.67	10.417	2.323	10200	11600	13100	14500	15000
2 7/8	0.281	2.875	0.281	0.266	7.79	10.231	2.313	10400	11800	13300	14800	15000
2 7/8	0.300	2.875	0.300	0.285	8.26	9.583	2.275	11100	12700	14300	15000	15000
3 1/4	0.145	3.250	0.145	0.137	4.81	22.414	2.960	4700	5400	6100	6700	7400
3 1/4	0.156	3.250	0.156	0.148	5.16	20.833	2.938	5100	5800	6600	7300	8000
3 1/4	0.175	3.250	0.175	0.167	5.75	18.571	2.900	5800	6600	7400	8200	9000
3 1/4	0.188	3.250	0.188	0.176	6.15	17.287	2.874	6100	6900	7800	8700	9500
3 1/4	0.204	3.250	0.204	0.192	6.64	15.931	2.842	6600	7600	8500	9500	10400
3 1/4	0.224	3.250	0.224	0.212	7.25	14.509	2.802	7300	8300	9400	10400	11500

Table A.5—Coiled Tubing Dimensions, Masses per Unit Length and Test Pressures (U.S. Customary Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure				
		D	Specified	Minimum								
			t	t_{min}	w_{pe}		d	CT70	CT80	CT90	CT100	CT110
Size	Wall	in.	in.	in.	lb/ft		in.	psig	psig	psig	psig	psig
3 1/4	0.250	3.250	0.250	0.238	8.02	13.000	2.750	8200	9400	10500	11700	12900
3 1/4	0.276	3.250	0.276	0.261	8.77	11.775	2.698	9000	10300	11600	12800	14100
3 1/4	0.281	3.250	0.281	0.266	8.92	11.566	2.688	9200	10500	11800	13100	14400
3 1/4	0.300	3.250	0.300	0.285	9.46	10.833	2.650	9800	11200	12600	14000	15000
3 1/2	0.156	3.500	0.156	0.148	5.58	22.436	3.188	4700	5400	6100	6800	7400
3 1/2	0.175	3.500	0.175	0.167	6.22	20.000	3.150	5300	6100	6900	7600	8400
3 1/2	0.188	3.500	0.188	0.176	6.66	18.617	3.124	5600	6400	7200	8000	8900
3 1/2	0.204	3.500	0.204	0.192	7.19	17.157	3.092	6100	7000	7900	8800	9700
3 1/2	0.224	3.500	0.224	0.212	7.84	15.625	3.052	6800	7800	8700	9700	10700
3 1/2	0.250	3.500	0.250	0.238	8.69	14.000	3.000	7600	8700	9800	10900	12000
3 1/2	0.276	3.500	0.276	0.261	9.51	12.681	2.948	8400	9500	10700	11900	13100
3 1/2	0.281	3.500	0.281	0.266	9.67	12.456	2.938	8500	9700	10900	12200	13400
3 1/2	0.300	3.500	0.300	0.285	10.26	11.667	2.900	9100	10400	11700	13000	14300

Table A.6—Coiled Tubing Dimensions, Masses per Unit Length, and Hydrostatic Test Pressures (SI Units)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure (N/mm^2 or MPa)				
		D_m	Specified	Minimum				Grade				
			t_m	$t_{m(min)}$	w_{pem}		d					
Size	Wall	mm	Mm	mm	kg/m		mm	CT70	CT80	CT90	CT100	CT110
0.750	2.0	19.1	2.0	1.9	0.85	9.375	15.0	77.2	88.3	99.3	103.4	103.4
0.750	2.1	19.1	2.1	2.0	0.88	9.036	14.8	80.3	91.8	103.3	103.4	103.4
0.750	2.2	19.1	2.2	2.1	0.92	8.621	14.6	84.4	96.5	103.4	103.4	103.4
0.750	2.4	19.1	2.4	2.3	0.99	7.895	14.2	92.7	103.4	103.4	103.4	103.4
0.750	2.6	19.1	2.6	2.5	1.05	7.353	13.9	99.9	103.4	103.4	103.4	103.4
1.000	1.9	25.4	1.9	1.8	1.10	13.333	21.6	54.1	61.8	69.5	77.2	84.9
1.000	2.0	25.4	2.0	1.9	1.17	12.500	21.3	57.9	66.2	74.5	82.7	91.0
1.000	2.1	25.4	2.1	2.0	1.21	12.048	21.2	60.2	68.8	77.4	86.0	94.7
1.000	2.2	25.4	2.2	2.1	1.26	11.494	21.0	63.3	72.4	81.4	90.5	99.5
1.000	2.4	25.4	2.4	2.3	1.37	10.526	20.6	69.5	79.4	89.4	99.3	103.4
1.000	2.6	25.4	2.6	2.5	1.46	9.804	20.2	74.9	85.6	96.3	103.4	103.4
1.000	2.8	25.4	2.8	2.6	1.55	9.174	19.9	80.3	91.8	103.3	103.4	103.4
1.000	3.0	25.4	3.0	2.8	1.66	8.475	19.4	84.9	97.1	103.4	103.4	103.4
1.000	3.2	25.4	3.2	3.0	1.74	8.000	19.1	90.3	103.3	103.4	103.4	103.4
1.000	3.4	25.4	3.4	3.2	1.85	7.463	18.6	97.3	103.4	103.4	103.4	103.4
1.250	1.9	31.8	1.9	1.8	1.40	16.667	27.9	43.2	49.4	55.6	61.8	68.0
1.250	2.0	31.8	2.0	1.9	1.49	15.625	27.7	46.3	53.0	59.6	66.2	72.8
1.250	2.2	31.8	2.2	2.1	1.61	14.368	27.3	50.7	57.9	65.1	72.4	79.6
1.250	2.4	31.8	2.4	2.3	1.75	13.158	26.9	55.6	63.5	71.5	79.4	87.4
1.250	2.6	31.8	2.6	2.5	1.86	12.255	26.6	59.9	68.5	77.0	85.6	94.2
1.250	2.8	31.8	2.8	2.6	1.98	11.468	26.2	64.2	73.4	82.6	91.8	101.0
1.250	3.0	31.8	3.0	2.8	2.13	10.593	25.8	68.0	77.7	87.4	97.1	103.4
1.250	3.2	31.8	3.2	3.0	2.24	10.000	25.4	72.3	82.6	92.9	103.3	103.4
1.250	3.4	31.8	3.4	3.2	2.38	9.328	24.9	77.8	89.0	100.1	103.4	103.4
1.250	3.7	31.8	3.7	3.5	2.55	8.621	24.4	84.6	96.7	103.4	103.4	103.4
1.250	4.0	31.8	4.0	3.8	2.72	8.013	23.8	91.4	103.4	103.4	103.4	103.4
1.250	4.4	31.8	4.4	4.2	2.99	7.143	22.9	103.2	103.4	103.4	103.4	103.4
1.500	2.2	38.1	2.2	2.1	1.96	17.241	33.7	42.2	48.2	54.3	60.3	66.3
1.500	2.4	38.1	2.4	2.3	2.12	15.789	33.3	46.3	53.0	59.6	66.2	72.8
1.500	2.6	38.1	2.6	2.5	2.27	14.706	32.9	49.9	57.1	64.2	71.3	78.5
1.500	2.8	38.1	2.8	2.6	2.41	13.761	32.6	53.5	61.2	68.8	76.5	84.1
1.500	3.0	38.1	3.0	2.8	2.59	12.712	32.1	56.6	64.7	72.8	80.9	89.0
1.500	3.2	38.1	3.2	3.0	2.73	12.000	31.8	60.2	68.8	77.4	86.0	94.7
1.500	3.4	38.1	3.4	3.2	2.91	11.194	31.3	64.9	74.1	83.4	92.7	101.9
1.500	3.7	38.1	3.7	3.5	3.13	10.345	30.7	70.5	80.6	90.7	100.8	103.4
1.500	4.0	38.1	4.0	3.8	3.34	9.615	30.2	76.2	87.1	98.0	103.4	103.4

Table A.6—Coiled Tubing Dimensions, Masses per Unit Length, and Hydrostatic Test Pressures (SI Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	*D/t* Ratio	Calculated Inside Diameter	Minimum Test Pressure (N/mm^2 or MPa)				
		D_m	Specified t_m	Minimum $t_{m(min)}$	w_{pem}		*d*	Grade				
Size	Wall	mm	Mm	mm	kg/m		mm	CT70	CT80	CT90	CT100	CT110
1.500	4.4	38.1	4.4	4.2	3.69	8.571	29.2	86.0	98.3	103.4	103.4	103.4
1.500	4.8	38.1	4.8	4.6	3.92	7.979	28.5	92.7	103.4	103.4	103.4	103.4
1.500	5.2	38.1	5.2	5.0	4.21	7.353	27.7	100.9	103.4	103.4	103.4	103.4
1.750	2.4	44.5	2.4	2.3	2.50	18.421	39.6	39.7	45.4	51.1	56.7	62.4
1.750	2.6	44.5	2.6	2.5	2.67	17.157	39.3	42.8	48.9	55.0	61.1	67.3
1.750	2.8	44.5	2.8	2.6	2.85	16.055	38.9	45.9	52.4	59.0	65.6	72.1
1.750	3.0	44.5	3.0	2.8	3.06	14.831	38.5	48.5	55.5	62.4	69.3	76.3
1.750	3.2	44.5	3.2	3.0	3.23	14.000	38.1	51.6	59.0	66.4	73.8	81.1
1.750	3.4	44.5	3.4	3.2	3.45	13.060	37.6	55.6	63.5	71.5	79.4	87.4
1.750	3.7	44.5	3.7	3.5	3.7	12.069	37.1	60.5	69.1	77.7	86.4	95.0
1.750	4.0	44.5	4.0	3.8	3.96	11.218	36.5	65.3	74.6	84.0	93.3	102.6
1.750	4.4	44.5	4.4	4.2	4.39	10.000	35.6	73.7	84.2	94.7	103.4	103.4
1.750	4.8	44.5	4.8	4.6	4.67	9.309	34.9	79.4	90.8	102.1	103.4	103.4
1.750	5.2	44.5	5.2	5.0	5.02	8.578	34.1	86.5	98.8	103.4	103.4	103.4
1.750	5.7	44.5	5.7	5.5	5.44	7.813	33.1	95.3	103.4	103.4	103.4	103.4
1.750	6.4	44.5	6.4	6.1	5.97	7.000	31.8	103.4	103.4	103.4	103.4	103.4
2.000	2.8	50.8	2.8	2.6	3.28	18.349	45.3	40.2	45.9	51.6	57.4	63.1
2.000	3.0	50.8	3.0	2.8	3.53	16.949	44.8	42.5	48.5	54.6	60.7	66.7
2.000	3.2	50.8	3.2	3.0	3.73	16.000	44.5	45.2	51.6	58.1	64.5	71.0
2.000	3.4	50.8	3.4	3.2	3.98	14.925	44.0	48.6	55.6	62.5	69.5	76.4
2.000	3.7	50.8	3.7	3.5	4.28	13.793	43.4	52.9	60.5	68.0	75.6	83.1
2.000	4.0	50.8	4.0	3.8	4.58	12.821	42.9	57.1	65.3	73.5	81.6	89.8
2.000	4.4	50.8	4.4	4.2	5.08	11.429	41.9	64.5	73.7	82.9	92.1	101.3
2.000	4.8	50.8	4.8	4.5	5.42	10.638	41.2	68.0	77.7	87.4	97.1	103.4
2.000	5.2	50.8	5.2	4.9	5.83	9.804	40.4	74.1	84.7	95.3	103.4	103.4
2.000	5.7	50.8	5.7	5.4	6.33	8.929	39.4	81.9	93.5	103.4	103.4	103.4
2.000	6.4	50.8	6.4	6.0	6.96	8.000	38.1	91.9	103.4	103.4	103.4	103.4
2.000	7.0	50.8	7.0	6.6	7.57	7.246	36.8	100.8	103.4	103.4	103.4	103.4
2.000	7.1	50.8	7.1	6.8	7.69	7.117	36.5	102.7	103.4	103.4	103.4	103.4
2 3/8	2.8	60.3	2.8	2.6	3.93	21.789	54.8	33.8	38.6	43.5	48.3	53.1
2 3/8	3.0	60.3	3.0	2.8	4.24	20.127	54.3	35.8	40.9	46.0	51.1	56.2
2 3/8	3.2	60.3	3.2	3.0	4.47	19.000	54.0	38.0	43.5	48.9	54.3	59.8
2 3/8	3.4	60.3	3.4	3.2	4.78	17.724	53.5	41.0	46.8	52.7	58.5	64.4
2 3/8	3.7	60.3	3.7	3.5	5.14	16.379	53.0	44.5	50.9	57.3	63.6	70.0
2 3/8	4.0	60.3	4.0	3.8	5.51	15.224	52.4	48.1	55.0	61.9	68.7	75.6
2 3/8	4.4	60.3	4.4	4.2	6.13	13.571	51.4	54.3	62.1	69.8	77.6	85.3

Table A.6—Coiled Tubing Dimensions, Masses per Unit Length, and Hydrostatic Test Pressures (SI Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	*D/t* Ratio	Calculated Inside Diameter	Minimum Test Pressure (N/mm^2 or MPa)				
		D_m	Specified t_m	Minimum $t_{m(min)}$	w_{pem}		*d*	Grade				
Size	Wall	mm	Mm	mm	kg/m		mm	CT70	CT80	CT90	CT100	CT110
2 3/8	4.8	60.3	4.8	4.5	6.54	12.633	50.8	57.2	65.4	73.6	81.8	89.9
2 3/8	5.2	60.3	5.2	4.9	7.05	11.642	50.0	62.4	71.3	80.3	89.2	98.1
2 3/8	5.7	60.3	5.7	5.4	7.67	10.603	48.9	68.9	78.8	88.6	98.5	103.4
2 3/8	6.4	60.3	6.4	6.0	8.45	9.500	47.6	77.4	88.4	99.5	103.4	103.4
2 3/8	7.0	60.3	7.0	6.6	9.22	8.605	46.3	84.9	97.0	103.4	103.4	103.4
2 3/8	7.1	60.3	7.1	6.8	9.36	8.452	46.1	86.5	98.8	103.4	103.4	103.4
2 3/8	7.6	60.3	7.6	7.2	9.90	7.917	45.1	92.7	103.4	103.4	103.4	103.4
2 5/8	3.7	66.7	3.7	3.5	5.72	18.103	59.3	40.3	46.1	51.8	57.6	63.3
2 5/8	4.0	66.7	4.0	3.8	6.13	16.827	58.8	43.5	49.8	56.0	62.2	68.4
2 5/8	4.4	66.7	4.4	4.2	6.82	15.000	57.8	49.1	56.1	63.2	70.2	77.2
2 5/8	4.8	66.7	4.8	4.5	7.29	13.963	57.1	51.8	59.2	66.6	74.0	81.4
2 5/8	5.2	66.7	5.2	4.9	7.86	12.868	56.3	56.5	64.6	72.6	80.7	88.8
2 5/8	5.7	66.7	5.7	5.4	8.56	11.719	55.3	62.4	71.3	80.2	89.1	98.0
2 5/8	6.4	66.7	6.4	6.0	9.45	10.500	54.0	70.0	80.0	90.0	100.0	103.4
2 5/8	7.0	66.7	7.0	6.6	10.32	9.511	52.7	76.8	87.7	98.7	103.4	103.4
2 5/8	7.1	66.7	7.1	6.8	10.48	9.342	52.4	78.3	89.4	100.6	103.4	103.4
2 5/8	7.6	66.7	7.6	7.2	11.10	8.750	51.4	83.8	95.8	103.4	103.4	103.4
2 7/8	3.4	73.0	3.4	3.2	5.84	21.455	66.2	33.8	38.7	43.5	48.3	53.2
2 7/8	3.7	73.0	3.7	3.5	6.30	19.828	65.7	36.8	42.1	47.3	52.6	57.8
2 7/8	4.0	73.0	4.0	3.8	6.75	18.429	65.1	39.8	45.4	51.1	56.8	62.5
2 7/8	4.4	73.0	4.4	4.2	7.52	16.429	64.1	44.9	51.3	57.7	64.1	70.5
2 7/8	4.8	73.0	4.8	4.5	8.04	15.293	63.5	47.3	54.0	60.8	67.5	74.3
2 7/8	5.2	73.0	5.2	4.9	8.67	14.093	62.7	51.6	58.9	66.3	73.7	81.0
2 7/8	5.7	73.0	5.7	5.4	9.45	12.835	61.6	56.9	65.1	73.2	81.3	89.5
2 7/8	6.4	73.0	6.4	6.0	10.44	11.500	60.3	63.9	73.1	82.2	91.3	100.5
2 7/8	7.0	73.0	7.0	6.6	11.41	10.417	59.0	70.1	80.1	90.1	100.1	103.4
2 7/8	7.1	73.0	7.1	6.8	11.6	10.231	58.8	71.4	81.7	91.9	102.1	103.4
2 7/8	7.6	73.0	7.6	7.2	12.29	9.583	57.8	76.5	87.5	98.4	103.4	103.4
3 1/4	3.7	82.6	3.7	3.5	7.16	22.414	75.2	32.6	37.2	41.9	46.5	51.2
3 1/4	4.0	82.6	4.0	3.8	7.68	20.833	74.6	35.2	40.2	45.2	50.2	55.3
3 1/4	4.4	82.6	4.4	4.2	8.56	18.571	73.7	39.7	45.3	51.0	56.7	62.4
3 1/4	4.8	82.6	4.8	4.5	9.16	17.287	73.0	41.8	47.8	53.8	59.7	65.7
3 1/4	5.2	82.6	5.2	4.9	9.89	15.931	72.2	45.6	52.1	58.7	65.2	71.7
3 1/4	5.7	82.6	5.7	5.4	10.78	14.509	71.2	50.4	57.6	64.8	72.0	79.2
3 1/4	6.4	82.6	6.4	6.0	11.93	13.000	69.9	56.5	64.6	72.7	80.8	88.9
3 1/4	7.0	82.6	7.0	6.6	13.06	11.775	68.5	62.0	70.9	79.7	88.6	97.5

Table A.6—Coiled Tubing Dimensions, Masses per Unit Length, and Hydrostatic Test Pressures (SI Units) (Continued)

(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Designation		Outside Diameter	Wall Thickness		Mass per Unit Length	D/t Ratio	Calculated Inside Diameter	Minimum Test Pressure (N/mm^2 or MPa)				
		D_m	Specified t_m	Minimum $t_{m(min)}$	w_{pem}		d	Grade				
Size	Wall	mm	Mm	mm	kg/m		mm	CT70	CT80	CT90	CT100	CT110
3 1/4	7.1	82.6	7.1	6.8	13.27	11.566	68.3	63.2	72.2	81.3	90.3	99.3
3 1/4	7.6	82.6	7.6	7.2	14.08	10.833	67.3	67.7	77.4	87.1	96.7	103.4
3 1/2	4.0	88.9	4.0	3.8	8.3	22.436	81.0	32.7	37.3	42.0	46.6	51.3
3 1/2	4.4	88.9	4.4	4.2	9.26	20.000	80.0	36.8	42.1	47.4	52.6	57.9
3 1/2	4.8	88.9	4.8	4.5	9.91	18.617	79.3	38.8	44.4	49.9	55.5	61.0
3 1/2	5.2	88.9	5.2	4.9	10.7	17.157	78.5	42.4	48.4	54.5	60.5	66.6
3 1/2	5.7	88.9	5.7	5.4	11.68	15.625	77.5	46.8	53.5	60.1	66.8	73.5
3 1/2	6.4	88.9	6.4	6.0	12.93	14.000	76.2	52.5	60.0	67.5	75.0	82.5
3 1/2	7.0	88.9	7.0	6.6	14.16	12.681	74.9	57.6	65.8	74.0	82.3	90.5
3 1/2	7.1	88.9	7.1	6.8	14.39	12.456	74.6	58.7	67.1	75.5	83.8	92.2
3 1/2	7.6	88.9	7.6	7.2	15.27	11.667	73.7	62.9	71.9	80.8	89.8	98.8

Table A.7—Tolerances [a] for Diameter at Tubing Body

(1)	(2)
Size Designation	Tolerance [a]
All sizes	+0.010 in (0.25 mm), –0.010 in (–0.25 mm)
a Tolerance measured at the place of manufacture, prior to spooling.	

Table A.8—Tolerances for Wall Thickness

(1)	(2)
Specified Wall Thickness (t)	Tolerance
Below 0.110 in. (2.8 mm)	–0.005 in.(–0.1 mm) to + 0.010 in. (+0.2 mm)
0.110 in. (2.8 mm) to 0.175 in. (4.4 mm)	–0.008 in. (–0.2 mm) to +0.012 in. (+0.3 mm)
0.176 in. (4,5 mm) to 0.250 in. (6.4 mm)	–0.012 in. (–0.3 mm) to +0.012 in. (+0.3 mm)
0.251 in. (6.4 mm) and greater	–0.015 in. (–0.4 mm) to +0.015 in. (+0.4 mm)

Table A.9—Maximum Depth of Trim

(1)	(2)
Specified Wall Thickness (t)	Maximum Depth of Trim
0.150 in. (3.8 mm) and less	0.10t
0.151 in. (3.9 mm) to 0.300 in. (7.6 mm)	0.015 in. (0.4 mm)

Table A.10—Gauge Ball Drift Dimensions and Standoff

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specified Outside Diameter, *D*		**Specified Wall Thickness, *t***		**Gauge Ball Size**		**Gauge Ball Stand Off**	
in.	mm	in.	mm	in.	mm	in.	mm
0.750	19.1	0.080	2.0	0.375	9.5	0.215	5.5
0.750	19.1	0.083	2.1	0.375	9.5	0.209	5.3
0.750	19.1	0.087	2.2	0.375	9.5	0.201	5.1
0.750	19.1	0.095	2.4	0.375	9.5	0.185	4.7
0.750	19.1	0.102	2.6	0.375	9.5	0.141	3.6
1.000	25.4	0.075	1.9	0.563	14.3	0.287	7.3
1.000	25.4	0.080	2.0	0.563	14.3	0.277	7.0
1.000	25.4	0.083	2.1	0.563	14.3	0.271	6.9
1.000	25.4	0.087	2.2	0.563	14.3	0.263	6.7
1.000	25.4	0.095	2.4	0.563	14.3	0.247	6.3
1.000	25.4	0.102	2.6	0.563	14.3	0.233	5.9
1.000	25.4	0.109	2.8	0.563	14.3	0.221	5.6
1.000	25.4	0.118	3.0	0.563	14.3	0.201	5.1
1.000	25.4	0.125	3.2	0.563	14.3	0.187	4.7
1.000	25.4	0.134	3.4	0.563	14.3	0.169	4.3
1.250	31.8	0.075	1.9	0.625	15.9	0.475	12.1
1.250	31.8	0.080	2.0	0.625	15.9	0.465	11.8
1.250	31.8	0.087	2.2	0.625	15.9	0.451	11.5
1.250	31.8	0.095	2.4	0.625	15.9	0.435	11.0
1.250	31.8	0.102	2.6	0.625	15.9	0.421	10.7
1.250	31.8	0.109	2.8	0.625	15.9	0.407	10.3
1.250	31.8	0.118	3.0	0.625	15.9	0.389	9.9
1.250	31.8	0.125	3.2	0.625	15.9	0.375	9.5
1.250	31.8	0.134	3.4	0.625	15.9	0.357	9.1
1.250	31.8	0.145	3.7	0.625	15.9	0.335	8.5
1.250	31.8	0.156	4.0	0.625	15.9	0313	8.0
1.250	31.8	0.175	4.4	0.625	15.9	0.275	7.0
1.500	38.1	0.087	2.2	1.000	25.4	0.326	8.3
1.500	38.1	0.095	2.4	1.000	25.4	0.310	7.9
1.500	38.1	0.102	2.6	1.000	25.4	0.296	7.5
1.500	38.1	0.109	2.8	1.000	25.4	0.282	7.2
1.500	38.1	0.118	3.0	1.000	25.4	0.264	6.7
1.500	38.1	0.125	3.2	1.000	25.4	0.250	6.4

Table A.10—Gauge Ball Drift Dimensions and Standoff (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specified Outside Diameter, *D*		**Specified Wall Thickness, *t***		**Gauge Ball Size**		**Gauge Ball Stand Off**	
in.	mm	in.	mm	in.	mm	in.	mm
1.500	38.1	0.134	3.4	1.000	25.4	0.232	5.9
1.500	38.1	0.145	3.7	1.000	25.4	0.210	5.3
1.500	38.1	0.156	4.0	1.000	25.4	0.188	4.8
1.500	38.1	0.175	4.4	1.000	25.4	0.150	3.8
1.500	38.1	0.188	4.8	0.750	19.1	0.374	9.5
1.500	38.1	0.204	5.2	0.750	19.1	0.342	8.7
1.750	44.5	0.095	2.4	1.313	33.4	0.247	6.3
1.750	44.5	0.102	2.6	1.313	33.4	0.233	5.9
1.750	44.5	0.109	2.8	1.313	33.4	0.219	5.6
1.750	44.5	0.118	3.0	1.313	33.4	0.201	5.1
1.750	44.5	0.125	3.2	1.313	33.4	0.187	4.7
1.750	44.5	0.134	3.4	1.313	33.4	0.169	4.3
1.750	44.5	0.145	3.7	1.313	33.4	0.147	3.7
1.750	44.5	0.156	4.0	1.000	25.4	0.206	5.2
1.750	44.5	0.188	4.8	1.000	25.4	0.374	9.5
1.750	44.5	0.204	5.2	1.000	25.4	0.342	8.7
1.750	44.5	0.224	5.7	1.000	25.4	0.302	7.7
1.750	44.5	0.250	6.4	1.000	25.4	0.250	6.4
2.000	50.8	0.109	2.8	1.500	38.1	0.282	7.2
2.000	50.8	0.118	3.0	1.500	38.1	0.264	6.7
2.000	50.8	0.125	3.2	1.500	38.1	0.250	6.4
2.000	50.8	0.134	3.4	1.500	38.1	0.232	5.9
2.000	50.8	0.145	3.7	1.500	38.1	0.210	5.3
2.000	50.8	0.156	4.0	1.500	38.1	0.188	4.8
2.000	50.8	0.175	4.4	1.500	38.1	0.150	3.8
2.000	50.8	0.188	4.8	1.313	33.4	0.311	7.9
2.000	50.8	0.204	5.2	1.313	33.4	0.279	7.1
2.000	50.8	0.224	5.7	1.313	33.4	0.239	6.1
2.000	50.8	0.250	6.4	1.313	33.4	0.187	4.7
2.000	50.8	0.276	7.0	1.313	33.4	0.135	3.4
2.000	50.8	0.281	7.1	1.313	33.4	0.125	3.2
2.375	60.3	0.109	2.9	1.750	44.5	0.407	10.3
2.375	60.3	0.118	3.0	1.750	44.5	0.389	10.1

Table A.10—Gauge Ball Drift Dimensions and Standoff (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specified Outside Diameter, *D*		**Specified Wall Thickness, *t***		**Gauge Ball Size**		**Gauge Ball Stand Off**	
in.	mm	in.	mm	in.	mm	in.	mm
2.375	60.3	0.125	3.2	1.750	44.5	0.375	9.5
2.375	60.3	0.134	3.4	1.750	44.5	0.357	9.1
2.375	60.3	0.145	3.7	1.750	44.5	0.335	8.5
2.375	60.3	0.156	4.0	1.750	44.5	0.313	8.0
2.375	60.3	0.175	4.4	1.750	44.5	0.275	7.0
2.375	60.3	0.188	4.8	1.750	44.5	0.248	6.3
2.375	60.3	0.204	5.2	1.750	44.5	0.217	5.5
2.375	60.3	0.224	5.7	1.750	44.5	0.177	4.5
2.375	60.3	0.250	6.4	1.750	44.5	0.125	3.2
2.375	60.3	0.276	7.0	1.625	41.3	0.198	5.0
2.375	60.3	0.281	7.1	1.625	41.3	0.188	4.8
2.375	60.3	0.300	7.6	1.500	38.1	0.275	7.0
2.625	66.7	0.145	3.7	2.000	50.8	0.335	8.5
2.625	66.7	0.156	4.0	2.000	50.8	0.313	8.0
2.625	66.7	0.175	4.4	2.000	50.8	0.275	7.0
2.625	66.7	0.188	4.8	2.000	50.8	0.249	6.3
2.625	66.7	0.204	5.2	2.000	50.8	0.217	5.5
2.625	66.7	0.224	5.7	2.000	50.8	0.177	4.5
2.625	66.7	0.250	6.4	2.000	50.8	0.125	3.2
2.625	66.7	0.276	7.0	1.750	44.5	0.323	8.2
2.625	66.7	0.281	7.1	1.750	44.5	0.313	8.0
2.625	66.7	0.300	7.6	1.750	44.5	0.275	7.0
2.875	73.0	0.134	3.4	2.250	57.2	0.357	9.1
2.875	73.0	0.145	3.7	2.250	57.2	0.335	8.5
2.875	73.0	0.156	4.0	2.250	57.2	0.313	8.0
2.875	73.0	0.175	4.4	2.250	57.2	0.275	7.0
2.875	73.0	0.188	4.8	2.250	57.2	0.248	6.3
2.875	73.0	0.204	5.2	2.250	57.2	0.217	5.5
2.875	73.0	0.224	5.7	2.250	57.2	0.177	4.5
2.875	73.0	0.250	6.4	2.250	57.2	0.125	3.2
2.875	73.0	0.276	7.0	2.000	50.8	0.323	8.2
2.875	73.0	0.281	7.1	2.000	50.8	0.313	8.0
2.875	73.0	0.300	7.6	2.000	50.8	0.275	7.0

Table A.10—Gauge Ball Drift Dimensions and Standoff (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specified Outside Diameter, *D*		**Specified Wall Thickness, *t***		**Gauge Ball Size**		**Gauge Ball Stand Off**	
in.	mm	in.	mm	in.	mm	in.	mm
3.250	82.6	0.145	3.7	2.625	66.7	0.335	8.5
3.250	82.6	0.156	4.0	2.625	66.7	0.313	8.0
3.250	82.6	0.175	4.4	2.625	66.7	0.275	7.0
3.250	82.6	0.188	4.8	2.625	66.7	0.248	6.3
3.250	82.6	0.204	5.2	2.625	66.7	0.217	5.5
3.250	82.6	0.224	5.7	2.625	66.7	0.177	4.5
3.250	82.6	0.250	6.4	2.625	66.7	0.125	3.2
3.250	82.6	0.276	7.0	2.250	57.2	0.448	11.4
3.250	82.6	0.281	7.1	2.250	57.2	0.438	11.1
3.250	82.6	0.300	7.6	2.250	57.2	0.400	10.1
3.500	88.9	0.156	4.0	2.875	73.0	0.313	8.0
3.500	88.9	0.175	4.4	2.875	73.0	0.275	7.0
3.500	88.9	0.188	4.8	2.875	73.0	0.248	6.3
3.500	88.9	0.204	5.2	2.875	73.0	0.217	5.5
3.500	88.9	0.224	5.7	2.875	73.0	0.177	4.5
3.500	88.9	0.250	6.4	2.875	73.0	0.125	3.2
3.500	88.9	0.276	7.0	2.500	63.5	0.448	11.4
3.500	88.9	0.281	7.1	2.500	63.5	0.438	11.1
3.500	88.9	0.300	7.6	2.500	63.5	0.400	10.1

Table A.11—ASTM Image Quality Indicator

(1)	(2)	(3)	(4)
Specified Single Wall Thickness	**ASTM Designation**	**Essential Hole**	**Wire Diameter**
$t \leq 0.150$ in. (3.8 mm)	10	2T	0.006 in (0.15 mm)
0.150 in. (3.8 mm) $< t \leq$ 0.250 in. (6.4 mm)	12	2T	0.008 in. (0.20 mm)
0.250 in. (6.4 mm) $< t \leq$ 0.375 in. (9.5 mm)	15	2T	0.010 in. (0.25 mm)

Table A.12—ISO Wire 4 Percent Image Quality Indicators

(1)	(2)		(3)		(4)	
Wire #	Wall Thickness				Wire diameter	
	Over		Through			
	in.	mm	in.	mm	in.	mm
Fe 6/12						
9	0.400	(10.2)	0.500	(12.7)	0.020	(0.50)
10	0.325	(8.3)	0.400	(10.2)	0.016	(0.40)
11	0.250	(6.4)	0.325	(8.3)	0.113	(0.32)
12	0.200	(5.1)	0.250	(6.4)	0.010	(0.25)
Fe 10/16						
10	0.325	(8.3)	0.400	(10.2)	0.016	(0.40)
11	0.250	(6.4)	0.325	(8.3)	0.013	(0.32)
12	0.200	(5.1)	0.250	(6.4)	0.010	(0.25)
13	0.162	(4.1)	0.200	(5.1)	0.008	(0.20)
14	0.125	(3.2)	0.162	(4.1)	0.006	(0.16)
15	0.100	(2.5)	0.125	(3.2)	0.005	(0.13)
16	0.080	(2.0)	0.100	(2.5)	0.004	(0.10)

Table A.13—ISO Wire 2 Percent Image Quality Indicators

(1)	(2)		(3)		(4)	
Wire #	Wall Thickness				Wire diameter	
	Over		Through			
	in.	mm	in.	mm	in.	mm
Fe 6/12						
12	0.400	(10.1)	0.500	(12.7)	0.010	(0.25)
Fe 6/12						
10	0.625	(16.2)	0.800	(20.3)	0.016	(0.40)
11	0.500	(12.7)	0.650	(16.2)	0.013	(0.32)
12	0.400	(10.1)	0.500	(12.7)	0.010	(0.25)
13	0.325	(8.3)	0.400	(10.1)	0.008	(0.20)
14	0.250	(6.4)	0.325	(8.3)	0.006	(0.16)
15	0.200	(5.1)	0.250	(6.4)	0.005	(0.13)
16	0.160	(4.1)	0.200	(5.1)	0.004	(0.10)

Table A.14—Acceptance Limits

(1)	(2)		(3)
Reference Indicator	**Size**		**Acceptance Limit Signal (%)**
	in.	mm	
L3 Notch	See 10.7.2		80
Hole	1/32	0.8	80
Hole	1/16	1.6	80
NOTE The L3 notch has a depth of 10 % of the specified wall.			

Table A.15—Retention of Records

(1)	(2)
Requirements	**Reference**
Location of Welds	
Skelp-end Welds	15.2.1
Tube-to-tube Butt Welds	15.2.1
Chemical Composition	
Heat Analysis	8.2.1, 15.2.1
Product Analysis	8.2.2, 15.2.1
Mechanical Tests	
Seam Weld Heat Treatment	15.2.1
Tensile Tests	8.3.1, 15.2.1
Flattening Tests	8.3.2, 15.2.1
Flaring Tests	8.3.3, 15.2.1
Fracture Toughness tests	6.2.6, 15.2.1
Hydrostatic Tests	
Tester recorder charts	8.4.2, 15.2.1
Nondestructive Inspection	
Qualification of Personnel	10.3
Radiographic (Film or digital)	10.6, 15.2.1
Ultrasonic and Electromagnetic	
Supplemental Nondestructive Inspection	Annex E, SR 37
Welding Procedure(s)	Annex B and Annex C
Tubing Spooling	15.2.1
Tubing Drying Certification	15.2.1

Annex B
(normative)

Requirements for Tube-to-tube Welding of Coiled Tubing

B.1 Method

Tube-to-tube welds shall be made in accordance with a qualified welding procedure per Annex C.

B.2 Workmanship

The ends of the tubing to be welded together shall be prepared for welding in accordance with the requirements of the procedure to be used. Each weld shall have a substantially uniform cross section around the entire circumference of the tubing. At no point shall its crowned surface be below the outside surface of the parent metal nor shall it rise above the parent metal by more than $^{1}/_{32}$ in. (0.8 mm).

B.3 Tube-to-tube Weld Location

The location of each tube-to-tube weld relative to the reference end of the coiled tubing shall be recorded. Documentation shall be maintained to identify the welder or operator.

B.4 Nondestructive Testing

The tube-to-tube welds between sections of coiled tubing shall be 100 % inspected for volumetric imperfections by radiographic or ultrasonic methods.

a) Radiographic inspection shall be performed in accordance with the procedures of 10.5.

b) Ultrasonic shear wave inspection and acceptance criteria shall be in accordance with API 1104.

c) The weld section shall be drift tested per 8.5. The gauge ball size may be up to 0.125 in. (3.2 mm) less than the size in Table A.10, and the size reported on the certification.

B.5 Disposition

Tubing-to-tubing welds failing to pass these tests shall be rejected.

Annex C
(normative)

Skelp-end and Tube-to-tube Welding Procedure Specification

C.1 General

The manufacturer shall maintain a record of the welding procedure (WPS) and procedure qualification (PQR) test results. These procedures and qualifications shall be on file and available for use during manufacturing and for purchaser review upon request. Welding procedures, welders and welding machine operators shall be qualified, where applicable, in accordance with ASME *BPVC* Section IX or API 1104. Welding processes outside the scope of ASME *BPVC* Section IX or API 1104 shall be performed according to a procedure, and by a welder or welding operator to the manufacturer's documented requirements, and as agreed upon between the purchaser and manufacturer.

C.2 Skelp-end and Tube-to-tube Welding Procedure Qualification

C.2.1 General

Welding procedures shall be qualified by preparing and testing welds in accordance with one of the following; ASME *BPVC*, Section IX; API 1104; the manufacturer's documented welding qualification requirements. Testing of skelp-end welds shall be performed after tube forming.

C.2.2 Essential Variables

The following shall be considered as additional essential variable(s) of any welding procedure, welder or welding operator qualification for coiled tubing skelp-end and tube-tube welds.

C.3 Welding Personnel Performance Qualification

Each welder and welding machine operator is required to qualify per ASME *BPVC* Section IX or API 1104 or the manufacturer's documented requirements. These qualifications shall be reviewed for accuracy every six months at a minimum and available for purchaser review upon request.

Annex D
(normative)

Supplementary Requirements

By agreement between the purchaser and the manufacturer and when specified on the purchase agreement, the following supplementary requirements (SR) shall apply.

SR37 Nondestructive Inspection of Coiled Tubing

SR37.1 Supplementary Nondestructive Inspection

When specified on the purchase agreement, the entire tube shall be inspected full length for surface and subsurface defects by either automated ultrasonic or electro-magnetic methods. The nondestructive inspection must take place after all heat treating and hydrostatic testing, if performed, but may take place before cropping of the coiled tubing, and addition of the end fitting.

Details of the specific techniques (such as method, reference standards, transducer properties, and sensitivity) shall be agreed upon between the purchaser and the manufacturer for the implementation of this supplementary requirement.

The permitted remaining wall thickness after repair shall be determined by the purchaser as a percentage of the specified wall thickness of the tubing at the location of imperfections or defects.

SR37.2 Qualification and Certification of Inspection

The technicians performing all facets of the inspection (automated inspection and prove-up where necessary) shall be certified in the applicable inspection discipline to Level II in accordance with the latest edition of SNT-TC-1A.

All records from the inspection shall be signed by a Level III inspector.

SR37.3 Equipment and Reference Standards

SR37.3.1 Equipment

In addition to the requirements for the ultrasonic or electromagnetic inspection equipment given in Section 10, the equipment shall contain a length counter that meets the following requirements:

a) capable of measuring the full length of the string with an accuracy of ±1 %;

b) a measurement resolution of ±0.1 ft (30 mm).

The automated inspection equipment shall be capable of creating a permanent electronic data file for each string.

Reinspection shall be conducted so as to verify NDT indications.

SR37.3.1.2 Procedures

All facets of the inspection shall be covered by written procedures.

a) A coverage calculation for all inspection functions performed by the equipment shall be performed and provided with the record of the inspection.

b) Ultrasonic inspection shall be conducted to the requirements of ASTM E273 for shear wave inspection, and ASTM E797 for compression wave inspection.

c) Electromagnetic inspection techniques shall be conducted to the requirements of ASTM E570.

SR37.3.3 Reference Standards

The reference standards shall be manufactured from pieces of the same grade of material, and have the same specified outside diameter and specified wall thickness as the string to be inspected. In the case of tapered strings, there shall be two reference standards, one with the thickest wall thickness in the string, and one with the thinnest wall thickness in the string. The inspection equipment shall be standardized on the reference standard with the thicker wall thickness. The thinner standard shall be used as a check at the end of the string inspection run.

SR37.3.4 Reference Indicators

For all sizes, the outer surface shall contain the following reference indicators:

a) a $^{1}/_{32}$ in. (0.8 mm) through drilled hole;

b) a $^{1}/_{16}$ in. (1.6 mm) hole, drilled from the OD surface to a depth to be determined by agreement between the customer and the manufacturer;

c) a Longitudinal EDM notch of depth 10 % of the specified wall, and length 0.500 in. (12.7 mm) maximum;

d) a transverse EDM notch of depth 10 % of the specified wall, and length 0.250 in. (6.3 mm) maximum;

e) a region of wall loss that is 10 % of the specified wall thickness of the tube.

SR37.3.5 For sizes greater than 1.5 in. (38.1 mm), the inside surface shall also contain the following reference indicators:

a) a longitudinal EDM notch of depth 10 % of the specified wall, and length 0.500 in. (12.7 mm) maximum;

b) a transverse EDM notch of depth 10 % of the specified wall, and length 0.250 in. (6.3 mm) maximum.

SR37.3.6 The maximum width of the EDM notches shall be 0.020 in. (0.5 mm).

SR37.3.7 Individual reference indicators shall be separated sufficiently to generate distinct signals. The signals corresponding to the reference indicators shall be clearly marked on the scans of the reference standard and included in the report.

SR37.3.8 The automated inspection equipment shall be adjusted so as to produce well-defined indications when the reference standard is scanned by the inspection unit in a manner simulating the actual inspection of the string.

SR37.3.9 The minimum signal from the reference standard indicators shall be the detection threshold for the automated NDE of the coiled tubing string.

SR 37.4 Inspection

The full body inspection shall be conducted to detect abnormalities in the tubing wall. The location of all indications exceeding the threshold shall be recorded. Any location in the string where the inspection equipment produces a signal greater than the detection threshold shall be investigated by at least one of the following techniques, until the origin of the indication is determined:

a) visual and dimensional inspection;

b) ultrasonic inspection;

c) electromagnetic (magnetic flux leakage) inspection;

d) magnetic particle inspection;

e) liquid penetrant inspection;

f) radiographic inspection.

The inspector may elect to further investigate signals from the automated inspection equipment that are smaller than those of the detection threshold.

SR37.5 Disposition

a) The coiled tubing string shall not be acceptable unless it meets one of the conditions in SR37.5.1 to SR37.5.4. Repair of imperfections or defects by welding is not permitted.

b) Imperfections on the OD surface may be removed using files and belt sanders so as to remove material over a length at least twice the tubing OD. The remaining wall thickness permitted after repair shall be specified in the purchase agreement as a percentage of the specified wall thickness.

SR37.5.1 The exposed surface shall be polished in the longitudinal direction using progressively finer emery cloth or other suitable polishing material ending with 400 grit to 600 grit. The repaired areas shall be reinspected with the techniques in SR37.4 as appropriate, and the minimum wall thickness reported following repair.

SR37.5.2 The section of tubing containing the defect can be cut off the end of the string.

SR37.5.3 The manufacturer obtains written approval from the purchaser to cut out the section of tubing containing the imperfection or defect, and to splice the cut ends of the string with a tube-to-tube weld or a mechanical connector.

SR37.5.4 Acceptance Criteria for Repaired Surfaces

Following removal of an imperfection, acceptance criteria are as follows:

a) there shall be no visible abnormalities;

b) there shall be no indications of material discontinuities from NDE equipment;

c) there shall be no dents;

d) the polished area shall have a surface finish at least as smooth as the surrounding undisturbed material.

SR37.6 Residual Magnetism Measurement Requirements

The requirements of this paragraph apply only to testing within the pipe manufacturing facility. Measurements of residual magnetism on tubing, subsequent to leaving the pipe manufacturing facility, may be affected by procedures and conditions imposed on the tubing during and after shipment.

a) The longitudinal magnetic field shall be measured on tubing that has been inspected full length by magnetic methods, and is to be butt-welded. Such measurements shall be taken on the root face or square cut face of finished tubing.

b) Measurements shall be made using a Hall-effect gaussmeter or other type of calibrated instrument. However, in case of dispute, measurements made with a Hall-effect gaussmeter shall govern. The gaussmeter shall be operated in accordance with written instructions demonstrated to produce accurate results.

c) As a minimum, four readings shall be taken approximately 90° apart around the circumference of each end of the pipe. The average of the four readings shall not exceed 10 gauss (1.0 mT), and no one reading shall exceed 12 gauss (1.2 mT) when measured with a Hall-effect gaussmeter, or equivalent values when measured with other types of instruments. If these values are exceeded, the tubing ends to be butt-welded shall be demagnetized.

d) If the full length of the tubing has been inspected by a magnetic method, the purchaser shall be notified that the pipe may contain sufficient magnetism to affect subsequent field welding operations.

SR37.7 Documentation

SR37.7.1 Report

The complete results of all NDE performed on a coiled tubing string shall be documented in a report. The axes of plots and headings for tabular data shall be clearly identified and labeled with the corresponding units. The report shall contain the following, as a minimum:

a) serial number or inventory control number of the string;

b) specified OD, length, specified wall thickness(es), and the material of the string;

c) the NDE method(s) utilized;

d) details of the NDE equipment including serial numbers of all calibration standards and the last date of their verification;

e) the NDE procedure(s) followed, including reference number, and revision level;

f) a description of the reference standard(s) used and the detection threshold selected for automated NDE of the string;

g) the output from the inspection equipment for scans of the reference standards with signals corresponding to the reference indicators clearly marked;

h) the results from automated NDE of the string with the location and signal strength of each indication exceeding the detection threshold clearly identified;

i) the method(s) used to prove up each suspect indication, the results from the prove-up, and the disposition of each;

j) the printed name, signature, inspection certification level of the NDE Technician performing the inspection, and the date of the inspection.

SR37.8 NDE System Capability Records

The NDE service provider shall maintain NDE system records verifying the system(s) capabilities in detecting the reference indicators used to establish the equipment test sensitivity. The verification and records shall cover, as a minimum, the following criteria:

a) coverage calculation (i.e. scan plan), including wall thickness verification;

b) capability for the intended wall thickness;

c) repeatability;

d) transducer orientation that provides detection of defects typical of the manufacturing process;

e) documentation demonstrating that defects typical of the manufacturing process are detected using the NDE method;

f) threshold setting parameters;

g) NDE system operating procedures;

h) NDE equipment description;

i) NDE personnel qualification information;

j) dynamic test data demonstrating the NDE system operation capabilities under dynamic production inspection conditions;

k) state of magnetization of tube.

Annex E
(normative)

Purchaser Inspection

E.1 Inspection Notice

Where the inspector representing the purchaser desires to inspect the tubing or witness the tests, reasonable notice shall be given to the inspector by the manufacturer of the time at which the run is to be made.

E.2 Plant Access

The inspector representing the purchaser shall have access at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works that will concern the manufacture of the tubing ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy the inspector that the tubing is being manufactured in accordance with this specification. All inspections should be made at the place of manufacture prior to shipment, unless otherwise specified on the purchase agreement and shall be so conducted as not to interfere unnecessarily with the operation. The inspector shall comply with the guidelines of API 5SI.

E.3 Compliance

The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may make any reasonable investigation necessary to ensure compliance by the manufacturer and may reject any material that does not comply with this specification.

E.4 Rejection

Unless otherwise provided, material that shows defects on inspection or subsequent to acceptance at the manufacturer's works, or material that proves defective when properly applied in service, may be rejected and the manufacturer so notified. Disposition of rejected product shall be a matter of agreement between the manufacturer and the purchaser.

Annex F
(informative)

Use of the API Monogram by Licensees

F.1 Scope

The API Monogram Program allows an API Licensee to apply the API Monogram to products. The API Monogram Program delivers significant value to the international oil and gas industry by linking the verification of an organization's quality management system with the demonstrated ability to meet specific product specification requirements. The use of the Monogram on products constitutes a representation and warranty by the Licensee to purchasers of the products that, on the date indicated, the products were produced in accordance with a verified quality management system and in accordance with an API product specification.

When used in conjunction with the requirements of the API License Agreement, API Spec Q1, in its entirety, defines the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products in accordance with an API product specification.

API Monogram Program licenses are issued only after an on-site audit has verified that the Licensee conforms to the requirements described in API Spec Q1 in total, and the requirements of an API product specification. Customers/users are requested to report to API all problems with API monogrammed products. The effectiveness of the API Monogram Program can be strengthened by customers/users reporting problems encountered with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.asp. API solicits information on new product that is found to be nonconforming with API-specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification deficiencies or nonconformities with API-specified requirements.

This annex sets forth the API Monogram Program requirements necessary for a supplier to consistently produce products in accordance with API-specified requirements. For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, NW, Washington, DC 20005 or call 202-962-4791 or by email at certification@api.org.

F.2 References

In addition to the referenced standards listed earlier in this document, this annex references the following standard:

API Specification Q1.

For Licensees under the Monogram Program, the latest version of this document shall be used. The requirements identified therein are mandatory.

F.3 API Monogram Program: Licensee Responsibilities

F.3.1 Maintaining a License to Use the API Monogram

For all organizations desiring to acquire and maintain a license to use the API Monogram, conformance with the following shall be required at all times:

a) the quality management system requirements of API Spec Q1;

a) the API Monogram Program requirements of API Spec Q1, Annex A;

c) the requirements contained in the API product specification(s) for which the organization desires to be licensed;

d) the requirements contained in the API Monogram Program License Agreement.

F.3.2 Monogrammed Product—Conformance with API Spec Q1

When an API-licensed organization is providing an API monogrammed product, conformance with API-specified requirements, described in API Spec Q1, including Annex A, is required.

F.3.3 Application of the API Monogram

Each Licensee shall control the application of the API Monogram in accordance with the following.

a) Each Licensee shall develop and maintain an API Monogram marking procedure that documents the marking/monogramming requirements specified by the API product specification to be used for application of the API Monogram by the Licensee. The marking procedure shall define the location(s) where the Licensee shall apply the API Monogram and require that the Licensee's license number and date of manufacture be marked on monogrammed products in conjunction with the API Monogram. At a minimum, the date of manufacture shall be two digits representing the month and two digits representing the year (e.g. 05-07 for May 2007) unless otherwise stipulated in the applicable API product specification. Where there are no API product specification marking requirements, the Licensee shall define the location(s) where this information is applied.

b) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the Licensee's API Monogram marking procedure if the product is subsequently found to be nonconforming with API-specified requirements. Products that do not conform to API-specified requirements shall not bear the API Monogram.

c) Only an API Licensee may apply the API Monogram and its license number to API monogrammable products. For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. The current API requirements for Monogram marking are detailed in the API Policy Document, Monogram Marking Requirements, available on the API Monogram Program website at http://www.api.org/certifications/monogram/.

d) The API Monogram shall be applied at the licensed facility.

e) The authority responsible for applying and removing the API Monogram shall be defined in the Licensee's API Monogram marking procedure.

F.3.4 Records

Records required by API product specifications shall be retained for a minimum of five years or for the period of time specified within the product specification if greater than five years. Records specified to demonstrate achievement of the effective operation of the quality system shall be maintained for a minimum of five years.

F.3.5 Quality Program Changes

Any proposed change to the Licensee's quality program to a degree requiring changes to the quality manual shall be submitted to API for acceptance prior to incorporation into the Licensee's quality program.

F.3.6 Use of the API Monogram in Advertising

Licensee shall not use the API Monogram on letterheads or in any advertising (including company-sponsored web sites) without an express statement of fact describing the scope of Licensee's authorization (license number). The Licensee should contact API for guidance on the use of the API Monogram other than on products.

F.4 Marking Requirements for Products

F.4.1 General

These marking requirements apply only to those API Licensees wishing to mark their products with the API Monogram.

F.4.2 Product Specification Identification

Manufacturers shall mark the product as specified in Section F.4.4, as a minimum, including “API Spec 5ST.”

F.4.3 Units

As a minimum, equipment should be marked with U.S. Customary (USC) units. Use of dual units [metric (SI) units and USC units] is acceptable.

F.4.4 Location of Marking

Nameplates and tags shall be made of a corrosion-resistant material and shall be marked as specified in Section 13 and below.

For all tubing, the location of identification markings shall be as specified in 13.1.

The API Monogram shall be marked on the nameplate or tag, in addition to the marking requirements of this specification.

F.4.5 Sequence of Markings

The sequence of identification markings shall be as specified in 13.2 and shall include the manufacturer's API license number, the API Monogram and date (defined as the month and year when the monogram is applied) before 13.2.b).

F.4.6 License Number

The API Monogram license number shall not be used unless it is marked in conjunction with the API Monogram.

F.5 API Monogram Program: API Responsibilities

The API shall maintain records of reported problems encountered with API monogrammed products. Documented cases of nonconformity with API-specified requirements may be reason for an audit of the Licensee involved (also known as audit for “cause”).

Documented cases of specification deficiencies shall be reported, without reference to Licensees, customers or users, to API Subcommittee 18 (Quality) and to the applicable API Standards Subcommittee for corrective actions.

Additional markings, including those for compatible standards following the Specification marking, are allowed and may be applied as desired by the manufacturer or as requested by the purchaser.

Annex G
(informative)

Coiled Tubing Shipping and Service Reels

G.1 General

Coiled tubular product is spooled onto large capstan-like reels, the bed-wrap diameter of which is designed to produce roughly 2 % to 3 % strain in the tubing.

G.2 Reel Dimensions

The size and dimensions (core diameter, core length, flange height) of the shipping reels determines the amount of coiled tubing that can be stored on a reel, and shall be by agreement between the purchaser and the manufacturer. Attention should be paid to the following when ordering coiled tubing:

a) the degree of stabilization of the base of the reel that is needed,

c) drying and backfilling with inert gas,

c) crating.

Typical core diameters for shipping reels sized for specified diameter sizes of coiled tubing strings are shown in Table G.1, along with the calculated spooling radius ratios. The minimum recommended spooling radius ratio for shipping reel core diameter to coiled tubing diameter is 40:1 for all coiled tubular products intended for use in well-servicing operations. Shipping reel core sizes yielding a spooling radius ratio of less than 40:1 for a specified size of coiled tubing shall be by agreement between the purchaser and the manufacturer.

G.3 Reel Transportation

The purchaser should determine local conditions with regard to the transportation of reels of coiled tubing. Size, mass, limitations to daylight travel, and the need for an escort should be considered.

Table G.1—Spooling Radius Ratio for Tubing on Various Core Diameter Reels

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Core Diameter		**Specified Outside Diameters of Coiled Tubing, D, in. (mm)**										
		0.750 (19.1)	**1.000 (25.4)**	**1.250 (31.8)**	**1.500 (38.1)**	**1.750 (44.5)**	**2.000 (50.8)**	**2.375 (60.3)**	**2.625 (66.7)**	**2.875 (73.0)**	**3.250 (82.6)**	**3.500 (88.9)**
in.	(mm)	**Spooling Radius Ratios**										
48	1219	64.0	48.0	NR	NR	NR	NR	NR	NR	NR	NR	NR
72	1829	96.0	72.0	57.6	48.0	41.1	NR	NR	NR	NR	NR	NR
80	2032	106.7	80.0	64.0	53.3	45.7	40.0	NR	NR	NR	NR	NR
82	2083	109.3	82.0	65.6	54.7	46.9	41.0	NR	NR	NR	NR	NR
92	2337	122.7	92.0	73.6	61.3	52.6	46.0	NR	NR	NR	NR	NR
95	2413	126.7	95.0	76.0	63.3	54.3	47.5	40.0	NR	NR	NR	NR
98	2489	130.7	98.0	78.4	65.3	56.0	49.0	41.3	NR	NR	NR	NR
112	2840	149.3	112.0	89.6	74.7	64.0	56.0	47.2	NR	NR	NR	NR
120	3048	160.0	120.0	96.0	80.0	68.6	60.0	50.5	41.7	41.7	NR	NR
130	3302	173.3	130.0	104.0	86.7	74.3	65.0	54.7	45.2	45.2	NR	NR
150	3810	200.0	150.0	120.0	100.0	85.7	75.0	63.2	52.2	52.2	46.2	42.9

NR = Not Recommended

Annex H
(normative)

SI Conversion Procedure

The following procedures were used to make the soft metric conversion of U.S. customary units to SI units in the metric conversion of API 5ST.

H.1 Fractions

Fractions and numbers with fractions in U.S. customary units were converted to the full decimal equivalents in U.S customary numbers in inches without rounding, and the full decimal equivalents in U.S. customary units were then converted to SI values using Equation (H.1).

$$N_{\mathrm{m}} = 25.4 \times N \tag{H.1}$$

where

N_{m} is the SI equivalent of an inch fraction, mm;

N is the full decimal equivalent of a U.S. customary fraction that has not been rounded, in.

The SI equivalent of inch fractions were then rounded to the appropriate number of places in millimeters.

H.2 Outside Diameter

The U.S. customary values for outside diameters of tubing were converted to SI values using Equation (H.2).

$$D_{\mathrm{m}} = 25.4 \times D \tag{H.2}$$

where

D_{m} is the SI outside diameter, mm;

D is the outside diameter, in.

The SI outside diameters of tubing were rounded to the nearest 0.1 mm.

H.3 Wall Thickness

The U.S. customary values for wall thickness were converted to SI values using Equation (H.3).

$$t_{\mathrm{m}} = 25.4 \times t \tag{H.3}$$

where

t_{m} is the SI wall thickness, mm;

t is the wall thickness, in.

The SI wall thicknesses were rounded to the nearest 0.1 mm.

H.4 Inside Diameter

The SI inside diameters of tubing were calculated (not converted) using Equation (H.4).

$$d_m = D_m - 2 \times t_m \quad \text{(H.4)}$$

where

d_m is the SI inside diameter, mm;

D_m is the SI outside diameter, mm;

t_m is the SI wall thickness, mm.

The SI inside diameters were rounded to the nearest 0.1 mm.

H.5 Plain-end Mass per Unit Length

The SI plain-end mass per unit length were calculated (not converted) using Equation (H.5).

$$w_{pem} = 0.024\,661\,5 \times (D_m - t_m)t_m \quad \text{(H.5)}$$

where

w_{pem} is the SI mass per unit length, kg/m;

D_m is the SI outside diameter, mm;

t_m is the SI wall thickness, mm.

The SI plain-end mass per unit length is rounded to the nearest 0.01 kg/m.

H.6 Yield Strength and Tensile Strength

The U.S. customary values for yield strength and tensile strength were converted to SI values using Equation (H.6) and Equation (H.7).

$$y_{sm} = 0.006\,894\,76 \times y_s \quad \text{(H.6)}$$

$$t_{sm} = 0.006\,894\,76 \times t_s \quad \text{(H.7)}$$

where

y_{sm} is the SI yield strength, MPa;

y_s is the yield strength, psi;

t_{sm} is the SI tensile strength, MPa;

t_s is the tensile strength, psi.

H.7 Hydrostatic Test Pressure

The SI hydrostatic test pressures were calculated (not converted) using Equation (H.8).

$$P_m = 1.6\, y_{sm} \times t_{m(min)} / D_m \quad \text{(H.8)}$$

where

P_m is the SI hydrostatic test pressure, MPa;

y_{sm} is the SI yield strength, MPa;

$t_{m(min)}$ is the SI minimum wall thickness, mm;

D_m is the SI outside diameter, mm.

The calculated hydrostatic test pressures were rounded to the nearest 0.1 MPa, not to exceed 103.4 MPa.

H.8 Temperature

The U.S. customary temperatures in degrees Fahrenheit were converted to SI temperature in degrees Celsius using Equation (H.9).

$$°C = (5/9)(°F - 32) \quad \text{(H.9)}$$

where

°C is the SI temperature in degrees Celsius;

°F is the temperature in degrees Fahrenheit.

The SI temperatures were rounded to the nearest 1 °C.

M.9 Charpy Impact Energy

The U.S. customary values for impact energy were converted to SI values using Equation (H.10).

$$E_m = 1.355\,82 \times E \quad \text{(H.10)}$$

where

E_m is the SI Charpy impact energy in joules;

E is the Charpy impact energy in ft-lbs.

The SI values were rounded to the nearest 1 J.

Bibliography

[1] API Recommended Practice 5C7, *Recommended Practice for Coiled Tubing Operations in Oil and Gas Well Services*

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