



Standard Specification for General Requirements for Nickel and Nickel Alloy Welded Tube¹

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1. Scope

1.1 This specification contains various requirements that, with the exception of Sections 6 and 7, are mandatory requirements to the following ASTM nickel and nickel alloy, longitudinally welded tubular product specifications:

Title of Specification	ASTM Designation
Welded UNS N08020, N08024, and UNS N08026 Alloy Tubes	B468
Welded UNS N08120, UNS N08800, UNS N08810, UNS N08811 Alloy Tubes	B515
Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06603, UNS N06025, and UNS N06045) Tubes	B516
Welded Nickel and Nickel-Cobalt Alloy Tube	B626
Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06603, UNS N06025, and UNS N06045) Tubes	B674
Welded Nickel and Nickel-Cobalt Alloy Tube	B674
UNS N08904, UNS N08925, and UNS N08926 Welded Tube	B676
UNS N08366 and UNS N08367 Welded Tube	B676
Welded UNS N06625, N06219, and N08825 Alloy Tubes	B704
Ni-Cr-Mo-Co-W-Fe-Si Alloy (UNS N06333) Welded Tube	B726
Welded Nickel (UNS N02200/UNS N02201) and Nickel Copper Alloy (UNS N04400) Tube	B730

1.2 One or more of the test requirements of Section 6 apply only if specifically stated in the product specification or in the purchase order.

1.3 In case of conflict between a requirement of the product specification and a requirement of this general specification, only the requirement of the product specification need be satisfied.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

¹ This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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2. Referenced Documents

2.1 ASTM Standards:²

- B468 Specification for Welded UNS N08020 Alloy Tubes
- B515 Specification for Welded UNS N08120, UNS N08800, UNS N08810, and UNS N08811 Alloy Tubes
- B516 Specification for Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06603, UNS N06025, and UNS N06045) Tubes
- B626 Specification for Welded Nickel and Nickel-Cobalt Alloy Tube
- B674 Specification for UNS N08925, UNS N08354, and UNS N08926 Welded Tube
- B676 Specification for UNS N08367 Welded Tube
- B704 Specification for Welded UNS N06625, UNS N06219 and UNS N08825 Alloy Tubes
- B726 Specification for Nickel-Chromium-Molybdenum-Cobalt-Tungsten-Iron-Silicon Alloy (UNS N06333) Welded Tube
- B730 Specification for Welded Nickel (UNS N02200/UNS N02201) and Nickel Copper Alloy (UNS N04400) Tube
- B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys
- E8 Test Methods for Tension Testing of Metallic Materials
- E18 Test Methods for Rockwell Hardness of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E39 Methods for Chemical Analysis of Nickel (Withdrawn 1995)³
- E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)³
- E112 Test Methods for Determining Average Grain Size
- E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing
- E273 Practice for Ultrasonic Testing of the Weld Zone of

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

TABLE 1 Permissible Variations for Outside Diameter and Wall Thickness of Welded Tube^{A,B}

Specified Outside Diameter in. (mm)	Outside Diameter		Permissible Variations of Thickness of Specified Nominal Wall, %		Thickness of Specified Minimum Wall, %	
	+	-	+	-	+	-
Over 0.125 (3.2) to 5/8 (16), excl	0.004 (0.13)	0.005 (0.10)	12.5	12.5	28	0
5/8 (16) to 1 1/2 (38), incl	0.0075 (0.19)	0.0075 (0.19)	12.5	12.5	28	0
Over 1 1/2 (38) to 3 (76), incl	0.010 (0.25)	0.010 (0.25)	12.5	12.5	28	0
Over 3 (76) to 4 1/2 (114), incl	0.015 (0.38)	0.015 (0.38)	12.5	12.5	28	0
Over 4 1/2 (114) to 6 (152), incl	0.020 (0.51)	0.020 (0.51)	12.5	12.5	28	0

^A These permissible variations in outside diameter apply only to material as finished at the mill before subsequent swaging, expanding, bending, polishing, or other fabricating operations.

^B The ovality provisions of 4.1 apply.

Welded Pipe and Tubing

E309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys

E571 Practice for Electromagnetic (Eddy-Current) Examination of Nickel and Nickel Alloy Tubular Products

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

2.2 Other Documents:

SNT-TC-1A Recommended Practice for Nondestructive Personnel Qualification and Certification⁴

3. Terminology

3.1 Definitions:

3.1.1 *average diameter, n*—the average of the maximum and minimum outside diameters, as determined at any one cross section of the tube.

3.1.2 *nominal wall, n*—a specified wall thickness with a plus and minus tolerance from the specified thickness.

3.1.3 *thin wall tube, n*—tube with specified wall thickness 3 % or less of the specified outside diameter.

3.1.4 *welded tube, n*—a hollow product of round or any other cross section having a continuous periphery.

4. Dimensions and Permissible Variations

4.1 *Diameter and Wall Thickness*—Individual measurements shall not exceed the tolerances specified in Table 1. The permissible variation in outside diameter is not sufficient to provide for ovality in thin-walled tubes. For thin-walled tubes the maximum and minimum diameters at any cross section shall not deviate from the nominal diameter by more than twice the permissible variation in outside diameter given in the table; however, the mean diameter at that cross section must still be within the permissible variation.

4.2 *Length*—When material is ordered cut-to-length, the length shall conform to the permissible variations prescribed in Table 2.

4.3 *Straightness*—Material shall be reasonably straight and free of bends and kinks.

⁴ Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

TABLE 2 Permissible Variations in Length^A

Outside Diameter, in. (mm)	Cut Length, in. (mm)	
	Over	Under
Cold-finished: under 2 (50.8)	1/8 (3.2)	0
Hot-finished: 2 (50.8) and over	3/16 (4.8)	0
all sizes	3/16 (4.8)	0

^A These permissible variations in length apply to tube in straight lengths. They apply to cut lengths up to and including 24 ft (7.3 m). For lengths over 24 ft an additional over-tolerance of 1/8 in. (3.2 mm) for each 10 ft (3.0 m) or fraction thereof shall be permissible up to a maximum additional over-tolerance of 1/2 in. (12.7 mm).

4.4 *Ends*—Ends shall be plain or cut and deburred.

5. Workmanship, Finish, and Appearance

5.1 The material shall be uniform in quality and temper, smooth, and free of imperfections that would render it unfit for use.

6. Test Requirements

6.1 Flange Test:

6.1.1 A length of tube not less than three times the specified diameter or 4 in. (102 mm), whichever is longer, shall be capable of having a flange turned over at a right angle to the body of the tube without cracking or showing imperfections rejectable under the provisions of the product specification. The width of the flange shall not be less than 15 % of the tube diameter.

6.1.2 The flanged specimen shall not exhibit through wall cracking or any cracking observable without magnification.

6.2 Flattening Test:

6.2.1 A length of tube not less than 4 in. (102 mm), shall be flattened under a load applied gradually at room temperature until the distance between the platens is five times the wall thickness. The weld shall be positioned 90° from the direction of the applied flattening force.

6.2.2 The flattened specimen shall not exhibit cracks.

6.2.3 Superficial ruptures resulting from surface imperfections shall not be a cause for rejection.

6.3 *Flare Test*—The flare test shall consist of flaring a test specimen with an expanding tool having an included angle of 60° until the specified outside diameter has been increased by 30 %. The flared specimen shall not exhibit cracking through the wall.

6.4 Pressure (Leak Test):

6.4.1 *Hydrostatic*—Each tube with an outside diameter $\frac{1}{8}$ in. (3 mm) and larger, and with wall thickness of 0.015 in. (0.38 mm) and over, shall be tested by the manufacturer to a minimum internal hydrostatic pressure of 1000 psi (6.9 MPa) provided that the fiber stress calculated in accordance with the following equation does not exceed the allowable fiber stress, S , indicated as follows:

$$P = 2St/D \quad (1)$$

where:

- P = hydrostatic test pressure, psi (MPa),
 S = allowable fiber stress, for material in the condition (temper) furnished as specified in the product specification (S is calculated as the lower of $\frac{2}{3}$ of the specified minimum 0.2 % offset yield strength or $\frac{1}{4}$ of the specified minimum ultimate strength for the material),
 t = minimum wall thickness, in. (mm), equal to the specified average wall minus the permissible minus wall tolerance, or the specified minimum wall thickness, and
 D = outside diameter of the tube, in. (mm).

6.4.1.1 The test pressure shall be held for a sufficient time to permit the entire length of the tube to be inspected.

6.4.2 *Pneumatic (Air Underwater) Test*—Each tube with a nominal wall thickness exceeding 0.025 in. (0.64 mm) shall be tested at a minimum pressure of 150 psi (1.05 MPa). The test pressure for tubes having a nominal wall thickness of 0.025 in. (0.64 mm) and under shall be 75 psi (0.52 MPa) minimum. The test pressure shall be held for a minimum of 5 s. Visual examination is to be made when the material is submerged and under pressure. The full length of material must be examined for leaks.

6.4.3 If any tube shows leaks during hydrostatic or pneumatic testing, it shall be rejected.

6.5 *Nondestructive Examination:*

6.5.1 Each tube shall be examined by a nondestructive examination method in accordance with Practices E213, E309, E426, or E571. Upon agreement, Practice E273 shall be employed in addition to one of the full periphery tests. The range of tube sizes that may be examined by each method shall be subject to the limitations in the scope of that practice. In case of conflict between these methods and practices and this specification, the requirements of this specification shall prevail.

6.5.2 The following information is for the benefit of the user of this specification.

6.5.2.1 Calibration standards for the nondestructive electric test are convenient standards for calibration of nondestructive testing equipment only. For several reasons, including shape, orientation, width, etc., the correlation between the signal produced in the electric test from an imperfection and from calibration standards is only approximate. A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific application of these examinations should discuss this with the manufacturer of the tubular product.

6.5.2.2 The ultrasonic examination referred to in this specification is intended to detect longitudinal discontinuities having a reflective area similar to or larger than the calibration

reference notches specified in 6.5.8. The examination may not detect circumferentially oriented imperfections or short, deep defects.

6.5.2.3 The eddy current examination referenced in this specification has the capability of detecting significant discontinuities, especially of the short abrupt type. Practices E309 and E426 contain additional information regarding the capabilities and limitations of eddy-current examination.

6.5.2.4 The hydrostatic test referred to in 6.4.1 is a test method provided for in many product specifications. This test has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. This test may not detect very tight, through-the-wall defects or defects that extend an appreciable distance into the wall without complete penetration.

6.5.2.5 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific application of these examinations should discuss this with the manufacturer of the tubular products.

6.5.3 *Time of Examination:* Nondestructive examination for specification acceptance shall be performed after all deformation processing, heat treating, welding, and straightening operations. This requirement does not preclude additional testing at earlier stages in the processing.

6.5.4 *Surface Condition:*

6.5.4.1 All surfaces shall be free of scale, dirt, grease, paint, or other foreign material that could interfere with interpretation of test results. The methods used for cleaning and preparing the surfaces for examination shall not be detrimental to the base metal or the surface finish.

6.5.4.2 Excessive surface roughness or deep scratches can produce signals that interfere with the test.

6.5.5 *Extent of Examination:*

6.5.5.1 The relative motion of the tube and the transducer(s), coil(s), or sensor(s) shall be such that the entire tube surface is scanned, except for end effects as noted in 6.5.5.2.

6.5.5.2 The existence of end effects is recognized, and the extent of such effects shall be determined by the manufacturer, and, if requested, shall be reported to the purchaser. Other nondestructive tests may be applied to the end areas, subject to agreement between the purchaser and the manufacturer.

6.5.6 *Operator Qualifications:*

6.5.6.1 The test unit operator shall be certified in accordance with SNT-TC-1A, or an equivalent documented standard agreeable to both purchaser and manufacturer.

6.5.7 *Test Conditions:*

6.5.7.1 For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.0 MHz, and the maximum transducer size shall be 1.5 in. (38 mm).

6.5.7.2 For eddy current testing, the excitation coil frequency shall be chosen to ensure adequate penetration, yet provide good signal-to-noise ratio. The maximum coil frequency shall be:

Specified Wall Thickness, in. (mm)	Maximum Frequency, kHz
<0.050 in. (1.25 mm)	100
0.050 to 0.150 (1.25 to 3.80 mm)	50
>0.150 (3.80 mm)	10

6.5.8 Reference Standards:

6.5.8.1 Reference standards of convenient length shall be prepared from a length of tube of the same grade, specified size (outside diameter and wall thickness), surface finish, and heat treatment condition as the tubing to be examined.

6.5.8.2 For eddy current testing, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

(a) *Drilled Hole*—The reference standard shall contain three or more holes, equally spaced circumferentially around the tube and longitudinally separated by a sufficient distance to allow distinct identification of the signal from each hole. The holes shall be drilled radially and completely through the tube wall, with care being taken to avoid distortion of the tube while drilling. The holes shall not be larger than 0.031 in. (0.8 mm) in diameter. As an alternative, the producer may choose to drill one hole and run the calibration standard through the test coil three times, rotating the tube approximately 120° each time. More passes with smaller angular increments may be used, provided testing of the full 360° of the coil is obtained. For welded tubing, if the weld is visible, one of the multiple holes or the single hole shall be drilled in the weld.

(b) *Transverse Tangential Notch*—Using a round tool or file with a ¼ in. (6.4 mm) diameter, a notch shall be milled or filed tangential to the surface and transverse to the longitudinal axis of the tube. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.04 in. (0.1 mm), whichever is greater.

(c) *Longitudinal Notch*—A notch 0.031 in. (0.8 mm) or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the tube, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.1 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

6.5.8.3 For ultrasonic testing, the reference ID and OD notches shall be any one of the three common notch shapes shown in Practice E213, at the option of the manufacturer. The depth of the notches shall not exceed 12½ % of the specified wall thickness of the tube or 0.004 in. (0.1 mm), whichever is greater. The width of the notch shall not exceed two times the depth. For welded tubing, the notches shall be placed in the weld, if the weld is visible.

6.5.8.4 More or smaller reference discontinuities, or both, may be used by agreement between the purchaser and the manufacturer.

6.5.9 Standardization Procedure:

6.5.9.1 The test apparatus shall be standardized at the beginning and end of each series of tubes of the same specified size (diameter and wall thickness), grade and heat treatment condition, and at intervals not exceeding 4 h during the examination of such tubing. More frequent standardizations may be performed at the manufacturer's option or may be required upon agreement between the purchaser and the manufacturer.

6.5.9.2 The test apparatus shall also be standardized after any change in test system settings, change of operator, equipment repair, or interruption due to power loss or shutdown.

6.5.9.3 The reference standard shall be passed through the test apparatus at the same speed and test system settings as the tube to be tested, except that, at the manufacturer's discretion, the tubes may be tested at a higher sensitivity.

6.5.9.4 The signal-to-noise ratio for the reference standard shall be 2.5:1 or greater, and the reference signal amplitude for each discontinuity shall be at least 50 % of full scale of the display. In establishing the noise level, extraneous signals from identifiable surface imperfections on the reference standard may be ignored. When reject filtering is used during UT testing, linearity must be demonstrated.

6.5.9.5 If, upon any standardization, the reference signal amplitude has decreased by at least 29 % (3.0 dB), the test apparatus shall be considered out of standardization. The test system settings may be changed, or the transducer(s), coil(s), or sensor(s) adjusted, and the unit restandardized, but all tubes tested since the last acceptable standardization must be retested.

6.5.10 Evaluation of Imperfections:

6.5.10.1 Tubing producing a test signal equal to or greater than the lowest signal produced by the reference standard shall be designated suspect, shall be clearly marked or identified, and shall be separated from the acceptable tubing.

6.5.10.2 Such suspect tubing shall be subject to one of the following three dispositions:

(a) The tubes shall be rejected without further examination, at the discretion of the manufacturer.

(b) If the test signal was produced by imperfections such as scratches, surface roughness, dings, straightener marks, loose ID bead and cutting chips, steel die stamps, stop marks, tube reducer ripple, or chattered flash trim, the tubing shall be accepted or rejected depending on visual observation of the severity of the imperfection, the type of signal it produces on the testing equipment used, or both.

(c) If the test signal was produced by imperfections that cannot be identified, or was produced by cracks or crack-like imperfections, the tubing shall be rejected.

6.5.10.3 Any tubes with imperfections of the types in 6.5.10.2, (a) and (b), exceeding 0.004 in. (0.1 mm) or 12½ % of the specified minimum wall thickness (whichever is greater) in depth shall be rejected.

6.5.10.4 Rejected tubes may be reconditioned and retested providing the wall thickness is not decreased to less than that required by this or the product specification. If grinding is performed, the outside diameter in the area of grinding may be reduced by the amount so removed. To be accepted, reconditioned tubes must pass the nondestructive examination by which they were originally rejected.

6.6 Chemical Composition:

6.6.1 In case of disagreement, the chemical composition shall be determined in accordance with Table 3.

6.6.2 The material shall conform to the chemical requirements prescribed in the individual specification.

TABLE 3 Chemical Composition

UNS No. Prefixes	ASTM Method
N02	E39
N04	E76
N06, N08	E1473

6.6.3 The product (check) analysis of the material shall meet the requirements for the ladle analysis within the tolerance limits prescribed in Specification **B880**.

6.7 Tension Test:

6.7.1 Tension testing shall be conducted in accordance with Test Methods **E8**.

6.7.2 The material shall conform to the tensile properties prescribed in the individual specification.

6.8 **Hardness Test**—Hardness testing shall be conducted in accordance with Test Methods **E18**.

6.9 **Grain Size**—The measurement of average grain size may be carried out by the planimetric method, the comparison method, or the intercept method described in Test Methods **E112**. In case of dispute, the “referee” method for determining average grain size shall be the intercept method.

6.10 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded in accordance with the rounding method of Practice **E29**:

Requirements	Rounded Unit for Observed or Calculated Value
Chemical composition and tolerances	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength and yield strength	nearest 1000 psi (7 MPa)
Elongation	nearest 1 %

7. Sampling

7.1 **Lot**—A lot for chemical analysis shall consist of one heat.

7.1.1 A lot for all other testing shall consist of all material from the same heat, nominal size (excepting length), and condition (temper). When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and the same heat which are heat-treated in the same furnace charge. When the final heat treatment is in a continuous furnace, a lot shall include all tubes of the same size and heat, annealed in the same furnace at the same temperature, time at temperature, and furnace speed, except not to exceed 20 000 lb.

7.1.2 Where material cannot be identified by heat, a lot shall consist of not more than 500 lb (277 kg) of material of the same alloy in the same condition (temper) and nominal size (excepting length).

NOTE 1—For tension, hardness, flare flattening, and flange test requirements, the term lot applies to all tubes prior to cutting.

7.2 Test Material Selection:

7.2.1 **Chemical Analysis**—Representative samples from each lot shall be taken during pouring or subsequent processing.

7.2.2 **Mechanical and Other Properties**—Samples of the material to provide test specimens for mechanical and other properties shall be taken from such locations in each lot as to be representative of that lot. Test specimens shall be taken from material in the final condition (temper).

8. Retests and Retreatment

8.1 **Retests**—If the results of the mechanical tests of any group or lot do not conform to the requirements specified in the individual specification, retests may be made on additional tubes of double the original number from the same group or lot, each of which shall conform to the requirements specified.

8.2 **Retreatment**—If the individual tube or the tubes selected to represent any group or lot fail to conform to the test requirements, the individual tubes or the group or lot represented may be reheat treated and resubmitted for test. Not more than two reheat treatments shall be permitted.

9. Specimen Preparation

9.1 **Room Temperature Tensile Specimen**—Material shall be tested in the direction of fabrication. Whenever possible, the tube shall be tested in full tubular size. When testing in full tubular size is not possible, longitudinal strip specimens or the largest possible round specimen shall be used. In the event of disagreement when full tubular testing is not possible, a longitudinal strip specimen with reduced gage length as contained in Test Methods **E8** shall be used.

9.2 **Hardness Specimen**—The hardness specimen shall be prepared in accordance with Test Methods **E18**. The test shall be made on the inside diameter surface of a specimen cut from the end or on the inside of the tube near the end, at the option of the manufacturer.

9.3 **Grain Size**—If required, the grain size specimen shall be a transverse sample representing full wall thickness.

10. Inspection

10.1 Inspection of the material shall be agreed upon by the purchaser and the supplier as part of the purchase contract.

11. Rejection and Rehearing

11.1 Material tested by the purchaser that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

12. Certification

12.1 When specified in the purchase order or contract, a manufacturer’s certification shall be furnished to the purchaser stating that the material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

13. Product Marking

13.1 **Material Marking:**

13.1.1 The name or brand of the manufacturer, the name of the material or UNS number, the letters ASTM, the product specification number, heat number, class and nominal size shall be legibly marked on each piece $\frac{3}{4}$ in. (19.0 mm) and over in outside diameter, provided the length is not under 3 ft (914 mm). The material marking shall be by any method that will not result in harmful contamination.

13.1.2 For material less than $\frac{3}{4}$ in. (19.0 mm) in outside diameter and material under 3 ft (914 mm) in length, the information specified in 13.1.1 shall be either legibly marked on each piece or marked on a tag securely attached to the bundle or box in which the tube is shipped at the option of the manufacturer.

13.2 *Packaging*—The following information shall be marked on the material or included on the package, or on a label or tag attached thereto: The name of the material or UNS number, heat number, condition (temper), the letters ASTM, the product specification number, the size, gross, tare and net weight, consignor and consignee address, contract or order number, or such other information as may be defined by the contract or purchase order.

14. Keywords

14.1 welded tube

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