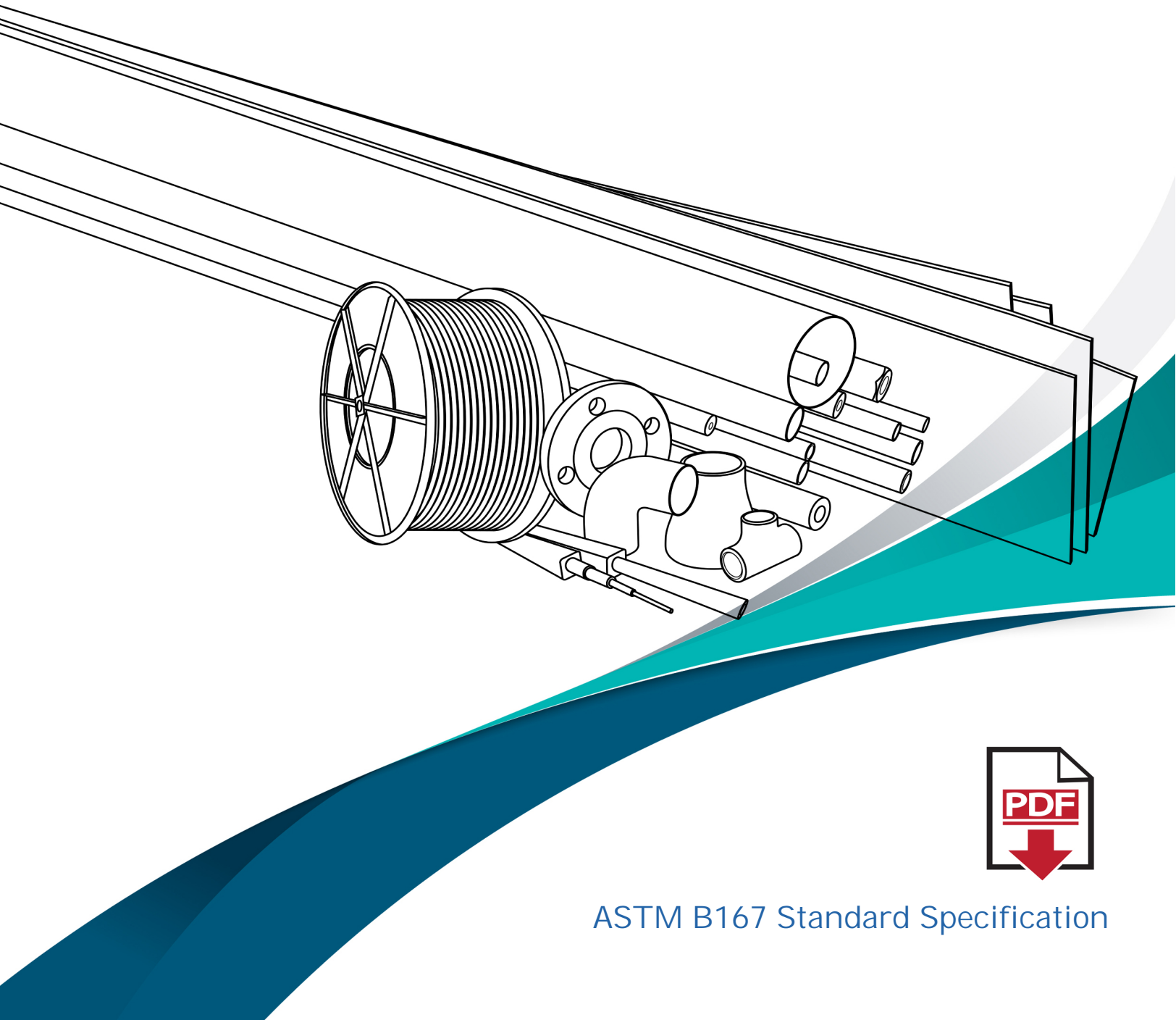




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ASTM B167 Standard Specification



Designation: B 167 – 01

## Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045)\* and Nickel- Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Seamless Pipe and Tube<sup>1</sup>

This standard is issued under the fixed designation B 167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

### 1. Scope

1.1 This specification<sup>2</sup> covers nickel-chromium-iron alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, and N06045)\* and nickel-chromium-cobalt-molybdenum alloy (UNS N06617) in cold-worked annealed, hot-worked annealed, and hot-finished seamless pipe and tube intended for general corrosion resistant and heat resistant applications.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 The following safety hazards caveat pertains only to the test methods portion, Section 12, of this specification: *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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys<sup>3</sup>

E 8 Test Methods for Tension Testing of Metallic Materials<sup>4</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>5</sup>

E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys<sup>6</sup>

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys<sup>7</sup>

#### 2.2 Federal Standards:<sup>8</sup>

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 182 Continuous Identification Marking of Nickel and Nickel-Base Alloys

#### 2.3 Military Standard:<sup>7</sup>

MIL-STD-129 Marking for Shipment and Storage

### 3. Terminology

#### 3.1 Definitions of Terms Specific to This Standard:

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

3.1.2 *pipe*—tube conforming to the particular dimensions commercially known as pipe sizes. See Table X2.1.

3.1.3 *seamless pipe or tube*—a pipe or tube produced with a continuous periphery in all stages of the operations.

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

### 4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 *Alloy Name or UNS Number*—see Table 1,

4.1.2 *ASTM Designation*, including year of issue,

<sup>1</sup> 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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\* New designation established in accordance with Practice E 527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SB-167 in Section II of that Code.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.04.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 14.02.

<sup>6</sup> Discontinued; see 1989 *Annual Book of ASTM Standards*, Vol 03.05.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>8</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

**TABLE 1 Chemical Requirements**

Element	Composition Limits, %							
	Alloy N06600	Alloy N06601	Alloy N06617	Alloy N06690	Alloy N06693	Alloy N06025	Alloy N06045	Alloy N06603
Nickel	72.0 min	58.0–63.0	44.5 min	58.0 min	remainder <sup>A</sup>	remainder <sup>A</sup>	45.0 min	remainder <sup>A</sup>
Chromium	14.0–17.0	21.0–25.0	20.0–24.0	27.0–31.0	27.0–31.0	24.0–26.0	26.0–29.0	24.0–26.0
Iron	6.0–10.0	remainder <sup>A</sup>	3.0 max	7.0–11.0	2.5–6.0	8.0–11.0	21.0–25.0	8.0–11.0
Manganese	1.0 max	1.5 max	1.0 max	0.5 max	1.0 max	0.15 max	1.0 max	0.15 max
Molybdenum	...	...	8.0–10.0	...	...	...	...	...
Cobalt	...	...	10.0–15.0	...	...	...	...	...
Aluminum	...	1.0–1.7	0.8–1.5	...	2.5–4.0	1.8–2.4	...	2.4–3.0
Carbon	0.15 max	0.10 max	0.05–0.15	0.05 max	0.15 max	0.15–0.25	0.05–0.12	0.20–0.40
Copper	0.5 max	1.0 max	0.5 max	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max
Boron	...	...	0.006 max	...	...	...	...	...
Silicon	0.5 max	0.5 max	1.0 max	0.5 max	0.5 max	0.5 max	2.5–3.0	0.50 max
Sulfur	0.015 max	0.015 max	0.015 max	0.015 max	0.01 max	0.010 max	0.010 max	0.010 max
Titanium	...	...	0.6 max	...	1.0 max	0.1–0.2	...	0.1–0.25
Niobium	...	...	...	...	0.5–2.5	...	...	...
Phosphorous	...	...	...	...	...	0.020 max	0.020 max	0.020 max
Zirconium	...	...	...	...	...	0.01–0.10	...	0.01–0.10
Yttrium	...	...	...	...	...	0.05–0.12	...	0.01–0.15
Cerium	...	...	...	...	...	...	0.03–0.09	...

<sup>A</sup>Element shall be determined arithmetically by difference.

4.1.3 *Condition* (see Appendix X3),

4.1.4 *Finish* (see Appendix X3),

4.1.5 *Dimensions*:

4.1.5.1 *Tube*—Specify outside diameter and nominal or minimum wall,

4.1.5.2 *Pipe*—Specify standard pipe size and schedule,

4.1.5.3 *Length*—Cut to length or random,

4.1.6 *Quantity*—Feet or number of pieces,

4.1.7 *Hydrostatic Pressure Requirements*—Specify test pressure if other than required by 12.3.1,

4.1.8 *Certification*— State if certification is required (Section 15),

4.1.9 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished (see 5.2),

4.1.10 *Purchaser Inspection*—If purchaser wishes to witness tests or inspection of material at place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed (Section 13), and

4.1.11 *Small-Diameter and Light-Wall Tube (Converter Sizes)*—See Appendix X1.

## 5. Chemical Composition

5.1 The material shall conform to the composition limits specified in Table 1.

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations in Specification B 880.

## 6. Mechanical Properties and Other Requirements

6.1 *Tensile Test*— The material shall conform to the tensile properties specified in Table 2.

6.1.1 Tensile properties for material specified as small-diameter and light-wall tube (converter sizes) shall be as prescribed in Table X1.1.

6.2 *Hydrostatic Test*—If any pipe or tube shows leaks during hydrostatic testing, it shall be rejected.

## 7. Dimensions and Permissible Variations

7.1 *Diameter and Wall Thickness*—The permissible variations in the outside diameter and wall thickness shall conform to the permissible variations prescribed in Table 3 or Table 4, as applicable.

7.2 *Length*—When material is ordered cut-to-length, the length shall conform to the permissible variations prescribed in Table 5.

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

7.4 *Ends*—Ends shall be plain cut and deburred.

7.5 Permissible variations for material specified as small-diameter and light-wall tube (converter size) shall conform to the permissible variations prescribed in Table X1.2.

## 8. Workmanship, Finish, and Appearance

8.1 The material shall be uniform in quality and temper, smooth, commercially straight, and free of injurious imperfections.

## 9. Sampling

9.1 *Lot Definition*:

9.1.1 A lot for chemical analysis shall consist of one heat.

9.1.2 A lot for all other testing shall consist of all material from the same heat, nominal size (excepting length), and condition.

9.1.2.1 Where material cannot be identified by heat, a lot shall consist of not more than 500 lb (227 kg) of material in the same condition and nominal size (excepting length).

9.2 *Test Material Selection*:

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

9.2.1.1 Product (check) analysis shall be wholly the responsibility of the purchaser.

9.2.2 *Mechanical and Other Properties*—Samples of the material to provide test specimens for mechanical and other



10.3 *Hydrostatic*— Each piece in each lot.

**TABLE 2 Mechanical Properties**

Condition and Size	Tensile Strength, min psi (MPa)	Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm or 4Dmin, %
<i>UNS N06600:</i> Hot-worked or hot-worked annealed: 5 in. (127 mm) in outside diameter and under	80 000 (550)	30 000 (205)	35
Over 5 in. (127 mm) in outside diameter	75 000 (515)	25 000 (170)	35
Cold-worked annealed: 5 in. (127 mm) in outside diameter and under	80 000 (550)	35 000 (240)	30
Over 5 in. (127 mm) in outside diameter	80 000 (550)	30 000 (205)	35
<i>UNS N06601:</i> Cold-worked annealed or hot-worked annealed: All sizes	80 000 (550)	30 000 (205)	30
<i>UNS N06617:</i> Cold-worked annealed or hot-worked annealed: All sizes	95 000 (665)	35 000 (240)	35
<i>UNS N06690:</i> Hot-worked or hot-worked annealed: 5 in. (127 mm) in outside diameter and under	85 000 (586)	30 000 (205)	35
Over 5 in. (127 mm) in outside diameter	75 000 (515)	25 000 (170)	35
Cold-worked annealed: 5 in. (127 mm) in outside diameter and under	85 000 (586)	35 000 (240)	30
Over 5 in. (127 mm) in outside diameter	85 000 (586)	30 000 (205)	35
<i>UNS N06693:</i> Cold-worked annealed or hot-worked annealed: 5 in. (127 mm) in outside diameter and under	85 000 (586)	40 000 (275)	30
<i>UNS N06603:</i> Hot-worked annealed or cold worked annealed (all sizes)	94 000 (650)	43 000 (300)	25
<del><i>UNS N06025:</i></del> Hot-worked annealed or cold worked annealed (all sizes)	98 000 (680)	39 000 (270)	30
<i>UNS N06045:</i> Hot-worked annealed or cold-worked annealed (all sizes)	90 000 (620)	35 000 (240)	35

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.

**10. Number of Tests**

- 10.1 *Chemical Analysis*—One test per lot.
- 10.2 *Tension*—One test per lot.

**11. Specimen Preparation**

11.1 *Room-Temperature Tension Specimen*—Material shall be tested in the direction of fabrication. Whenever possible, all pipe and 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 E 8 shall be used.

**12. Test Methods**

12.1 *Chemical Composition*—In case of disagreement, the chemical composition shall be determined in accordance with Test Methods E 1473 or Methods E 38. Methods E 38 is to be used only for elements not covered by Test Methods E 1473.

12.2 *Tension Test*— Tension testing shall be conducted in accordance with Test Methods E 8.

12.3 *Hydrostatic Test*— Each pipe or tube with an outside diameter 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 an 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 below:

$$P = 2St/D \tag{1}$$

where:

- P* = hydrostatic test pressure, psi (or MPa),
- S* = allowable fiber stress, for material in the condition (temper) furnished as follows:

*Hot-worked or hot-worked annealed:*

UNS N06600	20 000 (140 MPa)
UNS N06601	20 000 (140 MPa)
UNS N06603	24 000 (165 MPa)
UNS N06617	23 700 (163 MPa)
UNS N06690	21 200 (146 MPa)
UNS N06693	21 200 (146 MPa)
UNS N06025	24 000 (165 MPa)
UNS N06045	22 500 (155 MPa)

*Over 5 in. outside diameter:*

UNS N06600	16 700 (115 MPa)
UNS N06690	16 700 (115 MPa)

*Cold-worked annealed—All sizes:*

UNS N06600	20 000 (140 MPa)
UNS N06601	20 000 (140 MPa)
UNS N06690	21 200 (146 MPa)
UNS N06693	21 200 (146 MPa)
UNS N06025	24 500 (169 MPa)
UNS N06045	22 500 (155 MPa)

*t* = minimum wall thickness, in. (or mm), equal to the specified nominal wall minus the permissible minus wall tolerance, or the specified minimum wall thickness, and,

*D* = outside diameter of the pipe or tube, in. (or mm).

12.3.1 When so agreed upon between the manufacturer and purchaser, pipe or tube may be tested to 1½ times the allowable fiber stress given above.

12.4 *Rounding Method*— For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value, or a



**TABLE 3 Permissible Variations for Outside Diameter and Wall Thickness of Seamless Cold Worked Pipe and Tube<sup>A,B</sup>**

Nominal Outside Diameter, in. (mm)	Permissible Variations					
	Outside Diameter, in. (mm)		% of Thickness of Specified Nominal Wall		% of Thickness of Specified Minimum Wall	
	+	-	+	-	+	-
Over 0.400 (10) to 5/8 (16), excl	0.005(0.13)	0.005(0.13)	15.0	15.0	30	0
5/8(16) to 1 1/2 (38), incl	0.0075(0.19)	0.0075(0.19)	10.0	10.0	22	0
Over 1 1/2 (38) to 3 (76), incl	0.010(0.25)	0.010(0.25)	10.0	10.0	22	0
Over 3 (76) to 4 1/2 (114), incl	0.015(0.38)	0.015(0.38)	10.0	10.0	22	0
Over 4 1/2 (114) to 6 (152), incl	0.020(0.51)	0.020(0.51)	12.5	12.5	28	0
Over 6 (152) to 6 3/4 (168), incl	0.025(0.64)	0.025(0.64)	12.5	12.5	28	0

<sup>A</sup>**Ovality**—The permissible variations in this table apply to individual measurements, including out-of-roundness (ovality) except for the following: For pipe and tube having a nominal wall thickness of 3 % or less of the nominal outside diameter, the mean outside diameter shall conform to the permissible variations of this table and individual measurements (including ovality) shall conform to the plus and minus values of the table, with the values increased by 0.5 % of the nominal outside diameter. For pipe over 4 1/2 in. (114 mm) in outside diameter with a nominal wall thickness greater than 3 % of the nominal outside diameter, the mean outside diameter shall conform to the permissible variations of this table and individual measurements shall not exceed twice the permissible variations of the table.

<sup>B</sup>**Eccentricity**—The permissible variations in this table apply to individual measurements including eccentricity.

**TABLE 4 Permissible Variations for Outside Diameter and Wall Thickness of Seamless Hot-Worked Pipe and Tube<sup>A,B</sup>**

Nominal Outside Diameter, in. (mm)	Permissible Variations					
	Outside Diameter, in. (mm)		% of Thickness of Specified Nominal Wall		% of Thickness of Specified Minimal Wall	
	+	-	+	-	+	-
2 1/2(64) to 4 1/2(114), incl	0.031 (0.79)	0.031 (0.79)	16.0	12.5	28.5	0
over 4 1/2 (114) to 6 1/2(165), incl	0.047 (1.2)	0.047 (1.2)	16.0	12.5	28.5	0
over 6 1/2 (165) to 9 1/4 (235), incl	0.062 (1.6)	0.062 (1.6)	16.0	12.5	28.5	0

<sup>A</sup>**Ovality**—Tube 5 in. (127 mm) and under in outside diameter the tolerance on the outside diameter applies for individual measurements and includes ovality. Tube over 5 in. (125 mm) in outside diameter the mean outside diameter shall conform to the permissible variations of this table and individual measurements shall not exceed twice the permissible variations of this table.

<sup>B</sup>**Eccentricity**—The permissible variations in the above table apply to individual measurements including eccentricity.

**TABLE 5 Permissible Variations in Length<sup>A</sup>**

Outside Diameter, in. (mm)	Cut Length, in. (mm)	
	Over	Under
Under 2 (50.8)	1/8(3.2)	0
2 (50.8) and over	3/16(4.8)	0

<sup>A</sup>These permissible variations in length apply to pipe or 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. m) or fraction thereof shall be permissible up to a maximum additional over-tolerance of 1/2 in. (12.7 mm).

calculated value, shall be rounded as indicated below, in accordance with the rounding method of Practice E 29:

Test	Rounded Unit for Observed or Calculated Value
Chemical composition and tolerances (when expressed in decimals)	nearest unit in the last right-hand place of figures of the specified limit. If two choices are possible, as when the digits dropped are exactly a 5 or a 5 followed only by zeros, choose the one ending in an even digit with zero defined as an even digit.
Tensile strength, yield strength	nearest 1000 psi (6.9 MPa)
Elongation	nearest 1 %

### 13. Inspection

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

### 14. Rejection and Rehearing

14.1 Material 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.

### 15. Certification

15.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating that 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.

### 16. Product Marking

16.1 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), this 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 in the contract or order.



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### SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

#### S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchased form a part of this specification to the extent referenced herein: Federal Standards 102, 123, and 182 and Military Standard MIL-STD-129.

#### S2. Quality Assurance

##### S2.1 *Responsibility for Inspection:*

S2.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

#### S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 182, except that the ASTM specification number and the alloy number shall be used.

#### S4. Preparation for Delivery

##### S4.1 *Preservation, Packaging, Packing:*

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade, or class and shall be preserved and packaged, level A or C, packed level A, B, or C as specified in the contract or purchase order.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

##### S4.2 *Marking:*

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

## APPENDIXES

### (Nonmandatory Information)

#### X1. CONVERTER SIZES

X1.1 Small-diameter and light-wall tube in outside diameters 1¼ in. (31.8 mm) and under may be furnished in the conditions listed in Table X1.1 when so specified. The material is furnished in a limited range of sizes and the manufacturer

shall be consulted as to the various outside diameters and wall thicknesses that may be furnished. Material will have a bright finish. Such material shall conform to the applicable requirements in Table X1.1 and Table X1.2. Table X1.3



**TABLE X1.1 Mechanical Properties<sup>A</sup> of Small-Diameter and Light-Wall Tubing (Converter Sizes)**

Condition	Tensile Strength, psi (MPa)	Yield Strength (0.2 % offset) min, psi (MPa)	Elonga- tion in 2 in. or 50 mm, min, %
<i>UNS N06600:</i> Annealed <sup>B,C</sup>	80 000 (550) to 110 000 (760)	35 000 (240)	30
Half-hard <sup>D</sup>	105 000 (725) min	55 000 (380)	13
Full-hard <sup>E</sup>	130 000 (895) min	105 000 (725)	4
<i>UNS N06601:</i> Annealed <sup>B,C</sup>	80 000 (550) to 110 000 (760)	30 000 (205)	30
<i>UNS N06601:</i> <i>UNS N06603:</i> Annealed <sup>B,C</sup>	94 000 (650) to 140 000 (965)	43000 (300)	25
<i>UNS N06617:</i> Annealed <sup>B,C</sup>	95 000 (665) to 110 000 (760)	35 000 (240)	35
<i>UNS N06690:</i> Annealed <sup>B,C</sup>	85 000 (586) to 110 000 (760)	35 000 (240)	30
Half-hard <sup>D</sup>	105 000 (725) min	55 000 (380)	13
Full-hard <sup>E</sup>	130 000 (895) min	105 000 (725)	4
<i>UNS N06025:</i> Annealed <sup>B,C</sup>	98 000 (680) to 125 000 (860)	39 000 (270)	30
<i>UNS N06045:</i> Annealed <sup>B,C</sup>	90 000 (620) to 120 000 (830)	35 000 (240)	35

<sup>A</sup>Not applicable to outside diameters under 1/8 in. (3.2 mm) and wall thicknesses under 0.015 in. (0.38 mm).

<sup>B</sup>This condition is sometimes designated as "No. 1 Temper."

<sup>C</sup>The minimum tensile strength value applies only to tubing in straight lengths.

<sup>D</sup>This condition is sometimes designated as "No. 2 Temper."

<sup>E</sup>This condition is sometimes designated as "No. 3 Temper."

**TABLE X1.2 Permissible Variations for Small-Diameter and Light-Wall Tube (Converter Sizes)<sup>A,B,C,D,E ,F,G</sup>**

Specified Outside Diameter, in. (mm)	Outside Diameter		Inside Diameter		Wall thickness, %	
	+	- in. (mm)	+	-	+	-
Under 3/32 (2.4)	0.002 (0.05)	0	0	0.002 (0.05)	10	10
3/32 to 1/16 (2.4 to 4.8), excl	0.003 (0.08)	0	0	0.003 (0.08)	10	10
1/16 to 1/2 (4.8 to 12.7), excl	0.004 (0.10)	0	0	0.004 (0.10)	10	10
1/2 to 1 1/4 (12.7 to 31.8), incl	0.005 (0.13)	0	0	0.005 (0.13)	10	10

<sup>A</sup>Ovality, *Normal Wall Tube*—As-Drawn (No. 2 and 3) Tempers—Ovality will be held within the outside diameter tolerances shown in the table.

*Annealed (No. 1) Temper*—Ovality will be held within 2 % of the theoretical average outside diameter.

<sup>B</sup>Ovality, *Light Wall Tube*—As-Drawn (No. 2 and 3) Tempers—Up to but not including 1 1/4 in. (31.8 mm) in outside diameter, ovality will be held within 2 % of the theoretical average outside diameter.

*Annealed (No. 1) Temper*—Ovality will be held within 3 % of the theoretical average outside diameter.

<sup>C</sup>Wall Tolerances, *Light Wall Tube*—The plus and minus wall tolerance shown in the table shall apply down to and including 0.005 in. (0.13 mm) in wall thickness. For wall thicknesses less than 0.005 in. (0.13 mm), the tolerance shall be 6 0.005 in. (0.013 mm).

<sup>D</sup>Random Lengths:

Where nominal random lengths on tubing 1/8 in. (3.2 mm) and larger in outside diameter are specified, a length of 6 3/2 ft (1.06 m) applies to the nominal length. This is a total spread of 7 ft (2.10 m).

Random lengths in sizes 1/8 in. (3.2 mm) and larger in outside diameter shall be subject to a length range of 5 to 24 ft (1.50 to 7.30 m). Long random lengths are subject to a range of 15 to 22 ft (4.57 to 6.70 m).

Random lengths in sizes up to but not including 1/8 in. (3.2 mm) in outside diameter, and fragile light-wall tubes over this outside diameter are subject to the length range of 1 to 15 ft (0.30 to 4.57 m).

<sup>E</sup>Cut Lengths—Tolerances on cut lengths shall be in accordance with Table X1.3.

<sup>F</sup>Straightness—Round tubing is subject to a straightness tolerance of one part in 600 [equivalent to a depth of arc of 0.030 in. (0.76 mm) in any 3 ft (0.91 m) of length].

<sup>G</sup>When specified, the tolerance spreads of this table may be applied as desired. However, when not specified, the tolerances in this table will apply. It should be noted that inside diameter tolerances are based upon the outside diameter range.



**TABLE X1.3 Tolerances on Cut Lengths of Light-Wall Tube**

Length, ft (m)	Tube Size, in. (mm)	Permissible Variations, in. (mm)	
		Over	Under
Under 1 (0.30)	up to 1.250 (31.8), incl	1/32(0.8)	0 (0)
1 to 4 (0.30 to 1.22), incl	up to 1.250 (31.8), incl	1/16(1.6)	0 (0)
Over 4 to 10 (1.22 to 3.0), incl	up to 1.250 (31.8), incl	3/32(2.4)	0 (0)
Over 10 (3.0)	up to 1.250 (31.8), incl	3/16(4.8)	0 (0)

**X2. PIPE SCHEDULES**

X2.1 The schedules of pipe shown in Table X2.1 are regularly available. Other schedules may be furnished, and the manufacturer should be consulted. Table X2.1 is published for information only.

**TABLE X2.1 Pipe Schedules<sup>A</sup>**

Nominal Pipe Size, in.	Outside Diameter	Nominal Wall Thickness, in. (mm)			
		Schedule No. 5	Schedule No. 10	Schedule No. 40	Schedule No. 80
1/4	0.540(13.7)	...	0.065 (1.6)	0.088 (2.2)	...
3/8	0.675(17.1)	...	0.065 (1.6)	0.091 (2.3)	0.126 (3.2)
1/2	0.840(21.3)	0.065 (1.6)	0.083 (2.1)	0.109 (2.8)	0.147 (3.7)
3/4	1.050(26.7)	0.065 (1.6)	0.083 (2.1)	0.113 (2.8)	0.154 (3.9)
1	1.315(33.4)	0.065 (1.6)	0.109 (2.8)	0.133 (3.4)	0.179 (4.5)
1 1/4	1.660(42.2)	0.065 (1.6)	0.109 (2.8)	0.140 (3.6)	0.191 (4.8)
1 1/2	1.900(48.3)	0.065 (1.6)	0.109 (2.8)	0.145 (3.7)	0.200 (5.1)
2	2.375(60.3)	0.065 (1.6)	0.109 (2.8)	0.154 (3.9)	0.218 (5.5)
2 1/2	2.875(73.0)	0.083 (2.1)	0.120 (3.0)	0.203 (5.2)	0.276 (7.0)
3	3.500(88.9)	0.083 (2.1)	0.120 (3.0)	0.216 (5.5)	0.300 (7.6)
3 1/2	4.000(101.6)	0.083 (2.1)	0.120 (3.0)	0.226 (5.7)	0.318 (8.1)
4	4.500(114.3)	0.083 (2.1)	0.120 (3.0)	0.237 (6.0)	0.337 (8.6)
5	5.563(141.3)	...	...	0.258 (6.5)	...
6	6.625(168.3)	...	...	0.280 (7.1)	...

<sup>A</sup>The pipe schedules shown above conform with standards adopted by the American National Standards Institute.

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### X3. CONDITIONS AND FINISHES NORMALLY SUPPLIED

#### X3.1 Scope

X3.1.1 This appendix lists the conditions and finishes in which pipe and tube (other than converter sizes) are normally supplied. These are subject to change, and the manufacturer should be consulted for the latest information available.

#### X3.2 Cold-Worked Tube and Pipe

X3.2.1 *Cold-Worked, Annealed, with Ground Outside Diameter*—The inside diameter may have a bright finish when material is annealed in a protective atmosphere; otherwise, the inside diameter is supplied descaled as necessary. It is available in sizes ½ to 4 in. (12.7 to 102 mm), inclusive, in outside diameter in both normal and heavy-wall tube, and pipe sizes, all schedules, of corresponding outside-diameter dimensions.

X3.2.2 *Cold-Worked, Annealed, and Pickled (Not Ground)*—Outside and inside diameter will have dull, matte (pickled) surfaces. It is available in sizes ½ to 6⅝in. (12.7 to 168 mm), inclusive, in outside diameter in both normal and

heavy-wall tube, and pipe sizes, all schedules, of corresponding outside-diameter dimensions.

#### X3.3 Hot-Worked Tube

X3.3.1 *Hot-Worked or Hot-Worked-Annealed (Not Pickled) Tube*—Has an oxide surface resulting from the hot-working operation. Intended generally for machined parts where the oxide surface will be removed.

X3.3.2 *Hot-Worked or Hot-Worked-Annealed (Pickled) Tube*—Has the oxide surface removed on both outside and inside diameters by pickling. Surface may be spot ground for removal of minor surface imperfections at the manufacturer's option.

X3.3.3 *Hot-Worked or Hot-Worked-Annealed (Machined Outside and Inside Diameters) Tubes*—The outside and inside diameter surfaces are machined to specified dimensions. Minor surface imperfections may be spot ground for removal, at the manufacturer's option.

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