



B444-23

Standard Specification for Nickel-Chromium-Molybdenum-Niobium Alloys and Nickel-Chromium-Molybdenum-Silicon Alloy Pipe and Tube

This standard is issued under the fixed designation B444; 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 (ϵ) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification² covers nickel-chromium-molybdenum-niobium alloys (UNS N06625 and UNS N06852) and nickel-chromium-molybdenum-silicon alloy (UNS N06219)³ in the form of cold-worked seamless pipe and tube. The general requirements for pipe and tube are covered by Specification B829.

1.2 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.

1.3 The following precautionary caveat pertains only to the test methods portion, Section 8, 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 become familiar with all hazards including those identified in the appropriate Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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 For ASME Boiler and Pressure Vessel Code applications see related Specification SB-444 in Section II of that Code.

³ New designation established in accordance with Practice E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

2. Referenced Documents

2.1 ASTM Standards:⁴

- B829 Specification for General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube
- B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys
- B899 Terminology Relating to Non-ferrous Metals and Alloys
- E112 Test Methods for Determining Average Grain Size
- G28 Test Methods for Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys
- G48 Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

3. Terminology

3.1 Definition of Terms:

- 3.1.1 The terms and definitions of Terminology B899 apply.

4. Ordering Information

4.1 Orders for material to this specification shall include information with respect to the following:

- 4.1.1 Alloy name or UNS number,
- 4.1.2 ASTM designation,
- 4.1.3 Condition (temper) (see 5.2, 5.3, Table 1, and Annex A1),
 - 4.1.3.1 If neither grade of N06625 is specified, Grade 1 will be supplied.
- 4.1.4 Finish (See Appendix X1.1),
- 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 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.

*A Summary of Changes section appears at the end of this standard



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TABLE 1 Room Temperature Tensile Properties and Heat Treatment^{A,B}

Condition	Tensile Strength, min, ksi (MPa) ^C	Yield Strength (0.2 % offset), min, ksi (MPa) ^C	Elongation in 2 in. or 50.8 mm (or 4 D), min, %
Alloy N06625			
Grade 1 (annealed) ^D	120 (827)	60 (414)	30
Grade 2 (solution annealed) ^E	100 (690)	40 (276)	30
Alloy N06219			
All (solution annealed)	96 (660)	39 (270)	30
Alloy N06852			
All (solution annealed)	85 (586)	35 (241)	30

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

^B Hot forming quality pipe and tubing is furnished to chemical requirements and surface inspection only. No tensile properties are required.

^C The minimum strength values apply only to tubing in straight lengths.

^D Annealed at 1600 °F (871 °C) minimum.

^E Solution annealed at 2000 °F (1093 °C) minimum, with or without subsequent stabilization anneal at 1800 °F (982 °C) minimum to increase resistance to sensitization.

4.1.5.3 *Length*—Cut to length or random,

4.1.6 *Quantity*—Feet (or meters) or number of pieces,

4.1.7 *Hydrostatic Test or Nondestructive Electric Test*—Specify type of test (see 7.2),

4.1.8 *Hydrostatic Pressure Requirements*—Specify test pressure if other than required by 8.1.1,

4.1.9 *Certification*—State if certification is required,

4.1.10 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished (see 6.2),

4.1.11 *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, and

4.1.12 *Small-Diameter Tube and Tube with Specified Wall Thickness 3 % or Less of the Specified Outside Diameter (Converter Sizes)*—See Annex A1.

4.1.13 *Supplementary Ordering Requirements: Grain Size Test (S1); Intergranular Corrosion Test (S2); Pitting and Crevice Corrosion Test (S3)* may be ordered as an option by the purchaser in the purchase order indicating which tests are to be included.

5. Materials and Manufacture

5.1 Material furnished under this specification shall conform to the applicable requirements of Specification B829 unless otherwise provided herein.

5.2 UNS N06625 products are furnished in two grades of different heat-treated conditions:

5.2.1 Grade 1 (annealed)—Material is normally employed in service temperatures up to 1100 °F (593 °C).

5.2.2 Grade 2 (solution annealed)—Material is normally employed in service temperatures above 1100 °F (593 °C) when resistance to creep and rupture is required.

NOTE 1—Hot-working or reannealing may change properties significantly, depending on working history and temperatures.

5.3 Alloys UNS N06219 and UNS N06852 are supplied in the solution annealed condition only.

6. Chemical Composition

6.1 The material shall conform to the composition limits specified in Table 2. One test is required for each lot as defined in Specification B829.

6.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations in Table 1 of Specification B880.

7. Mechanical Properties and Other Requirements

7.1 *Tension Test*—One test per lot shall be performed. The material shall conform to the tensile properties specified in Table 1. The sampling and specimen preparation are as covered in Specification B829.

7.2 *Hydrostatic or Nondestructive Electric Test*—Each pipe or tube shall be subjected to either the hydrostatic test or to the nondestructive electric test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

8. Test Methods

8.1 *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 in accordance with Specification B829. The allowable fiber stress for material in the condition furnished, is as follows:

- UNS N06625:
- Grade 1—30 000 psi (207 MPa)
- UNS N06625:
- Grade 2—25 000 psi (172 MPa)
- UNS N06219:
- All—24 000 psi (165 MPa)
- UNS N06852:
- All—21 000 psi (145 MPa)

TABLE 2 Chemical Requirements

Element	Composition Limits, %		
	N06852	N06625	N06219
Carbon	0.05 max	0.10 max	0.05 max
Manganese	0.50 max	0.50 max	0.50 max
Silicon	0.50 max	0.50 max	0.70-1.10
Phosphorus	0.015 max	0.015 max	0.020 max
Sulfur	0.015 max	0.015 max	0.010 max
Chromium	20.0-23.0	20.0 min 23.0 max	18.0-22.0
Niobium ^B + Tantalum	...	3.15 min 4.15 max	...
Niobium ^B	0.51-1.00
Cobalt (if determined)	...	1.0 max	1.0 max
Molybdenum	8.0-10.0	8.0 min 10.0 max	7.0-9.0
Iron	15.0-20.0	5.0 max	2.0-4.0
Aluminum	0.40 max	0.40 max	0.50 max
Titanium	0.40 max	0.40 max	0.50 max
Copper	0.50 max
Nickel ^A	Bal.	58.0 min	Bal.

^A Element shall be determined arithmetically by difference.

^B Columbium and Niobium are interchangeable names for the same element and both names are acceptable for use in B02.07 specifications.



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

8.1.2 If any pipe or tube shows leak during hydrostatic testing, it shall be rejected.

8.2 *Nondestructive Electric Test*—Each pipe or tube shall be examined with a nondestructive electric test as per prescribed in Specification B829.

9. Keywords

9.1 seamless pipe; seamless tube; N06219; N06625; N06852

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Grain Size Test

S1.1 *Grain Size*—Grain size determinations shall be made in accordance with Test Methods E112 using an intercept procedure or using a procedure agreed upon by purchaser and seller. Alloys UNS N06625; UNS N06852; UNS N06219 shall be 5.0 or finer average Grain size. Grain size determinations shall be made on each heat treatment lot. In the event of a dispute or question an E112 intercept procedure or test method must be used.

S2. Intergranular Corrosion Test

S2.1 *Intergranular Corrosion Determinations*—Susceptibility to Intergranular Corrosion shall be tested in accordance with Test Methods G28 Method A with an acceptance criteria of a maximum corrosion rate of 0.003 ipm (0.914 mm/yr.).

S3. Pitting and Crevice Corrosion Test

S3.1 Susceptibility to pitting corrosion shall be tested in accordance with Test Methods G48 Method C. The test temperature shall be 75 °C (167 °F) \pm 1 °C and the exposure time 72 h. The acceptance criteria shall be no visible pitting greater than 0.001 in. (.025 mm) depth at 20× magnification and a weight loss less than 1.0 g/m² (1.422 × 10⁻⁶ lb/in²). End grain or edge grain attacks invalidate the tests. In the event the test is invalidated, a retest of the material may be made without penalty. If the material is invalidated by the retest, then the material is deemed unacceptable and may no longer be tested, and a new material test shall be made from a different heat treatment lot.

ANNEX

(Mandatory Information)

A1. CONVERTER SIZES

A1.1 Small-diameter and tube with specified wall thickness 3 % or less of the specified outside diameter, in outside diameters 1¼ in. (31.8 mm) and under may be furnished in a limited range of sizes and the manufacturer should 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 requirements in Table A1.1 and Table A1.2.

A1.2 Tension Test—One test per lot shall be performed. The material shall conform to the tensile properties specified in Table A1.3. The sampling and specimen preparation are as covered in Specification B829.

A1.3 *Hydrostatic or Nondestructive Electric Test*—Each tube shall be subjected to either the hydrostatic test (see 8.1) or to the nondestructive electric test (see 8.2). The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.



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TABLE A1.1 Permissible Variations for Small-Diameter and Tube with Specified Wall Thickness 3 % or Less of the Specified Outside Diameter (Converter Sizes)^{A,B,C,D,E,F,G}

Specified Outside Diameter, in. (mm)	Outside Diameter		Inside Diameter		Wall Thickness, %	
	Plus	Minus, in. (mm)	Plus	Minus	Plus	Minus
Under 3/32 (2.4)	0.002 (0.05)	0	0	0.002 (0.05)	10	10
3/32 to 3/16 (2.4 to 4.8), excl	0.003 (0.08)	0	0	0.003 (0.08)	10	10
3/16 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

^A *Ovality, Tube with Specified Wall Thickness >3 % of the Specified Outside Diameter*—Ovality will be held within 2 % of the theoretical average outside diameter.
^B *Ovality, Tube with Specified Wall Thickness #3 % Or Less of the Specified Outside Diameter*—Ovality will be held within 3 % of the theoretical average outside diameter.
^C *Wall Tolerances, Tube with Specified Wall Thickness #3 % Or Less of the Specified Outside Diameter*—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 ±0.0005 in. (0.013 mm).
^D *Random Lengths:*
 Where nominal random lengths on tubing 1/8 in. (3.2 mm) and larger in outside diameter are specified, a length tolerance of ±3 1/2 ft (1.07 m) applies to the nominal length. This is a total spread of 7 ft (2.13 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 ft to 24 ft (1.52 m to 7.32 m). Long random lengths are subject to a range from 15 ft to 22 ft (4.57 m to 6.71 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 from 1 ft to 15 ft (0.30 m to 4.57 m).
^E *Cut Lengths*—Tolerances on cut lengths shall be in accordance with Table A1.2.
^F *Straightness*—Round tubing is subject to a straightness tolerance of 1 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].
^G 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 A1.2 Tolerances on Cut Lengths of Tube with Specified Wall Thickness 3 % or Less of the Specified Outside Diameter

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)

TABLE A1.3 Room Temperature Tensile Properties and Heat Treatment for Small Diameter and Tube with Specified Wall Thickness 3 % or Less of the Specified Outside Diameter (Converter Sizes)^A

Condition	Tensile Strength, min, ksi (MPa) ^B	Yield Strength (0.2 % offset), min, ksi (MPa) ^B	Elongation in 2 in. or 50.8 mm (or 4 D), min, %
Grade 1 (annealed) ^C	120 (827)	60 (414)	30
Grade 2 (solution annealed) ^D	100 (690)	40 (276)	30
Alloy N06219			
All (solution annealed)	96 (660)	39 (270)	30
Alloy N06852			
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^A Not applicable to outside diameters under 1/8 in. (3.2 mm) and to wall thicknesses under 0.015 in. (0.38 mm).
^B The minimum strength values apply only to tubing in straight lengths.
^C Annealed at 1600 °F (871 °C) minimum.
^D Solution annealed at 2000 °F (1093 °C) minimum, with or without subsequent stabilization anneal at 1800 °F (982 °C) minimum to increase resistance to sensitization.



APPENDIX

(Nonmandatory Information)

X1. CONDITIONS AND FINISHES NORMALLY SUPPLIED

X1.1 Scope

X1.1.1 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.

X1.2 Cold-Worked Tube and Pipe

X1.2.1 *Cold-Drawn, Annealed or Solution Annealed with Ground Outside Diameter*—The inside diameter may have a bright finish when material is annealed or solution annealed in a protective atmosphere; otherwise, the inside diameter is

supplied descaled as necessary. It is available in sizes ½ in. to 4 in. (12.7 mm to 102 mm), incl, in outside diameter in both normal and heavy-wall tube, and pipe sizes, all schedules, of corresponding outside-diameter dimensions.

X1.2.2 *Cold-Drawn, Annealed or Solution Annealed and Pickled (Not Ground)*—Outside and inside diameter will have dull, matte (pickled) surfaces. Available in sizes ½ in. to 6⅝ in. (12.7 mm to 168 mm), incl, in outside diameter in both normal and heavy-wall tube, and pipe sizes, all schedules, of corresponding outside-diameter dimensions.

SUMMARY OF CHANGES

Committee B02 has identified the location of selected changes to this standard since the last issue (B444 – 18) that may impact the use of this standard. (Approved July 1, 2023.)

- (1) Revised Title.
- (2) Added Terminology Section and B899 to Referenced Documents section.
- (3) Added Materials and Manufacture section. Relocated General Requirements and Scope information to this section.
- (4) Changed light wall tube to tube with specified wall thickness 3 % or less of the specified outside diameter for converter sizes.
- (5) Deleted Dimensions and Permissible Variations section.
- (6) Moved converter sizes from Appendix to Annex.
- (7) Deleted Number of Tests section and addressed requirements under specific test.
- (8) Changes Columbium to Niobium in 1.1 and Table 2 and added equivalency footnote.
- (9) Updated Ordering Information references.
- (10) Revised 8.1.

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