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Standard Specification for Seamless Nickel Alloy Mechanical Tubing and Hollow Bar[1]

This standard is issued under the fixed designation B1020/B1020M; 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.

1. ~~Scope~~ Scope*

1.1 This specification covers seamless nickel alloy tubing for use in mechanical applications or as hollow bar for use in the production of hollow components such as, but not limited to, nozzles, reducers, and couplings by machining where corrosion-resistant or high-temperature strength is needed. The grades covered are listed in Table 1.

1.2 This specification covers seamless cold-finished mechanical tubing and hollow bar, and seamless hot-finished mechanical tubing and hollow bar in sizes up to 12¾ in.
[325 mm] in outside nominal diameter (for round tubing) with wall thicknesses or inside diameters as required.

1.3 Optional supplementary requirements are provided and when desired, shall be stated in the order.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
B829 Specification for General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube
E112 Test Methods for Determining Average Grain Size
2.2 *Federal Standard:*[3]
Fed. Std. No. 123 Marking for Shipments (Civil Agencies)
2.3 *Military Standards:*[3]
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage

3. Terminology

3.1 *Definitions:*

[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 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] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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

TABLE 1 Chemical Requirements

Grade	Composition, %												
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon, max	Nickel	Chromium	Molybdenum	Titanium	Niobium[C]	Cu	Iron	Other Elements
N10276	0.010 max	1.0 max	0.04	0.03	0.08	remainder[A]	14.5 to 16.5	15. to 17.0	...	...	...	4.0 to 7.0	W 3.0-4.5 V 0.35 max
N06625	0.10 max	0.50 max	0.015	0.015	0.50	58.0 min[A]	20.0 to 23.0	8.0 to 10.0	0.40 max	3.15 to 4.15	...	5.0 max	Co 1.0 max[B] Al 0.40 max
N07718	0.08 max	0.35 max	0.015	0.015	0.35	50.0 to 55.0	17.0 to 21.0	2.80 to 3.30	0.65 to 1.15	4.75 to 5.50	0.30 max	remainder[A]	Co 1.0 max[B] Al 0.20-0.80 B 0.006 max
N08825	0.05 max	1.0 max	...	0.03	0.5	38.0 to 46.0	19.5 to 23.5	2.5 to 3.5	0.6 to 1.2	...	1.5 to 3.0	22.0 min[A]	...
N09925	0.03 max	1.0 max	0.03	0.03	0.5	42.0 to 46.0	19.5 to 22.50	2.5 to 3.5	1.9 to 2.40	0.5 max	1.5 to 3.0	22.0 min	Al 0.1-0.5

TABLE 1 Chemical Requirements[A]

Grade	Composition, %												
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Titanium	Niobium[D]	Cu	Iron	Other Elements
N10276	0.010	1.0	0.04	0.03	0.08	remainder[B]	14.5 to 16.5	15. to 17.0	...	...	...	4.0 to 7.0	W 3.0-4.5 V 0.35 Co 2.5
N06625	0.10	0.50	0.015	0.015	0.50	58.0 min[B]	20.0 to 23.0	8.0 to 10.0	0.40	3.15 to 4.15	...	5.0	Co 1.0[C] Al 0.40
N07718	0.08	0.35	0.015	0.015	0.35	50.0 to 55.0	17.0 to 21.0	2.80 to 3.30	0.65 to 1.15	4.75 to 5.50	0.30	remainder[B]	Co 1.0[C] Al 0.20-0.80 B 0.006
N08825	0.05	1.0	...	0.03	0.5	38.0 to 46.0	19.5 to 23.5	2.5 to 3.5	0.6 to 1.2	...	1.5 to 3.0	22.0 min[B]	Al 0.2
N09925	0.03	1.0	0.03	0.03	0.5	42.0 to 46.0	19.5 to 22.50	2.5 to 3.5	1.9 to 2.40	0.5	1.5 to 3.0	22.0 min	Al 0.1-0.5

[A] Maximum unless range or minimum is given. Where ellipses (...) appear in this table, there is no requirement and analysis for the element need not be determined or reported.
[B] Element shall be determined arithmetically by difference.
[C] If determined.
[D] The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.

3.1.1 *hollow bar, n*—round tubing that is intended to produce engineering components by machining, generally specified by minimum outside diameter and maximum inside diameter.

3.1.2 *mechanical tubing, n*—tubing of various shapes used for mechanical and general engineering purposes, specified by nominal outside dimension and nominal wall.

4. Ordering Information

4.1 Orders for material under this specification should include the following as required to describe the desired material adequately:

4.1.1 Quantity (feet, mass, or number of pieces),

4.1.2 Name of material (seamless mechanical tubing or hollow bar),

4.1.3 Mechanical tubing form only (round, square, rectangular, special, see 6.6),

4.1.4 Dimensions (round, nominal outside diameter and nominal wall thickness, (see 8.1 and 8.2) or minimum outside diameter and maximum inside diameter (see 8.3); square and rectangular, nominal outside dimensions and nominal wall thickness, see Section 12; other, specify),

4.1.5 Length (specific or random, see 8.4),

4.1.6 Manufacture (cold- or hot-finished, see 6.5),

4.1.7 Grade (Section 7),

4.1.8 Condition (solution heat-treated, as cold worked, or with special heat treatment, controlled microstructural characteristics, or other condition as required, see 6.7 – 6.10),

4.1.8.1 For precipitation-hardening grades, unless otherwise specified, the material will be supplied in the solution heat-treated condition.

4.1.8.2 If neither grade of N06625 is specified, Grade 2 will be supplied.

4.1.9 Surface finish (special pickling, shot blasting, or polishing, as required, see Supplementary Requirement S4),

4.1.10 Specification designation,

4.1.11 Report of chemical analysis, if required (see 7.2 – 7.4),

4.1.12 Individual supplementary requirements, if required,

NOTE 1—Supplementary requirements S1 and S2 are required for hollow bar only (see Section 10).

4.1.13 End use,

4.1.14 Packaging,

4.1.15 Special marking (see 14.2),

4.1.16 Special packing (see 15.2), and

4.1.17 Special requirements.

5. General Requirements

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

6. Materials and Manufacture

6.1 The material may be made by any process.

6.2 If a specific type of melting is required by the purchaser, it shall be as stated on the purchase order.

6.3 The primary melting may incorporate separate degassing or refining and may be followed by secondary melting, such as electroslag remelting or vacuum-arc remelting. If secondary melting is employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

6.4 The nickel alloy may be cast in ingots or may be strand cast. When different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by an established procedure that positively separates the grades.

6.5 The tubes shall be made by a seamless process and by either cold working or hot working as specified. Seamless tubing is a tubular product made without a welded seam. It is usually manufactured by hot working and then cold finishing the hotworked tubing to produce the desired shape, dimensions, and properties.

6.6 Tubes for mechanical applications shall be furnished in one of the following shapes, as specified by the purchaser: round, square, rectangular, or special. Tubes to be used as hollow bar shall be furnished in round shape.

6.7 Round seamless mechanical tubing is generally supplied in the cold-worked and solution heat-treated condition (see 6.8 through 6.9). Square, rectangular, or other shapes of tubing are generally supplied solution heat-treated prior to final cold shaping. If some other condition is desired, details shall be included in the order. Round seamless hollow bar is generally applied in the hot-worked and solution heat-treated condition.

6.8 The thermal treatment for precipitation-hardening grades shall be performed by a method and at a temperature selected by the manufacturer unless otherwise specified by the purchaser.

6.9 Unless otherwise specified, all mechanical tubing and hollow bar shall be furnished in the solution heat-treated condition as specified in Table 2. Alternatively, immediately following hot forming while the temperature of the mechanical tubing or hollow bar is not less than the specified minimum solution treatment temperature, tubes may be individually quenched in water or rapidly cooled by other means. This solution heat treatment shall precede final cold work, when cold-worked tempers are required.

6.10 If any controlled microstructural characteristics are required, these shall be specified so as to be a guide to the most suitable heat treatment.

7. Chemical Composition

7.1 The material shall conform to the requirements as to chemical composition prescribed in Table 1.

7.2 An analysis of each heat shall be made by the manufacturer to determine the percentages of the elements specified. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the tubular product manufacturer, shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified. When requested in the order or contract, a report of this analysis shall be furnished to the purchaser.

7.3 A product analysis of either one billet or one tube shall be made for each heat.

TABLE 2 Heat Treatment

Grade	Recommended Solution Treatment/Anneal	Quench	Recommended Precipitation Hardening Treatment
N10276	solution heat-treated at 2050 °F [1121 °C]	quenched in water or rapidly cooled by other means	[B]
N06625 Grade 1	annealed 1600 °F [871 °C] min	quenched in water or rapidly cooled by other means	[B]
N06625 Grade 2	solution heat-treated at 2000 °F [1093 °C] min, with or without subsequent stabilization anneal at 1800 °F [982 °C] min to increase resistance to sensitization	quenched in water or rapidly cooled by other means	[B]
N07718[A]	solution heat-treated at 1700 to 1850 °F [924 to 1010 °C], hold ½ h min	cool at rate equivalent to air cool or faster	1325 ± 25 °F [718 ± 14 °C], hold at temperature for 8 h, furnace cool to 1150 ± 25 °F [621 ± 14 °C], hold until total precipitation heat treatment time has reached 18 h, air cool
N08825	solution heat-treated at 1725 °F [940 °C] to 1750 °F [980 °C]	quenched in water or rapidly cooled by other means	[B]
N09925[A]	solution heat-treated at 1825 to 1875 °F [996 to 1024 °C], hold ½ min, and 4 h max	cool at rate equivalent to air cool or faster	1365 ± 25 °F [740 ± 14 °C], hold at temperature for 6 to 9 h, furnace cool to 1150 ± 25 °F [621 ± 14 °C], hold until total precipitation heat treatment time has reached 18 h, air cool or faster

[A] The purchaser shall designate on the purchase order or inquiry any partial stage of heat treatment required on material to be shipped.
[B] Material is supplied solution heat-treated/annealed condition as indicated.

7.4 If the original test for product analysis fails, retests of two additional billets or tubes shall be made. Both retests, for the elements in question, shall meet the requirements of the specification, otherwise all remaining material in the heat or lot shall be rejected or, at the option of the producer, each billet or tube may be individually tested for acceptance. Billets or tubes which do not meet the requirements of this specification shall be rejected.

8. Permissible Variations in Dimensions of Round Mechanical Tubing and Hollow Bar

8.1 *Nominal Outside Diameter and Nominal Wall Thickness (Cold Finished Mechanical Tubing and Hollow Bar)*—Variations in outside diameter and wall thickness shall not exceed the amounts prescribed in Table 3.

8.2 *Nominal Diameter and Nominal Wall Thickness (Hot Finished Mechanical Tubing and Hollow Bar)*—Variations in outside diameter and wall thickness shall not exceed the amounts prescribed in Table 4.

8.3 *Minimum Outside Diameter and Maximum Inside Diameter (Cold-Finished and Hot-Finished Hollow Bar)*—Variations in outside diameter and wall thickness shall not exceed the amounts prescribed in Table 5.

8.4 *Lengths (Cold Finished or Hot Finished)*—Mechanical tubing and hollow bar are commonly furnished in mill lengths 5 ft [1.5 m] and over. When random lengths are ordered, mechanical tubing and hollow bar lengths may vary by an amount up to 7 ft [2.1 m]. Definite cut lengths are furnished, when specified, to the length tolerances shown in Table 3 or Table 4. For mechanical tubing and hollow bar ordered in multiple lengths, it is common practice to allow a definite amount over for each multiple for the purchaser's cutting operations. This amount depends on the type of purchaser's cutting and varies with differing wall thickness. The cutting allowance should be specified on the purchase order. When it is not specified, mechanical tubing and hollow bar are customarily supplied with the following allowance for each multiple:

Wall Thickness, in. [mm]	Excess Length per Multiple, in. [mm]
Up to ⅛ [3.2]	⅛ [3]
Over ⅛ to ½ [3.2 to 12.7]	3⁄16 [5]
Over ½ [12.7]	¼ [6]

8.5 *Straightness Tolerances (Cold Finished or Hot Finished Mechanical Tubing)*—The deviation from straightness shall not exceed the amounts shown in Table 6 when measured with a 3-ft [1 m] straightedge and feeler gauge. If determined by the dial indicator method, the values obtained will be approximately twice those determined by the straightedge feeler gauge method.

TABLE 3 Permissible Variations in Outside Diameter, Ovality, Wall Thickness, and Cut-Length Variations (Cold-Finished Round Mechanical Tubing and Hollow Bar)[A]

Outside Nominal Diameter, in. [mm]	Prevailing Range of Commercially Available Metric Sizes, mm	Outside Diameter, Tolerance,[B] in. [mm] Over and Under	Ovality,[B] Double Outside Diameter Tolerance when wall is:	Wall Thickness in %[C,D]		Permissible Variations in Cut Length, in. [mm][E]	
				Over	Under	Over	Under
Under ½ [13]	Under 12.7	0.005 [0.1]	less than 0.015 in. [0.4 mm]	15	15	⅛ [3]	0
½ [13] to 1½ [38], excl	12.7 to 38.1, excl	0.005 [0.1]	less than 0.065 in. [1.6 mm]	10	10	⅛ [3]	0
1½ [38] to 3½ [90], excl	38.1 to 88.9 excl	0.010 [0.3]	less than 0.095 in. [2.4 mm]	10	10	3⁄16 [5]	0
3½ [90] to 5½ [140], excl	88.9 to 139.7, excl	0.015 [0.4]	less than 0.150 in. [3.8 mm]	10	10	3⁄16 [5]	0
5½ [140] to 8 [200], excl	139.7 to 203.2, excl	0.030 [0.8]	less than 0.240 in. [6.1 mm]	10	10	3⁄16 [5]	0
8 [200] to 8⅝ [220], excl	203.2 to 219.1, excl	0.045 [1.1]	less than 0.300 in. [7.6 mm]	10	10	3⁄16 [5]	0
8⅝ [220] to 12¾ [325], incl	219.1 to 323.9, incl	0.062 [1.6]	less than 0.350 in. [8.9 mm]	10	10	3⁄16 [5]	0

[A] Tolerances of tubes produced by the rod or bar mandrel process and which have an inside diameter under ½ in. [12.7 mm] (or an inside diameter under ⅝ in. [15.8 mm] when the wall thickness is more than 20 % of the outside diameter) are as shown in this table, except that wall thickness tolerances are 10 % over and under the specified wall thickness.

[B] For ovality values, the tolerance for average outside diameter at any one cross section does not exceed the outside diameter tolerance value for the applicable outside diameter.

[C] Many tubes with wall thicknesses more than 25 % of outside diameter or with wall thicknesses over 1¼ in. [31.7 mm], or weighing more than 90 lb/ft [60.5 kg/m], are difficult to draw over a mandrel. Therefore, the wall thickness can vary 12½ % over and under that specified. Also see Footnote (*B*).

[D] For those tubes with inside diameter under ½ in. [12.7 mm] (or under ⅝ in. [15.8 mm] when the wall thickness is more than 20 % of the outside diameter) which are not commonly drawn over a mandrel, Footnote (*A*) is not applicable. Therefore, the wall thickness can vary 15 % over and under that specified, and the inside diameter is governed by both the outside diameter and wall thickness tolerances.

[E] These tolerances apply to cut lengths up to and including 24 ft [7.3 m]. For lengths over 24 ft [7.3 m], an additional over tolerance of ⅛ in. [3 mm] for each 10 ft [3 m] or fraction thereof shall be permissible, up to a maximum tolerance of ½ in. [13 mm].

8.6 *Straightness Tolerances (Cold Finished or Hot Finished Hollow Bar)*—The deviation from straightness of any hollow bar length (L) shall not exceed 0.0015 L, and not exceeding 0.072 in. per 3 ft [2 mm per 1 m] when measured with a 3-ft [1 m] straight edge and feeler gage. If determined by the dial indicator method, the values obtained will be approximately twice those determined by the straightedge feeler gauge method.

9. Permissible Variations in Dimensions of Square and Rectangular Mechanical Tubing

9.1 Square and rectangular seamless mechanical tubing is supplied as cold worked unless otherwise specified. For this tubing, variations in dimensions from those specified shall not exceed the amounts prescribed in Table 7, Table 8, Table 9, and Table 10.

9.2 The squareness of sides is commonly determined by one of the following methods.

9.2.1 A square, with two adjustable contact points on each arm, is placed on two sides. A fixed feeler gauge is then used to measure the maximum distance between the free contact point and the surface of the tubing.

9.2.2 A square, equipped with a direct reading vernier, may be used to determine the angular deviation which, in turn, may be related to distance in inches.

9.3 The squareness of sides varies in accordance with the following equation:

$$\pm b = c \times 0.006 \quad (1)$$

where:

b = tolerance for out-of-square, and
c = length of longest side.

Example: Rectangular tubes 2 by 1 may have sides fail to be 90° to each other by ±0.012 in. [0.3 mm].

TABLE 4 Permissible Variations in Outside Diameter, Wall Thickness, and Cut-Length Variations (Hot-Finished Round Mechanical Tubing and Hollow Bar)

Specified Nominal Inch Size, Outside Diameter, in. [mm]	Prevailing Range of Commercially Available Metric Sizes, mm	Ratio of Wall Thickness to Outside Diameter	Outside Diameter and Wall Thickness Tolerances										Permissible Variations in Cut *Length*, in. [mm][A]	
			Outside Diameter, in. [mm]		Wall Thickness, %									
					0.109 in. [2.77 mm] and under		0.109 [2.77] to 0.172 in. [4.37 mm], incl		Over 0.172 [4.37] to 0.203 in. [5.16 mm], incl		Over 0.203 in. [5.16 mm]		+	–
			Over	Under	Over	Under	Over	Under	Over	Under	Over	Under		
Under 3 [75]	Under 76.1	All wall thicknesses	0.023 [0.6]	0.023 [0.6]	16.5	16.5	15	15	14	14	12.5	12.5	3/16 [4.8]	0
3 [75] to 5½ [140], excl	76.1 to 139.7, excl	All wall thicknesses	0.031 [0.8]	0.031 [0.8]	16.5	16.5	15	15	14	14	12.5	12.5	3/16 [4.8]	0
5½ [140] to 8 [200], excl	139.7 to 203.2, excl	All wall thicknesses	0.047 [1.2]	0.047 [1.2]	...	...	...	...	14	14	12.5	12.5	3/16 [4.8]	0
8 [200] to 10¾ [275], excl	203.2 to 273.1, excl	5 % and over	0.047 [1.2]	0.047 [1.2]	...	...	...	...	...	...	12.5	12.5	3/16 [4.8]	0
10¾ [275] to 12¾ [325], incl	273.1 to 323.9, incl	Under 5 %	0.063 [1.6]	0.063 [1.6]	...	...	...	...	...	...	12.5	12.5	3/16 [4.8]	0

[A] These tolerances apply to cut lengths up to and including 24 ft [7.3 m]. For lengths over 24 ft [7.3 m], an additional over tolerance of ⅛ in. [3 mm] for each 10 ft [3 m] or faction thereof shall be permissible, up to a maximum tolerance of ½ in. [13 mm].