Designation: ~~B1007 – 17~~ B1007 – 21

Standard Specification for Welded Precipitation Hardenable or Cold Worked, Nickel Alloy Tube[1]

This standard is issued under the fixed designation B1007; 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 nominal and minimum wall-thickness welded tubes and welded and cold worked tubes made from the nickel alloys listed in Table 1. Anticipated uses cover applications where strength and strength at elevated temperatures are desired attributes. Some examples are hydraulic control lines, boilers, heat exchangers, and solar absorbers.

1.2 Tube shall be supplied in one of the following conditions; cold worked, cold worked and precipitation hardened, solution annealed plus precipitation hardened, or solution annealed and descaled conditions. When atmosphere control is used, descaling is not necessary.

1.3 This specification covers tube ⅛ to 6 in. (3.2 to 152.4 mm) in outside diameter and 0.015 to 0.148 in. (0.41 to 3.7 mm) inclusive in wall thickness.

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 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.*

1.6 *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]

B751/B751M Specification for General Requirements for Nickel and Nickel Alloy Welded 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
E8/E8M Test Methods for Tension Testing of Metallic Materials
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

[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.

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

TABLE 1 Chemical Requirements

Element	UNS N07725	UNS N07740	UNS N09945	UNS N09946	UNS N09925	UNS N07718	UNS N10276	UNS N06985
Aluminum	0.35 max	0.20-2.00	0.15-0.7	0.15-0.7	0.10-0.50	0.20-0.80	...	...
Boron	...	0.0006-0.006	...	...	...	0.006 max	...	...
Carbon	0.03 max	0.005-0.08	0.005-0.04	0.005-0.030	0.03 max	0.08 max	0.02 max	0.015 max
Chromium	19.0-22.5	23.5-25.5	19.5-23.0	19.5-22.5	19.5-23.5	17.0-21.0	14.5-16.5	21.0-23.5
Cobalt	...	15.0-22.0	...	...	...	1.0 max	2.5 max	5.0 max
Columbium[A]	2.75-4.00	0.50-2.5	2.4-4.5	3.5-4.5	0.50 max	4.75-5.50	...	0.50 max
Copper	...	0.50 max	1.5-3.0	1.5-3.0	1.50-3.00	0.30 max	...	1.5-2.5
Iron	Remainder[B]	3.0 max	Remainder[B]	Remainder[B]	22.0 min[C]	Remainder[B]	4.0-7.0	18.0-21.0
Manganese	0.35 max	1.00 max	1.00 max	1.00 max	1.00 max	0.35 max	1.00 max	1.00 max
Molybdenum	7.00-9.50	2.00 max	3.0-4.0	3.0-4.0	2.50-3.50	2.80-3.30	15.0-17.0	6.0-8.0
Nickel	55.0-59.0	Remainder[B]	45.0-55.0	50.0-55.0	3.80-46.0	50.0-55.0	Remainder[B]	Remainder[B]
Phosphorous	0.015 max	0.03 max	0.03 max	0.03 max	...	0.15 max	0.030 max	0.04 max
Silicon	0.20 max	1.0 max	0.5 max	0.5 max	0.50 max	0.35 max	0.08 max	1.0 max
Sulphur	0.010 max	0.03 max	0.03 max	0.03 max	0.030 max	0.015 max	0.030 max	0.03 max
Titanium	1.00-1.70	0.5-2.5	0.5-2.5	0.5-2.5	1.90-2.40	0.65-1.15	...	
Tungsten	...	...	...	...	...	...	3.0-4.5	1.5 max
Vanadium	...	...	...	...	...	...	0.35 max	...

[A] Columbium or Niobium (Nb) are references to the same element.
[B] Remainder: The element may be determined arithmetically by difference.
[C] Minimum: The element may be determined arithmetically by difference.

3. Terminology

3.1 Terms shall be defined in accordance with Terminology B899.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *average diameter, n*—see Terminology B899.

3.2.2 *tube, n*—see Terminology B899 and Specification B751/B751M.

4. Ordering Information

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

4.1.1 *Alloy*—See Table 1.

4.1.2 *Type* or condition if applicable (Table 2 and Table 3).

4.1.3 *Dimensions:*

4.1.3.1 *Tube*—Outside diameter, minimum or average wall thickness, and length. If coiled, coil specifics.

4.1.4 *Ends*—Plain ends cut and deburred will be furnished.

4.1.5 *Certification*—A report of test results is required.

4.1.6 *Samples for Check Analysis*—State whether samples for check analysis should be furnished.

4.1.7 *Purchaser Inspection*—If the purchaser wishes to witness tests or inspection of material at the place of manufacture, the purchase order must so state, indicating which tests or inspections are to be witnessed.

5. Manufacturing Requirements

5.1 Material furnished under this specification shall conform to the applicable requirements of Specification B751/B751M unless otherwise provided or clarified herein.

5.2 Welding will be by a fusion welding process using inert gas shielding and no addition of filler metal.

TABLE 2 Heat Treatments

Alloy	Solution Annealing Treatment	Precipitation Hardening Treatment (prec hard)
UNS N07725 Type 1	1900 ± 25°F (1040 ± 14°C), water quench or rapid air/gas cool	1350 ± 25°F (730 ± 14°C), hold 8 h, furnace cool at 100°F (56°C) per min. to 1150 25°F (620 ± 14°C), hold for 8 h, air cool
UNS N07725 Type 2	1900 ± 25°F (1040 ± 14°C), water quench or rapid air/gas cool	1350 ± 25°F (730 ± 14°C), hold 8 h, furnace cool at 100°F (56°C) per min. to 1150 ± 25°F (820 ± 14°C), hold for 8 h, air cool
~~UNS N07740 Type 1~~	~~2012°F (1100°C) min, hold 1 h per in. of thickness, rapid air cool~~	~~1400 to 1500°F (760 to 815°C), hold 4 h min for up to 2 in. thickness plus additional ½ h per each additional in. of thickness, air cool~~
UNS N07740 Type 1	2012 to 2192°F (1100 to 1200°C), water quench or rapid air/gas cool	1400 to 1500°F (760 to 815°C), hold 4 h min, air cool
~~UNS N09945 Type 1~~	~~1850 to1950°F (1010 to 1066°C) water quench or rapid air/gas cool~~	~~1300 to 1350°F (704 to 732°C), for 6 to 8 h, furnace cool at 50 to 100°F (26 to 56°C)/h to 1125 to 1175°F (607 to 635°C), hold 6 to 8 h, air cool~~
UNS N09945 Type 1	1850 to 1950°F (1010 to 1066°C), water quench or rapid air/gas cool	1300 to 1350°F (704 to 732°C), for 6 to 8 h, furnace cool at 50 to 100°F (26 to 56°C)/h to 1125 to 1175°F (607 to 635°C), hold 6 to 8 h, air cool
UNS N09946 Type 1	1850 to 1950°F (1010 to 1066°C) air cool, or faster	1300 to 1350 °F (704 to 732°C), for 6 to 8 h, furnace cool at 50 to 100°F (26 to 56°C)/h to 1125 to 1175°F (607 to 365°C), hold 6 to 8 h, air cool
UNS N09925 Type 1	1825 to 1875°C (996 to 1024°C) air cool or faster	1365°F (740°C), for 6 to 9 h, furnace cool to 1150°F (620°C), for total heat treatment 18 h min, air cool or faster
UNS N07718 Type 1	1875 ± 25°F (1024 ± 14°C), water quench or rapid air/gas cool	1425 to 1475°F (774 to 802°C), hold 6 to 8 h, air cool
UNS N10276	2050°F (1121°C) min, time commensurate with thickness. Type 3 – N/A this grade.	none
UNS N06985	2050°F (1121°C) min time commensurate with thickness. Type 3 – N/A this grade.	none

TABLE 3 Mechanical Properties

Alloy	Condition[A]	Tensile Strength min., ksi (MPa)	Yield Strength min., ksi (MPa)	Elongation in 2 in. (50 mm) or 4D,[B] min. %	Hardness Rc max
UNS N07725 Type 1	Solution Ann + prec hard	150 (1035)	120 (827)	20	43
UNS N07725 Type 2	Solution Ann + cw + prec hard	150 (1035)	120 (827)	20	.....
UNS N07725 Type 3	Solution Ann	105 (724)	40 (276)	45	10
	Solution Ann + prec hard	150 (1035)	120 (827)	20	...
UNS N07740 Type 1	Solution Ann + prec hard	150 (1035)	90 (620)	20	...
UNS N07740 Type 3	Solution Ann	105 (724)	60 (414)	30	...
	Solution Ann + prec hard	150 (1035)	90 (620)	20	...
UNS N09945 Type 1	Solution Ann + prec hard	150 (1035)	130 (896)	18	42
UNS N09945 Type 3	Solution Ann	100 (689)	65 (448)	30	...
	Solution Ann + prec hard	150 (1035)	130 (896)	18	42
UNS N09946 Type 1	Solution Ann + prec hard	165 (1035)	140 (896)	18	42
UNS N09946 Type 3	Solution Ann	100 (689)	65 (448)	30	...
	Solution Ann + prec hard	165 (1035)	140 (896)	18	42
UNS N09925 Type 3	Solution Ann	...	...	...	...
	Solution Ann + prec hard	140 (965)	110 (758)	18	38
UNS N07718 Type 1	Solution Ann + prec hard	150 (1034)	125 (862)	20	40
UNS N07718 Type 3	Solution Ann	...	...	...	...
	Solution Ann + prec hard	150 (1034)	125 (862)	20	40
UNS N10276 Type 1	Solution Ann + cw	115 (793)	110 (758)	11	40
UNS N10276 Type 2	Solution Ann + cw	130 (896)	125 (862)	10	40
UNS N06985 Type 1	Solution Ann + cw	115 (793)	110 (758)	11	40
UNS N06985 Type 2	Solution Ann + cw	130 (896)	125 (862)	10	40

[A] Further defined in Table 2.
[B] D refers to the diameter of the tension specimen.

5.3 Subsequent to welding the longitudinal weld of tubes 0.500 in. and larger OD shall be bead worked near flush.

5.3.1 The final wall thickness of the weld shall not exceed the wall thickness measured 90° from the weld by more than 5 % of the specified wall thickness or 0.003 in. (0.08 mm), whichever is greater. This requirement is not applicable when any of the following apply:

5.3.1.1 When the specified wall thickness exceeds 12 % of the specified outside diameter;

5.3.1.2 When the specified wall thickness exceeds 0.120 in. (3.0 mm).

5.3.2 Any bead work requirement placed on tubes smaller than 0.500 in. OD shall be by agreement between manufacturer and customer.

5.4 Subsequent to above, all tubes shall be solution annealed. The final solution anneal must be as presented in Table 2.

5.5 Subsequent to above, the mechanical manipulation tests of section 8.4 shall be successfully performed for each lot of production. Lot sizes are defined in Specification B751/B751M.

5.6 When cold work (cw) is required by the purchaser and in Table 3, it shall be full cross section reduction; by tube reducing, swaging or redrawing. The amount shall be sufficient to achieve the mechanical requirements in Table 3. When cold work (cw) is not specifically required in Table 3, it may still be used, by the manufacturer's option or by requirement.

6. Chemical Composition

6.1 The material shall conform to the composition limits specified in Table 1. One test is required for each lot as defined in Specification B751/B751M.

6.2 If a product (check) analysis is made by the purchaser, the material shall conform to the requirements specified in Table 1 subject to the permissible tolerances in accordance with Specification B880.

7. Conditions

7.1 Three conditions representing different levels of mechanical properties may be applicable depending on the alloy specified. Not every alloy is available in all types, consult Table 3. Where an alloy is only supplied in one condition in this specification, no type need be referenced.

7.2 *Type 1 or 2*—Heat ~~Treat or Cold Work Type~~treat or cold work type (Table 2 and Table 3).

7.3 *Type 3*—Alloys designed to be precipitation hardened can be manufactured and supplied in the solution annealed condition. If this is selected, mechanical testing will be performed in the solution annealed condition as well as after precipitation hardening (proof or capability testing of aging response) (Table 2 and Table 3). The expectation is that tubes will be precipitation hardened after subsequent fabrications by the customer or fabricator.

8. Mechanical Properties and Other Requirements

8.1 The material shall be supplied in the condition prescribed by the purchaser; cold worked (cw), or cold worked and precipitation hardened (prec hard), or solution annealed, or solution annealed plus precipitation hardened condition as described in Table 2 and shall meet or exceed corresponding requirements described in Table 3.

8.2 The mechanical properties at room temperature shall conform to those shown in Table 3. One test is required for each lot as defined in Specification B751/B751M and condition (8.1) if applicable.

8.3 If a material is to be supplied in the solution annealed condition (Type 3) with the intent of being precipitation hardened in

the future, then it shall be mechanically tested in the solution annealed condition as well as the age hardened condition (proof or capability testing of aging response). If no requirement is listed for the solution annealed condition in Table 3 the results for this condition will be for information only.

8.4 *Annealed – Mechanical Manipulation Tests*—One test is required for each 1500 ft (450 m) of finished tubing.

8.4.1 *Flattening Test Requirements:*

8.4.1.1 Evidence of laminated or unsound material or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

8.4.1.2 Surface imperfections in the test specimens before flattening, but revealed during the flattening test, shall be judged in accordance with the finish requirements.

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

8.4.2 *Flange Test Requirements:*

8.4.2.1 Flange test specimens shall show no cracking or flaws. Superficial ruptures resulting from surface imperfections shall not be cause for rejection.

8.4.2.2 For tubes less than 0.093 in. (2.36 mm) in inside diameter and tube having a wall thickness equal to or greater than the inside diameter, the flange test shall not be required.

8.4.3 *Reverse-Bend Test Requirement:*

8.4.3.1 A section 4 in. (100 mm) minimum in length shall be split longitudinally 90° on each side of the weld. The sample shall then be opened and bent around a mandrel with a maximum thickness of four times the wall thickness, with the mandrel parallel to the weld and against the original outside surface of the tube. The weld shall be at the point of maximum bend. There shall be no evidence of cracks, or of overlaps resulting from the reduction in thickness of the weld areas by cold working. When the geometry or size of the tubing make it difficult to test the sample as a single piece, the sample may be sectioned into smaller pieces provided a minimum of 4 in. of weld is subjected to reverse bending.

8.4.3.2 The reverse bend test is not applicable when the specified wall is 10 % or more of the specified outside diameter, or the wall thickness is 0.134 in. (3.4 mm) or greater, or the outside diameter size is less than 0.375 in. (9.5 mm). Under these conditions the reverse flattening test of Specification B751/B751M shall apply.

8.4.4 *Final Hardness Requirements:*

8.4.4.1 Tubes shall have a Rockwell hardness number not exceeding the values specified in Table 3. A test is required for each lot as defined in Specification B751/B751M.

9. Hydrostatic or Nondestructive Electric Test

9.1 Each tube shall at a minimum be subjected to either the hydrostatic or the nondestructive electric test as defined in Specification B751/B751M. The purchaser may specify which tests are to be used or optionally require additional testing. Examples would be; eddy current, ultrasonic, pneumatic (air underwater) or hydrostatic.

9.1.1 Hydrostatic leak testing may be performed when tubes are at final size and in the annealed condition unless otherwise agreed upon. When performed, test pressures and condition tested shall be reported.

9.1.2 Hydrostatic testing at a pressure greater than 1000 psi may be performed upon agreement between the purchaser and manufacturer or at the option of the manufacturer provided that the allowable fiber yield stress is not exceeded.

10. Dimensions and Permissible Variations

10.1 The permissible variations for outside diameter and wall thickness are available in Specification B751/B751M.