Designation: B 918/B 918M – 09

Standard Practice for Heat Treatment of Wrought Aluminum Alloys[1]

This standard is issued under the fixed designation B 918/B 918M; 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*

1.1 This practice is intended for use in the heat treatment of wrought aluminum alloys for general purpose applications.

1.1.1 The heat treatment of wrought aluminum alloys used in specific aerospace applications is covered in AMS 2772.[2]

1.1.2 Heat treatment of aluminum alloy castings for general purpose applications is covered in Practice B 917/B 917M.

1.2 Times and temperatures appearing in the heat-treatment tables are typical for various forms, sizes, and manufacturing methods and may not provide the optimum heat treatment for a specific item.

1.3 Some alloys in the 6xxx series may achieve the T4 temper by quenching from within the solution temperature range during or immediately following a hot working process, such as upon emerging from an extrusion die. Such alternatives to furnace heating and immersion quenching are indicated in Table 2, by Footnote *L*, for heat treatment of wrought aluminum alloys. However, this practice does not cover the requirements for a controlled extrusion press or hot rolling mill solution heat treatment. (Refer to Practice B 807 for extrusion press solution heat treatment of aluminum alloys and to Practice B 947 for hot rolling mill solution heat treatment of aluminum alloys.)[3]

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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 establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 The following documents, of the issue in effect on the date of material purchase, form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[3]

B 557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B 881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B 917/B 917M Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes

G 69 Test Method for Measurement of Corrosion Potentials of Aluminum Alloys

G 110 Practice for Evaluating Intergranular Corrosion Resistance of Heat Treatable Aluminum Alloys by Immersion in Sodium Chloride + Hydrogen Peroxide Solution

2.3 *American National Standard:*

H35.1/H35.1(M) Alloy and Temper Designation Systems for Aluminum[4]

3. Terminology

3.1 *Definitions*—Refer to Terminology B 881 for definitions of product terms used in this practice.

3.2 *Definition of Pyrometry Terms Specific to This Standard:*

3.2.1 *control sensor*—sensor connected to the furnace temperature controller, which may or may not be recording.

3.2.2 *load sensor*—sensor that is attached to the production material or a representation of production material, that supplies temperature data of the production material to process instrumentation.

3.2.3 *monitoring sensor*—sensor connected to the monitoring instrument.

3.2.4 *test sensor*—sensor used in conjunction with a test instrument to perform a system accuracy test or temperature uniformity survey.

4. Equipment

4.1 *Heating Media*—Aluminum alloys are typically heat-treated in air chamber furnaces or molten salt baths; however, lead baths, oil baths, or fluidized beds, may be used. The use of uncontrolled heating is not permitted. Whichever heating

[1] This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

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[2] Available from SAE International, 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[3] 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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

TABLE 1 Tests Required

Product Form	Tensile Properties[A]	Heat-Treat-Induced Porosity[B] [Periodic Test]	Intergranular Corrosion[C] [Periodic Test]	Diffusion (Alclad Only)[D] [Periodic Test]	Eutectic Melting [Periodic Test]
Plate and sheet	X	X	X[E]	X	X
Wire, rod, bar, and profiles	X	X	X	. . .	X
Forgings	X	X	X	. . .	X
Tubing	X	X	. . .	X	X
Rivets, fastener components	X	X	X	. . .	X

[A] Those specified in the applicable procurement material specification for lot release.
[B] Applicable only to material solution heat-treated in air furnaces.
[C] Applicable to the most quench-sensitive alloys-tempers in the following order of preference: (*1*) 2xxx in -T3 or -T4 and (*2*) 7xxx in -T6 temper. No test is required if 2xxx-T3 or -T4 or 7xxx-T6, was not solution heat-treated during the period since the prior verification test.
[D] Not applicable for thicknesses less than 0.020 in.
[E] Applicable to periodic testing of sheet product only.

means are employed, careful evaluation is required to ensure that the alloy being heat-treated responds properly to heat-treatment and is not damaged by overheating or by the heat-treatment environment.

4.1.1 Air chamber furnaces may be oil- or gas-fired or may be electrically heated. Furnace components that are significantly hotter than the metal should be suitably shielded for metal less than 0.250 in. [6.35 mm] thick to prevent adverse radiation effects. The atmosphere in air chamber furnaces must be controlled to prevent potential porosity resulting from solution heat treatment (see Note 1). The suitability of the atmosphere in an air-chamber furnace can be demonstrated by testing, in accordance with 7.4.2.1, that products processed in that furnace are free from heat-treat induced porosity.

NOTE 1—Heat-treat induced porosity may lower mechanical properties and commonly causes blistering of the surface of the material. The condition is most likely to occur in furnaces in which the products of combustion contact the work, particularly if the gases are high in water vapor or contain compounds of sulfur. In general, the high-strength wrought alloys of the 2xxx and 7xxx series are most susceptible. Low-strength and Alclad (two sides) products are practically immune to this type of damage. Anodic films and proprietary heat-treat coatings are also useful in protecting against porosity resulting from solution heat treatment. Surface discoloration is a normal result of solution heat treatment of aluminum alloys and should not be interpreted as evidence of damage from overheating or as heat-treat induced porosity (see 7.4.2.1).

4.1.2 Salt baths heat the work rapidly and uniformly. The temperature of the bath can be closely controlled, an important consideration in solution heat treatment of wrought aluminum alloys. High-temperature oxidation of aluminum is not a problem in salt baths.

4.2 *Furnace Temperature Uniformity and Calibration Requirements*:

4.2.1 After establishment of thermal equilibrium or a recurrent temperature pattern, the temperature in the working (soaking) zone, for all furnace control and test sensors, shall maintain temperature in the working (soaking) zone within the following allowable ranges:

4.2.1.1 50°F [28°C] range for furnaces used only for full annealing at 825°F [441°C] and higher, except 20°F [12°C] range if the annealing temperature is within 15°F [8°C] of the middle of the solution heat treating temperature range specified in Table 2.

4.2.1.2 30°F [17°C] range for furnaces used only for solution heat treatment of those 6xxx alloys for which Table 2 specifies a range from 30°F [17°C] or more.

4.2.1.3 20°F [12°C] range for furnaces used for other solution heat treatment specified in Table 2 and any aging heat treatment.

4.2.2 *Temperature-Measuring System Accuracy Test*—The accuracy of temperature-measuring system shall be checked weekly under operating conditions. This check should be made by inserting a calibrated test temperature-sensing element adjacent to the furnace temperature-sensing element and reading the test temperature-sensing element with a calibrated test potentiometer. When the furnace is equipped with dual potentiometer measuring systems which are checked daily against each other, the preceding checks may be conducted every 3 months rather than every week. The test temperature-sensing element, potentiometer, and cold junction compensation combination shall have been calibrated against National Institute of Standards and Technology (NIST) or equivalent national standard primary or secondary certified temperature-sensing elements, within the previous 3 months, to an accuracy of ±2°F [±1.1°C].

4.3 *Furnaces and Salt Baths Temperature Uniformity Surveys*—A temperature uniformity survey shall be performed for each furnace and salt bath to ensure compliance with temperature uniformity requirements (see 4.2) and the requirements presented herein.

4.3.1 A new temperature uniformity survey shall be made after any modification, repair, adjustment (for example, to power controls, or baffles), or re-build which alters the temperature uniformity characteristics of the furnace or salt bath and changes the effectiveness of the heat treatment.

4.3.2 The initial temperature survey shall be made at the maximum and minimum temperature of solution heat treatments and precipitation heat treatments for which each furnace is to be used. There shall be at least one test location for each 25 ft^3[0.69 m^3] of air furnace volume up to a maximum of 40 test locations, with a minimum of nine test locations, one in each corner and one in the center. For salt-bath furnaces, one test location is required for each 40 ft^3[1.1 m^3] of volume.

4.3.3 After the initial survey, each furnace shall be surveyed monthly thereafter, except as provided in 4.3.8 and 4.3.9. The monthly survey shall be at one operating temperature for solution heat treatment and one operating temperature for precipitation heat treatment.

TABLE 2 Recommended Heat Treatment for Wrought Aluminum Alloys[A]

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
			2011 Alloy[A]			
Cold-finished wire, rod, and bar	945-995 [507–535]	110 [43] max	T3[F]	320 [160]	14	T8[F]
			T4	. . .	. . .	. . .
			T451[G]	. . .	. . .	. . .
Drawn tube	975 [524]	110 [43] max	T3[F]	. . .	. . .	. . .
			T4511[G]			
			2014 Alloy[A]			
Flat sheet, bare or Alclad	935 [502]	110 [43] max	T3[F]	. . .	. . .	. . .
			T42	320 [160]	18	T62
Coiled sheet, bare or Alclad	935 [502]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
Plate, bare or Alclad	935 [502]	110 [43] max	T451[G]	320 [160]	18	T651[G]
			T42	. . .	. . .	. . .
Cold-finished wire, rod, and bar	935 [502]	110 [43] max	T4	320 [160]	18	T6
				or 350 [177]	8	
			T451[H]	320 [160]	18	T651[H]
				or 350 [177]	8	
			T42	320 [160]	18	T62
				or 350 [177]	8	
Extruded wire, rod, bar, profiles, and tube	935 [502]	110 [43] max	T4	320 [160]	18	T6
				or 350 [177]	8	
			T4510[H]	320 [160]	18	T6510[H]
				or 350 [177]	8	
			T4511[H]	320 [160]	18	T6511[H]
				or 350 [177]	8	
			T42	320 [160]	18	T62
				or 350 [177]	8	
Drawn tube	935 [502]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
Die forgings	935 [502]	140–180 [60-82]	T4	340 [171]	10	T6
Hand forgings and rolled rings	935 [502]	140–180 [60-82]	T452[I]	340 [171]	10	T652[I]
			T4	340 [171]	10	T6
			2017 Alloy[A]			
Cold-finished wire, rod, and bar	925–950 [496-510]	110 [43] max	T4	. . .	. . .	. . .
			T451[H]	. . .	. . .	. . .
			T42	. . .	. . .	. . .
			2018 Alloy[A]			
Die forgings	940–970 [504-521]	212 [100]	T4	340 [171]	10	T61
			2024 Alloy[A]			
Flat sheet, bare or Alclad	920 [493]	110 [43] max	T3[F]	375 [191]	12	T81[F]
			T361[J]	375 [191]	8	T861[J]
			T42	375 [191]	9	T62
			T42	375 [191]	16	T72
Coiled sheet, bare or Alclad	920 [493]	110 [43] max	T4	. . .	. . .	. . .
			T42	375 [191]	9	T62
Plate, bare or Alclad	920 [493]	110 [43] max	T351[G]	375 [191]	12	T851[G]
			T361[J]	375 [191]	8	T861[J]
			T42	375 [191]	9	T62
Cold-finished wire, rod, and bar	920 [493]	110 [43] max	T351[H]	375 [191]	12	T851[H]
			T36[J]	. . .	. . .	. . .
			T4	375 [191]	12	T6
			T42	375 [191]	16	T62
Extruded wire, rod, bar, profiles, and tube	920 [493]	110 [43] max	T3[F]	375 [191]	12	T81[F]
			T3510[H]	375 [191]	12	T8510[H]
			T3511[H]	375 [191]	12	T8511[H]
			T42	. . .	. . .	. . .
Drawn tube	920 [493]	110 [43] max	T3[F]	. . .	. . .	. . .
			T42	. . .	. . .	. . .
			2025 Alloy[A]			
Die forgings	960 [516]	140–160 [60-71]	T4	340 [171]	10	T6
			2117 Alloy[A]			
Cold-finished, wire or rod	925–950 [496-510]	110 [43] max	T4	. . .	. . .	. . .
			2124 Alloy[A]			
Plate	920 [493]	110 [43] max	T351[G]	350 [177]	12	T851[G]