



Designation: B917/B917M – 12 (Reapproved 2020)

Standard Practice for Heat Treatment of Aluminum-Alloy Castings From All Processes¹

This standard is issued under the fixed designation B917/B917M; 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 practice covers, when specified by material specification or purchase order, the heat treatment of aluminum alloy castings from all casting processes.

1.1.1 The heat treatment of aluminum alloy castings used in specific aerospace applications is covered in AMS 2771 and specific AMS material specifications.

1.1.2 The heat treatment of wrought aluminum alloys is covered in Practice B918/B918M.

1.2 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.

1.3 *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, 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.*

2. Referenced Documents

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

¹ This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.01 on Aluminum Alloy Ingots and Castings.

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2.2 ASTM Standards:²

B26/B26M Specification for Aluminum-Alloy Sand Castings

B108/B108M Specification for Aluminum-Alloy Permanent Mold Castings

B275 Practice for Codification of Certain Zinc, Tin and Lead Die Castings (Withdrawn 2020)³

B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)

B618/B618M Specification for Aluminum-Alloy Investment Castings

B686/B686M Specification for Aluminum Alloy Castings, High-Strength

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B918/B918M Practice for Heat Treatment of Wrought Aluminum Alloys

B955/B955M Specification for Aluminum-Alloy Centrifugal Castings

B969/B969M Specification for Aluminum-Alloy Castings Produced by Squeeze Casting, and the Semi-Solid Thixocast and Rheocast Casting Processes

G110 Practice for Evaluating Intergranular Corrosion Resistance of Heat Treatable Aluminum Alloys by Immersion in Sodium Chloride + Hydrogen Peroxide Solution

2.3 ANSI Standard:⁴

ANSI H35.1/H35.1M Alloy and Temper Designation Systems for Aluminum

2.4 SAE Standard:⁵

AMS 2771 Heat Treatment of Aluminum Alloy Castings

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 The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from Aluminum Association, 1400 Crystal Dr., Suite 430, Arlington, VA 22202, <http://www.aluminum.org>.

⁵ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology **B881** for terminology relating to the heat treatment of castings.

4. Equipment

4.1 *Heating Media*—Aluminum castings are typically heat treated in air chamber furnaces; however, lead baths, oil baths, fluidized beds, or even superheated steam may be used in specific applications. The use of uncontrolled heating is not permitted. Whichever heating means are employed, careful evaluation is required to ensure that the casting responds properly to heat treatment and is not overheated or damaged by the heat treatment environment. Salt baths are not recommended for the commercial heat treatment of aluminum castings in volume. (**Warning**—Nitrate baths must not be used in the heat treatment of 5xx.0 series castings because of the inherent explosion hazard.)

4.2 *Air Chamber Furnaces*—Air chamber furnaces may be oil or gas-fired or may be electrically heated. The atmosphere in air chamber furnaces must be controlled to prevent porosity resulting from solution heat treatment. Furnace components that are significantly hotter than the metal should be suitably shielded for section thicknesses of less than 0.250 in. [6 mm] to prevent adverse radiation effects. The atmosphere in air chamber furnaces must be controlled to prevent 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 **8.4.3.1**, that products processed in that furnace are substantially free of 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. 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.

4.3 *Automatic Recording and Control Equipment*, to control temperature of air furnaces shall be capable of maintaining temperature in the working zone to within ± 10 °F [± 5 °C] of the specified temperature.

4.4 *Quench Baths*—Quenching is normally performed by immersion of castings in a hot-water bath as described in **Tables 1-4**. The water baths must be located close enough to solution heat-treating facilities to minimize delay in quenching. Tanks must be of adequate size for the expected work load and must have the means of providing adequate circulation of the quenching media about the work load. Means for heating or cooling the quench water should be available when needed.

NOTE 2—Quenching may be performed by alternative means such as total immersion in a glycol and water solution, a liquefied gas, cold water, hot water, or boiling water, or by air blast or fog to minimize distortion provided samples from the material, so quenched, will conform to the (1) mechanical properties, (2) other requirements of the applicable casting specification, and (3) not exhibit more intergranular corrosion susceptibility than if the metal was immersion quenched in cold water. The use of water sprays or high-velocity high-volume jets of water in which the

material is thoroughly and effectively flushed is satisfactory for quenching. Alternative quench media are frequently contingent on the particular alloy and the end use of the casting.

5. Furnace Temperature Uniformity and Calibration Requirements

5.1 Calibration of Equipment:

5.1.1 Thermocouple wire and sensors shall be calibrated against wire or sensors whose calibration is traceable to NIST. Thermocouples made from calibrated wire rolls may be used in lieu of individually calibrated thermocouples in which case, the roll calibration shall be that of the average of samples taken from both ends of the roll. The roll shall not be used if the difference in the highest and lowest reading exceeds 2 °F [1 °C].

5.1.2 Working instruments shall be calibrated at least once every three months against a test instrument that is traceable to NIST. Accuracy shall be ± 0.3 % of range.

5.2 Furnace Temperature Survey:

5.2.1 A temperature survey, to ensure compliance with the applicable recommendations presented herein, shall be performed for each furnace.

5.2.2 A new temperature survey shall be made after any modification, repair, adjustment (for example, to power controls, or baffles), or rebuild which may have altered the temperature uniformity characteristics of the furnace and reduced the effectiveness of the heat treatment.

5.3 Batch Furnace Surveys:

5.3.1 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 ft³ [0.70 m³] 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.

5.3.2 After the initial survey, each furnace shall be surveyed monthly, except as provided in **5.3.7**. The monthly survey shall be at one operating temperature for solution heat treatment and one for precipitation heat treatment.

5.3.3 There shall be at least one test location for each 40 ft³ [1 m³] of load volume, with a minimum of nine test locations, one in each corner and one in the center.

5.3.4 The surveys shall reflect the normal operating characteristics of the furnace. If the furnace is normally charged after being stabilized at the correct operating temperature, the temperature-sensing elements shall be similarly charged. If the furnace is normally charged cold, the temperature-sensing elements shall be charged cold. After insertion of the temperature-sensing elements, readings should be taken frequently enough to determine when the temperature of the hottest region of the furnace approaches the bottom of the temperature range being surveyed. From that time until thermal equilibrium is reached, the temperature of all test locations should be determined at 2-min intervals in order to detect any over-shooting. After thermal equilibrium is reached, readings should be taken at 5-min intervals for sufficient time to determine the recurrent temperature pattern, but for not less than 30 min. Before thermal equilibrium is reached, none of the

TABLE 1 Recommended Heat Treatment for Sand and Investment Type Alloys (Inch-Pound Units)

Alloy ^A	Final Temper ^A	Solution Heat Treatment ^{B,C}		Precipitation Heat Treatment ^D		
		Metal Temperature, ±10 °F	Time at Temperature, h	Metal Temperature, ±10 °F	Time at Temperature, h	
201.0	T6	960 then 980	2 ^E 14 to 20	room temperature then 310	12 to 24 20	
	T7	960 then 980	2 ^E 14 to 20	room temperature then 370	12 to 24 5	
A201.0	T7	955 then 985	2 ^E 14 to 20	room temperature then 370	12 to 24 5	
203.0	T6	955 then 1010	2 ^E 5	room temperature then 425	12 to 24 16	
204.0	T4	970	10	room temperature	5 days ^F	
A206.0	T4	950 then 985	2 ^E 14 to 20	room temperature	5 days	
	T43	950 then 985	2 ^E 14 to 20	room temperature then 320	12 to 24 0.5 to 1	
	T6 ^G	950 then 985	2 ^E 14 to 20	room temperature then 310	12 to 24 20	
	T7	950 then 985	2 ^E 14 to 20	room temperature then 370	12 to 24 4 to 5	
	222.0	O ^{D,H}	600 ^H	3
	T61	945	6 to 12	310	11	
242.0	O ^{D,H}	...	...	650 ^H	3
	T571	...	...	400	8
A242.0	T61	960	2 to 6 ^I	450	1 to 3	
	T75	965	6 to 10	550	2 to 5	
	295.0	T4	960	6 to 12
	T6	960	6 to 12	310	3 to 6	
296.0	T62	960	6 to 12	310	12 to 24	
	T7	960	6 to 12	500	4 to 6	
	T4	950	4 to 8	...	...
	T6	950	4 to 8	310	2 to 8	
319.0	T7	950	4 to 8	500	4 to 6	
	T4	940	6 to 10	...	...
	T5	...	...	400	8
328.0	T6	940	6 to 12	310	2 to 5	
	T6	960	12	310	2 to 5	
355.0	T51	...	...	440	7 to 9
	T6	980	6 to 12	310	3 to 5	
	T7	980	6 to 12	440	3 to 5	
	T71	980	6 to 12	475	4 to 6	
C355.0 ^J	T6	985	6 to 12	room temperature then 310	8 3 to 5	
	T51	...	...	440	7 to 9
356.0	T6	1000	6 to 12 ^K	310	3 to 5	
	T7	1000	6 to 12 ^K	400	3 to 5	
	T71	1000	6 to 12 ^K	475	2 to 4	
	A356.0	T6	1000	6 to 12 ^K	310	2 to 5
357.0	T61	1000	6 to 12 ^K	330	6 to 12	
	T7	1000	6 to 12 ^K	440	8	
	T71	1000	6 to 12 ^K	475	3 to 6	
	T6	1000 ^H	8 ^K	330	6 to 12	
A357.0 ^J	T61	1000	10 to 12 ^K	310	10 to 12	
	T61	1000 ^H	8 to 10 ^K	room temperature then 310	8 8	
A390.0	T6	925	8 to 12	350	8	
520.0	T4	810	12 to 18 ^L	..	...
705.0	T1	...	...	room temperature	21 days
	T5	...	...	210	8
707.0	T1	...	...	room temperature	21 days
	T5	...	...	210	8
	T7	990	8 to 16	350	4 to 10	
710.0	T5	...	...	room temperature	21 days
	T5	...	...	or 315	6 to 8
712.0	T5	...	...	room temperature or 315	21 days 6 to 8
713.0	T1	...	...	room temperature	21 days
	T5	...	...	250	16
771.0	T5	...	...	355	3 to 5
	T51	...	...	405	6
	T52	...	...	330 ^J	6 to 16 ^M
	T6	1090	6 ^D	265	3	
	T53	...	...	360 ^{J,D}	4
	T71	1090	6 ^D	285	15	
850.0	T5	...	...	430	7 to 9
851.0	T5	...	...	430	7 to 9