Designation: B917/B917M – 09

Standard Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes[1]

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.

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[2] and specific AMS[2] material specifications.

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

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 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.

1.2.1 *SI Units*—The SI units are shown in brackets or in separate tables.

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 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]

B26/B26M Specification for Aluminum-Alloy Sand Castings

B108 Specification for Aluminum-Alloy Permanent Mold Castings

B275 Practice for Codification of Certain Nonferrous Metals and Alloys, Cast and Wrought

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 Specification for Aluminum-Alloy Investment Castings

B686 Specification for Aluminum Alloy Castings, High-Strength

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B918 Practice for Heat Treatment of Wrought Aluminum Alloys

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

2.3 *ANSI Standard:*

H35.1 Alloy and Temper Designation Systems for Aluminum[4]

2.4 *SAE Standard:*

AMS 2771 Heat Treatment of Aluminum Alloy Castings

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

[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] Available from Society of Automotive Engineers (SAE), 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 Aluminum Association, Inc., 1525 Wilson Blvd., Suite 600, Arlington, VA 22209, http://www.aluminum.org.

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

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*—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 ft^3 [0.70 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.

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 ft^3 [1 m^3] 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 temperature readings should exceed the maximum temperature of the range being surveyed. After thermal equilibrium is reached, the maximum temperature variation of all elements (both load and furnace thermocouples) shall not exceed 20°F [10°C] and shall not vary outside the range being surveyed.

5.3.5 For furnaces of 10 ft^3 [0.25 m^3] or less the temperature survey may be made with a minimum of three thermocouples located at front, center, and rear or at top, center, and bottom of the furnace.

5.3.6 For furnaces used only for precipitation treatment, after the initial temperature-uniformity survey, as outlined in 5.3.7, surveys need not be made more often than at each 6-month interval provided that (*1*) test specimens from each lot are tested and meet applicable material specifications requirements, (*2*) the furnace is equipped with a multipoint recorder,

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	2[E]	room temperature	12 to 24
		then 980	14 to 20	then 310	20
	T7	960	2[E]	room temperature	12 to 24
		then 980	14 to 20	then 370	5
A201.0	T7	955	2[E]	room temperature	12 to 24
		then 985	14 to 20	then 370	5
203.0	T6	955	2[E]	room temperature	12 to 24
		then 1010	5	then 425	16
204.0	T4	970	10	room temperature	5 days[F]
A206.0	T4	950	2[E]	room temperature	5 days
		then 985	14 to 20		
	T43	950	2[E]	room temperature	12 to 24
		then 985	14 to 20	then 320	0.5 to 1
	T6[G]	950	2[E]	room temperature	12 to 24
		then 985	14 to 20	then 310	20
	T7	950	2[E]	room temperature	12 to 24
		then 985	14 to 20	then 370	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
	T61	960	2 to 6[I]	450	1 to 3
A242.0	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
	T62	960	6 to 12	310	12 to 24
	T7	960	6 to 12	500	4 to 6
296.0	T4	950	4 to 8	...	...
	T6	950	4 to 8	310	2 to 8
	T7	950	4 to 8	500	4 to 6
319.0	T4	940	6 to 10	...	...
	T5	...	...	400	8
	T6	940	6 to 12	310	2 to 5
328.0	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	8
				then 310	3 to 5
356.0	T51	...	...	440	7 to 9
	T6	1000	6 to 12	310	3 to 5
	T7	1000	6 to 12	400	3 to 5
	T71	1000	6 to 12	475	2 to 4
A356.0	T6	1000	6 to 12	310	2 to 5
	T61	1000	6 to 12	330	6 to 12
	T7	1000	6 to 12	440	8
	T71	1000	6 to 12	475	3 to 6
357.0	T6	1000[H]	8	330	6 to 12
	T61	1000	10 to 12	310	10 to 12
A357.0[J]	T61	1000[H]	8 to 10	room temperature	8
				then 310	8
A390.0	T6	925	8 to 12	350	8
520.0	T4	810	12 to 18[K]	...	...
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
				or 315	6 to 8
712.0	T5	...	...	room temperature	21 days
				or 315	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[L]
	T6	1090	6[D]	265	3
	T53	...	...	360[J,D]	4
	T71	1090	6[D]	285	15
850.0	T5	...	...	430	7 to 9