Designation: B 918 – 01

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

This standard is issued under the fixed designation B 918; 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 press heat treatment. (Refer to Practice B 807 for press heat treatment of aluminum alloys.)

1.4 This practice is in inch-pound units.

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:*

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[3]

B 881 Terminology Relating to Aluminum- and Magnesium-Alloy Products[3]

B 917/B 917M Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes[3]

2.3 *American National Standard:*

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

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.

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*—temperature measurement sensor tied to the PID (proportional, integral, and derivative) furnace control for controlling heat input to the working (soaking) zone of the furnace.

3.2.2 *monitoring sensor*—a sensor which does not control the furnace temperature is designated as a monitoring sensor, and includes additional furnace temperature sensor(s) and load monitoring sensor(s).

[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-AEROSPACE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

[3] *Annual Book of ASTM Standards*, Vol 02.02.

[4] Available from American National Standards Institute, 25 West 43rd St., 4th Floor, New York, NY 10036.

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

3.2.3 *test sensor*—temperature measurement sensor(s) used in furnace temperature uniformity surveys.

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. However, the use of uncontrolled heating is not permitted. Whichever heating 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. 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 range for furnaces used only for full annealing at 825°F and higher, except 20°F range if the annealing temperature is within 15°F of the middle of the solution heat treating temperature range specified in Table 2.

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

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Temperature, h	Temper
			2011 Alloy[A]			
Cold-finished wire, rod, and bar	945-995	110 max	T3[F]	320	14	T8[F]
			T4	. . .	. . .	. . .
			T451[G]	. . .	. . .	. . .
Drawn tube	975	110 max	T3[F]	. . .	. . .	. . .
			T4511[G]			
			2014 Alloy[A]			
Flat sheet, bare or Alclad	935	110 max	T3[F]	. . .	. . .	. . .
			T42	320	18	T62
Coiled sheet, bare or Alclad	935	110 max	T4	320	18	T6
			T42	320	18	T62
Plate, bare or Alclad	935	110 max	T451[G]	320	18	T651[G]
			T42	. . .	. . .	. . .
Cold-finished wire, rod, and bar	935	110 max	T4	320	18	T6
				or 350	8	
			T451[H]	320	18	T651[H]
				or 350	8	
			T42	320	18	T62
				or 350	8	
Extruded wire, rod, bar, profiles, and tube	935	110 max	T4	320	18	T6
				or 350	8	
			T4510[H]	320	18	T6510[H]
				or 350	8	
			T4511[H]	320	18	T6511[H]
				or 350	8	
			T42	320	18	T62
				or 350	8	
Drawn tube	935	110 max	T4	320	18	T6
			T42	320	18	T62
Die forgings	935	140–180	T4	340	10	T6
Hand forgings and rolled rings	935	140–180	T452[I]	340	10	T652[I]
			T4	340	10	T6
			2017 Alloy[A]			

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Temperature, h	Temper
Cold-finished wire, rod, and bar	925–950	110 max	T4	...	...	...
			T451[H]	...	...	...
			T42	...	...	...
		2018 Alloy[A]				
Die forgings	940–970	212	T4	340	10	T61
		2024 Alloy[A]				
Flat sheet, bare or Alclad	920	110 max	T3[F]	375	12	T81[F]
			T361[J]	375	8	T861[J]
			T42	375	9	T62
			T42	375	16	T72
Coiled sheet, bare or Alclad	920	110 max	T4	...	...	...
			T42	375	9	T62
Plate, bare or Alclad	920	110 max	T351[G]	375	12	T851[G]
			T361[J]	375	8	T861[J]
			T42	375	9	T62
Cold-finished wire, rod, and bar	920	110 max	T351[H]	375	12	T851[H]
			T36[J]	...	...	...
			T4	375	12	T6
			T42	375	16	T62
Extruded wire, rod, bar, profiles, and tube	920	110 max	T3[F]	375	12	T81[F]
			T3510[H]	375	12	T8510[H]
			T3511[H]	375	12	T8511[H]
			T42	...	...	...
Drawn tube	920	110 max	T3[F]	...	...	...
			T42	...	...	...
		2025 Alloy[A]				
Die forgings	960	140–160	T4	340	10	T6
		2117 Alloy[A]				
Cold-finished, wire or rod	925–950	110 max	T4	...	...	...
		2124 Alloy[A]				
Plate	920	110 max	T351[G]	350	12	T851[G]
		2218 Alloy[A]				
Die forgings	950	212	T4	340	10	T61
		2219 Alloy[A]				
Flat sheet, bare or Alclad	995	110 max	T31[F]	350	18	T81[F]
			T37[K]	325	24	T87[K]
			T42	375	36	T62
Plate	995	110 max	T37[K]	350	18	T87[K]
			T351[G]	350	18	T851[G]
			T42	375	36	T62
Cold-finished wire, rod, and bar	995	110 max	T4	375	18	T6
			T351[H]	375	18	T851[H]
Extruded wire, rod, bar, profiles, and tube	995	110 max	T31[F]	375	18	T81[F]
			T3510[H]	375	18	T8510[H]
			T3511[H]	375	18	T8511[H]
			T42	375	36	T62
Die forgings and rolled rings	995	110 max	T4	375	26	T6
Hand forgings	995	110 max	T4	375	26	T6
			T352[I]	350	18	T852[I]
		2618 Alloy[A]				
Die, hand, and rolled ring forgings	985	212	T4	390	20	T61
		4032 Alloy				
Die forgings	940–970	140–180	T4	340	10	T6
		6005 Alloy				
Extruded rod, bar, profiles, and tube	...[L]	...	T1	350	8	T5
		6005A Alloy				
Extruded rod, bar, profiles, and tube	...[L]	...	T1	350	8	T5
		6013 Alloy[A]				

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Temperature, h	Temper
Sheet, bare	1055	110 max	T4	375	4	T6
				or 345	8	
Plate, bare	1020–1050	110 max	. . .	345	8–16	T651[G]
Cold-finished wire, rod, and bar	1050	110 max	. . .	375	4	T651[H]
			. . .	375	4	T8[F]
			6053 Alloy			
Cold-finished wire and rod	970	110 max	T4	355	8	T61
Die forgings	970	110 max	T4	340	10	T6
			6061 Alloy[A]			
Sheet, bare or Alclad	960–1075[M]	110 max	T4	320	18	T6
			T42	320	18	T62
Plate	960–1075	110 max	T451[G]	320	18	T651[G]
			T42	320	18	T62
Tread Sheet and Plate[N,O]	960–1075	110 max	T4	320	18	T6
Cold-finished wire, rod, and bar	960–1075	110 max[P]	T4	340	8	T6
				or 320	18	
			T3[F]	340	8	T89[Q,R]
				or 320	18	
			T4	340	8	T94[S]
				or 320	18	
			T451[H]	340	8	T651[H]
				or 320	18	
			T42	340	8	T62
				or 320	18	
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350	8	T51
	960–1075[L]	110 max[P]	T4	350	8	T6
			T4510[H]	350	8	T6510[H]
			T4511[H]	350	8	T6511[H]
			T42	350	8	T62
Structural profiles	960–1075[L]	110 max[P]	T4	350	8	T6
Pipe	960–1075[L]	110 max[P]	T4	350	8	T6
Drawn tube	960–1075	110 max	T4	340	8	T6
				or 320	18	
			T42	340	8	T62
				or 320	18	
Die and hand forgings	960–1075	110 max	T4	340	8	T6
				or 320	18	
Rolled rings	960–1075	110 max	T4	350	8	T6
			T452[T]	350	8	T652[T]
			6063 Alloy			
Extruded rod, bar, tube, and profiles	. . .[L]	. . .	T1	400	1 to 2	T5
				or 360	3	
			T1	400	1 to 2	T52
				or 360	3	
	970[L]	110 max[P]	T4	360	6	T6
				or 350	8	
			T42	360	6	T62
				or 350	8	
Drawn tube	970	110 max	T4	350	8	T6
			T3[F]	350	8	T83[R]
			T3[F]	350	8	T831[R]
			T3[F]	350	8	T832[R]
			T31[F]	. . .	. . .	. . .
			T42	350	8	T62
Pipe	970[L]	110 max[P]	T4	360	6	T6
				or 350	8	
			6066 Alloy			
Extruded rod, bar, profiles, and tube	960–1010	110 max	T4	350	8	T6
			T4510[H]	350	8	T6510[H]
			T4511[H]	350	8	T6511[H]
			T42	350	8	T62
Die forgings	960–1010	110 max	T4	350	8	T6
			6070 Alloy			
Extruded rod, bar, profiles, and tube	1015	110 max	T4	320	18	T6
			T42	320	18	T62
			6101 Alloy			

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Temperature, h	Temper
Extruded rod, bare tube, pipe and structural profiles	970[L]	110 max[P]	T4	390	10	T6
			T4	440	5	T61
			T4	410	9	T63
			T4	535	7	T64
			T4	430	3	T65
		6105 Alloy				
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350	8	T5
		6110 Alloy				
Cold-finished wire, rod, and bar	980–1050	110 max	T4	380	8	T9[S]
		6151 Alloy				
Die forgings	950–980	110 max	T4	340	10	T6
Rolled rings	960	110 max	T4	340	10	T6
			T452[I]	340	10	T652[I]
		6201 Alloy				
Wire	950	110 max	T3	320	4	T81[R]
		6262 Alloy				
Cold-finished wire, rod, and bar	960–1050	110 max	T4	340	8	T6
			T4	340	8	T9[S]
			T451[H]	340	8	T651[H]
Extruded rod, bar, profiles, and tube	960–1050[L]	110 max	T4	350	12	T6
			T4510[H]	350	12	T6510[H]
			T4511[H]	350	12	T6511[H]
			T42	350	12	T62
Drawn tube	960–1050	110 max	T4	340	8	T6
			T4	340	8	T9[S]
			T42	340	8	T62
		6351 Alloy				
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350	8	T5
				350	8	T51
				250	10	T54
				or 350	8	
	. . .[L]	. . .	T11	. . .	. . .	. . .
	960–1010[L]	110 max[P]	T4	350	8	T6
		6463 Alloy				
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	400	1	T5
				or 360	3	
	970[L]	110 max[P]	T4	350	8	T6
				or 360	6	
		7001 Alloy				
Extruded rod, bar, profiles, and tube	870	110 max	W[U]	250	24	T6
			W510[H,U]	250	24	T6510[H]
			W511[H,U]	250	24	T6511[H]
			W[U]	250	24	T62
		7005 Alloy				
Extruded rod, bar, and profiles	. . .[L]	. . .	T1	room temperature	72 plus	T53
				225	8 plus	
				300	16	
		7049 Alloy				
Extruded rod, bar, and profiles	875	110 max	W511[H,U]	room temperature	48 plus	T76511[H]
				250	24 plus	
				325	12 to 14	
			W511[H,U]	room temperature	48 plus	T73511[H]
				250	24 plus	
				300	12 to 21	
Die and hand forgings	875	140–160	W[U]	room temperature	48 plus	T73
				250	24 plus	
				330	10 to 16	
			W52[I,U]	room temperature	48 plus	T7352[I]
				250	24 plus	
				330	10 to 16	
		7050 Alloy				

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Temperature, h	Temper
Plate	890	110 max	W51[G,U]	250	3 to 6 plus	T7451[G]
				330	24 to 30	
			W51[G,U]	250	3 to 6 plus	T7651[G]
				330	12 to 15	
Cold-finished wire, rod	890	110 max	W[U]	250	4 plus	T7
				355	8 to 12	
Extruded rod, bar, and profiles	890	110 max	W510[H,U]	250	24 plus	T73510[H]
				350	12 to 15	
			W510[H,U]	250	24 plus	T74510[H]
				340	8 to 12	
			W510[H,U]	250	3 to 6 plus	T76510[H]
				315	15 to 18	
			W511[H,U]	250	24 plus	T73511[H]
				350	12 to 15	
			W511[H,U]	250	24 plus	T74511[H]
				340	8 to 12	
			W511[H,U]	250	3 to 6 plus	T76511[H]
				315	15 to 18	
Die forgings	890	140–160	W[U]	250	1 to 6 plus	T74
				350	4 to 12	
Hand forgings	890	140–160	W52[I,U]	250	1 to 6 plus	T7452
				350	4 to 8	
		7075 Alloy[A]				
Sheet, bare or Alclad	860–930[V]	110 max	W[U]	250	24	T6
				or 205	4 plus	
				315	8	
			W[U]	225	6 to 8 plus	T73[X]
				325	24 to 30	
				or 225	6 to 8 plus	
				335[W]	14 to 18	
			W[U]	250	3 to 5 plus	T76[X]
				325	15 to 18	
				250	24	T62
			W[U]	or 205	4 plus	
				315	8	
Plate, bare or Alclad	860–930[V,Y]	110 max	W51[G,U]	250	24	T651[G]
				or 205	4 plus	
				315	8	
			W51[G,U]	225	6 to 8 plus	T7351[G,X]
				325	24 to 30	
				or 225	6 to 8 plus	
				335[W]	14 to 18	
			W51[G,U]	250	3 to 5 plus	T7651[G,X]
				325	15 to 18	
			W[U]	250	24	T62
				or 205	4 plus	
				315	8	
Cold-finished wire, rod, and bar	860–930[V,Y]	110 max	W[U]	250	24	T6
			W[U]	225	6 to 8 plus	T73[X]
				350	8 to 10	
			W[U]	250	24	T62
			W51[G,U]	250	24	T651[H]
			W51[G,U]	225	6 to 8 plus	T7351[H,X]
				350	8 to 10	
Extruded rod, bar, profiles, and tube	860–930[V,Y]	110 max	W[U]	250	24	T6
				or 210	5 plus	
				250	4 plus	
				300	4	
			W[U]	225	6 to 8 plus	T73[X]
				350	6 to 8	
				or 225	6 to 8 plus	
				335	14 to 18	