INTERNATIONAL

Designation: ~~B918/B918M – 20~~ B918/B918M – 20a

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

This standard is issued under the fixed designation B918/B918M; 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 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 AMS2772.

1.1.2 Heat treatment of aluminum alloy castings for general purpose applications is covered in Practice B917/B917M.

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 1, 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; it only covers the requirements of artificial aging, annealing and associated pyrometry of those processes for products solution heat treated in accordance with Practices B807/B807M and B947. (Refer to Practice B807/B807M for extrusion press solution heat treatment of aluminum alloys and to Practice B947 for hot rolling mill solution heat treatment of aluminum alloys and associated pyrometry.)

1.4 *Units*—The values stated in either Metric or US Customary 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, 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 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:

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

TABLE 1 Recommended Heat Treatment for Wrought Aluminum Alloys[A,W]

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10 °F [±6 °C][C,D,V]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10 °F [±6 °C][V]	Time at Temperature, h	Temper
2011 Alloy[A]						
Cold-finished wire, rod, and bar	945–995 [507–535]	110 [43] max	T3	320 [160]	14	T8
			T4	. . .	. . .	. . .
			T451	. . .	. . .	. . .
Drawn tube and pipe	975 [524]	110 [43] max	T3	320 [160]	14	T8
			T4511	. . .	. . .	. . .
2014 Alloy[A]						
Flat sheet, bare or Alclad	925–945 [496–507]	110 [43] max	T3	. . .	. . .	. . .
	935 [502][U]		T42	320 [160][U]	18–20[U]	T62[U]
Coiled sheet, bare or Alclad	925–945 [496–507]	110 [43] max	T4	320 [160]	18	T6
	935 [502][U]		T42	320 [160][U]	18–20[U]	T62[U]
Plate, bare or Alclad	925–945 [496–507]	110 [43] max	T451	320 [160]	18	T651
	935 [502][U]		T42	350 [177][U]	8–9[U]	T62[U]
Cold-finished wire, rod, and bar	925–945 [496–507]	110 [43] max	T4	350 [177]	9	T6
			T451	350 [177]	9	T651
	935 [502][U]		T42	350 [177][U]	8–9[U]	T62[U]
Extruded wire, rod, bar, profiles, tube, and pipe	925–945 [496–507]	110 [43] max	T4	350 [177]	9	T6
			T4510	350 [177]	9	T6510
			T4511	350 [177]	9	T6511
	935 [502][U]		T42	350 [177][U]	8–9[U]	T62[U]
Drawn tube and pipe	925–945 [496–507]	110 [43] max	T4	350 [177]	9	T6
	935 [502][U]		T42	350 [177][U]	8–9[U]	T62[U]
Die forgings	925–945 [496–507]	140–180 [60–82]	T4	350 [177]	9	T6
Hand forgings and rolled rings	925–945 [496–507]	140–180 [60–82]	T4	350 [177]	9	T6
	935 [502][U]		T452	350 [177][U]	10[U]	T652[U]
2017 Alloy[A]						
Cold-finished wire, rod, and bar	925–950 [496–510]	110 [43] max	T4	. . .	. . .	. . .
			T451	. . .	. . .	. . .
			T42	. . .	. . .	. . .
2018 Alloy[A]						
Die forgings	940–970 [504–521]	Boiling Water[T]	T4	340 [171]	10	T61
2024 Alloy[A]						
Flat sheet, bare or Alclad	910–930 [488–499]	110 [43] max	T3	375 [191]	12	T81
	920 [493][U]		T361	375 [191[U]	8[U]	T861[U]
			T42	375 [191][U]	9–10[U]	T62[U]
			T42	375 [191][U]	16–18[U]	T72[U]
Coiled sheet, bare or Alclad	910–930 [488–499]	110 [43] max	T4	375 [191]	9–10	T6
	920 [493][U]		T42	375 [191][U]	9[U]	T62[U]
			T42	375 [191][U]	16–18[U]	T72[U]
Plate, bare or Alclad	910–930 [488–499]	110 [43] max	T351	375 [191]	12	T851
	920 [493][U]		T361	375 [191][U]	8[U]	T861[U]
			T42	375 [191][U]	9–10[U]	T62[U]
Cold-finished wire, rod, and bar	910–930 [488–499]	110 [43] max	T351	375 [191]	12	T851
			T36	. . .	. . .	. . .
			T4	375 [191]	12	T6
	920 [493][U]		T42	375 [191][U]	12–13[U]	T62[U]
Extruded wire, rod, bar, profiles, tube, and pipe	910–930 [488–499]	110 [43] max	T3	375 [191]	12	T81
			T3510	375 [191]	12	T8510
			T3511	375 [191]	12	T8511
	920 [493][U]		T42	375 [191][U]	12–13[U]	T62[U]
Drawn tube and pipe	910–930 [488–499]	110 [43] max	T3	375 [191]	12	T8
	920 [493][U]		T42	375 [191][U]	9–10[U]	T62[U]
2025 Alloy[A]						
Die forgings	950–970 [510–521]	140–160 [60–71]	T4	350 [177]	9	T6
2117 Alloy[A]						
Cold-finished, wire or rod	925–950 [496–510]	110 [43] max	T4	. . .	. . .	. . .

TABLE 1 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10 °F [±6 °C][C,D,V]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10 °F [±6 °C][V]	Time at Temperature, h	Temper
2124 Alloy[A]						
Plate	910–930 [488–499]	110 [43] max	T3	375 [191]	12	T8
			T31	370 [188]	12	T8151
			T4	375 [191]	9	T6
	920 [493][U]		T3	375 [191][U]	12[U]	T82[U]
			T42	375 [191][U]	10[U]	T62[U]
2218 Alloy[A]						
Die forgings	940–960 [504–516]	Boiling Water[T]	T4	340 [171]	10	T61
			T4	460 [238]	6	T7
	950 [510][U]		T4	340 [171][U]	10[U]	T62[U]
			T4	460 [238][U]	6[U]	T72[U]
2219 Alloy[A]						
Flat sheet, bare or Alclad	985–1005 [529–541]	110 [43] max	T31	350 [177]	18	T81
			T37	325 [163]	24	T87
	995 [535][U]		T42	375 [191][U]	17–19[U]	T62[U]
Plate	985–1005 [529–541]	110 [43] max	T37	325 [163]	17–19	T87
			T351	350 [177]	18	T851
	995 [535][U]		T42	375 [191][U]	35–37[U]	T62[U]
Cold-finished wire, rod, and bar	985–1005 [529–541]	110 [43] max	T4	375 [191]	18	T6
			T351	375 [191]	18	T851
Extruded wire, rod, bar, profiles, tube, and pipe	985–1005 [529–541]	110 [43] max	T31	375 [191]	18	T81
			T3510	375 [191]	18	T8510
			T3511	375 [191]	18	T8511
	995 [535][U]		T42	375 [191][U]	35–37[U]	T62[U]
			T3	375 [191][U]	17–19[U]	T82[U]
Die forgings and rolled rings	985–1005 [529–541]	110 [43] max	T4	375 [191]	26	T6
	995 [335][U]		T42	375 [191][U]	25–27[U]	T62[U]
			T352	350 [177][U]	17–19[U]	T82[U]
Hand forgings	985–1005 [529–541]	110 [43] max	T4	375 [191]	26	T6
	995 [335][U]		T42	375 [191][U]	25–27[U]	T62[U]
			T352	350 [177][U]	17–19[U]	T852[U]
2618 Alloy[A]						
Die, hand, and rolled ring forgings	975–995 [524–535]	Boiling Water[T]	T4	390 [199]	20	T61
	985 [529][U]		T42	390 [199][U]	19–21[U]	T62[U]
4032 Alloy						
Die forgings	940–970 [504–521]	140–180 [60–82]	T4	340 [171]	10	T6
	955 [513][U]		T42	340 [171][U]	9–11[U]	T62[U]
6005 Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	350 [177]	8	T5
6005A Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	350 [177]	8	T5
			T4	350 [177]	8	T61
6013 Alloy[A]						
Sheet, bare	1045–1065 [563–574]	110 [43] max	T4	375 [191]	4	T6
				or 345 [174]	8	
	1000 [538][U]		T42	375 [191][U]	4–5[U]	T62[U]
Plate, bare	1020–1050 [549–566]	110 [43] max	. . .	345 [174]	8–16	T651
Cold-finished wire, rod, and bar	1040–1060 [560–571]	110 [43] max	. . .	375 [191]	4	T651
			. . .	375 [191]	4	T8
6020 Alloy[A]						
Rod, bar & extrusion	1010–1050 [543–566]	110 [43] max	W[I]	355 [179]	8–10	T6511
Wire, rod, & bar	1010–1050 [543–566]	110 [43] max	W[I]	355 [179]	8–10	T8
6041 Alloy						
Extruded rod, bar, and profiles	1010–1050 [543–566]	110 [43] max	T4	350 [176]	8	T6
			T4511	350 [176]	8	T6511
6042 Alloy						
Extruded rod, bar, and profiles	1010–1050 [543–566]	110 [43] max	T1	350 [176]	8	T5
			T1	350 [176]	8	T5511

TABLE 1 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment^{B}		
	Metal Temperature, ±10 °F [±6 °C]^{C,D,V}	Quench Temperature, °F [°C]^{E}	Temper	Metal Temperature, ±10 °F [±6 °C]^{V}	Time at Temperature, h	Temper
			6053 Alloy^{A}			
Cold-finished wire and rod	960–980 [516–527]	110 [43] max	T4	355 [179]	8	T61
Die forgings	960–980 [516–527]	110 [43] max	T4	340 [171]	10	T6
	970 [521]^{U}		T42	340 [171]^{U}	10^{U}	T62^{U}
			6061 Alloy^{A}			
Sheet, bare or Alclad	960–1075 [516–579]^{F}	110 [43] max	T4	320 [160]	18	T6
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
			T42^{P}	320 [160]^{P,U}	17–19^{P,U}	T62^{P,U}
Plate	960–1075 [516–579]	110 [43] max	T451	320 [160]	18	T651
	985 [529]^{U}		T42	350 [177]^{U}	18^{U}	T62^{U}
Tread Sheet and Plate^{G}	960–1075 [516–579]	110 [43] max	T4	320 [160]	18	T6
Cold-finished wire, rod, and bar	960–1075 [516–579]	110 [43] max^{H}	T4	350 [177]	8	T6
				or 320 [160]	18	
			T3	340 [171]	8	T89
				or 320 [160]	18	
			T4	350 [177]	8	T94
			T451	350 [177]	8	T651
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
Extruded rod, bar, profiles, tube, and pipe	. . .^{L}	. . .	T1	350 [177]	8	T51
	960–1075 [516–579]^{L}	110 [43] max^{H}	T4	350 [177]	8	T6
			T4510	350 [177]	8	T6510
			T4511	350 [177]	8	T6511
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
Structural profiles	960–1075 [516–579]^{L}	110 [43] max^{H}	T4	350 [177]	8	T6
Drawn tube and pipe	960–1075 [516–579]^{L}	110 [43] max	T4	320 [160]	18	T6
				or 340 [171]	8	
	985 [529]^{U}		T42	340 [171]^{U}	8^{U}	T62^{U}
Die and hand forgings	960–1075 [516–579]	110 [43] max	T4	350 [177]	8	T6
				or 340 [171]	10	
Rolled rings	960–1075 [516–579]	110 [43] max	T4	350 [177]	8	T6
	985 [529]^{U}		T452	350 [177]^{U}	8–10	T652^{U}
			6063 Alloy			
Extruded rod, bar, tube, pipe, and profiles	. . .^{L}	. . .	T1	400 [204]	1–2	T5
				or 360 [182]	3	
			T1	400 [204]^{U}	1–2^{U}	T52^{U}
				or 360 [182]^{U}	3^{U}	
	960–1010 [516–543]^{L}	110 [43] max^{H}	T4	350 [177]	8	T6
				or 360 [182]	6	
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
Drawn tube and pipe	960–1010 [516–543]^{L}	110 [43] max	T4	350 [177]	8	T6
			T3	350 [177]	8	T83
			T3	350 [177]	8	T831
			T3	350 [177]	8	T832
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
			6064 Alloy			
Extruded rod, bar, profiles, tube, and pipe	. . .^{L}	. . .	T4	350 [177]	8	T6
			T4511	350 [177]	8	T6511
			6066 Alloy			
Extruded rod, bar, profiles, tube, and pipe	960–1010 [516–543]^{L}	110 [43] max	T4	350 [177]	8	T6
			T4510	350 [177]	8	T6510
			T4511	350 [177]	8	T6511
	985 [529]^{U}		T42	350 [177]^{U}	8–10^{U}	T62^{U}
Die forgings	960–1010 [516–543]	110 [43] max	T4	350 [177]	8	T6
			6070 Alloy			
Extruded rod, bar, profiles, tube, and pipe	1015 [546]^{L}	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]^{U}	18^{U}	T62^{U}
			6082 Alloy			
~~Extruded rod, bar,~~	~~980 [527]^{L}~~	~~. . .~~	~~T1~~	~~350 [177]~~	~~8~~	~~T6~~
Extruded rod, bar,	980 [527]^{L}	. . .	T4	350 [177]	8	T6
~~profiles, tube, and pipe~~			~~T1~~	~~350 [177]~~	8	~~T6511~~

TABLE 1 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10 °F [±6 °C][C,D,V]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10 °F [±6 °C][V]	Time at Temperature, h	Temper
profiles, tube, and pipe			T4511	350 [177]	8	T6511
6101 Alloy						
Extruded rod, bar, profiles, tube, and pipe	970 [521][L]	110 [43] max[H]	T4	390 [199]	10	T6
			T4	440 [227]	5	T61
			T4	410 [210]	9	T63
			T4	535 [279]	7	T64
			T4	430 [221]	3	T65
6105 Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	350 [177]	8	T5
			T4	350 [177]	8	T6
6110 Alloy						
Cold-finished wire, rod, and bar	980–1050 [527–566]	110 [43] max	T4	380 [193]	8	T9
6151 Alloy						
Die forgings	950–980 [510–527]	110 [43] max	T4	340 [171]	10	T6
Rolled rings	960 [516]	110 [43] max	T4	340 [171]	10	T6
	965 [518][U]		T452	340 [171][U]	10	T652[U]
6162 Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	350 [177]	8	T5
			T1510	350 [177]	8	T5510
			T1511	350 [177]	8	T5511
	980 [527][L]	. . .	T4	350 [177]	8	T6
			T4510	350 [177]	8	T6510
			T45111	350 [177]	8	T6511
6201 Alloy						
Wire	950 [510]	110 [43] max	T3	320 [160]	4	T81
6262 Alloy						
Cold-finished wire, rod, and bar	960–1050 [516–566]	110 [43] max	T4	340 [171]	8	T6
			T4	340 [171]	8	T9
			T451	340 [171]	8	T651
	1005 [541][U]		T42	340 [171][U]	8[U]	T62[U]
Extruded rod, bar, profiles, tube, and pipe	960–1050 [516–566][L]	110 [43] max	T4	350 [177]	12	T6
			T4510	350 [177]	12	T6510
			T4511	350 [177]	12	T6511
	1005 [541][U]		T42	350 [177][U]	11–13[U]	T62[U]
Drawn tube and pipe	960–1050 [516–566]	110 [43] max	T4	340 [171]	8	T6
			T4	340 [171]	8	T9
	1005 [541][U]		T42	340 [171][U]	8[U]	T62[U]
6351 Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	350 [177]	8	T5
				350 [177]	8	T51
	. . .[L]	. . .	T11	250 [121]	10	T54
				or 350 [177]	8	
	960–1010 [516–543][L]	110 [43] max[H]	T4	350 [177]	8	T6
6463 Alloy						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	T1	400 [204]	1	T5
				or 360 [182]	3	
	970 [521][L]	110 [43] max[H]	T4	350 [177]	8	T6
				or 360 [182]	6	
7005 Alloy						
Extruded rod, bar, and profiles	. . .[L]	. . .	T1	room temperature	72 plus	T53
				225 [107]	8 plus	
				300 [149]	16	
7049 Alloy[A]						
Extruded rod, bar, and profiles	860-900 [460-482]	110 [43] max	W511[I]	room temperature	48 plus	T76511
				250 [121]	24 plus	
				375 [163]	13	
			W511[I]	room temperature	48 plus	T73511
				250 [121]	24 plus	
				330 [166]	17	
Die and hand forgings*	860–900 [460–482]	140–160 [60–71]	W[I]	room temperature	48 plus	T73
				250 [121]	8–24	
				340 [171]	6–16	
			W51[I]	room temperature	8–24 plus	T7351
				250 [121]	8–24 plus	
				335 [168]	6–16	
	875 [468][U]		W52[I]	room temperature[U]	24 plus[U]	T7352[U]

TABLE 1 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10 °F [±6 °C][C,D,V]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10 °F [±6 °C][V]	Time at Temperature, h	Temper
				250 [121][U]	8–24 plus[U]	
*Continued on next page.				330 [166][U]	6–16[U]	
7049 Alloy *(Continued)*[A]						
Die and hand forgings *(Continued)*	875 [468][U]		W[I]	room temperature[U]	48 min[U]	T732[U]
				250 [121][U]	24 min plus[U]	
				325 [163][U]	13–14[U]	
7050 Alloy[A]						
Plate	880–900 [471–482]	110 [43] max	W51[I]	250 [121]	4–24 plus	T7351
				350 [177]	8–16	
			W51[I]	250 [121]	3–6 plus	T7451
				325 [163]	24–30	
			W51[I]	250 [121]	3–6 plus	T7651
				325 [163	12–15	
	890 [477][U]		W51[I]	250 [121][U]	6–8 plus[U]	T742[U]
				350 [177][U]	6–8[U]	
			W51[I]	250 [121][U]	6–8 plus[U]	T762[U]
				350 [177][U]	6.5–7[U]	
Cold-finished wire, rod	880–900 [471–482]	110 [43] max	W[I]	250 [121]	4–24 plus	T7
				350 [177]	6–12	
Extruded rod, bar, and profiles	880–900 [471–482]	110 [43] max	W510[I]	250 [121]	24 plus	T73510
				350 [177]	12–15	
			W510[I]	250 [121]	24 plus	T74510
				340 [171]	8–12	
			W510[I]	250 [121]	3–8 plus	T76510
				325 [163]	15–18	
			W511[I]	250 [121]	24 plus	T73511
				350 [177]	12–15	
			W511[I]	250 [121]	24 plus	T74511
				340 [171]	18–12	
			W511[I]	250 [121]	3–8 plus	T76511
				325 [163]	15–18	
	890 [477][U]		W[I]	250 [121][U]	6–8 plus[U]	T732[U]
				350 [177][U]	11.5–12.5[U]	
			W[I]	250 [121][U]	6–8 plus[U]	T742[U]
				350 [177][U]	6–8[U]	
			W[I]	250 [121][U]	6–8 plus[U]	T762[U]
				350 [177][U]	3.5–4.5[U]	
Die forgings & hand forgings	880–900 [471–482]	140–160 [60–71]	W[I]	250 [121]	3–6 plus	T74
				350 [177]	6–12	
			W51[I]	250 [121]	3–6 plus	T7451
				350 [177]	6–10	
			W52[I]	250 [121]	3–6 plus	T7452
				350 [177]	6–10	
			W[I]	room temperature	72 plus	T6
				250 [121]	48	
	890 [477][U]		W[I]	250 [121][U]	6–8 plus[U]	T742[U]
				350 [177][U]	6–8[U]	
			W[I]	250 [121][U]	6–8 plus[U]	T762[U]
				350 [177][U]	3.5–4.5[U]	
7075 Alloy[A]						
Sheet, bare or Alclad	860–930 [460–499][J]	110 [43] max	W[I]	250 [121]	24	T6
			W[I]	225 [107]	6–8 plus	T73[M]
				325 [163]	24–30	
				or 225 [107]	6–8 plus	
				335 [168][K]	14–18	
			W[I]	250 [121]	3–5 plus	T76[M]
				325 [163]	15–18	
	870 [466][U]		W[I]	250 [121][U]	23–25[U]	T62[U]
Plate, bare or Alclad*	860–930 [460–499][J,N]	110 [43] max	W51[I]	250 [121]	24	T651
				or 205 [96]	4 plus	
				315 [157]	8	
			W51[I]	225 [107]	6–8 plus	T7351[M]
				325 [163]	24–30	
				or 225 [107]	6–8 plus	
				335 [168][K]	14–18	
			W51[I]	250 [121]	24	T7651[M]
				or 250 [121]	3–5 plus	

TABLE 1 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10 °F [±6 °C][C,D,V]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10 °F [±6 °C][V]	Time at Temperature, h	Temper
				325 [163]	15–18	
** Continued on next page.*						
7075 Alloy[A] *(Continued)*						
Plate, bare or Alclad* *(Continued)*	870 [466][R,U]		W[I]	250 [121][U]	23–25[U]	T62[U]
				or 205 [96][U]	4 plus[U]	
				315 [157][U]	8[U]	
Cold-finished wire, rod, and bar	860–930 [460–499][J,N]	110 [43] max	W[I]	250 [121]	24	T6
			W[I]	225 [107]	6–8 plus	T73[M]
				350 [177]	8–10	
			W51[I]	250 [121]	24	T651
			W51[I]	225 [107]	6–8 plus	T7351[M]
				350 [177]	8–10	
	870 [466][U]		W[I]	225 [107][U]	23–25[U]	T62[U]
Extruded rod, bar, profiles, tube, and pipe	860–930 [460–499][J,N]	110 [43] max	W[I]	250 [121]	24	T6
				or 210 [99]	5 plus	
				250 [121]	4 plus	
				300 [149]	4	
			W[I]	225 [107]	6–8 plus	T73[M]
				350 [177]	6–8	
				or 225 [107]	6–8 plus	
				335 [168][K]	14–18	
			W[I]	250 [121]	3–5 plus	T76[M]
				325 [163]	15–18	
				or 250 [121]	3–5 plus	
				320 [160]	18–21	
			W510[I]	250 [121]	24	T6510
				or 210 [99]	5 plus	
				250 [121]	4 plus	
				300 [149]	4	
			W510[I]	225 [107]	6–8 plus	T73510[M]
				350 [177]	6–8	
				or 225 [107]	6–8 plus	
				335 [168][K]	14–18 plus	
			W510[I]	250 [121]	3–5 plus	T76510[M]
				325 [163]	15–18	
				or 250 [121]	3–5 plus	
				320 [160]	18–21	
			W511[I]	250 [121]	24	T6511
				or 210 [99]	5 plus	
				250 [121]	4 plus	
				300 [149]	4	
			W511[I]	225 [107]	6–8 plus	T73511[M]
				350 [177]	6–8	
				or 225[107]	6–8 plus	
				335 [168][K]	14–18	
			W511[I]	250 [121]	3–5 plus	T76511[M]
				325 [163]	15–18	
				or 225 [107]	3–5 plus	
				320 [160]	18–21	
	870 [466][U]		W[I]	250 [121][U]	23–25[U]	T62[U]
Drawn tube and pipe	870 [466]	110 [43] max	W[I]	250 [121]	24	T6
			W[I]	225 [107]	6–8 plus	T73[M]
				350 [177]	6–8	
				or 225 [107]	6–8 plus	
				335 [168][K]	14–18	
	870 [466][U]		W[I]	250 [121][U]	23–25[U]	T62[U]
Die forgings	860–900 [460–482]	140–160 [60–71]	W[I]	250 [121]	24	T6
			W[I]	225 [107]	6–8 plus	T73[M]
				350 [177]	8–10	
			W51[I]	225 [107]	6–8 plus	T7351[M]
				350 [177]	6–8	
			W52[I]	225 [107]	6–8 plus	T7352[M]
				350 [177]	6–8	
			W[I]	225 [107]	6–8 plus	T74
				350 [177]	6–8	
	870 [466][U]		W[I]	250 [121][U]	23–25[U]	T62[U]
Hand forgings*	860–900 [460–482]	140–160 [60–71]	W[I]	250 [121]	24	T6

TABLE 1 *Continued*

Product	Solution Heat Treatment: Metal Temperature, ±10 °F [±6 °C][C,D,V]	Solution Heat Treatment: Quench Temperature, °F [°C][E]	Temper	Precipitation Heat Treatment[B]: Metal Temperature, ±10 °F [±6 °C][V]	Precipitation Heat Treatment[B]: Time at Temperature, h	Temper
			W[I]	225 [107]	6–8 plus	T73[M]
**Continued on next page.*				350 [177]	8–10	
7075 Alloy[A] *(Continued)*						
Hand forgings *(Continued)*			W51[I]	225 [107]	6–8 plus	T7351[M]
				350 [177]	6–8	
			W52[I]	225 [107]	6–8 plus	T7352[M]
				350 [177]	6–8	
			W[I]	225 [107]	6–8 plus	T74
				350 [177]	6–8	
	870 [466][U]		W52[I]	250 [121][U]	23–25[U]	T652[U]
			W[I]	250 [121][U]	23–25[U]	T62[U]
			W[I]	225 [107][U]	6–7 plus[U]	T732[U]
				350 [177][U]	8–10[U]	
			W[I]	225 [107][U]	6–7 plus[U]	T7362[U]
				325 [163][U]	16–18[U]	
Rolled rings	860–900 [460–482]	110 [43] max	W[I]	250 [121]	24	T6
	870 [466][U]		W52[I]	250 [121][U]	24[U]	T652[U]
7116 Alloy[A]						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	W[I]	215 [102]	5 plus	T5
				330 [166]	5	
7129 Alloy[A]						
Extruded rod, bar, profiles, tube, and pipe	. . .[L]	. . .	W[I]	215 [102]	5 plus	T5
				320 [160]	5	
	900 [482][L]	110 [43] max	W[I]	215 [102]	5 plus	T6
				320 [160]	5	
7175 Alloy[A]						
Extruded rod, bar, profiles, tube, and pipe	880–910 [471–488]	. . .	W[I]	225 [107]	6–8 plus	T74
				350 [177]	6–8	
Die and hand forgings	880–910 [471–488]	140 [60–71]	W[I]	225 [107]	6–8 plus	T74
				350 [177]	6–8	
			W52[I]	225 [107]	6–8 plus	T7452
				350 [177]	6–8	
			W[I]	250 [151]	24	T6
7475 Alloy[A]						
Sheet	880–970 [471–521]	140–160 [60–71]	W[I]	250 [121]	3 plus	T61
				320 [160]	3	
			W[I]	250 [121]	3 plus	T761
				325 [163]	8–10	
Alclad Sheet	880–970 [471–521][S]	140–160 [60–71]	W[I]	280 [138]	3	T6
Plate	880–970 [471–521]	140–160 [60–71]	W[I]	250 [121]	24	T6
			W51[I]	240 [116]	24	T651
			W51[I]	250 [121]	6–8 plus	T7351[M]
				325 [163]	24–30	
			W51[I]	250 [121]	4–8 plus	T7651[M]
				310 [154]	26–32	
Rod	880–970 [471–521]	140–160 [60–71]	W[I]	250 [121]	3 plus	T62
				325 [163]	3	

[A] For specific aerospace applications, refer to SAE-AMS heat-treating and material specifications.[4]
[B] Typical or nominal time at temperature. Actual practice may vary depending on material requirements.
[C] Recommended soaking times to achieve specified metal temperature appear in Table 8.
[D] Where a temperature range exceeding 20 °F [12 °C] is shown, a temperature within that range shall be selected and adhered to within the ±10 °F [±6 °C] limits. For solution heat treatment of those 6xxx alloys for which the table specifies a range of 30 °F [17 °C] degrees or more, a range of 30 °F [17 °C] may be used. Limits thus derived must lie totally within the range specified.
[E] Unless otherwise indicated, when material is quenched by total immersion in water, the water should be at room temperature not exceeding 100°F [43°C] at the start of quenching and suitably cooled to remain below 110 °F [43 °C] during the quenching cycle.
[F] For Alclad sheet the maximum temperature is 1000 °F [538 °C].
[G] "Tread Plate" is a generic term and includes thicknesses below 0.250 in. [6.35 mm].
[H] Upon exiting the solution heat treating furnace, spray quenching may be used on thin sections where substantiated by test results.
[I] The "W" (as-quenched) condition is an unstable temper and at room temperature will change due to precipitation hardening.
[J] Under some conditions melting can occur when heating 7075 alloy above 900 °F [482 °C] and caution should be exercised to avoid this potential.
[K] A heat-up rate to 335 °F [168 °C] should be 25 °F/h [14 °C/h].
[L] With suitable control of extruding temperature and quench rate, product may be quenched upon emerging from an extrusion press instead of being furnace heat treated.
[M] The aging of aluminum alloy 7075 from any temper to the T73 (applicable to alloy 7075 only) or T76 temper series requires closer than normal controls on aging practice variables such as time, temperature, heating-up rates, and so forth, for any given item. In addition to the preceding, when aging material in the T6 temper series to the T73 or T76 temper series, the specific condition of the T6 temper material (such as its property level and other effect of processing variables) is extremely important and will affect the capability of the re-aged material to conform to the requirements specified for the applicable T73 or T76 temper series.
[N] For plate, rod, or bar over 4 in. in thickness or diameter, heat-treat 860 to 910 °F [460 to 488 °C].

[O] This footnote ([O]) is unused to avoid confusion.
[P] Alternate for sheet under 0.064 in. [0.16 mm].
[Q] This footnote ([Q]) is unused to avoid confusion.
[R] For alcad sheet, 0.020 in. [0.51 mm] and under in thickness, minimum temperature of 850 °F [454 °C] is permissible; for alclad sheet over 0.020 in. [0.51 mm] in temperature should not exceed 900 °F [482 °C].
[S] Alclad sheet maximum temperature of 945 °F [507 °C].
[T] There is no temperature requirement for boiling water.
[U] When performing response to heat treatment, for example T42/T62, solution and precipitation heat treatment temperatures and times for response to heat treatment practices are mandatory and shall conform to Table 1 unless otherwise agreed between producer and purchaser. This ensures that the material responds as expected to heat treatment and will meet material property requirements based on specific defined process temperatures and time.
[V] During the heating of a load, until it reaches the selected range, the temperature of the heating medium may exceed the maximum temperature provided that the temperature of the metal in the load does not exceed the maximum allowable temperature.
[W] Refer to ANSI H35.1/H35.1M for explanation of temper designations describing required processing.

2.2 *ASTM Standards:*[2]

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)
B807/B807M Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys
B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products
B917/B917M Practice for Heat Treatment of Aluminum-Alloy Castings From All Processes
B947 Practice for Hot Rolling Mill Solution Heat Treatment for Aluminum Alloy Plate
G69 Test Method for Measurement of Corrosion Potentials of Aluminum Alloys

2.3 *ANSI Standard:*[3]

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

2.4 *SAE Standard:*[4]

AMS2750 Pyrometry
AMS2772 Heat Treatment of Aluminum Alloy Raw Materials

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology B881 for definitions of product terms used in this practice.

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

3.2.1 *control sensor, n*—sensor connected to the furnace temperature controller, which may or may not be recording; also referred to as control thermocouple.

3.2.2 *load sensor, n*—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; also referred to as load thermocouple.

3.2.3 *monitoring sensor, n*—sensor connected to the monitoring instrument; also referred to as monitoring thermocouple.

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

3.2.5 *working zone*—the volume (length, width, height, diameter, or combinations thereof) and location within the thermal processing equipment defined by the placement of temperature sensors from the most recent compliant temperature uniformity survey; loading of the furnace for production operation shall contain all product within this defined working zone.

4. Equipment

4.1 *Equivalent Industry Standards Alternatively Fulfilling Pyrometry Requirements:*

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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.
[3] Available from Aluminum Association, 1400 Crystal Dr., Suite 430, Arlington, VA 22202, http://www.aluminum.org.
[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

4.1.1 Compliance to AMS2750 (latest revision) is an acceptable alternative for all pyrometry requirements as detailed in Section 4 of this practice.

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

4.2.1 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 when thermally processing 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).

4.2.2 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.

4.3 *Calibration of Control and Recording Instruments*—Instruments used to control, monitor, record and test furnace temperature shall be calibrated in accordance with Table 2.

4.3.1 Calibration of controlling, monitoring, or recording instruments shall be performed to the manufacturer's instructions or, if the manufacturer's instructions are not used, a minimum of three simulated sensor inputs shall be used at the minimum, midpoint, and maximum of the furnace Qualified Operating Temperature Range.

4.3.1.1 Calibration of controlling, monitoring, or recording instruments shall be performed to the manufacturer's instructions or, if the manufacturer's instructions are not used, a minimum of three simulated sensor inputs shall be used at the minimum, midpoint, and maximum of the furnace Qualified Operating Temperature Range.

4.4 *Temperature-measuring System Accuracy Test Requirements:*

4.4.1 The field test instrument and sensors (temperature-sensing element, potentiometer, and cold junction compensation combination) shall have been calibrated in accordance with Table 2 requirements.

TABLE 2 Instrument and Sensor Calibration

Device	Maximum Calibration Period	Calibration Accuracy Required	Used For:	Calibrated Against:
Controlling, monitoring, or recording sensor	Before first use (installation in equipment) and at least annual thereafter	±3 °F [±1.7 °C] or ±0.4% of reading, whichever is greater	Measuring, recording and controlling the temperature of thermal processing equipment	Instruments traceable to the National Institute of Standards and Technology (NIST) or equivalent national standard
Load Sensor	Before first use	±4 °F [±2.2 °C] or ±0.75% of reading, whichever is greater	Measuring, recording and controlling the temperature of the material being heat treated	
Field Test Sensor	Within last 12 months	±2 °F [±1.1 °C] or ±0.4% of reading, whichever is greater	System Accuracy Test	
Field Test Sensor	Within last 12 months	±4 °F [±2.2 °C] or ±0.75% of reading, whichever is greater	Temperature Uniformity Survey (TUS)	
Field test Instrument	Within last 12 months	±1 °F [±0.6 °C] or ±0.1% of reading, whichever is greater	SAT; TUS; Calibration of Record, Control or Monitoring Sensors	

4.4.2 Calibration of furnace controlling, monitoring, or recording instrument(s) may be performed with a load in process (for a single temperature range) if the furnace temperature remains within the processing tolerance and the furnace temperature record is appropriately annotated to indicate that a calibration occurred, including time and date.

Method, calibration accuracy, and frequency requirements for System Accuracy Tests in accordance with Table 3.

4.4.2.1 *Probe Method*—The accuracy of temperature-measuring system shall be checked by inserting a calibrated test temperature-sensing element adjacent (no further than 2 in. [50 mm]) to the furnace temperature-sensing element and reading the test temperature-sensing element with a calibrated test potentiometer.

4.4.2.2 *Comparative Method*—A comparison between the reading of the control system (control instrument, leadwire and sensor) and the reading of any permanently installed monitoring system (instrument, leadwire, and sensor) in the same work zone. The comparative check is to be performed at or near the original comparison temperature test and be representative of normal operating temperatures. The Comparative Method shall be performed in combination with the Probe Method at the reduced frequency Probe Method as described in Table 3.

(1) The monitoring system may include the over temperature control system or an alternate probe.

(2) When two probes are contained in the same protection tube, they shall be of a different type sensor (for example, Type K with Type N, Type R with Type S, etc.) in order to avoid the potential of similar degradation rate. (Note that in order to allow for a timely transition to this practice, a grace period of one year from the issuance of this practice following adoption shall be allowed by the end of 2021.)

(3) Use of the comparative Probe Method allows for reduced SAT frequency as specified in Table 3.

4.4.3 No SAT is required for monitoring systems that are not used for acceptance as part of production heat treatment. An example is an over-temperature protection system not used for any aspects of control.

4.5 *Furnace Temperature Uniformity Requirements:*

4.5.1 Temperature uniformity surveys shall be performed for each furnace and salt bath to ensure compliance with temperature uniformity requirements presented herein.

4.5.2 After establishment of thermal equilibrium or a recurrent temperature pattern, the temperature in the working (soaking) zone(s), for all furnace control and test sensors, shall maintain temperature in the working (soaking) zone(s) within the allowable ranges defined in Table 4.

4.5.3 A new temperature uniformity survey shall be made after any modification, repair, adjustment, or re-build which alters the temperature uniformity characteristics of the furnace or salt bath and changes the effectiveness of the heat treatment. Maintenance and repairs to heat treat furnace equipment shall be documented and determination shall be made by the producer quality/technical organization whether additional testing is required prior to returning equipment back to production. Examples may include but are not limited to:

TABLE 3 System Accuracy Test (SAT)

Method	Instrumentation of Furnace	Calibration Accuracy (Maximum SAT Difference Allowed)	SAT Frequency
Probe	No load sensors or no sensors located to represent the hottest and coldest temperatures based on most recent temperature uniformity survey under operating conditions	±4 °F [±2.2 °C]	Weekly (maximum 7 days)
Probe	Load sensors or sensors located to represent the hottest and coldest temperatures based on most recent temperature uniformity survey under operating conditions	±4 °F [±2.2 °C]	Monthly (maximum 31 days)
Probe in conjunction with Comparative Method	No load sensors or no sensors located to represent the hottest and coldest temperatures based on most recent temperature uniformity survey under operating conditions	Comparative Method ±4 °F [±2.2 °C]	Weekly (maximum 7 days)
		Probe ±4 °F [±2.2 °C]	Quarterly (maximum 91 days)
Probe in conjunction with Comparative Method	Load sensors or sensors located to represent the hottest and coldest temperatures based on most recent temperature uniformity survey under operating conditions	Comparative Method ±4 °F [±2.2 °C]	Weekly (maximum 7 days)
		Probe ±4 °F [±2.2 °C]	Semi-annually (maximum 183 days)