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General Data on Wrought Aluminum Alloys

SAE Information Report
Revised August 1987

Submitted for Recognition as
an American National Standard

The Engineering Society For Advancing Mobility Land Sea Air and Space®
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MATERIALS REPORT

SAE J454

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Ø GENERAL DATA ON WROUGHT ALUMINUM ALLOYS

The SAE Standards for wrought aluminum alloys cover materials with a considerable range of properties and other characteristics, but do not include all of the commercially available materials. If none of the materials listed provides the characteristics required by a particular application, users may find it helpful to consult with the suppliers of aluminum alloy products. See companion document, SAE J1434, Wrought Aluminum Applications Guidelines.

TABLE 1
ALLOY, TEMPER AND PRODUCT FORM USED IN AUTOMOTIVE APPLICATIONS

Application	Alloy and Temper (1)	Product Form
Body Sheet, Panels		
Body Panels	2036-T4	Sheet
	2038-T4	Sheet
	5052-0, H32, H34	Sheet
	5182-0, O2 (2)	Sheet
	6010-T4, T6	Sheet
	6111-T4, T6	Sheet
Interior Panels, Components	3004-0, H32	Sheet
	5052-0, H32, H34	Sheet
	5182-0, O2 (2)	Sheet
	6009-T4, T62	Sheet
Bumper Components (3)		
Reinforcements	6061-T4, T6	Sheet, Extrusions
Face Bar, Reinforcements	6009-T4, T6 (5)	Sheet
	7021-T61 (5)	Sheet
	7029-T5, T6 (4), (5)	Sheet, Extrusions
	7116-T6 (5)	Extrusions
	7129-T6 (5)	Extrusions
Structural & Weldable	5083-H111, H112, H116, H321	Sheet, Plate, Extrusions
	5086-H32, H34, H111	Sheet, Plate, Extrusions, Tube
	5182-0, O2 (2)	Sheet
	5454-0, H32, H34, H111	Sheet, Plate, Extrusions, Tube
	6009-T4, T62	Sheet
	6061-T4, T6, T651	Sheet, Plate, Extrusions, Forgings, Structural Shapes, Tube, Rod, Bar
General Purpose	3003-H14, H24	Sheet
	3004-0, H32	Sheet
	5052-0, H32, H34	Sheet
	5454-0, H32, H34	Sheet, Plate, Extrusions, Tube
	6061-T4, T6, T651	Sheet, Plate, Extrusions, Forgings, Structural Shapes, Tube, Rod, Bar
	6463-T521 (4)	Extrusions
	6063-T1, T5, T6	Extrusions, Tube

(Table continued on next page)

TABLE 1
ALLOY, TEMPER AND PRODUCT FORM USED IN AUTOMOTIVE APPLICATIONS
(Continued)

Application	Alloy and Temper (1)	Product Form
Trim		
Name Plates, Appliques	1100-0 3002-0 5005-0	Sheet Sheet Sheet
Strength Paramount	5252-H2X (6) 5457-H3X (6)	Sheet Sheet
Brightness Paramount	5657-H2X (6)	Sheet
Wheels (7), Fabricated	5454-0, H32, H34 H111, H112	Sheet, Plate, Extrusions
Fasteners (Mechanical)	2017-T4 2024-T4 2117-T4 6053-T61 6061-T4	Rivet and Cold Heading Wire and Rod
Heat Exchangers	A wide variety of alloys and tempers are currently specified or under consideration for heat-exchangers.	

NOTES:

1. Only the commonly used tempers are listed for the alloys shown. Other tempers of these alloys are available. For temper definitions, see SAE J1434.

2. Registered temper for a material which reduces incidence of stretcher strain.

3. Normally supplied with mill finish for bumper components if anodized or chrome plated finish is not required.

4. Suitable for bright dip and anodizing.

5. Suitable for chrome plating.

6. A wide variety of tempers are available to meet specific customer requirements. Normally a 2X temper is supplied.

7. Aluminum automotive wheels are also produced by the casting process.

TABLE 2A

Typical MECHANICAL PROPERTIES AND COMPARATIVE CHARACTERISTICS

Alloy and Temper[2]	Typical Mechanical Properties[1,3]								Comparative Characteristics					
	Tension			Shear	Fatigue	Modulus	Resistance to Corrosion					Weldability[16]		
	Strength		Elongation											
	Ultimate MPa	Yield 0.2% Offset MPa	percent In 50 mm (1.60 mm Thick Specimen)	Ultimate Shearing Strength MPa	Endurance Limit MPa	Modulus[7] of Elasticity MPa x 10°	General[8]	Stress-Corrosion Cracking[9]	Toughness[14]	Workability (Cold)[15]	Machinability[15]	Gas	Arc	Resistance Spot and Seam
1100-0	90	35	35	60	35[4]	69	A	A		A	E	A	A	B
2017-T4	425	275	20[11]	260	125[4]	75	D	C		C	B	N/A	N/A	N/A
2024-T4	470	325	20	285	140[4]	73	D	C		C	B	N/A	N/A	N/A
2036-T4	340	195	24	205	125[5]	71	C	A2[12]	A	B	C	-	B	B
2038-T4	325	170	25	205	125[5]	71	C	A2[12]		B	C	-	B	B
2117-T4	295	165	24[11]	195	95[4]	71	C	A		B	C	N/A	N/A	N/A
3002-0	95	40	33	70		69	A	A		A	E	A	A	B
3003-H14,H24	150	145	8	95	60[4]	69	A	A		B	D	A	A	A
3004-0	180	70	20	110	95[4]	69	A	A	B	A	D	B	A	B
-H32	215	170	10	115	105[4]	69	A	A		B	D	B	A	A
5005-0	125	40	25	75		69	A	A		A	E	A	A	B
5052-0	195	90	25	125	110[4]	70	A	A	A	A	D	A	A	B
-H32	230	195	12	140	115[4]	70	A	A		B	D	A	A	A
-H34	260	215	10	145	125[4]	70	A	A	B	B	C	A	A	A
5083-H321,H116	315	230	14[11]		160[4]	71	A	B		C	D	C	A	A
5086-H32	290	205	12			71	A	A		B	D	C	A	A
-H34	325	255	10		185[4]	71	A	B		B	C	C	A	A
-H112	270	130	14			71	A	A		A	D	C	A	B
5182-0	275	130	21	165	140[5]	71	A-B	A2[13]		A	D	C	A	B
-02	270	125	23			71	A-B	A2[13]		A	D	C	A	B
5252-H25	235	170	11	145		69	A	A		B	C	A	A	A
5454-0	250	115	22	160		70	A	A	A	A	D	C	A	B
-H32	275	205	10	165		70	A	A		B	D	C	A	A

(Table continued on next page)

TABLE 2A
(Continued)

Alloy and Temper[2]	Typical Mechanical Properties[1,3]								Comparative Characteristics					
	Tension			Shear	Fatigue	Modulus	Resistance to Corrosion					Weldability[16]		
	Strength		Elongation											
	Ultimate MPa	Yield 0.2% Offset MPa	percent In 50 mm (1.60 mm Thick Specimen)	Ultimate Shearing Strength MPa	Endurance Limit MPa	Modulus[7] of Elasticity MPa x 10°	General[8]	Stress-Corrosion Cracking[9]	Toughness[14]	Workability (Cold)[15]	Machinability[15]	Gas	Arc	Resistance Spot and Seam
-H34	305	240	10	180		70	A	A	B	B	C	C	A	A
5457-H25	180	160	12	110		69	A	A		A	E	A	A	B
5657-H25	160	140	12	95		69	A	A		B	D	A	A	A
6009-T4	220	125	25	150	115[5]	69	B	A2	A	A	C	A	A	A
6010-T4	290	165	24	195	125[5]	69	B	A2	A	B	C	A	A	A
6053-T61						69	A	A	-	-	C	N/A	N/A	N/A
6061-T4	240	145	22	165	95[4]	69	B	B	A	B	C	A	A	A
-T6,T651	310	275	12	205	95[4]	69	B	A	B	C	C	A	A	A
6063-T1	150	90	20	95	60[4]	69	A	A		B	D	A	A	A
-T5	185	145	12	115	70[4]	69	A	A		B	C	A	A	A
-T6	240	215	12	150	70[4]	69	A	A		C	C	A	A	A
6111-T1	290	160	26		69	69	B	A2	A	B	C	A	A	B
6463-T521	185	145	12			69	A	A		B	C	A	A	A
7021-T61	430	380	13		140[4]	71	B	A2[10]						
7029-T5,T6	430	380	15	270		70	B	A2[10]						
7116-T5	360	315	16				B	A1[10]		C				
7129-T6	430	380	15	270	145[6]	70	B	A2[10]						

NOTES:

1. Typical properties are not guaranteed since in most cases they are averages for various sizes, product forms and methods of manufacture and may not be exactly representative of any particular product or size. These data are intended only as a basis for comparing alloys and tempers and should not be specified as engineering requirements or used for design purposes. .

2. Only the commonly used tempers are listed for the alloys shown. Other tempers of these alloys are available.

3. The indicated typical mechanical properties for all except the O temper material are higher than the specified minimum properties. For O temper products, typical ultimate and yield values are slightly lower than specified (maximum) values.

(Notes continued on next page)

TABLE 2A
(Continued)

4. Based upon 500 000 000 cycles of completely reversed stress using the RR Moore type of machine and specimen.

5. Based upon a single series of tests, 10 000 000 cycles sheet flexural specimens.

6. Based upon 50 000 000 cycles in a single series of tests using the RR Moore type of machine and specimen.

7. Average of tension and compression moduli. Compression modulus is about 2% greater than tension modulus.

8. General corrosion ratings are based on exposures to sodium chloride solution by intermittent spraying or immersion. Ratings A through D are relative ratings in decreasing order of merit. The ratings do not necessarily imply acceptable performance in the intended application.

9. Stress-corrosion cracking ratings are based on service experience and on laboratory tests of specimens exposed to the 35% sodium chloride alternate immersion test for 2XXX, 6XXX, and copper containing 7XXX series alloys and total immersion in boiling in sodium chloride solution for 96 h for copper free 7XXX series alloys.

   A - No known instance of failure in service or in labortory tests.

   A2 - Insufficient service experience; no known instance of failure in laboratory tests.

   B - No known instance of failure in service; limited failures in laboratory tests of short transverse specimens.

   B2 - Insufficient service experience; limited failures in laboratory service.

   C - Service failures with sustained tension stress acting in short transverse direction relative to grain structure; limited failures in laboratory tests of long transverse specimens.

   D - Limited service failures with sustained longitudinal or long transverse stress.

10. Improved resistance to stress corrosion cracking can be realized by using controlled quenching and artificial aging practices in heat-treatable 7XXX aluminum alloys.

11. Elongation in 50 mm apply for thicknesses up through 12.50 mm and in 5D ($5.65\sqrt{A}$) for thicknesses over 12.50 mm where D and A are the diameter and cross sectional area of the specimen. Values for elongations in 5D ($5.65\sqrt{A}$) are shown in brackets.

12. This rating would be B2 for material exposed to elevated temperatures.

13. This rating may be different for material held at elevated temperatures for long periods.

14. Toughness ratings are based upon Kahn Tear Test of 1.60 mm thick sheet specimens in both longitudinal and transverse directions. This data is based on a limited number of tests and should be used for general comparisons only.

   Ratings A - over 175 000 Nm/m^2
   B - over 140 000 thru 175 000 Nm/m^2
   C - over 105 000 thru 140 000 Nm/m^2
   D - 0 through 105 000 Nm/m^2

15. Ratings A through D for workability (cold) and A through E for machinability are relative ratings in decreasing order of merit.

16. Ratings A through D for weldability are relative ratings as follows:

   A - Generally weldable by all commercial procedures and methods.
   B - Weldable with special techniques.
   C - Limited weldability due to crack sensitivity, loss in corrosion resistance, loss in mechanical properties.
   D - No commonly used welding methods have been developed.
   N/A - Rating not applicable for end use application requirements, that is, rivets.

TABLE 2B
MECHANICAL PROPERTY LIMITS[1][5]

Alloy and Temper	Product Form	Specified[2] Thickness or Diameter over mm	Specified[2] Thickness or Diameter thru mm	Area mm^2 thru	Tensile Strength[3] Ultimate min MPa	Tensile Strength[3] Ultimate max MPa	Tensile Strength[3] Yield min 0.2% Offset MPa	Elongation[4] % in 50 mm min
1100-0	Sheet	0.15	0.32		75	105	25	15
		0.32	0.63		75	105	25	17
		0.63	1.20		75	105	25	22
		1.20	6.30		75	105	25	30
2017-T4	Rivet and Cold Heading Wire and Rod	1.60	25.00		380		220	(10)
2024-T4	Rivet and Cold Heading Wire and Rod	1.60	25.00		425		275	(9)
2036-T4	Sheet	0.63	3.20		290		160	20
2038-T4	Sheet	0.63	1.80		275		140	20
2117-T4	Rivet and Cold Heading Wire and Rod	1.60	25.00		260		125	(10)
3002-0	Sheet	0.63	0.80		75	110	20	20
		0.80	1.20		75	110	20	23
		1.20	1.60		75	110	20	25
3003-H14,24	Sheet	0.20	0.32		140	180	115	1
		0.32	0.63		140	180	115	2
		0.63	1.20		140	180	115	3
		1.20	6.30		140	180	115	5
3004-0	Sheet	0.15	0.32		150	200	60	9
		0.32	0.63		150	200	60	12
		0.63	1.20		150	200	60	15
		1.20	6.30		150	200	60	18
-H32	Sheet	0.40	0.63		190	240	145	1
		0.63	1.20		190	240	145	3
		1.20	6.30		190	240	145	5
5005-0	Sheet	0.15	0.32		105	145	35	12
		0.32	0.63		105	145	35	16
		0.63	1.20		105	145	35	19
		1.20	6.30		105	145	35	21
5052-0	Sheet	0.15	0.32		170	215	65	13
		0.32	0.63		170	215	65	15
		0.63	1.20		170	215	65	17
		1.20	6.30		170	215	65	19
-H32	Sheet	0.40	0.63		215	265	160	4
		0.63	1.20		215	265	160	5
		1.20	6.30		215	265	160	7

(Table continued on next page)

TABLE 2B
MECHANICAL PROPERTY LIMITS[1][5]
(Continued)

Alloy and Temper	Product Form	Specified[2] Thickness or Diameter over mm	Specified[2] Thickness or Diameter thru mm	Area mm^2 thru	Tensile Strength[3] Ultimate min MPa	Tensile Strength[3] Ultimate max MPa	Tensile Strength[3] Yield min 0.2% Offset MPa	Elongation[4] % in 50 mm min
5052-H34	Sheet	0.20	0.32		235	285	180	3
		0.32	0.63		235	285	180	3
		0.63	1.20		235	285	180	4
		1.20	6.30		235	285	180	6
5083-H112	Plate	6.30	12.50		275		125	12
-H321	Sheet & Plate	4.00	12.50		305	385	215[6]	12
-H116	Sheet & Plate	1.60	12.50		305		215	10
-H111	Extrusions		130.00		275		165	12
-H112	Extrusions		130.00	20 000	270		110	12
5086-H32	Sheet & Plate	0.50	0.63		275	325	195	6
		0.63	1.20		275	325	195	6
		1.20	6.30		275	325	195	8
		6.30	50.00		275	325	195	12(10)
5086-H34	Sheet & Plate	0.20	0.32		300	350	235	4
		0.32	0.63		300	350	235	4
		0.63	1.20		300	350	235	5
		1.20	6.30		300	350	235	6
		6.30	25.00		300	350	235	10(9)
5086-H112	Extrusions		130.00	20 000	240		95	12
	Tubing	All		20 000	240		95	12
5182-0	Sheet	0.63	3.20		255	325	110	18
-02	Sheet	0.63	3.20		250	315	110	18
5252-H25	Sheet	0.63	2.50		215	270		9
5454-0	Sheet & Plate	0.50	0.63		215	285	85	12
		0.63	1.20		215	285	85	13
		1.20	6.30		215	285	85	16
		6.30	80.00		215	285	85	18(16)
-H32	Sheet & Plate	0.50	0.63		250	305	180	5
		0.63	1.20		250	305	180	6
		1.20	6.30		250	305	180	8
		6.30	50.00		250	305	180	12(10)
5454-H34	Sheet & Plate	0.50	0.63		270	325	200	4
		0.63	1.20		270	325	200	5
		1.20	6.30		270	325	200	6
		6.30	25.00		270	325	200	10(9)

(Table continued on next page)

TABLE 2B
MECHANICAL PROPERTY LIMITS[1][5]
(Continued)

Alloy and Temper	Product Form	Specified[2] Thickness or Diameter over mm	Specified[2] Thickness or Diameter thru mm	Area mm^2 thru	Tensile Strength[3] Ultimate min MPa	Tensile Strength[3] Ultimate max MPa	Tensile Strength[3] Yield min 0.2% Offset MPa	Elongation[4] % in 50 mm min
5454-0	Extrusions		130.00	20 000	215	285	85	14
-H111	Extrusions		130.00	20 000	230		130	12
5454-0	Tube	All		20 000	215	285	85	14
-H111	Tube	All		20 000	230		130	12
5457-H-25	Sheet	0.75	2.50		160	215		7
5657-H25	Sheet	0.63	2.50		140	195		8
6009-T4	Sheet	0.50	1.80		185		105	21
		1.80	3.20		165		90	21
6009-T62	Sheet	0.50	1.80		270		235	9
6010-T4	Sheet	0.50	1.80		240		140	20
6010-T62		0.50	1.80		340		310	8
6053-T61	Rivet and Cold Heading Wire and Rod	1.60	25.00		205		135	(12)
6061-T4	Sheet	0.15	0.20		205		110	10
		0.20	0.25		205		110	12
		0.25	0.50		205		110	14
		0.50	6.30		205		110	16
6061-T6	Sheet	0.15	0.20		290		240	4
		0.20	0.25		290		240	6
		0.25	0.50		290		240	8
		0.50	6.30		290		240	10
6061-T651	Plate	6.30	12.50		290		240	10
		12.50	25.00		290		240	(8)
		25.00	50.00		290		240	(7)
6061-T4	Extrusions & Tube	All		All	180		110	16
6061-T6	Extrusions & Tube		6.30	All	260		240	8
		6.30		All	260		240	10
6061-T6	Rivet and Cold Heading Wire and Rod	1.60	25.00		290		240	(9)
6061-T6	Forgings (Die Forgings)		100.00		260		240	7(6)[7] 5(4)[8]
6063-T1	Extrusions & Tube		12.50	All	115		60	12
		12.50	25.00	All	110		55	

(Table continued on next page)

TABLE 2B
MECHANICAL PROPERTY LIMITS(1)(5)
(Continued)

Alloy and Temper	Product Form	Specified(2) Thickness or Diameter over mm	Specified(2) Thickness or Diameter thru mm	Area mm^2 thru	Tensile Strength(3) Ultimate min MPa	Tensile Strength(3) Ultimate max MPa	Tensile Strength(3) Yield min 0.2% Offset MPa	Elongation(4) % in 50 mm min
6063-T5	Extrusions & Tube		12.50	All	150		110	8
		12.50	25.00	All	145		105	
6063-T6	Extrusions & Tube		3.20	All	205		170	8
		3.20	25.00	All	205		170	10
6111-T4	Sheet	0.50	1.80		275		140	22
6111-T6	Sheet	0.50	1.80		320		275	10
6463-T521	Extrusion		25.0		150		95(6)	8(7)
7021-T61	Sheet	1.60	6.30		380		345	8
7029-T5,T6	Extrusions	2.50	6.30		380		340	10
	Sheet							
7116-T5	Extrusions	3.20	12.50		330		290	8
7129-T5,T6	Extrusions		6.30		380		340	9

(Notes continued on next page)

TABLE 2B
MECHANICAL PROPERTY LIMITS[1][5]
(Continued)

NOTES:

1. Tensile property limits are based on producer analysis of data accumulated from standard production material which has been sampled and tested using standard procedures as detailed in the Quality Control Section of "Aluminum Standards and Data" published by The Aluminum Association Inc. The limits are established after sufficient test data has been accumulated to adequately determine the form of the frequency distribution curve and to provide a reliable estimate of the population mean and standard deviation. In most instances, the distribution is normal in form and properties are based on the results of a minimum of 100 tests from at least 10 different lots of material. The limits are subsequently established at levels at which 99 percent of the material is expected to conform at a confidence level of 0.95.

2. Thicknesses shown are provided as a guide to the designer and should not be used for ordering purposes. Consult material supplier for details.

3. Tensile values are determined in accordance with ASTM B557M "Method of Tension Testing Aluminum and Magnesium Alloys."

4. Elongations in 50 mm apply for thicknesses up through 12.50 mm and in 5D ($5.65\sqrt{A}$) for thicknesses over 12.50 mm where D and A are the diameter and cross sectional area of the specimen. Values for elongations in 5D ($5.65\sqrt{A}$) are shown in brackets.

5. Ultimate Shearing Strength for Rivet and Cold Heading Wire & Rod

Alloy and Temper	Ultimate Shearing Strength min, MPa
2017-T4	225
2024-T4	255
2117-T4	180
6053-T6	135
6061-T6	170

6. Yield Maximum = 295 MPa for Alloy 5083-H321 Sheet and Plate
   = 180 MPa for Alloy 6463-T521 Extrusions

7. Specimen from forging axis parallel to direction of grain flow.

8. Specimen from forging axis not parallel to direction of grain flow.

TABLE 3
CHEMICAL COMPOSITION LIMITS(1)(2)

AA Number	UNC Number	Si	Fe	Cu	Mn	Mg	Cr	Zn		Ti	Other(3) Each	Other(3) Total(4)	Aluminum(5) Min
1100	A91100	0.95	Si+Fe	0.05-0.20	0.05	---	---	0.10	---	---	0.05	0.15	99.0
2017	A92017	0.20-0.8	0.7	3.5-4.5	0.40-1.0	0.40-0.8	0.10	0.25	---	0.15	0.05	0.15	Remainder
2024	A92024	0.50	0.50	3.8-4.9	0.30-0.9	1.2-1.8	0.10	0.25	---	0.15	0.05	0.15	
2036	A92036	0.50	0.50	2.2-3.0	0.10-0.40	0.30-0.6	0.10	0.25	---	0.15	0.05	0.15	
2038	A92038	0.50-1.3	0.6	0.8-1.8	0.10-0.40	0.40-1.0	0.20	0.50	0.05V-0.05Ga	0.15	0.05	0.15	
2117	A92117	0.8	0.7	2.2-3.0	0.20	0.20-0.50	0.10	0.25	---	---	0.05	0.15	
3002	A93002	0.08	0.10	0.15	0.05-0.25	0.05-0.20	---	0.05	0.05V	0.03	0.03	0.10	
3003	A93003	0.6	0.7	0.05-0.20	1.0-1.5	---	---	0.10	---	---	0.05	0.15	
3004	A93004	0.30	0.7	0.25	1.0-1.5	0.8-1.3	---	0.25	---	---	0.05	0.15	
5005	A95005	0.30	0.7	0.20	0.20	0.50-1.1	0.10	0.25	---	---	0.05	0.15	
5052	A95052	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	0.10	---	---	0.05	0.15	
5083	A95083	0.40	0.40	0.10	0.40-1.0	4.0-4.9	0.05-0.25	0.25	---	0.15	0.05	0.15	
5086	A95086	0.40	0.50	0.10	0.20-0.7	3.5-4.5	0.05-0.25	0.25	---	0.15	0.05	0.15	
5182	A95182	0.20	0.35	0.15	0.20-0.50	4.0-5.0	0.10	0.25	---	0.10	0.05	0.15	
5252	A95252	0.08	0.10	0.10	0.10	2.2-2.8	---	0.05	0.05V	---	0.03	0.10	
5454	A95454	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	0.25	---	0.20	0.05	0.15	
5457	A95457	0.08	0.10	0.20	0.15-0.45	0.8-1.2	---	0.05	0.05V	---	0.03	0.10	
5657	A95657	0.08	0.10	0.10	0.03	0.6-1.0	---	0.05	0.05V-0.03Ga	---	0.02	0.05	
6009	A96009	0.6-1.0	0.50	0.15-0.6	0.20-0.8	0.40-0.8	0.10	0.25	---	0.10	0.05	0.15	
6010	A96010	0.8-1.2	0.50	0.15-0.6	0.20-0.8	0.6-1.0	0.10	0.25	---	0.10	0.05	0.15	
6053	A96053	(6)	0.35	0.10	---	1.1-1.4	0.15-0.35	0.10	---	---	0.05	0.15	
6061	A96061	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	0.25	---	0.15	0.05	0.15	
6063	A96063	0.20-0.6	0.35	0.10	0.10	0.45-0.9	0.10	0.10	---	0.10	0.05	0.15	
6111	A96111	0.7-1.1	0.40	0.50-0.9	0.15-0.45	0.50-1.0	0.10	0.15	---	0.10	0.05	0.15	
6463	A96463	0.20-0.6	0.15	0.20	0.05	0.45-0.9	---	0.05	---	---	0.05	0.15	
7021	A97021	0.25	0.40	0.25	0.10	1.2-1.8	0.05	5.0-6.0	0.08-0.18Zr	0.10	0.05	0.15	
7029	A97029	0.10	0.12	0.50-0.9	0.03	1.3-2.0	---	4.2-5.2	0.05V	0.05	0.03	0.10	
7116	A97116	0.15	0.30	0.50-1.1	0.05	0.8-1.4	---	4.2-5.2	0.05V-0.03Ga	0.05	0.05	0.15	
7129	A97129	0.15	0.30	0.50-0.9	0.10	1.3-2.0	0.10	4.2-5.2	0.05V-0.03Ga	0.05	0.05	0.15	

NOTES:

1. Composition in percent maximum unless shown as a range.

2. For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis is rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit in accordance with the rounding-off method of ASTM E29.

3. Analysis is required for elements other than aluminum for which specific limits are shown. Analysis for other elements is made when their presence is suspected to be, or in the course of routine analysis is indicated to be, in excess of the specified limits.

4. Other elements total is the sum of those other metallic elements 0.010% or more, each expressed to the second decimal before determining the sum.

5. The aluminum content for unalloyed aluminum not made by a refining process is the difference between 100.0% and the sum of all other metallic elements present in amounts of 0.010% or more each expressed to the second decimal before determing the sum.

6. 45%-65% of actual Mg.

TABLE 4
TYPICAL HEAT TREATMENTS FOR ALUMINUM ALLOY MILL PRODUCTS(1)

Alloy	Product	Solution Heat Treatment(2)		Precipitation Heat Treatment		
		Metal(3) Temperature °C	Temper Designation	Metal(3) Temperature °C	Approx.(4) Time at Temperature Hours	Temper Designation
2036	Sheet	(5)	T4			
2038	Sheet	(5)	T4			
6009	Sheet	(5)	T4	200-210°	1	T6(6)
6010	Sheet	(5)	T4	200-210°	1	T6(6)
6061	Sheet	515-550	T4	155-165	18	T6
	Plate	515-550	T451	155-165	18	T651
	Extrusions, Tube, Rod, Bar	515-550(7)	T4	170-180	8	T6
	Forgings	515-550	T4	170-180	8	T6
6063	Extrusions, Tube	(7)	T1	175-185(8)	3	T5
		515-525(7)	T4	170-180(9)	8	T6
6111	Sheet	(5)	T4	200-210	1	T6
6463	Extrusions	(7)	T1	175-185(8)	3	T5
		515-525	T4	170-180(9)	8	T6
7021	Sheet	395-405(10)	W	(11)	(11)	T61
7029	Extrusions	480-520(12)	W	(13)	(13)	T5,T6
7116	Extrusions	425-540	W	(14)	(14)	T5
7129	Extrusions	480-520	S	(13)	(13)	T5,T6

NOTES:

1. The times and temperatures shown are typical for various forms, sizes and methods of manufacture and may not exactly describe the optimum treatment for a specific item.

2. Material should be quenched in water or by high velocity fans from the solution heat-treating temperature as rapidly as possible and with minimum delay after removal from the furnace. Unless otherwise indicated, when material is quenched by total immersion in water, the water should be at room temperature and suitably cooled to remain below 35°C during the quench cycle. The use of high velocity, high volume jets of cold water is also effective for some material.

3. The metal temperature should be attained as rapidly as possible. Where a temperature range exceeding 10°C is shown, a temperature range of 10° within the listed range should be selected and maintained during the time at temperature.

4. The time at temperature will depend on the time required for load to reach temperature. The times shown are based on rapid heating with soaking time measured from the time the load reaches the 10°C range listed or selected.

5. These alloys are supplied in the solution heat-treated condition. For optimum properties, subsequent re-heat treatment is not recommended.

(Notes continued on next page)

TABLE 4
TYPICAL HEAT TREATMENTS FOR ALUMINUM ALLOY MILL PRODUCTS(1)

(Continued)

6. Mechanical properties of material will meet tensile property limits of T6 temper as specified in Table 2B.

7. By suitable control of extrusion temperature, product may be quenched directly from extrusion press to provide specified properties for this temper. Some products may be adequately quenched in air blast at room temperature.

8. An alternate treatment comprised of 1-2 h at 200-210°C may be used.

9. An alternate treatment comprised of 6 h at 175-185°C may be used.

10. Quenched at a minimum average cooling rate of 35°C/s as measured over the range 385-205°C.

11. A minimum of 8 h at room temperature followed by 2 h at 95-105°C plus 4 h at 155-165°C.

12. 10 minute soak at temperature followed by cold water quench.

13. 5 h at 95-105°C plus 5 h at 155-165°C.

14. 5 h at 95-105°C plus 5 h at 160-170°C.