

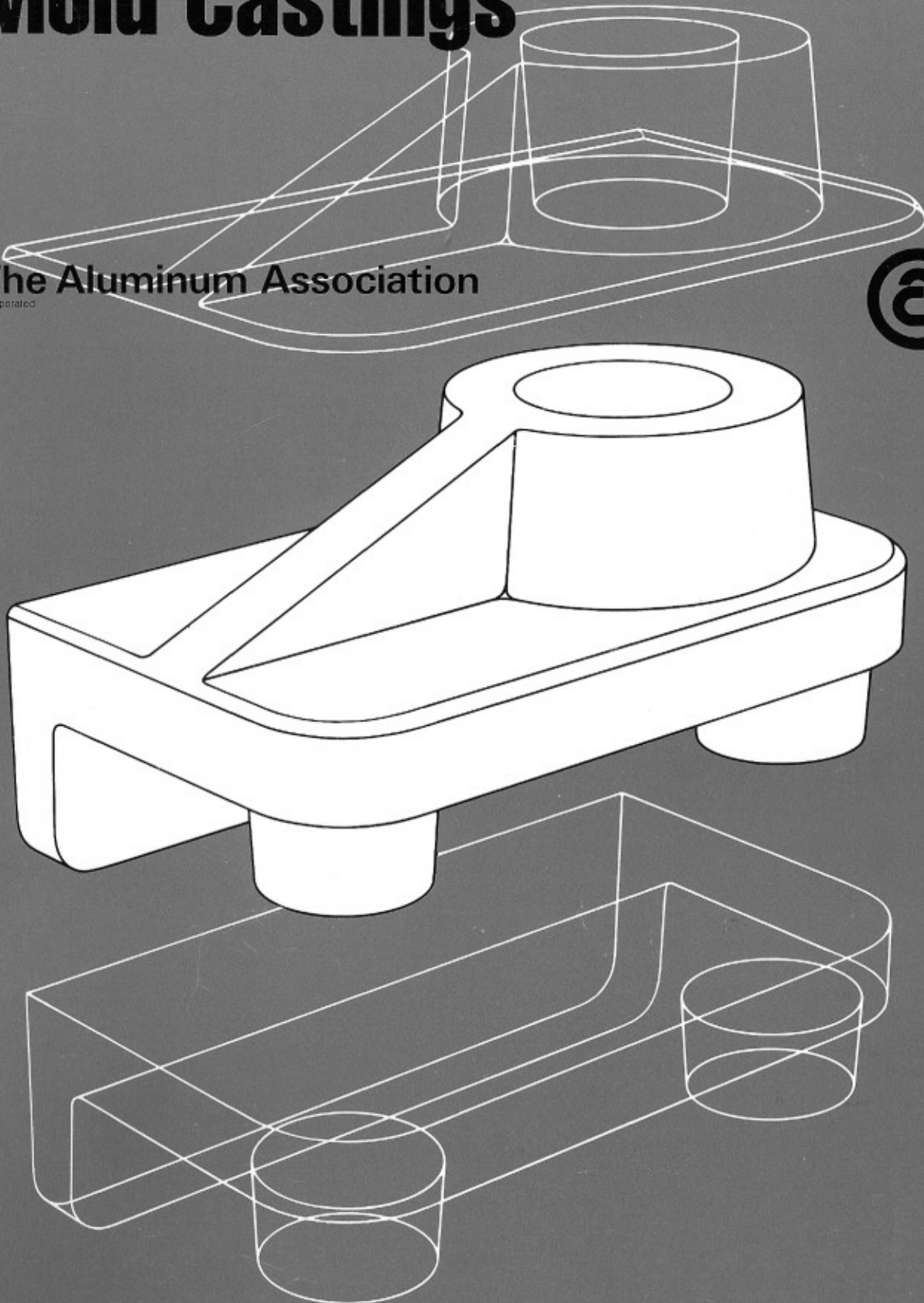
Standards for Aluminum Sand and Permanent Mold Castings

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The Aluminum Association
Incorporated



Standards for Aluminum
Sand and Permanent Mold Castings
13th Edition 1992



\$15.00



CHEMICAL COMPOSITION LIMITS FOR COMMONLY USED SAND AND PERMANENT MOLD CASTING ALLOYS ^(a) ^(b)

Alloy	Product ^(c)	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Others	
											Each	Total ^(k)
201.0	S	0.10	0.15	4.0-5.2	0.20-0.50	0.15-0.55	—	—	—	0.15-0.35	0.05 ^(b)	0.10
204.0	S&P	0.20	0.35	4.2-5.0	0.10	0.15-0.35	—	0.05	0.10	0.15-0.30	0.05 ⁽ⁱ⁾	0.15
208.0	S&P	2.5-3.5	1.2	3.5-4.5	0.50	0.10	—	0.35	1.0	0.25	—	0.50
222.0	S&P	2.0	1.5	9.2-10.7	0.50	0.15-0.35	—	0.50	0.8	0.25	—	0.35
242.0	S&P	0.7	1.0	3.5-4.5	0.35	1.2-1.8	0.25	1.7-2.3	0.35	0.25	0.05	0.15
295.0	S	0.7-1.5	1.0	4.0-5.0	0.35	0.03	—	—	0.35	0.25	0.05	0.15
296.0	P	2.0-3.0	1.2	4.0-5.0	0.35	0.05	—	0.35	0.50	0.25	—	0.35
308.0	P	5.0-6.0	1.0	4.0-5.0	0.50	0.10	—	—	1.0	0.25	—	0.50
319.0	S&P	5.5-6.5	1.0	3.0-4.0	0.50	0.10	—	0.35	1.0	0.25	—	0.50
328.0	S	7.5-8.5	1.0	1.0-2.0	0.20-0.6	0.20-0.6	0.35	0.25	1.5	0.25	—	0.50
332.0	P	8.5-10.5	1.2	2.0-4.0	0.50	0.50-1.5	—	0.50	1.0	0.25	—	0.50
333.0	P	8.0-10.0	1.0	3.0-4.0	0.50	0.05-0.50	—	0.50	1.0	0.25	—	0.50
336.0	P	11.0-13.0	1.2	0.50-1.5	0.35	0.7-1.3	—	2.0-3.0	0.35	0.25	0.05	—
354.0	S&P	8.6-9.4	0.20	1.6-2.0	0.10	0.40-0.6	—	—	0.10	0.20	0.05	0.15
355.0	S&P	4.5-5.5	0.6 ^(d)	1.0-1.5	0.50 ^(d)	0.40-0.6	0.25	—	0.35	0.25	0.05	0.15
C355.0	S&P	4.5-5.5	0.20	1.0-1.5	0.10	0.40-0.6	—	—	0.10	0.20	0.05	0.15
356.0	S&P	6.5-7.5	0.6 ^(d)	0.25	0.35 ^(d)	0.20-0.45	—	—	0.35	0.25	0.05	0.15
A356.0	S&P	6.5-7.5	0.20	0.20	0.10	0.25-0.45	—	—	0.10	0.20	0.05	0.15
357.0	S&P	6.5-7.5	0.15	0.05	0.03	0.45-0.6	—	—	0.05	0.20	0.05	0.15
A357.0	S&P	6.5-7.5	0.20	0.20	0.10	0.40-0.7	—	—	0.10	0.04-0.20	0.05 ^(e)	0.15
359.0	S&P	8.5-9.5	0.20	0.20	0.10	0.50-0.7	—	—	0.10	0.20	0.05	0.15
443.0	S&P	4.5-6.0	0.8	0.6	0.50	0.05	0.25	—	0.50	0.25	—	0.35
B443.0	S&P	4.5-6.0	0.8	0.15	0.35	0.05	—	—	0.35	0.25	0.05	0.15
A444.0	P	6.5-7.5	0.20	0.10	0.10	0.05	—	—	0.10	0.20	0.05	0.15
512.0	S	1.4-2.2	0.6	0.35	0.8	3.5-4.5	0.25	—	0.35	0.25	0.05	0.15
513.0	P	0.30	0.40	0.10	0.30	3.5-4.5	—	—	1.4-2.2	0.20	0.05	0.15
514.0	S	0.35	0.50	0.15	0.35	3.5-4.5	—	—	0.15	0.25	0.05	0.15
520.0	S	0.25	0.30	0.25	0.15	9.5-10.6	—	—	0.15	0.25	0.05	0.15
535.0	S&P	0.15	0.15	0.05	0.10-0.25	6.2-7.5	—	—	—	0.10-0.25	0.05 ^(f)	0.15
705.0	S&P	0.20	0.8	0.20	0.40-0.6	1.4-1.8	0.20-0.40	—	2.7-3.3	0.25	0.05	0.15
707.0	S&P	0.20	0.8	0.20	0.40-0.6	1.8-2.4	0.20-0.40	—	4.0-4.5	0.25	0.05	0.15
710.0	S	0.15	0.50	0.35-0.65	0.05	0.6-0.8	—	—	6.0-7.0	0.25	0.05	0.15
711.0	P	0.30	0.7-1.4	0.35-0.65	0.05	0.25-0.45	—	—	6.0-7.0	0.20	0.05	0.15
712.0	S	0.30	0.50	0.25	0.10	0.50-0.65	0.40-0.6	—	5.0-6.5	0.15-0.25	0.05	0.20
713.0	S&P	0.25	1.1	0.40-1.0	0.6	0.20-0.50	0.35	0.15	7.0-8.0	0.25	0.10	0.25
771.0	S	0.15	0.15	0.10	0.10	0.8-1.0	0.06-0.20	—	6.5-7.5	0.10-0.20	0.05	0.15
850.0	S&P	0.7	0.7	0.7-1.3	0.10	0.10	—	0.7-1.3	—	0.20	— ^(g)	0.30
851.0	S&P	2.0-3.0	0.7	0.7-1.3	0.10	0.10	—	0.30-0.7	—	0.20	— ^(g)	0.30
852.0	S&P	0.40	0.7	1.7-2.3	0.10	0.6-0.9	—	0.9-1.5	—	0.20	— ^(g)	0.30

(a) The alloys listed are those which have been included in Federal Specifications QQ-A-596d, ALUMINUM ALLOYS PERMANENT AND SEMI-PERMANENT MOLD CASTINGS, QQ-A-601E, ALUMINUM ALLOY SAND CASTINGS, and Military Specification MIL-A-21180c, ALUMINUM ALLOY CASTINGS, HIGH STRENGTH. Other alloys are registered with The Aluminum Association and are available. Information on these should be requested from individual foundries or ingot suppliers.

(b) Except for "Aluminum" and "Others," analysis normally is made for elements for which specific limits are shown. For purposes of determining conformance to these limits, an observed value or 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 following:

When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained should be kept unchanged.

When the figure next beyond the last figure or place to be retained is greater than 5, the figure in the last place retained should be increased by 1.

When the figure next beyond the last figure or place to be retained is 5 and

(1) there are no figures or only zeros, beyond this 5, if the figure in the last place to be retained is odd, it should be increased by 1; if even, it should be kept unchanged;

(2) if the 5 next beyond the figure in the last place to be retained is followed by any figures other than zero, the figure in the last place retained should be increased by 1; whether odd or even.

(c) S = Sand Cast P = Permanent Mold Cast

(d) If iron exceeds 0.45 percent, manganese content shall not be less than one-half the iron content.

(e) Also contains 0.04-0.07 percent beryllium.

(f) Also contains 0.003-0.007 percent beryllium, boron 0.005 percent maximum.

(g) Also contains 5.5-7.0 percent tin.

(h) Also contains 0.40-1.0 percent silver.

(i) Also contains 0.05 percent tin.

(k) The sum of those "Others" metallic elements 0.010 percent or more each, expressed to the second decimal before determining the sum.



MECHANICAL PROPERTY LIMITS FOR COMMONLY USED ALUMINUM SAND CASTING ALLOYS (a)

Alloy	Temper (b)	MINIMUM PROPERTIES			Typical Brinell Hardness (c) 500 - kgf load 10 - mm ball
		Tensile Strength		% Elongation in 2 inches or 4 times diameter	
		Ultimate ksi (MPa)	Yield (0.2% Offset) ksi (MPa)		
201.0	T7	60.0 (414)	50.0 (345)	3.0	110-140
204.0	T4	45.0 (310)	28.0 (193)	6.0	---
208.0	F	19.0 (131)	12.0 (83)	1.5	40-70
222.0	0	23.0 (159)	---	---	65-95
222.0	T61	30.0 (207)	---	---	100-130
242.0	0	23.0 (159)	---	---	55-85
242.0	T571	29.0 (200)	---	---	70-100
242.0	T61	32.0 (221)	20.0 (138)	---	90-120
242.0	T77	24.0 (165)	13.0 (90)	1.0	60-90
295.0	T4	29.0 (200)	13.0 (90)	6.0	45-75
295.0	T6	32.0 (221)	20.0 (138)	3.0	60-90
295.0	T62	36.0 (248)	28.0 (193)	---	80-110
295.0	T7	29.0 (200)	16.0 (110)	3.0	55-85
319.0	F	23.0 (159)	13.0 (90)	1.5	55-85
319.0	T5	25.0 (172)	---	---	65-95
319.0	T6	31.0 (214)	20.0 (138)	1.5	65-95
328.0	F	25.0 (172)	14.0 (97)	1.0	45-75
328.0	T6	34.0 (234)	21.0 (145)	1.0	65-95
354.0	(c)	---	---	---	---
355.0	T51	25.0 (172)	18.0 (124) (2)	---	50-80
355.0	T6	32.0 (221)	20.0 (138)	2.0	70-105
355.0	T7	35.0 (241)	---	---	70-100
355.0	T71	30.0 (207)	22.0 (152)	---	60-95
C355.0	T6	36.0 (248)	25.0 (172)	2.5	75-105
356.0	F	19.0 (131)	---	2.0	40-70
356.0	T51	23.0 (159)	16.0 (110)	---	45-75
356.0	T6	30.0 (207)	20.0 (138)	3.0	55-90
356.0	T7	31.0 (214)	29.0 (200)	---	60-90
356.0	T71	25.0 (172)	18.0 (124)	3.0	45-75
A356.0	T6	34.0 (234)	24.0 (165)	3.5	70-105
357.0	(c)	---	---	---	---
A357.0	(c)	---	---	---	---
359.0	(c)	---	---	---	---
443.0	F	17.0 (117)	7.0 (49)	3.0	25-55
B433.0	F	17.0 (117)	6.0 (41)	3.0	25-55
512.0	F	17.0 (117)	10.0 (69)	---	35-65
514.0	F	22.0 (152)	9.0 (62)	6.0	35-65
520.0	T4 (1)	42.0 (290)	22.0 (152)	12.0	60-90
535.0	F or T5	35.0 (241)	18.0 (124)	9.0	60-90
705.0	F or T5	30.0 (207)	17.0 (117)	5.0	50-80
707.0	T5	33.0 (228)	22.0 (152)	2.0	70-100
707.0	T7	37.0 (255)	30.0 (207)	1.0	65-95
710.0	F or T5	32.0 (221)	20.0 (138)	2.0	60-90
712.0	F or T5	34.0 (234)	25.0 (172)	4.0	60-90
713.0	F or T5	32.0 (221)	22.0 (152)	3.0	60-90
771.0	T5	42.0 (290)	38.0 (262)	1.5	85-115
771.0	T51	32.0 (221)	27.0 (186)	3.0	70-100
771.0	T52	36.0 (248)	30.0 (207)	1.5	70-100
771.0	T53	36.0 (248)	27.0 (186)	1.5	---
771.0	T6	42.0 (290)	35.0 (241)	5.0	75-105
771.0	T71	48.0 (331)	45.0 (310)	2.0	105-135
850.0	T5	16.0 (110)	---	5.0	30-60
851.0	T5	17.0 (117)	---	3.0	30-60
852.0	T5	24.0 (165)	18.0 (124)	---	45-75

(a) Values represent properties obtained from separately cast test bars and are derived from ASTM B-26, Standard Specification for Aluminum-Alloy Sand Castings; Federal Specification QQ-A-601e, Aluminum Alloy Sand Castings; and Military Specification MIL-A-21180c, Aluminum Alloy Castings, High Strength. Unless otherwise specified, the average tensile strength, average yield strength and average elongation values of specimens cut from castings shall be not less than 75 percent of the tensile and yield strength values and not less than 25 percent of the elongation values given above. The customer should keep in mind that (1) some foundries may offer additional tempers for the above alloys, and (2) foundries are constantly improving casting techniques and, as a result, some may offer minimum properties in excess of the above.

(b) F indicates "as cast" condition; refer to AA-CS-M11 for recommended times and temperatures of heat treatment for other tempers to achieve properties specified.

(c) Mechanical properties for these alloys depend on the casting process. For further information consult the individual foundries.

(d) Hardness values are given for information only; not required for acceptance.

(1) The T4 temper of Alloy 520.0 is unstable; significant room temperature aging occurs within life expectancy of most castings. Elongation may decrease by as much as 80 percent.



MECHANICAL PROPERTY LIMITS FOR COMMONLY USED ALUMINUM PERMANENT MOLD CASTING ALLOYS (a)

Alloy	Temper (b)	MINIMUM PROPERTIES			Typical Brinell Hardness (c) 500 - kgf load, 10 - mm ball
		Tensile Strength		% Elongation in 2 inches, or 4 times diameter	
		Ultimate ksi (MPa)	Yield (0.2% Offset) ksi (MPa)		
204.0	T4	48.0 (331)	29.0 (200)	8.0	---
208.0	T4	33.0 (228)	15.0 (103)	4.5	60-90
208.0	T6	35.0 (241)	22.0 (152)	2.0	75-105
208.0	T7	33.0 (228)	16.0 (110)	3.0	65-95
222.0	T551	30.0 (207)	---	---	100-130
222.0	T65	40.0 (276)	---	---	125-155
242.0	T571	34.0 (234)	---	---	90-120
242.0	T61	40.0 (276)	---	---	95-125
296.0	T6	35.0 (241)	---	2.0	75-105
308.0	F	24.0 (165)	---	---	55-85
319.0	F	28.0 (193)	14.0 (97)	1.5	70-100
319.0	T6	34.0 (234)	---	2.0	75-105
332.0	T5	31.0 (214)	---	---	90-120
333.0	F	28.0 (193)	---	---	65-100
333.0	T5	30.0 (207)	---	---	70-105
333.0	T6	35.0 (241)	---	---	85-115
333.0	T7	31.0 (214)	---	---	75-105
336.0	T551	31.0 (214)	---	---	80-120
336.0	T65	40.0 (276)	---	---	110-140
354.0	T61	48.0 (331)	37.0 (255)	3.0	---
354.0	T62	52.0 (359)	42.0 (290)	2.0	---
355.0	T51	27.0 (186)	---	---	60-90
355.0	T6	37.0 (255)	---	1.5	75-105
355.0	T62	42.0 (290)	---	---	90-120
355.0	T7	36.0 (248)	---	---	70-100
355.0	T71	34.0 (234)	27.0 (186)	---	65-95
C355.0	T61	40.0 (276)	30.0 (207)	3.0	75-105
356.0	F	21.0 (145)	---	3.0	40-70
356.0	T51	25.0 (172)	---	---	55-85
356.0	T6	33.0 (228)	22.0 (152)	3.0	65-95
356.0	T7	25.0 (172)	---	3.0	60-90
356.0	T71	25.0 (172)	---	3.0	60-90
A356.0	T61	37.0 (255)	26.0 (179)	5.0	70-100
357.0	T6	45.0 (310)	---	3.0	75-105
A357.0	T61	45.0 (310)	36.0 (248)	3.0	85-115
359.0	T61	45.0 (310)	34.0 (234)	4.0	75-105
359.0	T62	47.0 (324)	38.0 (262)	3.0	85-115
443.0	F	21.0 (145)	7.0 (49)	2.0	30-60
B443.0	F	21.0 (145)	6.0 (41)	2.5	30-60
A444.0	T4	20.0 (138)	---	20.0	---
513.0	F	22.0 (152)	12.0 (83)	2.5	45-75
535.0	F	35.0 (241)	18.0 (124)	8.0	60-90
705.0	T5	37.0 (255)	17.0 (117)	10.0	55-85
707.0	T7	45.0 (310)	35.0 (241)	3.0	80-110
711.0	T1	28.0 (193)	18.0 (124)	7.0	55-85
713.0	T5	32.0 (221)	22.0 (152)	4.0	60-90
850.0	T5	18.0 (124)	---	8.0	30-60
851.0	T5	17.0 (117)	---	3.0	30-60
851.0	T6	18.0 (124)	---	8.0	---
852.0	T5	27.0 (186)	---	3.0	55-85

(a) Values represent properties obtained from separately cast test bars and are derived from ASTM B-108, Standard Specification for Aluminum-Alloy Permanent Mold Castings; Federal Specification QQ-A-598d, Aluminum Alloy Permanent and Semi-Permanent Mold Castings; and Military Specification MIL-A-21180c, Aluminum Alloy Castings, High Strength. Unless otherwise specified, the average tensile strength, average yield strength and average elongation values of specimens cut from castings shall be not less than 75 percent of the tensile and yield strength values and not less than 25 percent of the elongation values given above. The customer should keep in mind that (1) some foundries may offer additional tempers for the above alloys, and (2) foundries are constantly improving casting techniques and, as a result, some may offer minimum properties in excess of the above.

(b) F indicates "as cast" condition; refer to AA-CS-M11 for recommended times and temperatures of heat treatment for other tempers to achieve properties specified.

(c) Hardness values are given for information only; not required for acceptance.



Selection of an alloy for a particular application requires consideration not only of mechanical properties, but also of numerous other characteristics, such as behavior in the casting process or subsequent treatments in the course of manufacture, and response to the environmental conditions of service.

The following table includes several significant characteristics which deserve consideration in the selection of an alloy. The characteristics are comparatively rated from 1 to 5 in decreasing order of performance.

Alloy	Product	Fluidity	Resistance to Hot Cracking	Pressure Tightness	Normally Heat Treated	Strength at Elevated Temperatures	Corrosion Resistance	Machinability	Polishing	Anodizing Appearance	Weldability
201.0	S	3	4	3	Yes	1	4	1	1	2	4
204.0	S&P	3	4	3	Yes	1	4	1	2	3	4
208.0	S	2	2	2	Optional	3	4	3	3	3	2
222.0	S&P	3	3	3	Yes	1	4	1	2	3	3
242.0	S&P	3	4	4	Yes	1	4	2	2	3	4
295.0	S	3	4	4	Yes	3	4	2	2	2	3
296.0	P	3	4	3	Yes	2	4	3	2	3	3
308.0	P	2	2	2	No	3	3	3	3	4	2
319.0	S&P	2	2	2	Optional	3	3	3	4	4	2
328.0	S	1	1	2	Optional	2	3	3	3	4	1
332.0	P	1	2	2	Yes	1	3	4	4	4	2
333.0	P	1	2	2	Optional	2	3	3	3	4	3
336.0	P	1	2	2	Yes	1	3	4	4	4	3
354.0	P	1	1	1	Yes	2	3	4	4	4	3
355.0	S&P	1	1	1	Yes	2	3	3	3	4	1
C355.0	S&P	1	1	1	Yes	2	3	3	3	4	1
356.0	S&P	1	1	1	Yes	3	2	3	4	4	1
A356.0	S&P	1	1	1	Yes	3	2	3	4	4	1
357.0	S&P	1	1	1	Yes	3	2	3	4	4	1
A357.0	S&P	1	1	1	Yes	2	2	3	4	4	1
359.0	S&P	1	2	2	Yes	2	2	4	4	4	1
443.0	S&P	1	1	1	No	4	3	5	4	4	1
B443.0	S&P	1	1	1	No	4	2	5	4	4	1
A444.0	P	1	1	1	Optional	4	2	5	4	4	1
512.0	S	3	3	4	No	3	1	2	2	2	3
513.0	P	4	4	4	No	3	1	1	1	1	3
514.0	S	4	4	5	No	3	1	1	1	1	3
520.0	S	4	4	5	Yes	5	1	1	1	1	4
535.0	S	5	4	5	Optional	3	1	1	1	1	4
705.0	S&P	4	4	4	No	4	2	1	2	2	4
707.0	S&P	4	4	4	No	4	2	1	2	2	4
710.0	S	4	5	4	No	4	4	1	2	2	4
711.0	P	4	5	4	Yes	5	2	1	1	1	4
712.0	S	3	5	4	No	4	3	1	2	2	4
713.0	S&P	3	4	4	No	4	3	1	1	1	4
771.0	S	3	4	4	Yes	4	3	1	1	1	4
850.0	S&P	4	5	5	Yes	5	4	1	3	*	5
851.0	S&P	4	5	5	Yes	5	4	1	3	*	5
852.0	S&P	4	5	5	Yes	5	4	1	3	*	5

*Information not available.