4 Aluminum Alloys

Selecting Aluminum Alloys

Aluminum (Al) die casting alloys have a specific gravity of approximately 2.7 g/cc, placing them among the lightweight structural metals. The majority of die castings produced worldwide are made from aluminum alloys.

Six major elements constitute the die cast aluminum alloy system: silicon, copper, magnesium, iron, manganese, and zinc. Each element affects the alloy both independently and interactively.

This aluminum alloy subsection presents guideline tables for chemical composition, typical properties, and die casting, machining and finishing characteristics for 11 aluminum die casting alloys. This data can be used in combination with design engineering tolerancing guidelines for aluminum die casting and can be compared with the guidelines for other alloys in this section and in the design engineering section.

- Alloy A380 (ANSI/AA A380.0) is by far the most widely cast of the aluminum die casting alloys, offering a very good combination of material properties and ease of production. It may be specified for most general purpose product applications. Some of the uses of this alloy include electronic and communications equipment, automotive components, engine brackets, transmission and gear cases, appliances, lawn mower housings, furniture components, hand and power tools.
- Alloy 383 (ANSI/AA 383.0) and alloy 384 (ANSI/AA 384.0) are alternatives to A380 for intricate components requiring improved die filling characteristics. Alloy 383 offers improved resistance to hot cracking (strength at elevated temperatures).
- Alloy A360 (ANSI/AA A360.0) offers higher corrosion resistance, superior strength at elevated temperatures, and somewhat better ductility, but is more difficult to cast.
- Alloy A413 (ANSI/AA A413.0) offers excellent pressure tightness, making it a good choice for hydraulic cylinders and pressure vessels. Its casting characteristics make it useful for intricate components.
- Alloy B390 (ANSI/AA B390.0) was developed for automotive engine blocks. Its resistance to wear is excellent but, its ductility is low. It is used for die cast valve bodies and sleeve-less piston housings.
- Alloy 518 (ANSI/AA 518.0) provides the best combination of strength, ductility, corrosion resistance and finishing qualities, but it is more difficult to die cast.

Different sets of properties can be achieved with alternate processes (such as high vacuum, squeeze, and semi-solid casting) and alternate alloys (such as A356, Aural 2 or 365, and Silafont 36). Information on these processes and alloys can be found in the NADCA Standards for High Integrity and Structural Die Casting Process (NADCA Publication #403) and the High Integrity Die Castings book (NADCA Publication #404).

Machining Characteristics

Machining characteristics vary somewhat among the commercially available aluminum die casting alloys, but the entire group is superior to iron, steel and titanium. The rapid solidification rate associated with the die casting process makes die casting alloys somewhat superior to wrought and gravity cast alloys of similar chemical composition.

Alloy A380 has better than average machining characteristics. Alloy 518, with magnesium the major alloying element, exhibits among the best machinability. Alloy B390, with the highest silicon content and free silicon constituent, exhibits the lowest.

Surface Treatment Systems

Surface treatment systems are applied to aluminum die castings to provide a decorative finish, to form a protective barrier against environmental exposure, and to improve resistance to wear.

Decorative finishes can be applied to aluminum die castings through painting, powder coat finishing, polishing, epoxy finishing, and electro-chemical processing. Aluminum can be plated by applying

Alloy Data

an initial immersion zinc coating, followed by conventional copper-nickel-chromium plating procedure similar to that used for plating zinc metal/alloys.

Protection against environmental corrosion for aluminum die castings is achieved through painting, anodizing, chromating, and iridite coatings.

Improved wear resistance can be achieved with aluminum die castings by hard anodizing.

Where a part design does not allow the production of a pressure-tight die casting through control of porosity by gate and overflow die design, the location of ejector pins, and the reconfiguration of hard-to-cast features, impregnation of aluminum die castings can be used. Systems employing anaerobics and methacrylates are employed to produce sealed, pressure-tight castings with smooth surfaces. A detailed discussion of finishing methods for aluminum die castings can be found in Product Design For Die Casting (NADCA Publication E-606).

Table A-3-1 Chemical Composition: Al Alloys

All single values are maximum composition percentages unless otherwise stated.

	Aluminum Die Casting Alloys Ⓐ Ⓓ									
Common:	360*	A360*	380 Ⓑ	A380 Ⓑ	383	384 Ⓑ	B390	413	A413	518
ANSI/AA	360.0	A360.0	380.0	A380.0	383.0	384.0	B390.0	413.0	A413.0	518.0
Nominal Comp:	Mg 0.5 Si 9.0	Mg 0.5 Si 9.5	Cu 3.5 Si 8.5	Cu 3.5 Si 8.5	Cu 2.5 Si 10.5	Cu 3.8 Si 11.0	Cu 4.5 Si 17.0	Si 12.0	Si 12.0	Mg 8.0
Detailed Composition										
Silicon Si	9.0-10.0	9.0-10.0	7.5-9.5	7.5-9.5	9.5-11.5	10.5-12.0	16.0-18.0	11.0-13.0	11.0-13.0	0.35
Iron Fe	2.0	1.3	2.0	1.3	1.3	1.3	1.3	2.0	1.3	1.8
Copper Cu	0.6	0.6	3.0-4.0	3.0-4.0	2.0-3.0	3.0-4.5	4.0-5.0	1.0	1.0	0.25
Magnesium Mg	0.4-0.6	0.4-0.6	0.30 Ⓔ	0.30 Ⓔ	0.10	0.10	0.45-0.65	0.10	0.10	7.5-8.5
Manganese Mn	0.35	0.35	0.50	0.50	0.50	0.50	0.50	0.35	0.35	0.35
Nickel Ni	0.50	0.50	0.50	0.50	0.30	0.50	0.10	0.50	0.50	0.15
Zinc Zn	0.50	0.50	3.0	3.0	3.0	3.0	1.5	0.50	0.50	0.15
Tin Sn	0.15	0.15	0.35	0.35	0.15	0.35	—	0.15	0.15	0.15
Titanium Ti	—	—	—	—	—	—	0.20	—	—	—
Others Each	—	—	—	—	—	—	0.10	—	—	—
Total Others Ⓒ	0.25	0.25	0.50	0.50	0.50	0.50	0.20	0.25	0.25	0.25
Aluminum Al	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance

Ⓐ Analysis shall ordinarily be made only for the elements mentioned in this table. If, however, the presence of other elements is suspected, or indicated in the course of routine analysis, further analysis shall be made to determine that the total of these other elements are not present in excess of specified limits. Ⓑ With respect to mechanical properties, alloys A380.0, 383.0 and 384.0 are substantially interchangeable. Ⓒ For RoHS (the European Union's Directive on Restriction of Hazardous Substances) compliance, certification of chemical analysis is required to ensure that the "total others" category does not exceed the following weight percent limits: 0.01% cadmium, 0.4% lead, and 0.1% mercury. Hexavalent chromium does not exist in the alloys and therefore meets the 0.1% limit. Ⓓ Registration for REACH (the European Union's Directive on Registration, Evaluation, and Authorization of Chemicals) is not required for die castings, even if coated, since die castings are considered articles. Notification may be required if some contained substances in the die casting or coating exceed the 0.1% total weight of the article level and are listed as SVHC (substances of very high concern). Ⓔ NADCA allows 0.30 maximum magnesium as opposed to 0.10. A380 with 0.30 magnesium has been registered with the Aluminum Association as E380 and 383 with 0.30 magnesium as B383.

** Two other aluminum alloys, 361 and 369, are being utilized in limited applications where vibration and wear are of concern. There are also other heat treatable specialty alloys available for structural applications, such as the Silafonts and AA365, and high ductility, high strength alloys such as Mercalloy and K-Alloy. Contact your alloy producer for more information. Sources: ASTM B85-92a; Aluminum Association.*

Typical values based on "as-cast" characteristics for separately die cast specimens, not specimens cut from production die castings.

Table A-3-2 Typical Material Properties: Al Alloys

	Aluminum Die Casting Alloys									
Common:	360*	A360*	380	A380 ⒺⒻ	383 Ⓔ	384	B390	413	A413	518
ANSI/AA	360.0	A360.0	380.0	A380.0	383.0	384.0	B390.0	413.0	A413.0	518.0
Mechanical Properties										
Ultimate Tensile Strength										
ksi	44	46	46	47	45	48	46	43	42	45
(MPa)	(303)	(317)	(317)	(324)	(310)	(331)	(317)	(296)	(290)	(310)
Yield Strength Ⓐ										
ksi	25	24	23	23	22	24	36	21	19	28
(MPa)	(172)	(165)	(159)	(159)	(152)	(165)	(248)	(145)	(131)	(193)
Elongation										
% in 2in. (51mm)	2.5	3.5	3.5	3.5	3.5	2.5	<1	2.5	3.5	5.0
Hardness Ⓑ										
BHN	75	75	80	80	75	85	120	80	80	80
Shear Strength										
ksi	28	26	28	27	—	29	—	25	25	29
(MPa)	(193)	(179)	(193)	(186)		(200)		(172)	(172)	(200)
Impact Strength Ⓓ										
ft-lb	—	—	3	—	3	—	—	—	—	7
(J)			(4)		(4)					(9)
Fatigue Strength Ⓒ										
ksi	20	18	20	20	21	20	20	19	19	20
(MPa)	(138)	(124)	(138)	(138)	(145)	(138)	(138)	(131)	(131)	(138)
Young's Modulus										
psi x 10^6	10.3	10.3	10.3	10.3	10.3	—	11.8	10.3	—	—
(GPa)	(71)	(71)	(71)	(71)	(71)		(81)	(71)		
Physical Properties										
Density										
lb/in³	0.095	0.095	0.099	0.098	0.099	0.102	0.098	0.096	0.096	0.093
(g/cm³)	(2.63)	(2.63)	(2.74)	(2.71)	(2.74)	(2.82)	(2.71)	(2.66)	(2.66)	(2.57)
Melting Range										
°F	1035-1105	1035-1105	1000-1100	1000-1100	960-1080	960-1080	950-1200	1065-1080	1065-1080	995-1150
(°C)	(557-596)	(557-596)	(540-595)	(540-595)	(516-582)	(516-582)	(510-650)	(574-582)	(574-582)	(535-621)
Specific Heat										
BTU/lb °F	0.230	0.230	0.230	0.230	0.230	—	—	0.230	0.230	—
(J/kg °C)	(963)	(963)	(963)	(963)	(963)			(963)	(963)	
Coefficient of Thermal Expansion										
μ in/in°F	11.6	11.6	12.2	12.1	11.7	11.6	10.0	11.3	11.9	13.4
(μ m/m°K)	(21.0)	(21.0)	(22.0)	(21.8)	(21.1)	(21.0)	(18.0)	(20.4)	(21.6)	(24.1)
Thermal Conductivity										
BTU/ft hr°F	65.3	65.3	55.6	55.6	55.6	55.6	77.4	70.1	70.1	55.6
(W/m °K)	(113)	(113)	(96.2)	(96.2)	(96.2)	(96.2)	(134)	(121)	(121)	(96.2)
Electrical Conductivity										
% IACS	30	29	27	23	23	22	27	31	31	24
Poisson's Ratio	0.33	0.33	0.33	0.33	0.33	—	—	—	—	—

Ⓐ 0.2% offset. Ⓑ 500 kg load, 10mm ball. Ⓒ Rotary Bend 5 x 10^8 cycles. Ⓓ Notched Charpy. Sources: ASTM B85-92a; ASM; SAE; Wabash Alloys. Ⓔ A 0.3% Mg version of A380 and 383 have been registered with the Aluminum Association as E380 and B383. Ⓕ Higher levels of Mg and the addition of Sr to alloy A380 have shown positive results.

** Two other aluminum alloys, 361 and 369, are being utilized in limited applications where vibration and wear are of concern. There are also other heat treatable specialty alloys and processes available for structural applications, such as the Silafonts and AA365 (Aural 2), and high ductility, high strength alloys such as Mercalloy and K-Alloy. Contact your alloy producer for more information. More information can also be obtained from Microstructures and Properties of Aluminum Die Casting Alloys Book, NADCA Publication #215 and the High Integrity Aluminum Die Casting Book, NADCA Publication #307.*

Alloy Data

Die casting alloy selection requires evaluation not only of physical and mechanical properties, and chemical composition, but also of inherent alloy characteristics and their effect on die casting production as well as possible machining and final surface finishing.

This table includes selected die casting and other special characteristics which are usually considered in selecting an aluminum alloy for a specific application.

The characteristics are rated from (1) to (5), (1) being the most desirable and (5) being the least. In applying these ratings, it should be noted that all the alloys have sufficiently good characteristics to be accepted by users and producers of die castings. A rating of (5) in one or more categories would not rule out an alloy if other attributes are particularly favorable, but ratings of (5) may present manufacturing difficulties.

The benefits of consulting a custom die caster experienced in casting the aluminum alloy being considered are clear.

Table A-3-3 Die Casting And Other Characteristics: Al Alloys
(1 = most desirable, 5 = least desirable)

	Aluminum Die Casting Alloys									
Common: ANSI/AA	360* 360.0	A360* A360.0	380 380.0	A380 A380.0	383 383.0	384 384.0	390 B390.0	413 413.0	A413 A413.0	518 518.0
Resistance to Hot Cracking Ⓐ	1	1	2	2	1	2	4	1	1	5
Pressure Tightness	2	2	2	2	2	2	4	1	1	5
Die-Filling Capacity Ⓑ	3	3	2	2	1	1	1	1	1	5
Anti-Soldering to the Die Ⓒ	2	2	1	1	2	2	2	1	1	5
Corrosion Resistance Ⓓ	2	2	4	4	3	5	3	2	2	1
Machining Ease & Quality Ⓔ	3	3	3	3	2	3	5	4	4	3
Polishing Ease & Quality Ⓕ	3	3	3	3	3	3	5	5	5	1
Electroplating Ease & Quality Ⓖ	2	2	1	1	1	2	3	3	3	5
Anodizing (Appearance) Ⓗ	3	3	3	3	3	4	5	5	5	1
Chemical Oxide Protective Coating Ⓘ	3	3	4	4	4	5	5	3	3	1
Strength at Elevated Temp. Ⓙ	1	1	3	3	2	2	3	3	3	4

Ⓐ Ability of alloy to withstand stresses from contraction while cooling through hot-short or brittle temperature ranges. Ⓑ Ability of molten alloy to flow readily in die and fill thin sections. Ⓒ Ability of molten alloy to flow without sticking to the die surfaces. Ratings given for anti-soldering are based on nominal iron compositions of approximately 1%. Ⓓ Based on resistance of alloy in standard type salt spray test. Ⓔ Composite rating based on ease of cutting, chip characteristics, quality of finish, and tool life. Ⓕ Composite rating based on ease and speed of polishing and quality of finish provided by typical polishing procedure. Ⓖ Ability of the die casting to take and hold an electroplate applied by present standard methods. Ⓗ Rated on lightness of color, brightness, and uniformity of clear anodized coating applied in sulphuric acid electrolyte. Ⓘ Rated on combined resistance of coating and prolonged heating at testing temperature. Sources: ASTM B85-92a; ASM; SAE Ⓙ Rating based on tensile and yield strengths at temperatures up to 500F (260C), after prolonged heating at testing temperature. Sources: ASTM B176-93a

** Two other aluminum alloys, 361 & 369, are being utilized in limited applications where vibration and wear are of concern. There are also other heat treatable specialty alloys available for structural applications, such as the Silafonts and AA365, and high ductility, high strength alloys such as Mercalloy and K-Alloy. Contact your alloy producer for more information.*

Note: *Die castings are not usually solution heat treated. Low-temperature aging treatments may be used for stress relief or dimensional stability. A T2 or T5 temper may be given to improve properties. Because of the severe chill rate and ultra-fine grain size in die castings, their "as-cast" structure approaches that of the solution heat-treated condition. T4 and T5 temper results in properties quite similar to those which might be obtained if given a full T6 temper. Die castings are not generally gas or arc welded or brazed.*

Table 3-6 Additional A380 Alloy Tensile Data
(Data is from separately cast specimines in the naturally aged condition)

Alloys	Tensile ksi (MPa)	Yield ksi (MPa)	Elong %
A380 at 0.09% Mg	45.5 (243)	23.8 (135)	2.6
A380 with 0.26% Mg	47.0 (201)	26.6 (183)	2.8
A380 with 0.33% Mg + 0.035% Sr*	45.7 (177)	28.5 (196)	2.4

** Identified as AMC380* in research being conducted by WPI and funded by DoD/DLA. The values in this table are the average mean values and are provided to indicate the effect of a higher magnesium content and additional strontium. The properties shown do not represent design minimums and should be used for reference only.*

Table 3-7: Composition of suggested alloys and company specific alloys as compared to A380

	Composition (%)									
	Si	Cu	Mg	Fe	Mn	Zn	Ni	Ti	Sr	Other
A380	7.5-9.5	3-4	0.1	1.3	0.5	3	0.5	-	-	0.5
High Mg A380	7.5-9.5	3-4	0.5	1.3	0.5	3	0.5	-	-	0.5
F380	8.5-9.5	3-4	0.1-0.3	0.4	0.25-0.35	1	0.1	-	0.05-0.07	0.5
B360	9.0-10.0	0.25	0.4-0.6	0.4	0.25-0.35	0.5	0.1	-	0.05-0.07	0.25
Gibbsalloy MN	0.1-0.3	0.1	2.6-3.7	0.2-0.5	0.4-1.0	0.05	-	0.03-0.07	-	0.5

Table 3-8: Tensile properties of separately die cast specimens of the suggested and company specific alloys compared to separately die cast specimens of alloy A380.

Alloy	UTS (ksi)	UTS (MPa)	YS (ksi)	YS (MPa)	e (%)
A380	47.0	324	23.0	159	3.5
Hi Mg 380	45.8	316	27.2	188	3.0
Hi Mg 380-T5	46.7	322	39.3	271	1.2
F380	46.1	318	23.4	161	5.0
F380-T5	48.4	334	31.4	216	3.3
F380-T6	61.0	421	49.0	338	2.9
B360	46.6	321	23.5	162	6.1
B360-T4	38.0	262	18.0	124	15.0
B360-T5	52.0	359	37.1	256	3.6
B360-T6	53.0	434	41.0	283	5.8
B360-T7	29.0	200	18.0	124	11.0
Gibbsalloy MN	30.6	211	15.9	110	12.1
Gibbsalloy MN-T5	32.5	224	18.5	128	11.7

Note: *This data was developed through research sponsored by NADCA and funded by DOD/DLA and NADCA. The properties shown do not represent design minimums and should be used for reference only.*

Table 3-9: Tensile Properties of as-cast specimens removed from castings

Alloy	UTS (ksi)	UTS (MPa)	YS (ksi)	YS (MPa)	e (%)
A380	31.4	216	19.5	134	3.9
E380	31.9	220	24.4	168	2.9
F380	35.6	244	24.0	165	2.6
B360	35.9	248	30.6	211	6

Note: *This data was developed through research sponsored by NADCA and funded by DOD/DLA and NADCA. The properties shown do not represent design minimums and should be used for reference only.*

Table 3-10: Tensile Properties of heat treated specimens removed from castings

Alloy	UTS (ksi)	UTS (MPa)	YS (ksi)	YS (MPa)	e (%)
T5					
E380	37.1	256	36.7	253	1.0
F380	35.4	244	33.1	228	1.4
B360	40.8	281	27.6	190	5.1
T6					
E380	42.3	292	40.3	278	2.0
B360	35.3	243	24.5	169	7.9

Note: *This data was developed through research sponsored by NADCA and funded by DOD/DLA and NADCA. The properties shown do not represent design minimums and should be used for reference only.*

5 Aluminum Metal Matrix Composites

Selecting Aluminum Composites

Aluminum metal matrix composites (MMC) are aluminum-based alloys reinforced with up to 20% silicon carbide (SiC) particles, which are now being used for high-performance die cast components.

The mechanical properties of ASTM test specimens made from these materials typically exceed those of most aluminum, magnesium, zinc and bronze components produced by die casting, and match or approach many of the characteristics of iron castings and steel at lighter weight.

The expected properties of MMC parts are higher stiffness and thermal conductivity, improved wear resistance, lower coefficient of thermal expansion, and higher tensile and fatigue strengths at elevated temperature, with densities within 5% of aluminum die casting alloys. These composites can also yield castings with reduced porosity.

Preliminary data also indicates that less vibrational noise is generated by parts made from these composites, under certain conditions, than by identical parts made from unreinforced aluminum.

Duralcan F3D.10%v/v and 20%v/v aluminum metal matrix composites reinforced with SiC ceramic powder are general purpose die casting alloys.

Duralcan F3N.10%v/v and 20%v/v aluminum metal matrix composites reinforced with SiC ceramic powder contain virtually no copper or nickel and are designed for use in corrosion sensitive applications. All of these composites are heat treatable.

Machining Characteristics

Al-MMCs are significantly more abrasive to cutting tools than all other aluminum die cast and gravity cast alloys, except for hypereutectic Al-Si alloys (those containing primary Si phases).

Coarse grades of polycrystalline diamond (PCD) tools are recommended for anything more than prototype quantities of machining.

With the proper tooling, Al-MMC can be readily turned, milled, or drilled. However, cutting speeds are lower and feed rates are higher than for unreinforced alloys. General machining guidelines are described in Volume 1 of the SME Tool & Manufacturing Engineers Handbook.

Surface Treatment Systems

Surface treatments are generally applied to aluminum MMC to provide a protective barrier to environmental exposure, to provide decorative finish, or to reduce the abrasiveness of the MMC to a counterface material. Because of the inherently high wear resistance of the Al-MMCs, surface treatments on these materials are generally not used to improve their wear resistance.

Decorative finishes can be applied by painting, powder coat finishing, epoxy finishing and plating, using procedures similar to those used for conventional aluminum alloys.

Although conventional and hard-coat anodized finishes can be applied to Al-MMC die castings, the results are not as cosmetically appealing as for conventional aluminum. The presence of the SiC particles results in a darker, more mottled appearance. This problem can be minimized, although not entirely eliminated, by using the darker, more intensely colored dyes to color the anodic coatings. Another problem often noted is that the presence of the ceramic particles produces a rougher surface, particularly after chemical etching. This, in turn, leads to a less lustrous anodic coating than usually seen with unreinforced aluminum.

Recommended procedures for painting, plating and anodizing Duralcan MMCs can be obtained through Rio Tinto Alcan, 2040 Chemin de la Reserve, Chicoutimi (Quebec) G7H 5B3, Canada.

This aluminum composite subsection presents guideline tables for chemical composition, typical properties, and die casting and other characteristics for the two families of aluminum matrix composite alloys for die casting. Design engineering tolerancing guidelines have yet to be developed.

Rio Tinto Alcan - Dubuc Works, produces Duralcan metal matrix composites for die casting using a patented process and proprietary technology, mixing ceramic powder into molten aluminum. Further technical and application information can be obtained from Rio Tinto Alcan, 2040 Chemin de la Reserve, Chicoutimi (Quebec) G7H 5B3, Canada.

Table A-3-4 Chemical Composition: Al-MMC Alloys

	Duralcan Aluminum Metal Matrix Composite Alloys Ⓑ			
Commercial:	F3D.10S-F	F3D.20S-F	F3N.10S-F	F3N.20S-F
Detailed Composition				
SiC Particulate Volume Percent	10%	20%	10%	20%
Silicon Si	9.50-10.50	9.50-10.50	9.50-10.50	9.50-10.50
Iron Fe	0.8-1.20	0.8-1.20	0.8-1.20	0.8-1.20
Copper Cu	3.0-0.50	3.0-3.50	0.20 max.	0.20 max.
Magnesium Mg	0.30-0.50	0.30-0.50	0.50-0.70	0.50-0.70
Manganese Mn	0.50-0.80	0.50-0.80	0.50-0.80	0.50-0.80
Nickel Ni	1.00-1.50	1.00-1.50	—	—
Titanium Ti	0.05 max.	0.20 max.	0.20 max.	0.20 max.
Zinc Zn	0.05 max.	0.05 max.	0.05 max.	0.05 max.
Total Others Ⓐ	0.10 Total 0.03 max.	0.10 Total 0.03 max.	0.10 Total 0.03 max.	0.10 Total 0.03 max.
Aluminum Al	Balance	Balance	Balance	Balance

Ⓐ For RoHS (the European Union's Directive on Restriction of Hazardous Substances) compliance, certification of chemical analysis is required to ensure that the "total others" category does not exceed the following weight percent limits: 0.01% cadmium, 0.4% lead, and 0.1% mercury. Hexavalent chromium does not exist in the alloys and therefore meets the 0.1% limit. Ⓑ Registration for REACH (the European Union's Directive on Registration, Evaluation, and Authorization of Chemicals) is not required for die castings, even if coated, since die castings are considered articles. Notification may be required if some contained substances in the die casting or coating exceed the 0.1% total weight of the article level and are listed as SVHC (substances of very high concern).
Source: Rio Tinto Alcan Dubuc Works

Alloy Data

Table A-3-5 Typical Material Properties: Al-MMC Alloys
Typical values based on "as-cast" characteristics for separately die cast specimens, not specimens cut from production die castings.

	Duralcan Aluminum Metal Matrix Composite Alloys			
Commercial:	F3D.10S-F	F3D.20S-F	F3N.10S-F	F3N.20S-F
Mechanical Properties				
Ultimate Tensile Strength Ⓐ ksi (MPa)	50 (345)	51 (352)	45 (310)	44 (303)
Yield Strength Ⓐ ksi (MPa)	35 (241)	44 (303)	32 (221)	36 (248)
Elongation Ⓐ % in 2in. (51mm)	1.2	0.4	0.9	0.5
Rockwell Hardness Ⓐ HRB	77	82	56	73
Impact Energy Ⓑ Charpy impact ASTM E-23 (J)	1.9	0.7	1.4	0.7
Fatigue Strength Ⓒ ksi (MPa)	22 (152)	22 (152)	—	—
Elastic Modulus Ⓐ psi x 10^6 (GPa)	10.3 (71)	10.3 (71)	20 (140)	15.7 (108.2)
Physical Properties				
Density lb/in^3 (g/cm^3)	0.0997 (2.76)	0.1019 (2.82)	0.0957 (2.65)	0.0979 (2.71)
Melting Range ˚F (˚C)	975-1060 (524-571)	975-1060 (524-571)	1067-1112 (575-600)	1067-1112 (575-600)
Specific Heat BTU/lb ˚F @ 77 ˚F (J/kg ˚C @ 22 ˚C)	0.201 (841.5)	0.198 (829.0)	0.208 (870.9)	0.193 (808.1)
Average Coefficient of Thermal Expansion μ in/in˚F (μ m/m˚K)	10.7 (19.3)	9.4 (16.9)	11.9 (21.4)	9.2 (16.6)
Thermal Conductivity BTU/ft hr˚F @ 72 ˚F (W/m ˚K @ 22 ˚C)	71.6 (123.9)	83.2 (144.0)	93.0 (161.0)	97.1 (168.1)
Electrical Conductivity % IACS @ 22 ˚C	22.0	20.5	32.7	24.7
Poisson's Ratio	0.296	0.287	—	0.293

Ⓐ *Based on cast-to-size tensile bars.* Ⓑ *Cast-to-size test specimens.* Ⓒ *Axial fatigue, R=0.1, RT (room temperature), 1 x 107 cycles. Source: Alcan ECP Canada*

Alloy Data

Die casting alloy selection requires evaluation not only of physical and mechanical properties, and chemical composition, but also of inherent alloy characteristics and their effect on die casting production as well as possible machining and final surface finishing.

This table includes selected die casting and other special characteristics which are usually considered in selecting an aluminum matrix alloy for a specific application.

The characteristics are rated from (1) to (5), (1) being the most desirable and (5) being the least. In applying these ratings, it should be noted that all the alloys have sufficiently good characteristics to be accepted by users and producers of die castings. A rating of (5) in one or more categories would not rule out an alloy if other attributes are particularly favorable, but ratings of (5) may present manufacturing difficulties.

The benefits of consulting a custom die caster experienced in casting the aluminum matrix alloy being considered are clear.

Table A-3-6 Die Casting and Other Characteristics: Al-MMC Alloys
(1 = most desirable, 5 = least desirable)

	Duralcan Aluminum Metal Matrix Composite Alloys			
Commercial: ANSI/AA	F3D.10S-F	F3D.20S-F	F3N.10S-F	F3N.20S-F
Resistance to Hot Cracking Ⓐ	1	1	1	1
Die-Filling Capacity Ⓑ	1	1	1	1
Anti-Soldering to the Die Ⓒ	3	3	2	2
Pressure Tightness	2	2	2	2
Corrosion Resistance Ⓓ	5	5	3	3
Machining Ease & Quality Ⓔ	4	4	4	4
Polishing Ease & Quality Ⓕ	5	5	5	5
Electroplating Ease & Quality Ⓖ	2	2	2	2
Anodizing (Appearance) Ⓗ	4	4	4	4
Anodizing (Protection)	5	5	4	4
Strength at Elevated Temp. Ⓘ	1	1	1	1
Resistance to Wear	1	1	1	1

Ⓐ Ability of alloy to withstand stresses from contraction while cooling through hot-short or brittle temperature range. Ⓑ Ability of molten alloy to flow readily in die and fill thin sections. Ⓒ Ability of molten alloy to flow without sticking to the die surfaces. Ⓓ Based on resistance of alloy in standard type salt spray test. Ⓔ Composite rating based on ease of cutting, ship characteristics, quality of finish, and tool life. Ⓕ Composite rating based on ease and speed of polishing and quality of finish provided by typical polishing procedures. Ⓖ Ability of the die casting to take and hold an electroplate applied by present standard methods. Ⓗ Rated on lightness of color, brightness, and uniformity of clear anodized coating applied in sulphuric acid electrolyte. Generally aluminum die castings are unsuitable for light color anodizing where pleasing appearance is required. Ⓘ Rating based on tensile and yield strengths at temperatures up to 500 °F (260 °C), after prolonged heating at testing temperatures. Source: Alcan ECP Canada

Note: *There are additional metal matrix composites materials being developed. These include Aluminum and Magnesium matrix composites and nano-composites are being produced by means of SHS (Self-propagating high-temperature synthesis) technology under NADCA sponsored research projects. Contact the NADCA Technology Department for more information about these composite materials.*