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Technical data sheets for heat treated aluminium high pressure die castings

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Contents:

Page
2. Copyright and disclaimer
2. Important information about this document
3. Contents and data sheet page references
4. Summary
5. Introduction to Heat Treatment of High Pressure Die Castings
8. Conversions between SI and imperial units
8. Related publications and further reading
9. HPDC alloys Strength : Hardness Correlations
10. Method to Estimate Cost Savings

Data Sheets

11.	(US)	A380-F and B380-F	(incl. EN AC AlSi8Cu3Fe)
12.	(US)	A380-T4 and B380-T4	(incl. EN AC AlSi8Cu3Fe)
13.	(US)	A380-T6 and B380-T6	(incl. EN AC AlSi8Cu3Fe)
14.	(US)	A380-T7 and B380-T7	(incl. EN AC AlSi8Cu3Fe)
15.	(US)	A380-T64 and B380-T64	(incl. EN AC AlSi8Cu3Fe)
16.	(US)	C380-F and D380-F	(incl. EN AC AlSi8Cu3Fe)
17.	(US)	C380-T4 and D380-T4	(incl. EN AC AlSi8Cu3Fe)
18.	(US)	C380-T6 and D380-T6	(incl. EN AC AlSi8Cu3Fe)
19.	(US)	C380-T64 and D380-T64	(incl. EN AC AlSi8Cu3Fe)
20.	(JIS)	ADC10-F	(incl. EN AC AlSi9Cu3Fe)
21.	(JIS)	ADC10-T4	(incl. EN AC AlSi9Cu3Fe)
22.	(JIS)	ADC10-T6	(incl. EN AC AlSi9Cu3Fe)
23.	(JIS)	ADC12-F	(incl. US A383)
24.	(JIS)	ADC12-T4	(incl. US A383)
25.	(JIS)	ADC12-T6	(incl. US A383)
26.	(US)	A360-F	(incl. EN AC AlSi10Mg & JIS ADC3)
27.	(US)	A360-T4	(incl. EN AC AlSi10Mg & JIS ADC3)
28.	(US)	A360-T6	(incl. EN AC AlSi10Mg & JIS ADC3)
29.	(US)	A360-T64	(incl. EN AC AlSi10Mg & JIS ADC3)
30.	(CIS)	AK9-F	(AlSi9)
31.	(CIS)	AK9-T4	(AlSi9)
32.	(CIS)	AK9-T6	(AlSi9)
33.	(CIS)	AK9M2-F	(AlSi9Cu2)
34.	(CIS)	AK9M2-T4	(AlSi9Cu2)
35.	(CIS)	AK9M2-T6	(AlSi9Cu2)

Summary

High pressure die castings made from aluminium alloys cannot normally be heat treated because they contain pores which expand to cause surface blistering and dimensional change in components. Recent work has revealed a method by which heat treatment is now possible, resulting in significant improvements in the properties of these alloys that respond to age hardening. Tensile properties, fatigue resistance, fracture resistance and thermal heat transfer may all be improved by heat treatment. This document provides an introduction to the heat treatment of high pressure diecastings, followed by technical data sheets of test results for properties of different alloys in various tempers. Data sheets for as-cast properties of each alloy tested are also provided for comparison purposes.

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Introduction to Heat Treatment of Aluminium High Pressure Diecastings

High pressure die-casting (HPDC) is widely used as a cost effective way to mass produce metal components that are required to have close dimensional tolerances and smooth surface finishes. Standard HPDC components cannot however be conventionally heat treated to improve mechanical properties because the castings are relatively porous. During conventional solution treatment (e.g. at 500°C for 8h), the pores expand resulting in the unacceptable surface blisters, distortion and lower mechanical properties.

Recent work within the CSIRO Light Metals Flagship[1] in Australia has revealed a heat treatment cycle for HPDC aluminium alloys that avoids these problems. As a result, large improvements in tensile properties have been achieved as compared with the as-cast condition. In general, the 0.2% proof stress may be approximately doubled when compared to the as-cast condition, although the actual properties that result depend on the alloy, the part geometry, wall thickness, its quality and the exact procedures utilized.

Some HPDC aluminium alloys from various countries or regions which are capable of responding to heat treatment are shown in Table 1.

Table 1

Alloy / w%	Si	Fe	Cu	Mn	Mg	Ni	Zn	Pb	Sn	Ti	Other total
CA313 (Aus)*	7.5-9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.3	Max 0.5	Max 3	Max 0.35	Max 0.25	Max 0.2	Max 0.2
A380 (US)	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3		Max 0.35		Max 0.5
C380 (US)	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	0.1-0.3	Max 0.5	Max 3		Max 0.35		Max 0.5
A383 (US)	9.5-11.5	Max 1.3	2.0-3.0	Max 0.5	0.1-0.3	Max 0.5	Max 3		Max 0.15		Max 0.5
383 (US)	9.5-11.5	Max 1.3	2.0-3.0	Max 0.5	Max 0.1	Max 0.5	Max 3		Max 0.15		Max 0.5
A384 (US)	10.5-12	Max 1.3	3.0-4.5	Max 0.5	Max 0.1	Max 0.5	Max 1		Max 0.35		Max 0.5
B384 (US)	10.5-12	Max 1.3	3.0-4.5	Max 0.5	0.1-0.3	Max 0.5	Max 1		Max 0.35		Max 0.5
390 (US)	16-18	Max 1.3	4 - 5	Max 0.5	0.45-0.65	Max 0.1	Max 1.5			Max 0.1	Max 0.2
ADC10 (JIS)	7.5 - 9.5	Max 1.3	2.0-4.0	Max 0.5	Max 0.3	Max 0.5	Max 1		Max 0.3		
ADC12 (JIS)	10.5-12.5	Max 1.3	1.5-3.5	Max 0.5	Max 0.3	Max 0.5	Max 1		Max 0.3		
AlSi8Cu3(Fe) (ISO)	7.5-9.5	Max 1.3	2.5-4.0	Max 0.6	Max 0.3	Max 0.5	Max 1.2	Max 0.3	Max 0.2	Max 0.2	Max 0.5 (each)
AlSi9Cu3(Fe) (DIN 226)	8.0-11.0	Max 1.2	2.0-3.5	0.1-0.5	0.1-0.5	Max 0.3	Max 1.2	Max 0.2	Max 0.1	Max 0.15	Max 0.15
SC84R (Canada)	7.5 - 9.5	0.7-1.2	3.0-4.0	Max 0.5	0.45-0.75		0.7-1.2			Max0.1	Max 0.15
LM2 (UK)	9-11.5	Max 1.0	0.7-2.5	Max 0.5	Max 0.3	Max 0.5	Max 2	Max 0.3	max 0.2	Max 0.2	Max 0.05
A360 (US)	9.0-10.0	Max 1.3	Max 0.6	Max 0.35	0.4 - 0.6	Max 0.5	Max 0.5		Max 0.15		Max 0.25
AlSi10Mg (DIN 239B)	9-11	Max 0.8	Max 0.8	Max 0.4	0.2-0.5		Max 0.1			Max 0.15	Max 0.15
AK9 (CIS)	8-11	Max 0.8	Max 1	0.2-0.5	0.2-0.8	Max 0.5	Max 0.5				Max 2.4
AK9M2 (CIS)	7.5-10	Max 0.9	0.5-2.0	0.1-0.4	0.2-0.8	Max 0.5	Max 1.2	Pb+Sn 0.3 Max		0.05-0.2	Max 2.5

* May contain up to 0.1Cr

[1] Patent Pending PCT / 2005 / 001909

The following outline briefly describes the procedures recommended for successful heat treatment of conventionally produced HPDC alloys that avoids problems with blistering or dimensional instability. Compared to conventional heat-treatments, these procedures involve a severely truncated solution treatment stage at lower than normal temperatures to avoid blistering, and involves multiple microstructural changes that occur simultaneously. Due to the unique microstructure generated by the high pressure die casting process, these procedures are sufficient to attain at least a partial solid solution of alloying elements so that strengthening by heat treatment is facilitated.

CSIRO has found that the optimal procedures for the heat treatment of some alloys are as shown in Table 2 below.

Table 2.

Alloy	**Optimal Solution Treatment**	**Quench**	**Ageing T6 temper**	**Ageing T4 temper**
All alloys	480-505°C. Note that the time between 420°C and the maximum temperature ideally should not exceed 10 minutes (E.g. 15 minutes total immersion)	Hot or cold water (No quench sensitivity has been detected);	150°C 16-24h, (best) 180°C 2.5-4h may be preferred for some alloys.	>20°C for 4 days minimum (stabilized condition)

Limitations and part quality

Properties achieved in a particular cast product will depend on the casting quality which in turn depends on the casting process, the die design and other factors. Technical data of the type contained in these date sheets is often derived from simple castings, e.g. test bars. Readers are advised to consider the effects of factors such as defect size and location, casting wall thickness, die design, machine and die process parameters, grain size and alloy composition on the actual properties which may be achieved in practice. A number of these factors may introduce variability of the properties between nominally identical castings.

Mechanical properties derived from test bars cast for the purpose, or taken from complex castings are normally used to compare properties more generally, but pedantically, they are applicable only for the bars tested. The results presented in this publication are means from at least 5 test results, and the source of the results is generally identified.

Application of the procedures to industrial parts is not as straight forward as it is for simple test bars, because of the above factors. However, provided parts have normally acceptable levels of porosity as viewed, for example, by x-ray radiography, the procedures listed in Table 2 should provide close to the optimum properties. For parts containing higher levels of porosity, or where blistering is found to be a particular problem in initial trials, the maximum solution treatment temperature can be reduced to as low as 430°C. Usually, this will still usually produce around 50% increase in yield strength (0.2% offset) compared to the as-cast condition in all alloys, except for the low-Cu alloys such as A360, for which the solution treatment temperature should not be reduced below about 470°C.

Note: Heat treatment should not be used as a remedy for inferior castings containing severe casting defects.

Other tempers

In addition to the T4 and T6 tempers mentioned above, another option is the T7 temper that involves overageing at temperatures such as 180°C for 16h, or 200°C for 2-4 hours. This condition may produce optimal thermal stability at elevated temperatures and thermal conductivity is also maximized. Tensile properties will however be reduced as compared to the T6 condition.

Another alternate is the T64 temper, wherein the alloy is underaged to produce a partial T6 temper (e.g. 6h at 150°C). Although peak hardness and strength properties are slightly reduced compared to the peak aged T6 temper (e.g. by 10-15%), the fracture resistance is typically much higher.

References

Details of the scientific background leading to these developments may be obtained by referring to the publications listed on the following page. For specific information on alloys, applications, heat treatment processes, or industrial implementation, contact the author at the address listed on the title page.

Data sheets of mechanical properties

The associated technical data sheets have been compiled from data gained from CSIRO research. For ease of reference and comparison, properties for the as-cast state (Temper F) as well as the heat treated conditions are provided in separate date sheets for each alloy.

Conversions Between SI and Imperial Units:

1KSI = 0.14505 MPa; 1MPa = 6.894 KSI
1 in-lb/in^2 = 0.1751271 KJ/m^2 1KJ/m^2 = 5.71 in-lb/in^2
1KSI√in = 1.0989 MPa√m 1MPa√m=0.91004 KSI√in
1BTU (thermo)(hr^{-1}ft^{-2}F^{-1}) =0.1441314 W/m.K 1W/m.K=6.93811 BTU(thermo) (hr^{-1}ft^{-2}F^{-1})

Related publications and further reading

1. R.N. Lumley, R.G. O'Donnell, D.R. Gunasegaram, M. Givord, International Patent Application, Heat Treatment of High Pressure Diecasting Alloys, PCT / 2005 / 001909.

2. R.N. Lumley, R.G. O'Donnell, D.R. Gunasegaram, M. Givord, Heat treatment of high pressure diecastings, Metallurgical and Materials Transactions A, 2007, 38a, 2564-2574.

3. R.N. Lumley, R.G. O'Donnell, D.R. Gunasegaram, M. Givord, Development of heat treatments to strengthen high pressure diecastings, International Foundry Research / Giessereiforschung, 59, #3, p.8-13, 2007.

4. R.N. Lumley, R.G. O'Donnell, D.R. Gunasegaram, M. Givord, Blister free heat treatment of high pressure diecasting alloys, Materials Science Forum vols. 519-522, p.351-359, 2006.

5. R.N. Lumley, R.G. O'Donnell, D.R. Gunasegaram, M. Givord, Heat treatment of high pressure diecastings, Die Casting Bulletin, #97, p.10-18, 2006.

6. R.N. Lumley, R.G. O'Donnell, D.R Gunasegaram, M. Givord., New Heat Treatment for High Pressure Diecastings, Heat Treating Progress magazine, September/October 2006, p.31-37, *reproduced as* "The development of heat treatment procedures for aluminium high pressure diecastings"., in 13th ADCA conference proceedings 2006, Melbourne, Australia, P25.

7. R.N. Lumley, S. Tartaglia, A new heat treatment process for aluminium high pressure diecastings – development of procedures for industrially produced components, conf. proc. 111th metalcasting congress, NADCA, 2007, T07-023.

8. R.N. Lumley, D.R. Gunasegaram, M. Gershenzon, R.G. O'Donnell, conf. proc 111th metalcasting congress, The effect of alloy composition on the heat treatment of aluminium high pressure diecastings, NADCA, 2007, T07-013.

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11. R.N. Lumley, I.J. Polmear, H. Groot, J. Ferrier, "Thermal Characteristics of Heat Treated Aluminum High Pressure Die-Castings" Scripta Materialia, in press, 2008

12. R.N. Lumley, A Preliminary Evaluation on the Fracture Toughness of Heat Treated Aluminium High Pressure Diecastings., Conf. Proc. Structural Integrity and Failure 2008, Advanced Materials Research, in press 2008.

13. R.N. Lumley, J.R. Griffiths, Fatigue Resistance of Heat Treated Aluminium High Pressure Die-castings, Conf. Proc. Structural Integrity and Failure 2008, Advanced Materials Research, in press 2008.

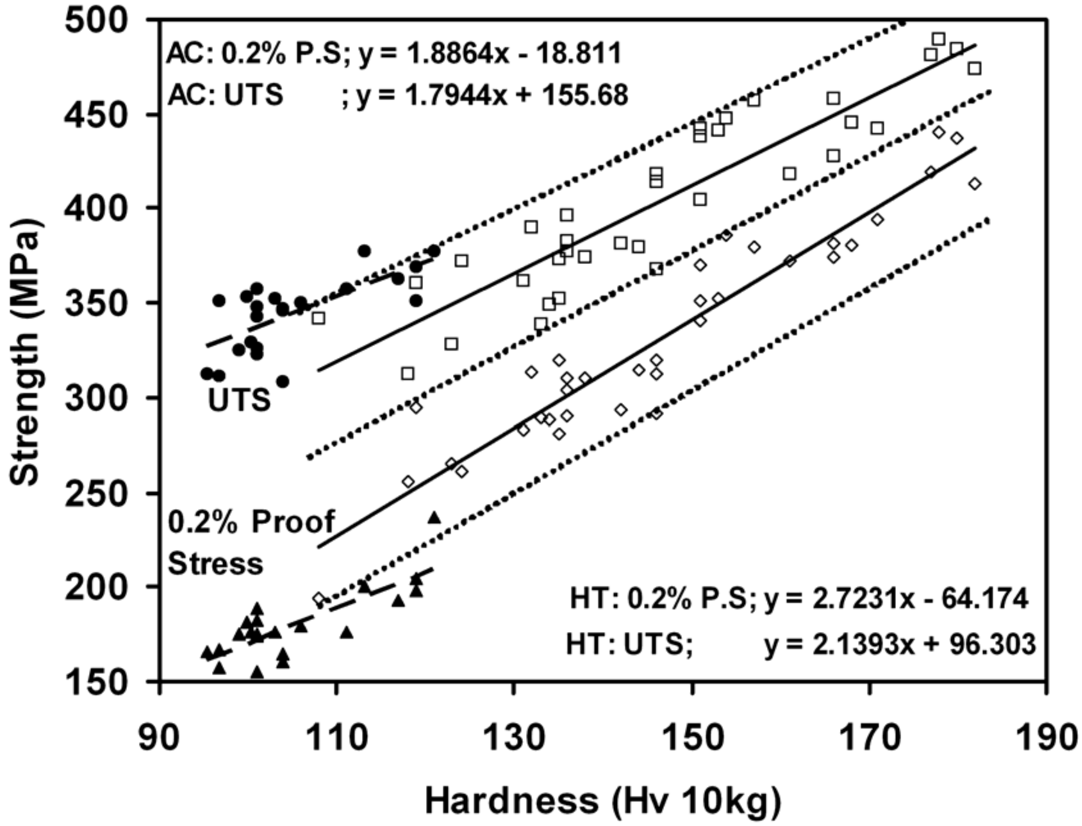
14. R.N. Lumley, I.J. Polmear, P.R. Curtis, A.C. Yob, M. Gershenzon, D.R. Gunasegaram, R.G. O'Donnell, Rapid Heat Treatment of Aluminum High Pressure Diecastings, NADCA 2008, in press.

15. R.N. Lumley, J.R. Griffiths, Fatigue and Fracture Resistance of Heat Treated Aluminium High Pressure Die-castings, NADCA 2008, in press.

HPDC alloys Strength : Hardness correlations

In general terms, the tensile properties and hardness in HPDC aluminium alloys are linearly related. For many products it is not possible, or cost effective, to regularly machine tensile samples from castings and it is often more appropriate to use hardness as a measure of properties. The following figure has been derived from CSIRO testing of over 20 different alloy compositions that have been heat treated using a variety of procedures.

Each data point represents the average of 5 or more tensile tests and 3 or more hardness tests. As cast values (AC) are shown as solid symbols, heat treated (HT) as open symbols. Predictive lines of best fit and ranges are shown (dotted) in the plot.



Note:
Brinell Hardness HB 500kg (10mm ball) = 0.807 (Hv 10kg) +9.1753

A Method to Estimate Cost Savings

The ability to produce higher strength HPDC parts by heat treatment may allow significant weight reduction and hence cost reduction to be achieved through redesign. Alternately, replacement of more expensive permanent mold or sand cast components, for example, will also lead to cost reduction. An evaluation of cost savings afforded by using higher strength, lower weight HPDC parts may be made by using a series of calculations that allow for the comparison of different materials and processing routes for the same component, as shown by equation 1♣:

$$\Delta Q_{metal} = \frac{1}{u}\left[\frac{\Delta P}{\left(\frac{Wo}{Wc}-1\right)} - Po\right] \qquad (1)$$

Where

ΔQ_{metal}= cost difference per (lb or kg) of weight saved;

u is the materials utilization (ratio between weight of the part and the weight of the purchased material required to produce the part)

ΔP is the difference in price per (lb or kg) between the candidate and the baseline material,

Wo is the weight of the baseline part

Wc is the weight of the candidate part

Po is the price per (lb or kg) of the baseline material.

The above calculations do not take into account other savings in production costs. When the metal required for each part is reduced, additional advantages arise from a combination of reduced cycle times, consumable use, capital and tooling costs. Cycle time alone and its consequent effects on labour, consumables and capital cost can account for 15-20% of total component cost in production and therefore the potential savings or cost of the final part may be adjusted accordingly. The overall reduction in production costs ΔQ achieved by using less metal in a heat treated HPDC may then be given by:

$$\Delta Q_{production} = \left[\frac{((\Gamma \times Wc \times Po) + (\Delta P \times Wc)) - (\Gamma \times Wo \times Po)}{(Wo - Wc)}\right] \qquad (2)$$

(i.e. The cost to produce the new lower weight heat treated part, minus the cost to produce the original part, all divided by the weight difference)

Where terms W, P and Q are as for equation 1 above, and Γ is a "production factor", which is a descriptor giving the production cost of the part as a simple multiplier of base metal cost (i.e. production cost = Γ × metal cost). In the case of equation 2, *u* from equation 1 is incorporated in the Γ term. The value of Γ will vary between different parts and different production facilities, so will be known or able to be determined on a case by case basis. Fewer, or small complex parts will typically mean higher values of Γ, whereas large, simple parts in high production runs may have lower values. As may be appreciated, the higher the production factor, Γ, the higher is the predicted cost reduction per kg of weight saved by heat treatment.

♣ Adapted from: **E.A. Starke & J.T. Staley, *Prog. Aerospace. Sci.* 1996, 32, 131-172**

Technical data sheet

HPDC alloy A380 and B380 in the as-cast (F) condition

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3	Max 0.35	Max 0.5

Note B380 alloy has 1Zn max

Applications: Diverse applications across a range of industrial and consumer products. The automotive sector dominates usage of HPDC alloy A380.

Hardness

Vickers Hardness Number (VHN)	90-110
Brinell 500kg-10mm (estimated from VHN)	80-98

Tensile properties[A]

Yield stress, 0.2% offset:	160-180 MPa
Tensile strength:	320-370 MPa
Elongation:	3-4% typical
Elastic modulus:	71 GPa

Strength at elevated temperature:

0.2% proof stress at 150°C	180 MPa[F]
0.2% proof stress at 200°C	167 MPa[F]

Thermal properties

Thermal conductivity at 23°C:	111 W/m.K
50°C	116 W/m.K
100°C	123 W/m.K
150°C	136 W/m.K

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	205 MPa

Fracture properties[D]

Tear strength	218 MPa
Notch sensitivity index (TYR)[E]	1.15
Unit total energy	17.6 KJ/m^2
Unit propagation energy	6.46 KJ/m^2
Fracture toughness K_c [D],	31.3 MPa√m

Other

Heat treatment: none

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.
F. Test alloy had a 0.2% proof stress at 25°C of 172 MPa.

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Technical data sheet

HPDC alloy A380 and B380 in the T4 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3	Max 0.35	Max 0.5

Note B380 alloy has 1Zn max

Potential applications: Where increased ductility, fracture resistance and tensile properties are required above the as-cast condition. Applications below 60°C. Above 60°C, additional strengthening results.

Hardness

Vickers Hardness Number (VHN)	120-130
Brinell 500kg-10mm (estimated from VHN)	106-114

Tensile properties[A]

Yield stress, 0.2% offset:	200-240 MPa
Tensile strength:	380-410 MPa
Elongation:	6% typical
Elastic modulus:	71 GPa

Thermal properties

Thermal conductivity at 23°C:	120 W/m.K

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	240 MPa

Fracture properties[D]

Tear strength	311 MPa
Notch sensitivity index (TYR)[E]	1.34
Unit total energy	32.5 KJ/m^2
Unit propagation energy	12.4 KJ/m^2
Fracture toughness K_c [D],	41 MPa√m

Corrosion resistance, Better than A380-F

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

Technical data sheet

HPDC alloy A380 and B380-in the T6 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3	Max 0.35	Max 0.5

Note B380 has 1Zn max

Potential applications: Where high strength above the as-cast condition is required. Similar applications to heat treated permanent mold, sand cast aluminium.

Hardness

Vickers Hardness Number (VHN)	145-160
Brinell 500kg-10mm (estimated from VHN)	127-138

Tensile properties[A]

Yield stress, 0.2% offset:	340-380 MPa
Tensile strength:	430-460 MPa
Elongation:	3% typical
Elastic modulus:	71 GPa

Strength at elevated temperature:

0.2% proof stress at 150°C	340 MPa[F]
0.2% proof stress at 200°C	320 MPa[F]

Thermal properties

Thermal conductivity at 23°C:	129 W/m.K
50°C	133 W/m.K
100°C	141 W/m.K
150°C	146 W/m.K

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	260 MPa

Fracture properties[D]

Tear strength	233 MPa
Notch sensitivity index (TYR)[E]	0.67
Unit total energy	11.9 KJ/m^2
Unit propagation energy	2 KJ/m^2

Fracture toughness K_c [D], 21 MPa√m

Corrosion resistance, Similar to A380-F

Other:

Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.
F. Test alloy had a 0.2% proof stress at 25°C of 340 MPa.

Technical data sheet

HPDC alloy A380 and B380 in the T7 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3	Max 0.35	Max 0.5

Note B380 has 1Zn max

Potential applications: Where high strength above the as-cast condition is required. Similar applications to heat treated permanent mold, sand cast aluminium. Good high temperature strength, stability and thermal conductivity up to 200°C.

Hardness

Vickers Hardness Number (VHN)	120-130
Brinell 500kg-10mm (estimated from VHN)	106-114

Tensile properties[A]

Yield stress, 0.2% offset:	250-300 MPa[G]
Tensile strength:	360-400 MPa
Elongation:	3.5% typical
Elastic modulus:	71 GPa
Strength at elevated temperature:	
0.2% proof stress at 150°C	257 MPa[F]
0.2% proof stress at 200°C	248 MPa[F]

Thermal properties

Thermal conductivity at 23°C:	136 W/m.K
50°C	141 W/m.K
100°C	149 W/m.K
150°C	152 W/m.K
200°C	155 W/m.K

Corrosion resistance, Similar to A380-F

Other:
Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"
Properties found to be stable at temperatures of 150°C for at least 2500h.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.
F. Test alloy had a 0.2% proof stress at 25°C of 252 MPa.
G. Lower limits shown for over ageing temperature of 200°C, high limits shown for overageing temperature of 180°C.

  See p.2 for additional important information

Technical data sheet

HPDC alloy A380 and B380 in the T64 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	Max 0.1	Max 0.5	Max 3	Max 0.35	Max 0.5

Note B380 has 1Zn max

Potential applications: Where strength and fracture toughness levels above the as-cast condition are required. Similar applications to heat treated permanent mold, sand cast aluminium. Good strength and better fracture resistance than A380-T6, B380-T6, C380-T6 and D380-T6. Better strength and similar fracture resistance to A380-T4 and B380-T4.

Hardness

Vickers Hardness Number (VHN)	125-135
Brinell 500kg-10mm (estimated from VHN)	110-118

Tensile properties[A]

Yield stress, 0.2% offset:	270-290 MPa
Tensile strength:	340-370 MPa
Elongation:	2% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	300 MPa
Notch sensitivity index (TYR)[E]	1.06
Unit total energy	27.7 KJ/m^2
Unit propagation energy	9.7 KJ/m^2
Fracture toughness K_c [D],	37.1 MPa√m

Other:

Heat treatment: Alloys are aged 6h at 150°C to produce an underaged condition. See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

A. Results from specimens machined from cast plate coupons
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy C380 and D380 in the as-cast (F) condition

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	0.1-0.3	Max 0.5	Max 3	Max 0.35	Max 0.5

Note D380 has 1Zn max.

Applications: As for A380-F. C380-F and D-380-F have a higher Mg allowance, similar to other alloys internationally such as Australian specification CA313.

Hardness

Vickers Hardness Number (VHN)	100-115
Brinell 500kg-10mm (estimated from VHN)	89-102

Tensile properties[A]

Yield stress, 0.2% offset:	180-200 MPa
Tensile strength:	330-380 MPa
Elongation:	3% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	215 MPa

Fracture properties[D]

Tear strength	231 MPa
Notch sensitivity index (TYR)[E]	1.28
Unit total energy	21.9 KJ/m^2
Unit propagation energy	9.2 KJ/m^2
Fracture toughness K_c [D],	36.3 MPa√m

Other:

Heat treatment: None

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

National Research FLAGSHIPS Light Metals CSIRO

Technical data sheet

HPDC alloy C380 and D380 in the T4 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	0.1-0.3	Max 0.5	Max 3	Max 0.35	Max 0.5

Note D380 has 1Zn max.

Potential applications: Where strength, ductility and fracture toughness levels above the as-cast condition are required. Similar applications to heat treated permanent mold, sand cast aluminium. Applications below 60°C. Above 60°C, additional strengthening results.

Hardness

Vickers Hardness Number (VHN)	130-150
Brinell 500kg-10mm (estimated from VHN)	114-130

Tensile properties[A]

Yield stress, 0.2% offset:	240-260 MPa
Tensile strength:	400-420 MPa
Elongation:	4.5% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	230 MPa

Fracture properties[D]

Tear strength	314 MPa
Notch sensitivity index (TYR)[E]	1.35
Unit total energy	40.1 KJ/m^2
Unit propagation energy	18 KJ/m^2
Fracture toughness K_c [D],	49 MPa√m

Other:

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy C380 and D380 in the T6 temper

Composition wt% (US specification A380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	0.1-0.3	Max 0.5	Max 3	Max 0.35	Max 0.5

Note D380 has 1Zn max.

Potential applications: Where high strength above the as-cast condition is required. Similar applications to heat treated permanent mold, sand cast aluminium.

Hardness

Vickers Hardness Number (VHN)	160-180
Brinell 500kg-10mm (estimated from VHN)	138-154

Tensile properties[A]

Yield stress, 0.2% offset:	370-420 MPa
Tensile strength:	450-480 MPa
Elongation:	2% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	260 MPa

Fracture properties[D]

Tear strength	263 MPa
Notch sensitivity index (TYR)[E]	0.75
Unit total energy	13.3 KJ/m^2
Unit propagation energy	2 KJ/m^2
Fracture toughness K_c [D],	21.6 MPa√m

Other

Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

National Research FLAGSHIPS Light Metals CSIRO

Technical data sheet

HPDC alloy C380 and D380 in the T64 temper

Composition wt% (US specification C380)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	3.0-4.0	Max 0.5	0.1-0.3	Max 0.5	Max 3	Max 0.35	Max 0.5

Note D380 has 1Zn max

Potential applications: Suggested applications: Where strength and fracture toughness levels above the as-cast condition are required. Similar applications to heat treated permanent mold, sand cast aluminium. Good strength and better fracture resistance than A380-T6, B380-T6, C380-T6 and D380-T6. Better strength and similar fracture resistance to A380-T4, B380-T4, C380-T4 or D380-T4.

Hardness

Vickers Hardness Number (VHN)	125-145
Brinell 500kg-10mm (estimated from VHN)	110-127

Tensile properties[A]

Yield stress, 0.2% offset:	270-290 MPa[G]
Tensile strength:	410-430 MPa
Elongation:	2% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	297 MPa
Notch sensitivity index (TYR)[E]	1.06
Unit total energy	30.2 KJ/m^2
Unit propagation energy	12 KJ/m^2
Fracture toughness K_c [D],	40.8 $MPa\sqrt{m}$

Other:

Heat treatment: Alloys are aged 6h at 150°C to produce an underaged condition. See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

A. Results from samples machined from cast plate coupons
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

National Research FLAGSHIPS Light Metals CSIRO

Technical data sheet

HPDC alloy ADC10 in the as-cast (F) condition

Composition wt% (JIS Alloy ADC10)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	2.0-4.0	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Applications: As for A380. JIS alloy ADC10 alloy incorporates US alloys B380, D380.

Hardness

Vickers Hardness Number (VHN)	95-115
Brinell 500kg-10mm (estimated from VHN)	82-102

Tensile properties[A]

Yield stress, 0.2% offset:	157-200 MPa
Tensile strength:	311-380 MPa
Elongation:	3-4% typical
Elastic modulus:	71 GPa

Other:

Heat treatment: none

See accompanying data sheets on alloy B380 and D380 for additional information on this alloy.

A. Results from cast test bars. Lower limit test results are shown for an ADC10 alloy containing 2.0Cu meaning values shown are close to minimums. Maximums from data sheet for D380.

  See p.2 for additional important information

Technical data sheet

HPDC alloy ADC10 in the T4 temper

Composition wt% (JIS Alloy ADC10)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	2.0-4.0	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Potential applications: Where strength, ductility and fracture toughness levels above the as-cast condition are required. Similar applications to heat treated permanent mold, sand cast aluminium. Applications below 60°C. Above 60°C, additional strengthening results. JIS alloy ADC10 alloy incorporates US alloys B380, D380.

Hardness

Vickers Hardness Number (VHN)	110-150
Brinell 500kg-10mm (estimated from VHN)	98-130

Tensile properties[A]

Yield stress, 0.2% offset:	190-260 MPa
Tensile strength:	300-410 MPa
Elongation:	4.5% typical
Elastic modulus:	71 GPa

Other:

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See accompanying data sheets on alloy B380-T4 and D380-T4 for additional information on this alloy.

A. Results from cast test bars. Lower limit of test results are shown for an ADC10 alloy containing 2.0Cu meaning values shown are close to minimums. Maximums from data sheet for D380-T4.

Technical data sheet

HPDC alloy ADC10 in the T6 temper

Composition wt% (JIS Alloy ADC10)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	7.5 - 9.5	Max 1.3	2.0-4.0	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Potential applications: Where high strength above the as-cast condition is required. Similar applications to heat treated permanent mold, sand cast aluminium. JIS alloy ADC10 alloy incorporates US alloys B380, D380.

Hardness

Vickers Hardness Number (VHN)	140-180
Brinell 500kg-10mm (estimated from VHN)	123-154

Tensile properties[A]

Yield stress, 0.2% offset:	290-420 MPa
Tensile strength:	360-480 MPa
Elongation:	2.5% typical
Elastic modulus:	71 GPa

Other:

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See accompanying data sheets on alloy B380-T6 and D380-T6 for additional information on this alloy.

A. Results from cast test bars. Lower limits of test results are shown for an ADC10 alloy containing 2.0Cu meaning values shown are close to minimums. Maximums from data sheet for D380.

  See p.2 for additional important information

Technical data sheet

HPDC alloy ADC12 in the as-cast (F) condition

Composition wt% (JIS Alloy ADC12)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	10.5-12.5	Max 1.3	1.5-3.5	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Applications: Alloy ADC12 is commonly utilized as a general purpose HPDC alloy by a large proportion of the automotive industry worldwide. JIS alloy ADC12 has similar mechanical properties to alloys ADC10, B380 or D380 at the same levels of Cu and Mg.

Hardness

Vickers Hardness Number (VHN)	95-110
Brinell 500kg-10mm (estimated from VHN)	83-98

Tensile properties[A]

Yield stress, 0.2% offset:	165 MPa
Tensile strength:	308 MPa
Elongation:	3 % typical

Other:

Heat treatment: none.

See accompanying data sheets on alloy ADC10-F, B380-F and D380-F for additional information relevant to this alloy. Properties expected to be similar for 383 and A383 alloys.

A. Results from cast test bars Test results are shown for an ADC12 alloy containing 1.7Cu meaning values shown are close to minimums.

Technical data sheet

HPDC alloy ADC12 in the T4 temper

Composition wt% (JIS Alloy ADC12)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	10.5-12.5	Max 1.3	1.5-3.5	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Potential applications: Where strength, ductility and fracture toughness levels above the as-cast condition are required. Similar applications to heat treated permanent mold, sand cast aluminium. Applications below 60°C. Above 60°C, additional strengthening results. JIS alloy ADC12-T4 has similar mechanical properties to alloys ADC10-T4, B380-T4 or D380-T4 at the same levels of Cu and Mg.

Hardness

Vickers Hardness Number (VHN)	Similar to ADC10-T4
Brinell 500kg-10mm (estimated from VHN)	Similar to ADC10-T4

Tensile properties[A]

Yield stress, 0.2% offset:	193 MPa
Tensile strength:	323 MPa
Elongation:	4% typical

Other:

Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

See accompanying data sheets on alloy ADC10-T4, B380-T4 and D380-T4 for additional information relevant to this alloy.

A. Results from cast test bars. Test results are shown for an ADC12 alloy containing 1.7Cu meaning values shown are close to minimums.

  See p.2 for additional important information

Technical data sheet

HPDC alloy ADC12 in the T6 temper

Composition wt% (JIS Alloy ADC12)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	10.5-12.5	Max 1.3	1.5-3.5	Max 0.5	Max 0.3	Max 0.5	Max 1	Max 0.3	---------

Potential applications: Where high strength above the as-cast condition is required. Similar applications to heat treated permanent mold, sand cast aluminium. JIS alloy ADC12 alloy is similar to US alloys 383 and A383, with the exception of Zn content.

Hardness

Vickers Hardness Number (VHN)	140-145
Brinell 500kg-10mm (estimated from VHN)	123-127

Tensile properties[A]

Yield stress, 0.2% offset:	294 MPa
Tensile strength:	382 MPa
Elongation:	2% typical

Other:

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See accompanying data sheets on alloy ADC10-T6, B380-T6 and D380-T6 for additional information relevant to this alloy.

A. Results from cast test bars. Test results are shown for an ADC12 alloy containing 1.7Cu meaning values shown are close to minimums.

National Research FLAGSHIPS Light Metals CSIRO

Technical data sheet

HPDC alloy A360 in the as-cast (F) condition

Composition wt% (US specification A360)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	9.0-10.0	Max 1.3	Max 0.6	Max 0.35	0.4 - 0.6	Max 0.5	Max 0.5	Max 0.15	Max 0.25

Applications: A360-F alloy is a popular alloy for automotive and transport applications due to its improved corrosion resistance compared to A380-F. A360-F also has higher fracture resistance than 380-F alloys. A360 incorporates Australian Designation HPDC alloy CA605.

Hardness

Vickers Hardness Number (VHN)	95-105
Brinell 500kg-10mm (estimated from VHN)	83-93

Tensile properties[A]

Yield stress, 0.2% offset:	160-185 MPa
Tensile strength:	300-350 MPa
Elongation:	3-5% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	235 MPa
Notch sensitivity index (TYR)[E]	1.39
Unit total energy	29.4 KJ/m^2
Unit propagation energy	14.4 KJ/m^2
Fracture toughness K_c [D],	44.2 MPa√m

Other

Heat treatment: none.

See also data sheet for the related CIS alloy, AK9-F.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

Technical data sheet

HPDC alloy A360 in the T4 temper

Composition wt% (US specification A360)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	9.0-10.0	Max 1.3	Max 0.6	Max 0.35	0.4 - 0.6	Max 0.5	Max 0.5	Max 0.15	Max 0.25

Potential applications: Where high ductility, high energy absorption and maximum fracture resistance above the as-cast condition is required, but for similar levels of yield strength and tensile strength. A360-T4 has exceptional energy absorption and fracture resistance, better than that of the as-cast condition. A360 incorporates Australian Designation HPDC alloy CA605.

Tensile properties[A]

Yield stress, 0.2% offset:	160-185 MPa
Tensile strength:	300-350 MPa
Elongation:	6-9% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	277 MPa
Notch sensitivity index (TYR)[E]	1.54
Unit total energy	55 KJ/m^2
Unit propagation energy	29.2 KJ/m^2
Fracture toughness K_c [D],	61.6 MPa√m

Other

Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings"

See also data sheet for the related CIS alloy, AK9-T4.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy A360 in the T6 temper

Composition wt% (US specification A360)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	9.0-10.0	Max 1.3	Max 0.6	Max 0.35	0.4 - 0.6	Max 0.5	Max 0.5	Max 0.15	Max 0.25

Potential applications: Where high strength above the as-cast condition is required in applications where A380-T6 or C380-T6 are not suitable. A360-T6 has better fracture resistance than A380-T6 or C380-T6 but generally lower tensile properties.
Similar applications to heat treated permanent mold, sand cast aluminium. A360 incorporates Australian Designation HPDC alloy CA605.

Hardness

Vickers Hardness Number (VHN)	130-133
Brinell 500kg-10mm (estimated from VHN)	114-118

Tensile properties[A]

Yield stress, 0.2% offset:	285-330 MPa
Tensile strength:	330-365 MPa
Elongation:	3.5% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	262 MPa
Notch sensitivity index (TYR)[E]	0.9
Unit total energy	19.8 KJ/m^2
Unit propagation energy	6.7 KJ/m^2

Fracture toughness K_c [D], 31.7 MPa√m

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See also data sheet for the related CIS alloy, AK9.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy A360 in the T64 temper

Composition wt% (US specification A360)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Other total
Balance	9.0-10.0	Max 1.3	Max 0.6	Max 0.35	0.4 - 0.6	Max 0.5	Max 0.5	Max 0.15	Max 0.25

Potential applications: Where high strength above the as-cast condition is required in applications where A380-T6 or C380-T6 are not suitable. A360-T64 has better fracture resistance than A360-T6, A380-T6 or C380-T6 and similar fracture resistance to A380-T64.
Similar applications to heat treated permanent mold, sand cast aluminium. A360 incorporates Australian Designation HPDC alloy CA605.

Hardness

Vickers Hardness Number (VHN)	123-127
Brinell 500kg-10mm (estimated from VHN)	109-112

Tensile properties[A]

Yield stress, 0.2% offset:	269 MPa
Tensile strength:	330 MPa
Elongation:	2% typical
Elastic modulus:	71 GPa

Fracture properties[D]

Tear strength	293 MPa
Notch sensitivity index (TYR)[E]	1.09
Unit total energy	26.9 KJ/m^2
Unit propagation energy	10.5 KJ/m^2
Fracture toughness K_c[D],	38.5 MPa√m

Other

Heat treatment: See accompanying information sheet, "Introduction to Heat Treatment of High Pressure Diecastings". Alloy is aged 2.5h at 150°C to achieve this temper.

See also data sheet for the related CIS alloy, AK9.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy AK9 in the as-cast (F) condition

Composition wt% (CIS specification AK9)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	8-11	Max 0.8	Max 1	0.2-0.5	0.2-0.8	Max 0.5	Max 0.5	Max 2.4

Applications: Similar applications to A360-F. Alloy AK9 has higher Mg and Cu allowances than A360 and lower minimum Si. AK9 incorporates DIN alloy 239B and other alloys internationally.

Hardness

Vickers Hardness Number (VHN)	95-105
Brinell 500kg-10mm (estimated from VHN)	83-93

Tensile properties[A]

Yield stress, 0.2% offset:	160-180 MPa
Tensile strength:	280-320 MPa
Elongation:	3-4% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	215 MPa

Fracture properties[D]

Tear strength	235 MPa
Notch sensitivity index (TYR)[E]	1.3
Unit total energy	25.2 KJ/m^2
Unit propagation energy	10 KJ/m^2
Fracture toughness K_c[D],	37.6 MPa√m

Other

Heat treatment: none.

See also data sheet for the related US specification alloy, A360-F and the related CIS alloy AK9M2-F.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

Technical data sheet

HPDC alloy AK9 in the T4 temper

Composition wt% (CIS specification AK9)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	8-11	Max 0.8	Max 1	0.2-0.5	0.2-0.8	Max 0.5	Max 0.5	Max 2.4

Potential applications: Where high fracture resistance and energy absorption is required. Alloy AK9-T4 has excellent fracture resistance, slightly superior to Alloy A360-T4, but lower ductility. Similar applications to heat treated permanent mold, sand cast aluminium. Alloy AK9 has slightly higher Mg and Cu allowances than A360, and lower minimum Si. AK9 incorporates DIN alloy 239B and other alloys internationally.

Hardness

Vickers Hardness Number (VHN)	105-109
Brinell 500kg-10mm (estimated from VHN)	93-97

Tensile properties[A]

Yield stress, 0.2% offset:	189 MPa
Tensile strength:	328 MPa
Elongation:	5% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	215 MPa

Fracture properties[D]

Tear strength	299 MPa
Notch sensitivity index (TYR)[E]	1.7
Unit total energy	62.36 KJ/m^2
Unit propagation energy	35.7 KJ/m^2
Fracture toughness K_c[D],	67.7 MPa√m

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See also data sheet for the related US specification alloy, A360-T4 and the related CIS alloy AK9M2-T4.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

Technical data sheet

HPDC alloy AK9 in the T6 Temper

Composition wt% (CIS specification AK9)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	8-11	Max 0.8	Max 1	0.2-0.5	0.2-0.8	Max 0.5	Max 0.5	Max 2.4

Potential applications: Where high strength above the as-cast condition is required in applications where A380-T6 or C380-T6 are not suitable. Similar to A360-T6. Alloy AK9-T6 has exceptional fatigue resistance. Similar applications to heat treated permanent mold, sand cast aluminium. Alloy AK9 has slightly higher Mg and Cu allowances than A360, and a lower minimum Si content. AK9 incorporates DIN alloy 239B and other alloys internationally.

Hardness

Vickers Hardness Number (VHN)	132-136
Brinell 500kg-10mm (estimated from VHN)	116-119

Tensile properties[A]

Yield stress, 0.2% offset:	285-310 MPa
Tensile strength:	330-400 MPa
Elongation:	2% typical
Elastic modulus:	71 GPa

Fatigue properties[B]

Fatigue limit[B,C] R=0.1,	265 MPa

Fracture properties[D]

Tear strength	270 MPa
Notch sensitivity index (TYR)[E]	0.92
Unit total energy	20.9 KJ/m^2
Unit propagation energy	6.5 KJ/m^2
Fracture toughness K_c[D],	31.4 MPa√m

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See also data sheet for the related US specification alloy, A360-T6, and the related CIS alloy AK9M2-T6.

A. Results from cast test bars
B. Cast axial fatigue test bars in tension-tension
C. Estimated from run-out data at 10^7 cycles.
D. Derived from ASTM B871 using specimens machined from cast plate coupons. Fracture toughness estimated from unit propagation energy.
E. Notch sensitivity index is the ratio of tear strength:yield stress (TYR) for the same material. A greater result implies lower sensitivity. Alloys displaying high sensitivity (TYR <1) should have transition radii > wall thickness.

  See p.2 for additional important information

Technical data sheet

HPDC alloy AK9M2 in the as-cast (F) condition

Composition wt% (CIS specification AK9M2)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	7.5-10	Max 0.9	0.5-2.0	0.1-0.4	0.2-0.8	Max 0.5	Max 1.2	Max 2.5

Applications: AK9M2-F is similar to alloy AK9-F, but with better strength and often ductility. Properties are similar to A360-F and A380-F. The alloy can be used universally for sand casting, permanent mold casting and HPDC.

Hardness

Vickers Hardness Number (VHN)	95-105
Brinell 500kg-10mm (estimated from VHN)	83-93

Tensile properties[A]

Yield stress, 0.2% offset:	155-180 MPa
Tensile strength:	310-340 MPa
Elongation:	3-5% typical
Elastic modulus:	71 GPa

Other

Heat treatment: none.

See also data sheet for the related US specification alloy, A360-F and the related CIS alloy AK9-F.

A. Results from cast test bars

Technical data sheet

HPDC alloy AK9M2 in the T4 temper

Composition wt% (CIS specification AK9M2)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	7.5-10	Max 0.9	0.5-2.0	0.1-0.4	0.2-0.8	Max 0.5	Max 1.2	Max 2.5

Potential applications: AK9M2-T4 is similar to alloy AK9-T4, but with better strength and ductility. Properties are higher than A360-T4, similar to A380-T4. Similar applications to heat treated permanent mold, sand cast aluminium. The alloy can be used universally for sand casting, permanent mold casting and HPDC.

Tensile properties[A]

Yield stress, 0.2% offset:	190-210 MPa
Tensile strength:	320-380 MPa
Elongation:	5-9% typical
Elastic modulus:	71 GPa

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See also data sheet for the related US specification alloy, A360-T4 and the related CIS alloy AK9-T4.

A. Results from cast test bars

  See p.2 for additional important information

Technical data sheet

HPDC alloy AK9M2 in the T6 temper

Composition wt% (CIS specification AK9M2)

Al	Si	Fe	Cu	Mn	Mg	Ni	Zn	Other total
Balance	7.5-10	Max 0.9	0.5-2	0.1-0.4	0.2-0.8	Max 0.5	Max 1.2	Max 2.5

Potential applications: AK9M2-T6 is similar to AK9-T6. Where high strength above the as-cast condition is required in applications where A380-T6 or C380-T6 or equivalents are not suitable. Similar applications to heat treated permanent mold, sand cast aluminium. The alloy can be used universally for sand, permanent mold and HPDC.

Hardness

Vickers Hardness Number (VHN) 122-126
Brinell 500kg-10mm (estimated from VHN) 108-111

Tensile properties[A]

Yield stress, 0.2% offset: 300-320 MPa
Tensile strength: 400-420 MPa
Elongation: 3-6% typical
Elastic modulus: 71 GPa

Other

Heat treatment: See accompanying information sheet, “Introduction to Heat Treatment of High Pressure Diecastings”

See also data sheet for the related US specification alloy, A360-T6, and the related CIS alloy AK9-T6.

A. Results from cast test bars

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