NASA 398 Material Properties Data Sheet

(Revision date: April 20, 2001)

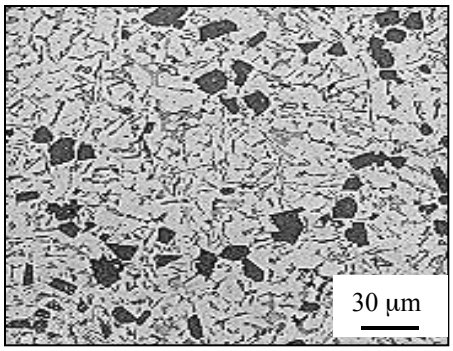
Applications

High performance pistons for gasoline and diesel engines, cylinder blocks, air-cooled engines, compressors and pumps requiring abrasive resistance at elevated temperatures. Other applications where high wear resistance, hardness, low thermal expansion, low dimensional distortion, and superior tensile and fatigue strengths at elevated-temperatures are required. Suitable for sand, permanent mold and die castings in hypereutectic (NASA 398) and eutectic form (NASA 388). In permanent mold, both alloys can provide three to four times the tensile strengths of conventional alloys test at 600°F-800°F for more than 100 hrs.

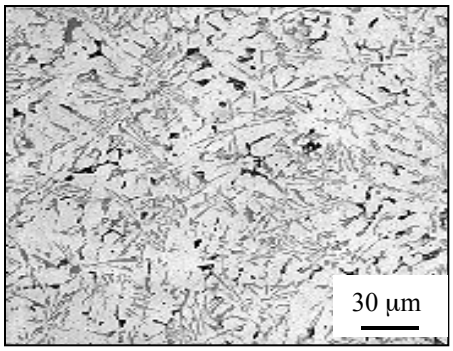
Specification Equivalents

NASA 398 hypereutectic alloy (16% w. Si): Similar to SAE A390.0, Mahle 126, Zolloy Z16 and AE 425. A heat treatable Al-Si alloy consists of small polygonal primary silicon particles evenly distributed in aluminum matrix for high strength and wear resistance applications at elevated temperatures.

NASA 388 eutectic alloy (<13% wt. Si): Similar to A384.0, A413.0, AE 413, Mahle 124. A heat treatable Al-Si alloy for high ductility, high strength and hardness applications at elevated temperatures.



NASA 398 typical microstructure
(Hypereutectic alloy)



NASA 388 typical microstructure
(Eutectic alloy)

Mechanical Properties

Tensile strength, yield strength, elongation, hardness and elastic modulus: See Tables 1.
Axial push-pull fatigue strengths: See Table 2.
NASA 398 data from permanent mold casting with T5 heat treatment. T6 type properties are available.

Density and Thermal Properties

Density: 2.76 g/cm^3 (0.099 lb/in^3) at 25°C for NASA 398, and 2.73 g/cm^3 (0.098 lb/in^3) for NASA 388.
Liquidus temperature: 619°C (1156°F) for NASA 398, and 581°C (1078°F) for NASA 388.
Solidus temperature: 486°C (907°F) for NASA 398, and 483°C (901°F) for NASA 388.
Solidification temperature range: 619°C-486°C for NASA 398, and 581°C-483°C for NASA 388.
Thermal expansion coefficient, thermal conductivity, thermal diffusivity and specific heat: See Table 3.
NASA 398 data from permanent mold casting with T5 heat treatment. T6 type properties are available.

Additional Technical Data

Additional non-proprietary data is available on request from NASA-Marshall Space Flight Center, Metallic Materials & Processes Group (ED33), Huntsville, AL 35812. E-mail: Jonathan.Lee@msfc.nasa.gov.
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Table 1 NASA 398-T5 Permanent Mold Cast: Typical Mechanical Properties

Temperature		Time at test temperature	Tensile strength		Yield strength		Elongation in 4D, %	Hardness (HRB)	Modulus of elasticity (b)	
°F	°C	(hour)	ksi	MPa	ksi	MPa	(a)		10^6 psi	GPa
72	25	…	40	277	34	235	0.4	71	12.8	88.6
300	150	1	38	263	33	228	0.5	…	12.5	86.5
		100	36	249	32	221	0.5	68	12.5	86.5
		1,000	35	242	31	215	0.5	…	12.5	86.5
400	205	1	35	242	31	215	0.6	…	11.0	76.1
		100	32	221	28	194	0.8	64	11.0	76.1
		1,000	31	215	27	187	1.0	…	11.0	76.1
500	260	1	31	215	28	194	1.3	…	10.5	72.7
		100	27	187	23	159	1.5	55	10.5	72.7
		1,000	26	180	22	152	2.0	…	10.5	72.7
600	315	1	27	187	23	159	2.5	…	9.0	62.3
		100	22	152	18	124	2.5	48	9.0	62.3
		1,000	21	145	17	118	3.0	…	9.0	62.3
700	370	1	21	145	17	118	4.5	…	8.0	55.4
		100	16	111	13	90	4.5	33	8.0	55.4
		1,000	15	104	12	83	5.0	…	8.0	55.4
800	427	1	14	97	11	76	6.0	…	…	…
		100	10	69	7	49	8.0	20	…	…
		1,000	9	62	6	42	8.0	…	…	…

(a) Elongation given for hypereutectic alloy (16% Si). Ductility values are significantly greater for hypoeutectic and eutectic alloy.
(b) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English unit; metric values are converted and rounded.

Table 2 NASA 398-T5 Permanent Mold Cast: Typical Fatigue Properties

Temperature		Soak time at temperature before test	Fatigue strengths at indicated temperatures and cycles (a)							
			10^5 cycles		10^6 cycles		10^7 cycles		10^8 cycles	
°F	°C	(hour)	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
72	25	…	26	180	22	152	19	131	16	112
400	205	1	23	159	19	132	15	104	11	76
		100	19	132	15.5	107	12.5	86	10	69
500	260	1	21	145	17	118	13	90	10	69
		100	16	111	13.5	94	11	76	9.0	62
600	315	1	18	124	15	104	11	76	8.0	55
		100	15	104	12	83	9	62	6.0	41
730	388	1	16	111	12	83	9	62	7.0	48
		100	11	76	8	55	7	48	5.0	35

(a) Average values as determined by axial push-pull stress fatigue machines with smooth test specimens.
Source data are in English units; metric values are converted and rounded for hypereutectic alloy (16% Si).

Table 3 NASA 398-T5 Permanent Mold Cast: Thermal and Physical Properties

Temperature		Thermal expansion (a)	Thermal diffusivity	Specific heat	Thermal conductivity	Density
°F	°C	(10^{-6}.K)	(cm^2/sec)	(J/kg.K)	(W/m.K)	(g/cm^3)
72	25	18.50	0.525	820	120.0	2.76
212	100	18.65	0.519	874	125.4	…
392	200	19.17	0.506	915	128.0	…
572	300	19.72	0.489	952	129.0	…
662	350	19.93	0.480	990	131.4	…

(a) Thermal expansion coefficients given for hypereutectic alloy (16% Si).