Mechanics and Mechanisms of Fracture: An Introduction
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APPENDIX 7

Mechanical Properties Data for Selected Aluminum Alloys

LIMITED MECHANICAL PROPERTIES DATA for several selected aluminum alloys are compiled in this appendix. Relatively new aluminum alloys included are 7033, Al-Li 8090 and 2090, rapidly solidified power metallurgy (P/M) aluminum, and B201 and D357 aluminum castings.

A7.1 Conventional and High-Strength Aluminum Alloys

Both 2000 and 7000 series aluminum alloys are used in the aerospace/aircraft industry. Tables A7.1 and A7.2 along with Fig. A7.1 to A7.3 present tensile properties and fracture toughness test data for several of these alloys. Plane-stress fracture toughness values and crack growth resistance curves for these alloys are shown in Fig. A7.4 and A7.5, respectively. Figures A7.6 and A7.7 plot fatigue crack growth rate curves.

Tensile and fracture toughness data for the new 7033-T6 high-strength automotive alloy are presented in Table A7.3, which also compares these properties with the conventional 2014-T6 and 6061-T6 alloys. *S-N* curves for all three alloys are presented in Fig. A7.8.

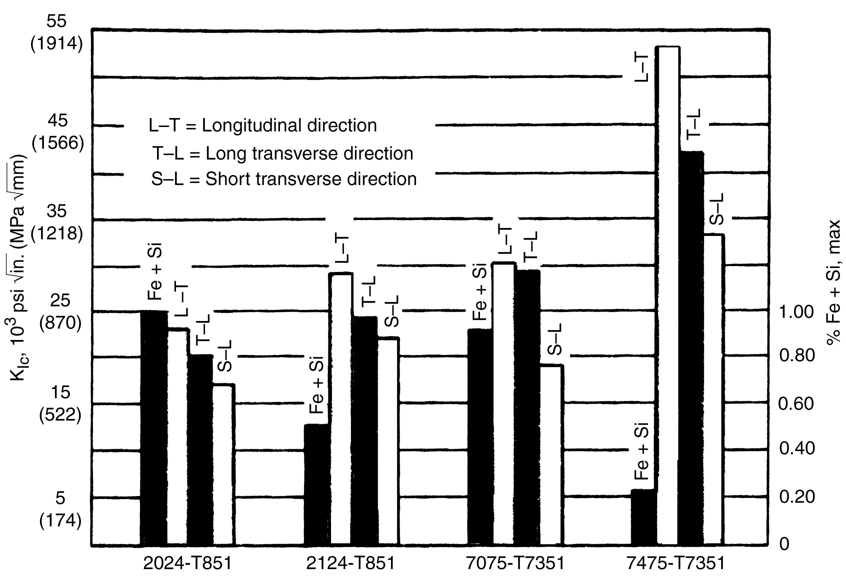

Fig. A7.1 Comparison of regular and high-purity (lower iron and silicon contents) versions of alloys 2024 and 7075. Plane-strain fracture toughness is higher in the high-purity alloys (designated as 2124 and 7475). Source: Ref A7.2

A7.2 P/M Aluminum

Mechanical properties data for several P/M aluminum forgings and extrusions are listed in Table A7.4. These data are taken from a report for the Air Force Advanced Aluminum Fighter Structures (AAFS) program (Ref A7.11).

A7.3 Aluminum-Lithium Alloys

Sheet and plate mechanical properties data for the low-density 8090 and 2090 Al-Li alloys are presented in Table A7.5. Table A7.6 lists the test results for extrusions. Fatigue and fatigue crack growth rate data for the 8090-TU51 extrusion are shown in Fig. A7.9 to A7.11.

A7.4 Aluminum Casting Alloys

This appendix includes mechanical test data for two casting materials: B201-T7 and D357-T6. Composition specifications for these castings are, respectively, AMS 4242 and AMS 4241, to which a small amount of strontium (0.014 wt% max) or sodium (0.012 wt% max) was added as a silicon modifier. Tensile properties and plane-strain fracture toughness data are listed in Tables A.7.7 to A7.10. High- and low-cycle fatigue and fatigue crack growth rate data are shown in Fig. A7.12 to A7.17.

Table A7.1 Mechanical properties of aluminum alloys at room temperature

Alloy	7150-T6E189(a)	7050-T7451	7050-T7651	7475-T7351	7475-T7651	7475-T651
Plate thickness, mm (in.)	25.4 (1)	6.4–38.1 (0.25–1.5)	6.4–25.4 (0.25–1.0)	6.4–38.1 (0.25–1.5)	12.7–25.4 (0.5–1.0)	12.7–25.4 (0.5–1.0)
Orientation	LT	T	T	T	T	T
E, MPa (ksi)	. . .	71,070 (10,300)	71,070 (10,300)	71,070 (10,300)	70,380 (10,200)	70,380 (10,200)
F_{tu}, MPa (ksi)	628 (91)	524 (76)	524 (76)	504 (73)	483 (70)	538 (78)
F_{ty}, MPa (ksi)	587 (85)	455 (66)	455 (66)	428 (62)	407 (59)	469 (68)
Elongation, %	12	9	8	9	8	9
E_c, MPa (ksi)	. . .	73,140 (10,600)	74,520 (10,800)	73,140 (10,600)	73,140 (10,600)	73,140 (10,600)
F_{cy}, MPa (ksi)	. . .	469 (68)	469 (68)	435 (63)	428 (62)	490 (7)
F_{su}, MPa (ksi)	. . .	297 (43)	297 (43)	290 (42)	269 (39)	297 (43)
F_{bru}, MPa (ksi) (e/D = 1.5)	. . .	759 (110)	759 (110)	725 (105)	711 (103)	780 (113)
F_{bry}, MPa (ksi) (e/D = 1.5)	. . .	614 (89)	600 (87)	580 (84)	559 (81)	642 (93)
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	31 (28)	. . .	. . .	(b)	. . .	. . .
K_C, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	. . .	. . .	. . .	. . .	110 (100)(c)	99 (90)(c)

Alloy	2124-T351(a)	2124-T851	2024-T351	2024-T851	7075-T651	7075-T7351
Plate thickness, mm (in.)	25.4 (1)	25.4–38.1 (1.0–1.5)	12.7–25.4 (0.5–1.0)	12.7–25.4 (0.5–1.0)	12.7–25.4 (0.5–1.0)	6.4–12.7 (0.25–0.5)
Orientation	LT	T	T	T	T	T
E, MPa (ksi)	. . .	71,760 (10,400)	73,830 (10,700)	. . .	71,070 (10,300)	71,070 (10,300)
F_{tu}, MPa (ksi)	469 (68)	455 (66)	449 (65)	455 (66)	552 (80)	476 (69)
F_{ty}, MPa (ksi)	366 (53)	393 (57)	304 (44)	400 (58)	476 (69)	393 (57)
Elongation, %	22	5	. . .	. . .	7	7
E_c, MPa (ksi)	. . .	75,210 (10,900)	75,210 (10,900)	. . .	73,140 (10,600)	73,140 (10,600)
F_{cy}, MPa (ksi)	. . .	393 (57)	324 (47)	407 (59)	511 (74)	407 (59)
F_{su}, MPa (ksi)	. . .	. . .	262 (38)	262 (38)	311 (45)	262 (38)
F_{bru}, MPa (ksi) (e/D = 1.5)	. . .	. . .	676 (98)	697 (101)	828 (120)	704 (102)
F_{bry}, MPa (ksi) (e/D = 1.5)	. . .	. . .	524 (76)	600 (87)	711 (103)	545 (79)
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	47.9 (43.5)	(b)	. . .	(b)	30.3 (27.5)(d)	(b)
K_C, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	. . .	. . .	105 (95)(c)	. . .	71.5 (65)(c)	. . .
Fatigue strength, MPa (ksi)	. . .	. . .	138 (20)(e)	. . .	159 (23)(e)	. . .

(a) Ref A7.1. (b) See Fig. A7.1. (c) Thin-sheet K_C value (Ref A7.2). (d) Ref A7.3. (e) At 500 million cycles, $K_t = 1$, $R = -1$ (Ref A7.4). All test data in this table are S or B values (per Ref A7.5), unless otherwise noted.

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Table A7.2 Plane-strain fracture toughness data for aluminum alloys at various test temperatures

Alloy and condition	Room-temperature yield strength		Specimen design	Orientation	Fracture toughness, K_{1c} or $K_{1c}(J)$ at: 24 °C (75 °F)		−196 °C (−320 °F)		−253 °C (−423 °F)		−269 °C (−452 °F)	
	MPa	ksi			MPa$\sqrt{m}$	ksi$\sqrt{in.}$	MPa$\sqrt{m}$	ksi$\sqrt{in.}$	MPa$\sqrt{m}$	ksi$\sqrt{in.}$	MPa$\sqrt{m}$	ksi$\sqrt{in.}$
2014–T651	432	62.7	Bend	T-L	23.2	21.2	28.5	26.1	...	...	...	...
2024–T851	444	64.4	Bend	T-L	22.3	20.3	24.4	22.2	...	...	...	...
2124–T851(a)	455	66.0	CT	T-L	26.9	24.5	32.0	29.1	...	...	...	...
	435	63.1	CT	L-T	29.2	26.6	35.0	31.9	...	...	...	...
	420	60.9	CT	S-L	22.7	20.7	24.3	22.1	...	...	...	...
2219–T87	382	55.4	Bend	T-S	39.9	36.3	46.5	42.4	52.5	48.0	...	...
			CT	T-S	28.8	26.2	34.5	31.4	37.2	34.0	...	...
	412	59.6	CT	T-L	30.8	28.1	38.9	32.7	...	...	...	...
5083–O	142	20.6	CT	T-L	27.0(b)	24.6(b)	43.4(b)	39.5(b)	...	...	48.0(b)	43.7(b)
6061–T651	289	41.9	Bend	T-L	29.1	26.5	41.6	37.9	...	...	...	...
7039–T6	381	55.3	Bend	T-L	32.3	29.4	33.5	30.5	...	...	...	...
7075–T651	536	77.7	Bend	T-L	22.5	20.5	27.6	25.1	...	...	...	...
7075–T7351	403	58.5	Bend	T-L	35.9	32.7	32.1	29.2	...	...	...	...
7075–T7351	392	56.8	Bend	T-L	31.0	28.2	30.9	28.1	...	...	...	...

(a) 2124 is similar to 2024, but with higher-purity base and special processing to improve fracture toughness. (b) $K_{1c}(J)$. Source: *Metals Handbook,* 9th ed., Vol 3, American Society for Metals, 1980, p 746, compiled from several references

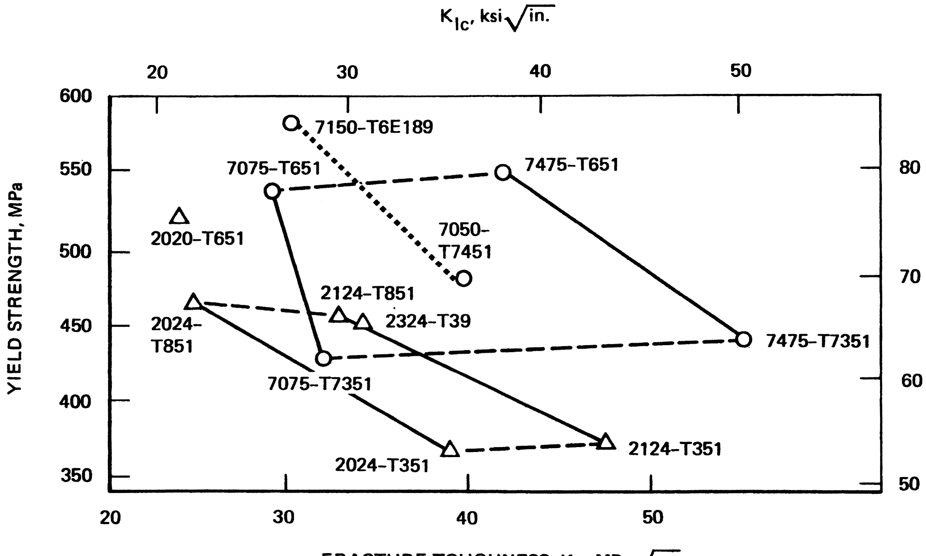


Fig. A7.2 Plane-strain fracture toughness as a function of material tensile yield strength. Comparison of several 2000 and 7000 series aluminum alloys. Source: Ref A7.1

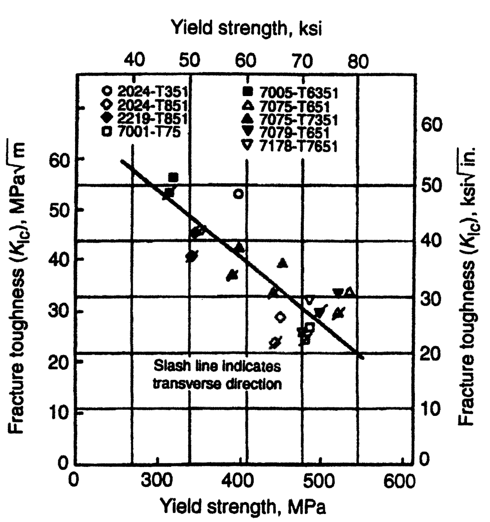


Fig. A7.3 Plane-strain fracture toughness for 25.4 to 38.1 mm (1 to 1.5 in.) thick commercial aluminum alloys. Source: Ref A7.6

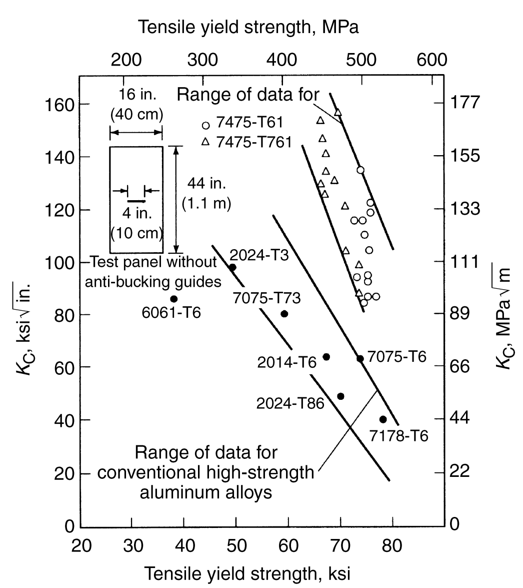


Fig. A7.4 Plane-stress fracture toughness for 1 to 4.8 mm (0.04 to 0.2 in.) thick aluminum alloy sheet. Source: Ref A7.7

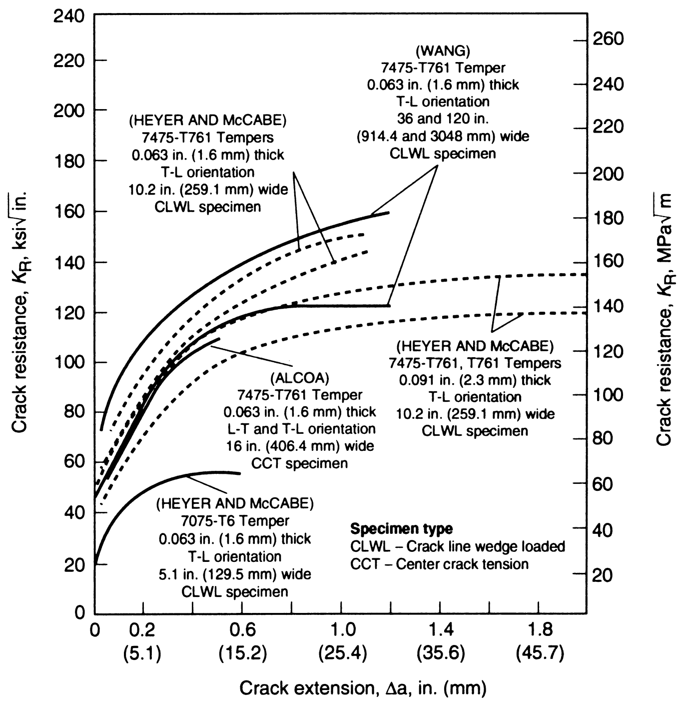


Fig. A7.5 Crack growth resistance curves for thin 7475 aluminum sheet. Source: Ref A7.8

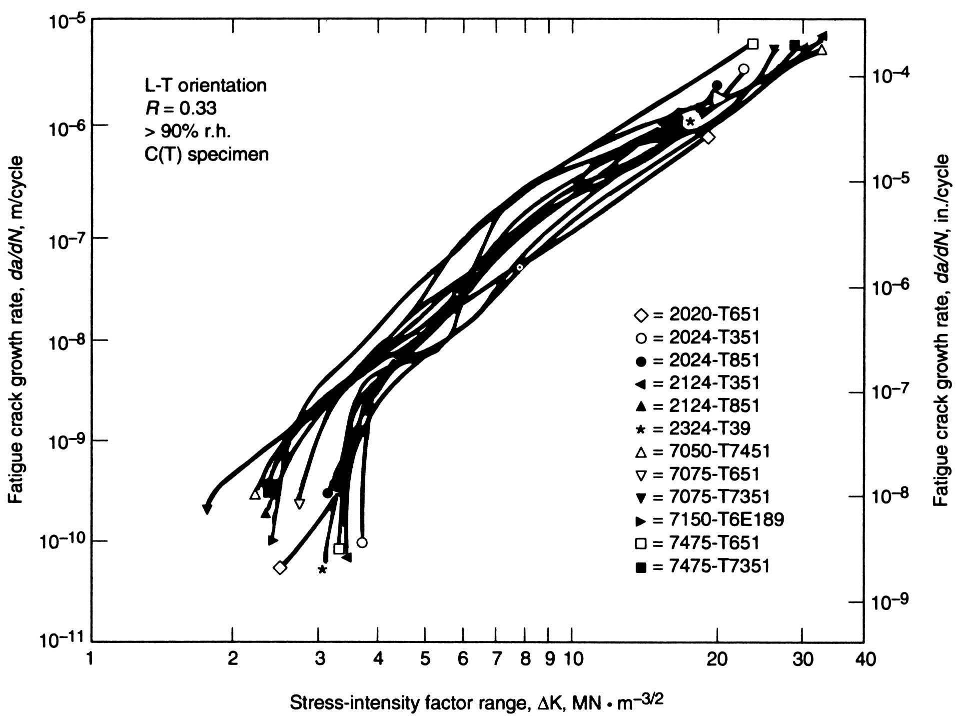


Fig. A7.6 *da/dN* curves for 12 aerospace aluminum alloys, $R = 0.33$. Source: Ref A7.9

Table A7.3 Comparison of mechanical properties for 7033-T6, 2014-T6, and 6061-T6 aluminum alloys

Property	7033-T6	6061-T6	2014-T6
Tensile			
Tensile strength, MPa (ksi)	518 (75)	331 (48)	449 (65)
Yield strength, MPa (ksi)	483 (70)	297 (43)	407 (59)
Elongation, % (2.0 in. gage length)	12	14	9
Elevated-temperature yield strength, MPa (ksi)			
40 °C (100 °F)	483 (70)	290 (42)	407 (59)
95 °C (200 °F)	455 (66)	283 (41)	435 (63)
150 °C (300 °F)	373 (54)	262 (38)	276 (40)
205 °C (400 °F)	248 (36)	228 (33)	110 (16)
260 °C (500 °F)	138 (20)	124 (18)	65 (9.5)
Compression			
Peak stress, MPa (ksi)	483 (70)	317 (46)	Not tested
Yield stress, MPa (ksi)	455 (66)	297 (43)	Not tested
Fracture toughness, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)			
Round bar (plate equivalent orientation)			
R-L (T-L)	41 (37)	26 (24)	21 (19)
L-R (L-T)	66 (60)	Invalid test	7.7 (7)
R-C (S-T)	39 (36)	Not tested	Not tested
Hardness, HRB	80	60	79
Electrical conductivity, % IACS	39	44	40

Source: Ref A7.10

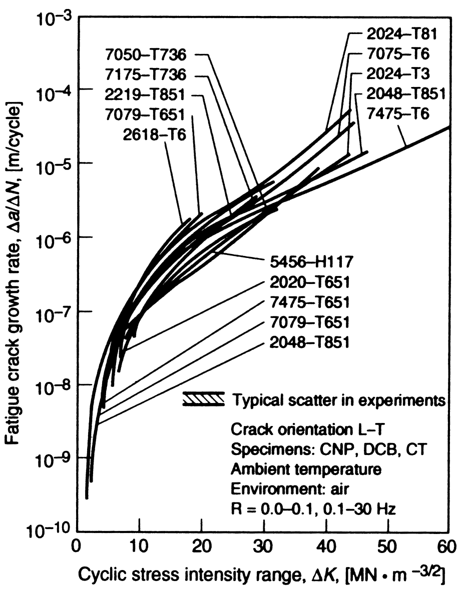


Fig. A7.7 *da/dN* curves for 15 aluminum alloys, R = 0 to 0.1. Source: Ref A7.8

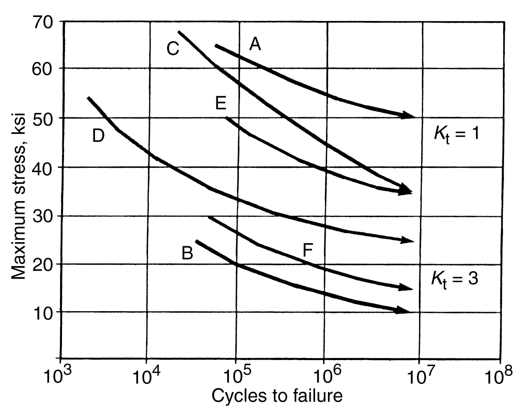


Fig. A7.8 *S-N* curves for three aluminum alloys, R = 0.1. Curves A and B: 7033-T6; curves C and D: 2014-T6; curves E and F: 6061-T6. Source: Ref A7.10

Table A7.4 Tensile strength and plane-strain fracture toughness of P/M (RST) aluminum alloys

Alloy and temper	CW67-T7E94 (Alcoa data)			CW67-T7E94			PM7064-TX7652	
Product form	(a)	(a)	(a)	(a)	(a)		Hand forging	
Orientation	L	T	S	L	T		L	T
E, MPa (ksi)	. . .	. . .	. . .	71,070 (10,300)	75,210 (10,900)		72,222 (10,467)	72,222 (10,467)
F_{tu}, MPa (ksi)	631.7 (91.55)	574.4 (83.25)	573.0 (83.05)	600.6 (87.05)	567.9 (82.3)		601.2 (87.13)	596.4 (86.43)
F_{ty}, MPa (ksi)	611.3 (88.6)	534.1 (77.4)	526.8 (76.35)	572.0 (82.9)	532.3 (77.15)		554.1 (80.3)	549.0 (79.57)
Elongation, %	12.2	8	7.05	9.96	10.87		9.18	6.52
E_c, MPa (ksi)	. . .	. . .	. . .				78,660 (11,400)	77,970 (11,300)
F_{cy}, MPa (ksi)	. . .	. . .	. . .				587.4 (85.13)	576.7 (83.58)
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	43.07 (39.15)	21.07 (19.15)	23.1 (21)					
Alloy and temper	**CW67-T7E94 (Alcoa data)**			**CW67-T7E94**			**PM7064-TX76510**	
Product form	(b)	(b)	(b)	(b)			Extrusion	
Orientation	L	T	S	L			L	T
E, MPa (ksi)	. . .	. . .	. . .	75,555 (10,950)			71,298 (10,333)	74,058 (10,733)
F_{tu}, MPa (ksi)	657.2 (95.25)	610.7 (88.5)	585.1 (84.8)	631.4 (91.5)			651.4 (94.4)	623.3 (90.33)
F_{ty}, MPa (ksi)	638.3 (92.5)	579.9 (84.05)	564.1 (81.75)	651.0 (94.35)			617.1 (89.43)	586.5 (85)
Elongation, %	11.25	8.20	5.15	9.71			8.29	8.67
E_c, MPa (ksi)	76,935 (11,150)	77,453 (11,225)	. . .	. . .			76,590 (11,100)	79,578 (11,533)
F_{cy}, MPa (ksi)	599.2 (86.84)	583.1 (84.51)	. . .	. . .			629.4 (91.22)	620.2 (89.88)
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	. . .	. . .	22.1 (20.1)	. . .			. . .	. . .
Alloy and temper	**CW67-T7E94 (Alcoa data)**			**CW67-T7E94**				
Product form	(c)	(c)	(c)	(c)	(c)	(c)		
Orientation	L	T	S	L	T	S		
E, MPa (ksi)	. . .	. . .	. . .	69,462 (10,067)	70,953 (10,283)	70,842 (10,267)		
F_{tu}, MPa (ksi)	572.4 (82.95)	534.6 (77.48)	559.1 (81.03)	606.3 (87.87)	583.7 (84.6)	565.3 (81.93)		
F_{ty}, MPa (ksi)	535.4 (77.6)	481.1 (69.73)	508.4 (73.68)	580.3 (84.1)	548.2 (79.45)	526.1 (76.25)		
Elongation, %	14.38	8.5	6.75	11.52	8.45	8.3		
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	43.73 (39.75)	. . .	30.8 (28)	. . .	. . .	. . .		

(a) Specimens cut from the 58.4 mm (2.3 in.) thick flange of a die forging. (b) Specimens cut from the 12.7 mm (0.5 in.) thick flange of a die forging. (c) Specimens cut from a 114.3 mm (4.5 in.) thick hand forging. Source: Ref A7.11

Table A7.5 Tensile strength and plane-strain fracture toughness of 8090 and 2090 Al-Li sheet and plate

Alloy and temper	**8090-TU51**	**8090-TU51**	**8090-TU51**	**8090-TU51**	**8090-TU51**		**8090-T6**	**8090-T6**
Thickness, mm (in.)	1.6 (0.063)	1.6 (0.063)	63.5 (2.5)	63.5 (2.5)	63.5 (2.5)		1.6 (0.063)	1.6 (0.063)
Orientation	L	T	L	T	S		L	T
E, MPa (ksi)	80,502 (11,667)	80,730 (11,700)	78,432 (11,367)	79,578 (11,533)	76,818 (11,133)		80,958 (11,733)	82,800 (12,000)
F_{tu}, MPa (ksi)	529.9 (76.8)	517.3 (74.97)	492.7 (71.4)	492.7 (71.4)	451.1 (65.37)		481.1 (69.73)	463.9 (67.23)
F_{ty}, MPa (ksi)	464.4 (67.3)	438.2 (63.5)	458.0 (66.37)	405.0 (58.7)	351.0 (50.87)		380.7 (55.17)	376.9 (54.63)
Elongation, %	3.35	8.35	4.85	5.22	1.71		5.86	8.85
E_c, MPa (ksi)	. . .	. . .	81,248 (11,775)	83,490 (12,100)	82,110 (11,900)		. . .	. . .
F_{cy}, MPa (ksi)	. . .	. . .	424.0 (61.45)	442.6 (64.15)	403.3 (58.45)		. . .	. . .
F_{su}, MPa (ksi)	. . .	. . .	249.6 (36.17)	240.6 (34.87)	. . .		. . .	. . .
F_{bru}, MPa (ksi) (e/D = 2)	774.2 (112.2)	. . .	908.2 (131.63)	. . .	. . .		719.7 (104.3)	. . .
F_{bry}, MPa (ksi) (e/D = 2)	635.3 (92.07)	. . .	704.7 (102.13)	. . .	. . .		578.4 (83.83)	. . .
K_{IC}, MPa$\sqrt{m}$ (ksi$\sqrt{in.}$)	. . .	. . .	37.5 (34.08)	29.1 (26.45)	. . .		. . .	. . .
Alloy and temper	**2090-T3E27**	**2090-T3E27**	**2090-T8(a)**	**2090-T8(a)**	**2090-T8(b)**	**2090-T8(b)**	**2090-T6**	**2090-T6**
Thickness, mm (in.)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)	1.6 (0.063)
Orientation	L	T	L	T	L	T	L	T
E, MPa (ksi)	80,040 (11,600)	80,385 (11,650)	78,315 (11,350)	77,280 (11,200)	77,970 (11,300)	77,625 (11,250)	76,935 (11,150)	75,900 (11,000)
F_{tu}, MPa (ksi)	349.5 (50.65)	349.5 (50.65)	534.8 (77.5)	540.3 (78.3)	549.6 (79.65)	533.0 (77.25)	458.9 (66.5)	476.8 (69.1)
F_{ty}, MPa (ksi)	233.2 (33.8)	231.2 (33.5)	484.4 (70.2)	509.9 (73.9)	525.4 (76.15)	479.9 (69.55)	380.5 (55.15)	411.6 (59.65)
Elongation, %	17.93	17.39	7.54	6.24	5.36	7.59	8.03	6.9
E_c, MPa (ksi)	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
F_{cy}, MPa (ksi)	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
F_{bru}, MPa (ksi)(e/D = 1.5)	477.5 (69.2)	. . .	774.5 (112.25)	. . .	724.2 (104.95)	. . .	650.7 (94.3)	. . .
F_{bry}, MPa (ksi) (e/D = 1.5)	323.6 (46.9)	. . .	671.7 (97.35)	. . .	623.4 (90.35)	. . .	548.6 (79.5)	. . .

(a) Peak age 24 h at 160 °C (325 °F). (b) Peak age 24 h at 175 °C (350 °F). Source: Ref A7.11

Table A7.6 Tensile properties of 8090 and 2090 Al-Li extrusions

Alloy and temper	8090-TU51 Al-Li		2029-T8E41 (Alcoa data)	
Product form	25.4 × 102 mm (1 × 4 in.) extrusion		10.2 × 51 mm (0.4 × 2 in.) extrusion	
Orientation	L	T	L	T
E, MPa (ksi)	80,268 (11,633)	79,350 (11,500)	81,192 (11,767)	77,508 (11,233)
F_{tu}, MPa (ksi)	589.3 (85.4)	530.1 (76.83)	595.0 (86.23)	532.9 (77.23)
F_{ty}, MPa (ksi)	555.5 (80.5)	455.2 (65.97)	574.1 (83.2)	502.8 (72.87)
Elongation, %	4.29	6.34	7.98	5.01
E_c, MPa (ksi)	81,648 (11,833)	81,993 (11,883)	...	...
F_{cy}, MPa (ksi)	511.8 (74.17)	489.7 (70.97)	...	...
F_{bru}, MPa (ksi) (e/D = 2)	736.2 (106.7)	...	...	...
F_{bry}, MPa (ksi) (e/D = 2)	549.8 (79.68)	...	...	...

Alloy and temper	8090-TU51 Al-Li			2029-T8E41 (Kaiser data)	
Product form	76.2 × 102 mm (3 × 4 in.) extrusion			T-extrusion	
Orientation	L	T	S	L	T
E, (ksi)	79,350 (11,500)	80,040 (11,600)	78,833 (11,425)	80,040 (11,600)	81,192 (11,767)
F_{tu}, (ksi)	562.7 (81.55)	497.5 (72.1)	489.6 (70.95)	600.0 (86.95)	541.0 (78.4)
F_{ty}, (ksi)	532.0 (77.1)	403.13 (58.425)	379.8 (55.05)	572.7 (83)	494.2 (71.63)
Elongation, %	5.30	4.28	3.33	3.07	1.33

Source: Ref A7.11

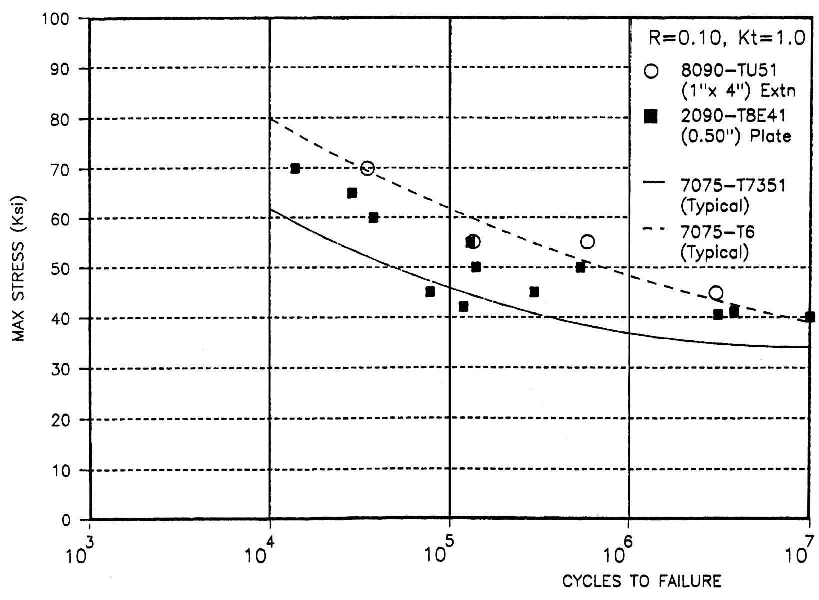


Fig. A7.9 Comparison of S-N curves for 8090-TU51 extrusion with 2090-T8E41 plate and typical 7075-T6/T7351 aluminum, R = 0.1, K_t = 1. Source: Ref A7.11

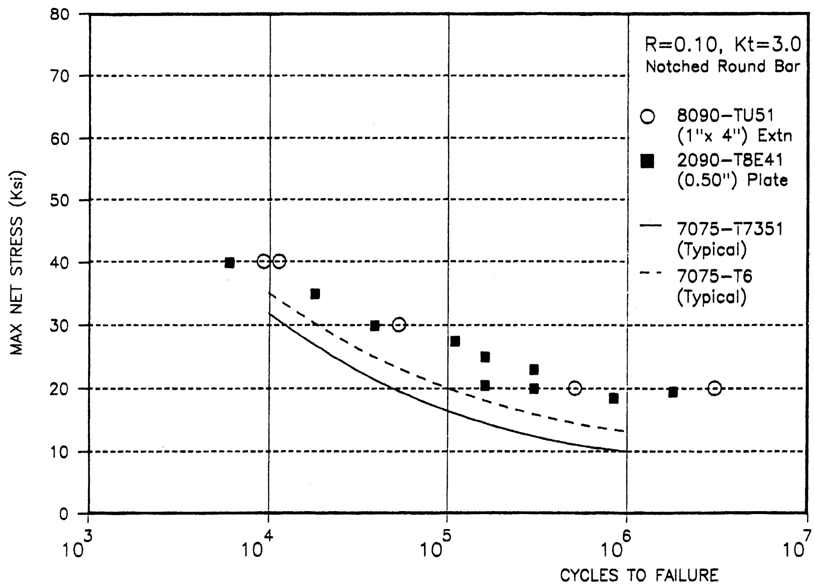


Fig. A7.10 Comparison of *S-N* curves for 8090-TU51 extrusion with 2090-T8E41 plate and typical 7075-T6/T7351 aluminum, $R = 0.1$, $K_t = 3$. Source: Ref A7.11

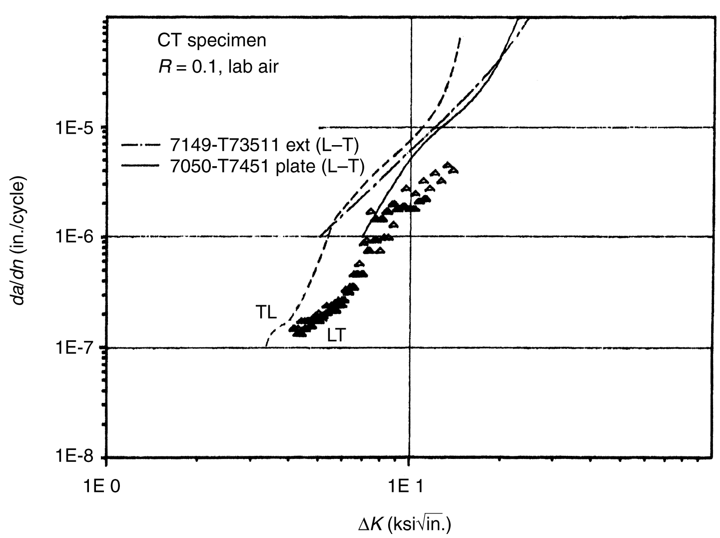


Fig. A7.11 Comparison of *da/dN* curves for 8090-TU51 extrusion (LT and TL) with 7149-T73511 extrusion and 7050-T7451 plate, $R = 0.1$. Source: Ref A7.11

Table A7.7 Tensile properties of 31.8 mm (1.25 in.) thick B201-T7 plate

	Ultimate tensile strength, MPa (ksi)		Yield strength, MPa (ksi)		Elongation, %	
Foundry	Avg.	Range	Avg.	Range	Avg.	Range
A	455 (66)	449–462 (65–67)	393 (57)	373–400 (54–58)	8.7	8.3–11
B	483 (70)	469–504 (68–73)	435 (63)	414–455 (60–66)	8.2	7.5–8.8
C	462 (67)	442–483 (64–70)	414 (60)	400–428 (58–62)	8.3	6.5–9.5
Average	**469 (68)**		**414 (60)**		**8.4**	

Source: Ref A7.12

Table A7.8 Fracture toughness and notch tensile strength of 31.8 mm (1.25 in.) thick B201-T7 plate

	Fracture toughness (K_Q)		Notch tensile strength		Yield strength		
Foundry	$MPa\sqrt{m}$	$ksi\sqrt{in.}$	MPa	ksi	MPa	ksi	NTS/YS
A	51	46	639.6	92.7	398.1	57.7	1.62
	43	39	611.3	88.6	394.7	57.2	1.55
B	30	27	562.4	81.5	431.3	62.5	1.37
	35	32	585.1	84.8	454.0	65.8	1.29
C	54	49	625.8	90.7	416.1	60.3	1.50
	51	46	593.4	86.0	414.7	60.1	1.44
Average	**44**	**40**	**602.4**	**87.3**	**418.1**	**60.6**	**1.46**

Source: Ref A7.12

Table A7.9 Tensile properties of 31.8 mm (1.25 in.) thick water- and glycol-quenched D357-T6 plate

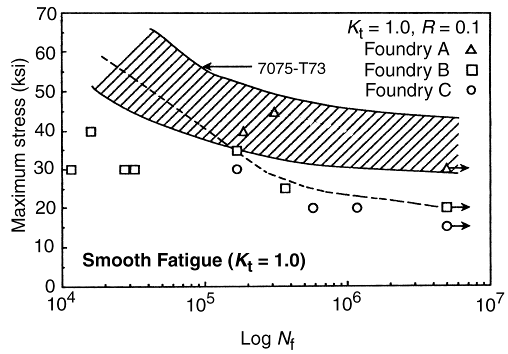
		Ultimate tensile strength, MPa (ksi)		Yield strength, MPa (ksi)		Elongation, %	
Foundry	Quench medium(a)	Avg.	Range	Avg.	Range	Avg.	Range
A	Water	373 (54)	352–380 (51–55)	311 (45)	304–324 (44–47)	5.9	3.5–8.5
	Glycol(b)	366 (53)	352–380 (51–55)	297 (43)	290–304 (42–44)	6.6	5.5–9.0
B	Water	359 (52)	345–366 (50–53)	311 (45)	304–317 (44–46)	4.5	3.0–5.6
	Glycol(b)	338 (49)	331–345 (48–50)	290 (42)	283–297 (41–43)	3.4	2.5–4.3
C	Water	373 (54)	366–380 (53–55)	324 (47)	317–331 (46–48)	5.4	3.9–8.2
	Glycol(b)	352 (51)	345–359 (50–52)	304 (44)	297–304 (43–44)	4.9	4.6–5.2
Average	**Water**	**366 (53)**		**317 (46)**		**5.2**	
	Glycol(b)	**352 (51)**		**297 (43)**		**5.0**	

(a) Room temperature. (b) 25% glycol solution. Source: Ref A7.12

Table A7.10 Fracture toughness and notch tensile strength of 31.8 mm (1.25 in.) thick D357-T6 plate

		Fracture toughness, $MPa\sqrt{m}$ ($ksi\sqrt{in.}$)		Notch tensile strength		Yield strength		
Foundry	Quench medium	K_{IC}	K_Q	MPa	ksi	MPa	ksi	NTS/YS
A	Water	. . .	28 (25)	435	63	311	45	1.4
	Glycol(a)	23 (21)	. . .	400	58	297	43	1.3
B	Water	. . .	26 (24)	429	62	311	45	1.4
	Glycol(a)	24 (22)	. . .	400	58	290	42	1.4
C	Water	. . .	25 (23)	366	53	324	47	1.1
	Glycol(a)	24 (22)	. . .	304	44	304	44	1.0
Average	**Water**	**. . .**	**26 (24)**	**407**	**59**	**317**	**46**	**1.3**
	Glycol(a)	**24 (22)**	**. . .**	**366**	**53**	**297**	**43**	**1.2**

(a) 25% glycol solution. Source: Ref A7.12



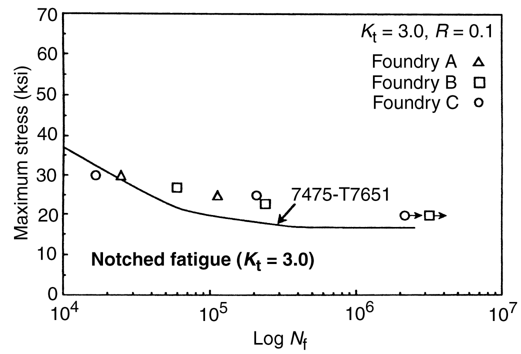


Fig. A7.12 Comparison of *S-N* curves for B201-T7 aluminum casting with HIP A201-T7 casting (dashed line, Northrop data: Ref A7.13), 7075-T73 wrought (Alcoa Green Letter GL-206, 1971), and 7475-T7651 wrought (Alcoa Green Letter GL-216, 1985). Source: Ref A7.12

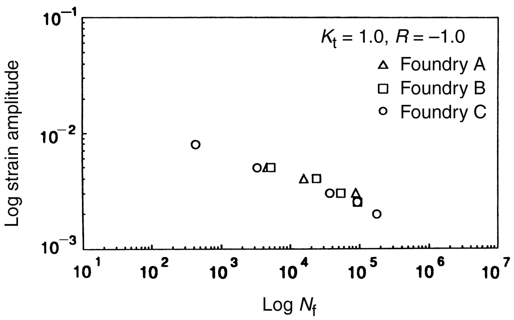


Fig. A7.13 Strain-life data for B201-T7 aluminum casting. Source: Ref A7.12

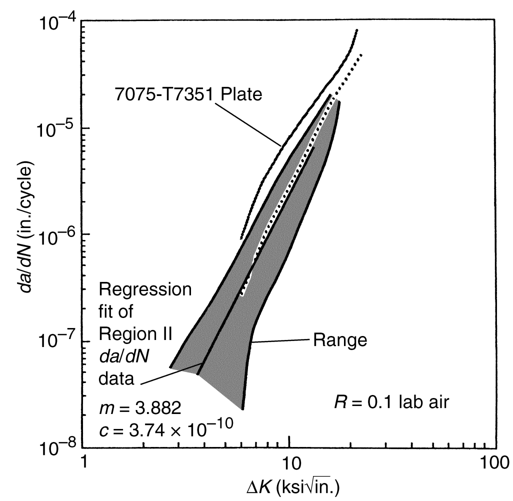
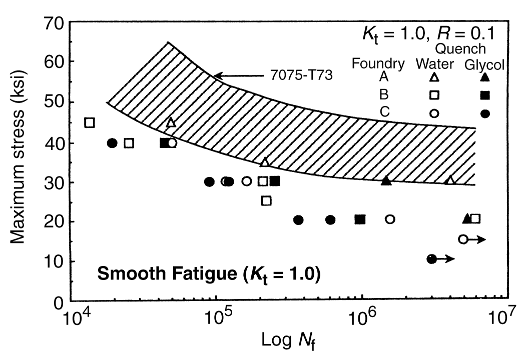


Fig. A7.14 Comparison of *da/dN* curves for B201-T7 aluminum casting with other Northrop in-house data (dotted line) and 7075-T7351 plate. Source: Ref A7.12



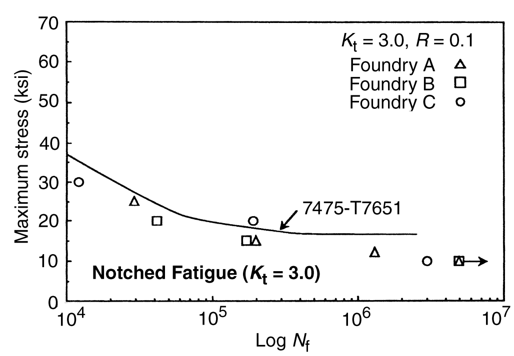


Fig. A7.15 Comparison of *S-N* curves for D357-T6 aluminum casting with 7075-T73 (Alcoa Green Letter GL-206, 1971) and 7475-T7651 (Alcoa Green Letter GL-216, 1985) wrought materials. Source: Ref A7.12

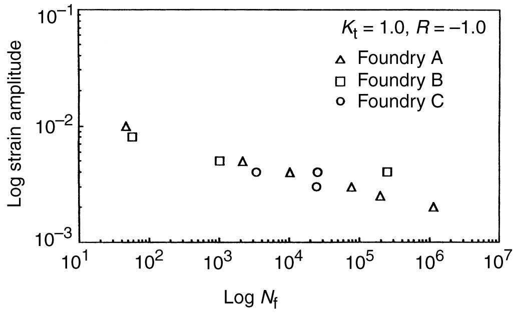


Fig. A7.16 Strain-life data for D357-T6 aluminum casting. Source: Ref A7.12

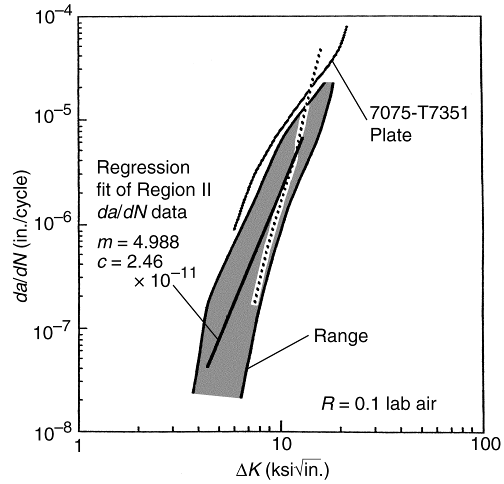


Fig. A7.17 Comparison of *da/dN* curves for D357-T6 aluminum casting with other Northrop in-house data (dotted line) and 7075-T7351 plate. Source: Ref A7.12