

K_{IC} VALUES

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MECHANICS OF ENGR. MATL
3rd Ed.

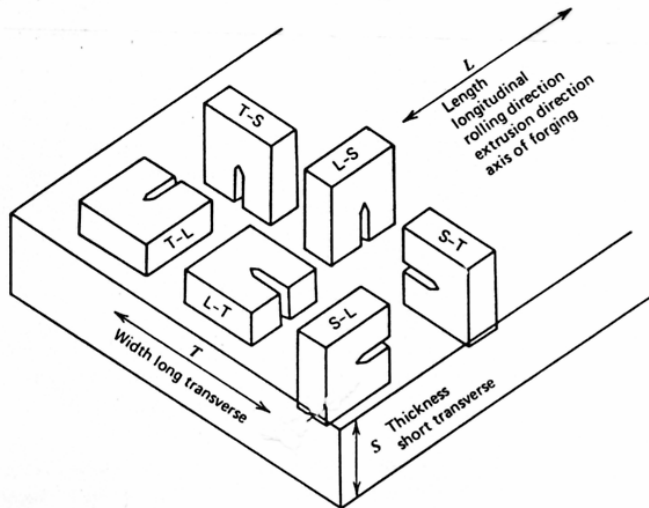


FIGURE 10.12 Code system for specimen orientation and crack propagation direction in plate.

TABLE 10.2a Plane-Strain Fracture-Toughness Anisotropy in Wrought, High-Strength Aluminum Alloys¹⁷

Alloy and Temper Designation	Product	K_{IC} (MPa \sqrt{m})		
		L-T	T-L	S-T
2014-T651	127-mm plate	22.9	22.7	20.4
7075-T651	45-mm plate	29.7	24.5	16.3
7079-T651	45-mm plate	29.7	26.3	17.8
7075-T6511	90 × 190-mm extruded bar	34.0	22.9	20.9
7178-T6511	90 × 190-mm extruded bar	25.0	17.2	15.4

TABLE 10.2b Plane-Strain Fracture-Toughness Anisotropy in Wrought, High-Strength Aluminum Alloys¹⁷

Alloy and Temper Designation	Product	K_{IC} (ksi $\sqrt{in.}$)		
		L-T	T-L	S-T
2014-T651	5-in. plate	20.8	20.6	18.5
7075-T651	1½-in. plate	27.0	22.3	14.8
7079-T651	1½-in. plate	27.0	23.9	16.2
7075-T6511	3½ × 7½-in. extruded bar	30.9	20.8	19.0
7178-T6511	3½ × 7½-in. extruded bar	22.7	15.6	14.0

TABLE 10.7a Strength and Fracture-Toughness Data for Selected Materials^{17a}

Alloy	Material Supply	Specimen Orientation	Test Temperature (°C)	σ_{ys} (MPa)	K_{Ic} (MPa√m)
<i>Aluminum Alloys</i>					
2014-T651	Plate	L-T	21-32	435-470	23-27
"	"	T-L	"	435-455	22-25
"	"	S-L	24	380	20
2014-T6	Forging	L-T	"	440	31
"	"	T-L	"	435	18-21
<i>continued</i>					
Alloy	Material Supply	Specimen Orientation	Test Temperature (°C)	σ_{ys} (MPa)	K_{Ic} (MPa√m)
2020-T651	Plate	L-T	21-32	525-540	22-27
"	"	T-L	"	530-540	19
2024-T351	"	L-T	27-29	370-385	31-44
"	"	T-L	"	305-340	30-37
2024-T851	"	L-T	21-32	455	23-28
"	"	T-L	"	440-455	21-24
2124-T851	"	L-T	"	440-460	27-36
"	"	T-L	"	450-460	24-30
2219-T851	"	L-T	"	345-360	36-41
"	"	T-L	"	340-345	28-38
7049-T73	Forging	L-T	"	460-510	31-38
"	"	T-L	"	460-470	21-27
7050-T73651	Plate	L-T	"	460-510	33-41
"	"	T-L	"	450-510	29-38
"	"	S-L	"	430-440	25-28
7075-T651	Plate	L-T	21-32	515-560	27-31
"	"	T-L	"	510-530	25-28
"	"	S-L	"	460-485	16-21
7075-T7351	"	L-T	"	400-455	31-35
"	"	T-L	"	395-405	26-41
7475-T651	"	T-L	"	505-515	33-37
7475-T7351*	"	T-L	"	395-420	39-44
7079-T651	"	L-T	"	525-540	29-33
"	"	T-L	"	505-510	24-28
7178-T651	"	L-T	"	560	26-30
"	"	T-L	"	540-560	22-26
"	"	S-L	"	470	17
<i>Ferrous Alloys</i>					
4330V(275°C temper)	Forging	L-T	21	1400	86-94
4330V(425°C temper)	"	L-T	"	1315	103-110
4340(205°C temper)	"	L-T	"	1580-1660	44-66
4340(260°C temper)	Plate	L-T	"	1495-1640	50-63
4340(425°C temper)	Forging	L-T	"	1360-1455	79-91
D6AC(540°C temper)	Plate	L-T	"	1495	102
D6AC(540°C temper)	"	L-T	-54	1570	62
9-4-20(550°C temper)	"	L-T	21	1280-1310	132-154
18 Ni(200)(480°C 6 hr)	Plate	L-T	21	1450	110
18 Ni(250)(480°C 6 hr)	"	L-T	"	1785	88-97
18 Ni(300)(480°C)	"	L-T	"	1905	50-64
18 Ni(300)(480°C 6 hr)	Forging	L-T	"	1930	83-105
AFC77 (425°C temper)	"	L-T	24	1530	79
<i>Titanium Alloys</i>					
Ti6 Al-4V	(Mill anneal plate)	L-T	23	875	123
"	"	T-L	"	820	106
"	(Recryst. anneal plate)	L-T	22	815-835	85-107
"	"	T-L	22	825	77-116
<i>Ceramics^c</i>					
Mortar ^{18b}	—	—	—	—	0.13-1.3
Concrete ^{18a}	—	—	—	—	2-2.3

continued

Alloy	Material Supply	Specimen Orientation	Test Temperature (°C)	σ_{ys} (MPa)	K_{IC} (MPa \sqrt{m})
Al ₂ O ₃ ¹⁶⁵⁻¹⁶⁷		—	—	—	3–5.3
SiC ¹⁶⁵		—	—	—	3.4
SiN ₄ ¹⁶⁶		—	—	—	4.2–5.2
Soda lime silicate glass ¹⁶⁶		—	—	—	0.7–0.8
Electrical porcelain ceramics ¹⁶⁸		—	—	—	1.03–1.25
WC(2.5–3 μ m)—3 w/o Co ¹⁶⁹		—	—	—	10.6
WC(2.5–3 μ m)—9 w/o Co ¹⁶⁹		—	—	—	12.8
WC(2.5–3.3 μ m)—15 w/o Co ^{169,170}		—	—	—	16.5–18
Indiana limestone ¹⁷¹		—	—	—	0.99
ZrO ₂ (Ca stabilized) ¹⁷²		—	—	—	7.6
ZrO ₂ ¹⁷²		—	—	—	6.9
Al ₂ O ₃ /SiC whiskers ¹⁷³		—	—	—	8.7
SiC/SiC fibers ¹⁷³		—	—	—	25
Borosilicate glass/SiC fibers ¹⁷³		—	—	—	18.9
<i>Polymers</i>					
PMMA ¹⁷⁴		—	—	—	0.8–1.75 ^b
PS ¹⁷⁵		—	—	—	0.8–1.1 ^b
Polycarbonate ¹⁷⁶		—	—	—	2.75–3.3 ^b

^aSpecial processing.

^b K_{IC} is f (crack speed).

^cFor additional K_{IC} data, see reference 177 and Fig. 10.32.

TABLE 10.7b Strength and Fracture-Toughness Data for Selected Materials¹⁷⁸

Alloy	Material Supply	Specimen Orientation	Test Temperature (°F)	σ_{ys} (ksi)	K_{IC} (ksi $\sqrt{in.}$)
<i>Aluminum Alloys</i>					
2014-T651	Plate	L-T	70–89	63–68	21–24
"	"	T-L	"	63–66	20–22
"	"	S-L	75	55	18
2014-T6	Forging	L-T	"	64	28
"	"	T-L	"	63	16–19
2020-T651	Plate	L-T	70–89	76–78	20–25
"	"	T-L	"	77–78	17–18
2024-T351	"	L-T	80–85	54–56	28–40
"	"	T-L	"	44–49	27–34
2024-T851	"	L-T	70–89	66	21–26
"	"	T-L	"	64–66	19–21
2124-T851	"	L-T	"	64–67	25–33
"	"	T-L	"	65–67	22–27
2219-T851	"	L-T	"	50–52	33–37
"	"	T-L	"	49–50	26–34
7049-T73	Forging	L-T	"	67–74	28–34
"	"	T-L	"	67–68	19–25
7050-T73651	Plate	L-T	"	67–74	30–37
"	"	T-L	"	65–74	26–35
"	"	S-L	"	62–64	22–26
7075-T651	Plate	L-T	70–89	75–81	25–28
"	"	T-L	"	74–77	23–26
"	"	S-L	"	67–70	15–19
7075-T7351	"	L-T	"	58–66	28–32
"	"	T-L	"	57–59	24–37

continued

Alloy	Material Supply	Specimen Orientation	Test Temperature (°F)	σ_{ys} (ksi)	K_{IC} (ksi $\sqrt{\text{in.}}$)
7475-T651	"	T-L	"	73-75	30-33
7475-T7351 ^a	"	T-L	"	57-61	35-40
7079-T651	"	L-T	"	76-78	26-30
"	"	T-L	"	73-74	22-25
7178-T651	"	L-T	"	81	23-27
"	"	T-L	"	78-81	20-23
"	"	S-L	"	68	15
<i>Ferrous Alloys</i>					
4330V(525°F temper)	Forging	L-T	70	203	78-85
4330V(800°F temper)	"	L-T	"	191	94-100
4340(400°F temper)	"	L-T	"	229-241	40-60
4340(500°F temper)	Plate	L-T	"	217-238	45-57
4340(800°F temper)	Forging	L-T	"	197-211	72-83
D6AC(1000°F temper)	Plate	L-T	"	217	93
D6AC(1000°F temper)	Plate	L-T	-65	228	56
9-4-20(1025°F temper)	Plate	L-T	70	186-190	120-140
18 Ni(200)(900°F 6 hr)	Plate	L-T	70	210	100
18 Ni(250)(900°F 6 hr)	Plate	L-T	"	259	80-88
18 Ni(300)(900°F)	"	L-T	"	276	45-58
18 Ni(300)(900°F 6 hr)	Forging	L-T	"	280	75-95
AFC77 (800°F temper)	"	L-T	75	222	72
<i>Titanium Alloys</i>					
Ti-6 Al-4V	(Mill anneal plate)	L-T	74	127	112
"	"	T-L	"	119	96
"	(Recryst. anneal plate)	L-T	72	118-121	77-97
"	"	T-L	72	120	70-105
<i>Ceramics</i>					
Mortar ¹⁶³	—	—	—	—	1.8-2.1
Concrete ¹⁶⁴	—	—	—	—	0.21-1.30
Al ₂ O ₃ ¹⁶⁵⁻¹⁶⁷	—	—	—	—	2.7-4.8
SiC ¹⁶⁵	—	—	—	—	3.1
Si ₃ N ₄ ¹⁶⁶	—	—	—	—	3.8-4.7
Soda lime silicate glass ¹⁶⁶	—	—	—	—	0.64-0.73
Electrical porcelain ceramics ¹⁶⁸	—	—	—	—	0.94-1.14
WC(2.5-3 μm)—3 w/o Co ¹⁶⁹	—	—	—	—	9.6
WC(2.5-3 μm)—9 w/o Co ¹⁶⁹	—	—	—	—	11.6
WC(2.5-3 μm)—15 w/o Co ^{169,170}	—	—	—	—	15-16.4
Indiana limestone ¹⁷¹	—	—	—	—	0.9
ZrO ₂ (Ca stabilized) ¹⁷²	—	—	—	—	6.9
ZrO ₂ ¹⁷²	—	—	—	—	6.3
Al ₂ O ₃ /SiC whiskers ¹⁷³	—	—	—	—	7.9
SiC/SiC fibers ¹⁷³	—	—	—	—	22.7
Borosilicate glass/SiC fibers ¹⁷³	—	—	—	—	17.2
<i>Polymers</i>					
PMMA ¹⁷⁴	—	—	—	—	0.73-1.6 ^b
PS ¹⁷⁵	—	—	—	—	0.73-1.0 ^b
Polycarbonate ¹⁷⁶	—	—	—	—	2.5-3.0 ^b

^aSpecial processing.

^b K_{IC} is f (crack speed).

^cFor additional K_{IC} data, see reference 177 and Fig. 10.32.