

Wrought Alloys: 6xxx Al-Mg-Si Alloys

Principal characteristics and applications of the 6xxx series of aluminum alloys include:

- Heat treatable
- High corrosion resistance, excellent extrudability; moderate strength
- Building and construction, highway, automotive, marine applications
- Representative alloys: 6061, 6063

- Typical ultimate tensile strength range: 18 to 58 ksi (125 to 400 MPa)

The 6xxx alloys are heat treatable and have moderately high strength coupled with excellent corrosion resistance. They are readily welded. A unique feature is the extrudability, which makes them the first choice for architectural and structural members where unusual or complex shapes or particularly strength- or stiffness-criticality is important.

Alloy 6063 is perhaps the most widely used

because of its extrudability; it was a key in the recent all-aluminum bridge structure erected in only a few days in Foresmo, Norway, and it is the choice for the Audi automotive space frame members.

Higher strength alloy 6061 finds broad use in welded structural members, such as truck and marine frames, railroad cars, and pipelines. Specialty alloys in the series include 6066-T6 for high strength forgings; 6111 for automotive body panels with high dent resistance; and 6101 and 6201 for high-strength electrical bus and electrical conductor wire, respectively.

6005-T5 Extrusions: Typical Tensile Properties

Temperature			At temperature indicated					At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %	Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		ksi	MPa	ksi	MPa	
75	25	...	44	305	39	270	12	44	305	39	270	12
212	100	0.1	39	270	36	250	14	44	305	39	270	12
		0.5	39	270	36	250	14	44	305	39	270	12
		10	39	270	36	250	14	44	305	39	270	12
		100	39	270	36	250	13	45	310	40	275	12
		1,000	41	285	38	260	12	46	315	42	290	11
300	150	10,000	41	285	38	260	12	46	315	42	290	11
		0.1	34	235	32	220	14	44	305	39	270	12
		0.5	34	235	32	220	14	44	305	40	275	12
		10	35	240	33	230	13	45	310	41	285	12
		100	34	235	33	230	12	44	305	41	285	11
350	177	1,000	28	195	26	180	15	38	260	34	235	12
		10,000	24	165	21	145	18	30	205	25	170	13
		0.1	32	220	30	205	14	44	305	39	270	12
		0.5	32	220	30	205	13	44	305	40	275	12
		10	31	215	30	205	12	43	295	40	275	11
400	205	100	26	180	24	165	14	36	250	32	220	12
		1,000	21	145	18	125	19	29	200	23	160	14
		10,000	17	115	13	90	26	22	150	15	105	17
		0.1	28	195	27	185	13	44	305	39	270	12
		0.5	28	195	27	185	13	43	295	39	270	11
450	230	10	23	160	22	150	18	36	250	29	200	13
		100	18	125	16	110	22	28	195	21	145	15
		1,000	13	90	10	70	29	21	145	13	90	18
		10,000	8.5	59	6.0	41	50	14	95	7	48	35
		0.1	26	180	25	170	12	43	295	38	260	12
500	260	0.5	25	170	24	165	13	...	...	...	...
		0.1	20	140	19	130	12	38	260	35	240	12
600	315	0.5	17	115	16	110	20	...	...	...	...
		0.1	11	75	10	70	22	30	205	24	165	14
700	370	0.5	9.0	62	8.5	59	30	...	...	...	...
		0.1	...	...	...	...	...	21	145	11	75	17

Source data are in English units; metric values are converted and rounded.

6061-O: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	ksi	MPa	ksi	MPa	10 ⁶ psi		GPa	ksi	MPa	ksi	MPa		
-320	-196	...	33	230	10	70	45	11.1	77	...	...	...	...	...
-112	-80	...	20	140	8.5	59	37	10.4	72	...	...	...	...	...
-18	-28	...	19	130	8.0	55	33	10.1	70	...	...	...	...	...
75	25	...	18	125	8.0	55	30	9.9	68	18	125	8.0	55	30
212	100	0.1	18	125	8.0	55	30	9.5	66	18	125	8.0	55	30
		0.5	18	125	8.0	55	30	9.5	66	18	125	8.0	55	30
		10	18	125	8.0	55	30	9.5	66	18	125	8.0	55	30
		100	18	125	8.0	55	30	9.5	66	18	125	8.0	55	30
		1,000	18	125	8.0	55	30	9.5	66	18	125	8.0	55	30
		10,000	18	125	8.5	59	30	9.5	66	19	130	10	70	30
300	150	0.1	16	110	8.0	55	35	9.1	63	18	125	8.0	55	30
		0.5	16	110	8.0	55	35	9.1	63	18	125	8.0	55	30
		10	16	110	8.0	55	35	9.1	63	18	125	8.0	55	30
		100	16	110	8.5	59	35	9.1	63	18	125	8.5	59	30
		1,000	16	110	9.0	62	35	9.1	63	18	125	9.0	62	30
		10,000	15	105	9.5	66	35	9.1	63	18	125	10	70	30
350	177	0.1	14	95	8.0	55	45	8.9	61	18	125	8.0	55	30
		0.5	14	95	8.0	55	45	8.9	61	18	125	8.0	55	30
		10	14	95	8.0	55	45	8.9	61	18	125	8.0	55	30
		100	14	95	8.5	59	45	8.9	61	18	125	6.5	45	30
		1,000	13	90	8.5	59	45	8.9	61	18	125	9.0	62	30
		10,000	12	85	8.5	59	45	8.9	61	18	125	9.5	66	30
400	205	0.1	11	75	8.0	55	60	8.6	59	18	125	8.0	55	30
		0.5	11	75	8.0	55	60	8.6	59	18	125	8.0	55	30
		10	11	75	8.0	55	60	8.6	59	18	125	8.0	55	30
		100	11	75	8.0	55	60	8.6	59	18	125	9.0	62	30
		1,000	11	75	8.0	55	60	8.6	59	18	125	8.5	59	30
		10,000	10	70	7.5	52	60	8.6	59	18	125	8.0	55	30
450	230	0.1	8.5	59	6.5	45	75	8.3	57	18	125	8.0	55	30
		0.5	8.5	59	6.5	45	75	8.3	57	18	125	8.0	55	30
		10	8.5	59	6.5	45	75	8.3	57	18	125	8.0	55	30
		100	8.5	59	6.5	45	75	8.3	57	18	125	8.0	55	30
		1,000	8.5	59	6.5	45	75	8.3	57	18	125	8.0	55	30
		10,000	8.5	59	6.0	41	75	8.3	57	18	125	8.0	55	30
500	260	0.1	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		0.5	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		10	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		100	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		1,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		10,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
		100,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
600	315	0.1	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		0.5	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		10	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		100	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		1,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		10,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		100,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
700	370	0.1	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		0.5	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		10	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		100	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		1,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		10,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		100,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
800	425	...	2.8	19	2.2	15	80	...	...	...	...	...	...	...
900	480	...	2.2	15	1.6	11	80	...	...	...	...	...	...	...
1000	540	...	1.6	11	1.2	8.0	65	...	...	...	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6061-O: Creep and Stress-Relaxation Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep		Stress relaxation	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	Time under strain(a), h	Loss in stress, %
75	25	0.1	18	125	17	115	17	115	17	115	17	115	...	...
		1	18	125	17	115	17	115	17	115	17	115	1	2.0
		10	18	125	17	115	17	115	17	115	17	115	10	7.0
		100	18	125	17	115	17	115	17	115	17	115	100	11
		1,000	18	125	17	115	17	115	17	115	17	115	1,000	18
212	100	...	...	...	...	...	...	...	...	...	...	...	10,000	27
		0.1	18	125	17	115	17	115	17	115	17	115	...	...
		1	18	125	17	115	17	115	17	115	17	115	1	2.0
		10	18	125	17	115	17	115	17	115	17	115	10	15
		100	18	125	17	115	17	115	17	115	17	115	100	29
300	150	1,000	18	125	17	115	17	115	17	115	17	115	1,000	43
		...	...	...	...	...	...	...	...	...	...	...	10,000	62
		0.1	16	110	14	95	13	90	11	75	10	70	...	...
		1	16	110	14	95	13	90	10	70	9.5	66	1	27
		10	16	110	13	90	12	85	10	70	9.0	62	10	41
350	177	100	16	110	13	90	12	85	10	70	9.0	62	100	55
		1,000	16	110	13	90	12	85	10	70	9.0	62	1,000	72
		...	...	...	...	...	...	...	...	...	...	...	10,000	100
		0.1	14	95	11	75	10	70	8.0	55	7.5	52	...	...
		1	14	95	10	70	9.0	62	7.5	52	7.0	48	...	...
400	205	10	13	90	9.0	62	8.0	55	6.5	45	6.0	41	...	...
		100	12	85	8.5	59	7.5	52	6.0	41	5.5	38	...	...
		1,000	9.5	66	8.0	55	7.0	48	6.0	41	5.5	38	...	...
		0.1	11	75	8.0	55	7.5	52	6.5	45	6.0	41	...	...
		1	10	70	7.0	48	6.5	45	6.0	41	5.5	38	...	...
450	230	10	8.5	59	6.0	41	5.5	38	5.0	34	4.8	33	...	...
		100	7.0	48	5.5	38	5.0	34	4.6	32	4.4	30	...	...
		1,000	5.5	38	4.7	32	4.5	31	4.3	30	4.1	28	...	...
		10,000	4.8	33	...	...	...	...	...	...	...	...	...	...
		0.1	8.5	59	6.5	45	6.0	41	5.5	38	5.0	34	...	...
500	260	1	7.5	52	5.5	38	5.0	34	4.9	34	4.6	32	...	...
		10	6.5	45	5.0	34	4.8	33	4.5	31	4.2	29	...	...
		100	5.5	38	4.6	32	4.5	31	4.1	28	3.8	26	...	...
		1,000	4.7	32	4.0	28	3.9	27	3.7	26	3.5	24	...	...
		0.1	7.0	48	5.5	38	4.9	34	4.5	31	4.3	30	...	...
600	315	1	6.0	41	4.7	32	4.4	30	4.1	28	3.9	27	...	...
		10	5.0	34	4.3	30	4.1	28	3.8	26	3.6	25	...	...
		100	4.3	30	3.9	27	3.8	26	3.4	23	3.2	22	...	...
		1,000	3.8	26	3.4	23	3.3	23	3.1	21	2.9	20	...	...
		0.1	4.7	32	3.6	25	3.4	23	3.2	22	3.0	21	...	...
700	370	1	4.0	28	3.2	22	3.1	21	2.9	20	2.7	19	...	...
		10	3.4	23	2.9	20	2.8	19	2.6	18	2.3	16	...	...
		100	2.9	20	2.6	18	2.5	17	2.2	15	2.0	14	...	...
		1,000	2.3	16	2.2	15	2.1	14	1.9	13	1.7	12	...	...
		10,000	1.7	12	...	...	...	...	...	...	...	...	...	...
700	370	0.1	3.0	21	2.5	17	2.4	17	2.2	15	2.1	14	...	...
		1	2.7	19	2.3	16	2.2	15	2.0	14	1.9	13	...	...
		10	2.4	17	2.0	14	1.9	13	1.8	12	1.7	12	...	...
		100	2.1	14	1.8	12	1.7	12	1.6	11	1.5	10	...	...
		1,000	1.8	12	1.6	11	1.5	10	1.4	10	1.3	9.0	...	...

(a) Stressed in tension to 60% of the tensile yield strength at the stressing temperature. Strain held constant during exposure. Source data are in English units; metric values are converted and rounded.

6061-T4, -T451: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
°F	°C													
-423	-253	...	85	585	38	260	41	...	...	...	...	...	...	...
-320	-196	...	53	365	29	200	31	11.1	77	...	...	...	...	...
-112	-80	...	39	270	23	160	27	10.4	72	...	...	...	...	...
-18	-28	...	37	255	22	150	26	10.1	70	...	...	...	...	...
75	25	...	35	240	21	145	25	9.9	68	35	240	21	145	25
212	100	0.1	32	220	21	145	27	9.5	66	...	...	...	...	...
		0.5	32	220	21	145	27	9.5	66	35	240	21	145	25
		10	32	220	21	145	27	9.5	66	...	...	...	...	...
		100	35	240	26	180	26	9.5	66	...	...	...	...	...
		1,000	38	260	31	215	24	9.5	66	...	...	...	...	...
		10,000	41	285	34	235	22	9.5	66	...	...	...	...	...
		100,000	42	290	36	250	18	9.5	66	...	...	...	...	...
300	150	0.1	30	205	20	140	28	9.1	63	...	...	...	...	...
		0.5	30	205	20	140	28	9.1	63	35	240	22	150	25
		10	32	220	23	160	27	9.1	63	(b)	(b)	(b)	(b)	...
		100	38	260	36	250	22	9.1	63	(b)	(b)	(b)	(b)	...
		1,000	38	260	36	250	18	9.1	63	(b)	(b)	(b)	(b)	...
		10,000	33	230	31	215	19	9.1	63	(b)	(b)	(b)	(b)	...
		100,000	29	200	27	185	21	9.1	63	35	240	(b)	(b)	...
350	177	0.1	29	200	20	140	27	8.9	61	...	...	...	...	...
		0.5	29	200	20	140	26	8.9	61	38	260	29	200	...
		10	36	250	35	240	22	8.9	61	(b)	(b)	(b)	(b)	...
		100	34	235	32	220	18	8.9	61	(b)	(b)	(b)	(b)	...
		1,000	30	205	28	195	19	8.9	61	(b)	(b)	(b)	(b)	...
		10,000	24	165	22	150	22	8.9	61	33	230	27	185	18
		100,000	20	140	17	115	28	8.9	61	28	195	21	145	19
400	205	0.1	29	200	22	150	24	8.6	59	...	...	...	...	...
		0.5	30	205	28	195	22	8.6	59	41	285	34	235	17
		10	30	205	30	205	18	8.6	59	40	275	(b)	(b)	16
		100	27	185	25	170	19	8.6	59	35	240	30	205	17
		1,000	22	150	20	140	23	8.6	59	31	215	24	165	17
		10,000	17	115	14	95	28	8.6	59	26	180	18	125	19
		100,000	13	90	9.0	62	40	8.6	59	21	145	11	75	24
450	230	0.1	28	195	27	185	20	8.3	57	...	...	...	...	...
		0.5	29	200	28	195	18	8.3	57	40	275	34	235	16
		10	24	165	23	160	18	8.3	57	34	235	28	195	17
		100	19	130	18	125	23	8.3	57	29	200	21	145	18
		1,000	15	105	13	90	30	8.3	57	25	170	15	105	19
		10,000	12	85	8.5	59	40	8.3	57	20	140	11	75	24
		100,000	9.0	62	6.5	45	70	8.3	57	18	125	8.0	55	30
500	260	0.1	25	170	24	165	17	7.9	54	...	...	...	...	...
		0.5	23	160	22	150	16	7.9	54	35	240	29	200	16
		10	18	125	16	110	20	7.9	54	29	200	20	140	18
		100	13	90	11	75	29	7.9	54	25	170	14	95	20
		1,000	10	70	8.0	55	45	7.9	54	21	145	10	70	24
		10,000	8.0	55	6.0	41	65	7.9	54	18	125	8.0	55	30
		100,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
600	315	0.1	14	95	13	90	18	6.8	47	...	...	...	...	...
		0.5	12	85	11	75	23	6.8	47	27	185	17	115	19
		10	9.0	62	8.0	55	30	6.8	47	23	160	12	85	22
		100	6.0	41	4.5	31	65	6.8	47	20	140	8.5	59	29
		1,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		10,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		100,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
700	370	0.1	8.5	59	8.0	55	35	5.5	38	...	...	...	...	...
		0.5	7.0	48	6.5	45	35	5.5	38	23	160	12	85	22
		10	3.8	26	3.0	21	80	5.5	38	19	130	8.0	55	30
		100	3.6	25	3.0	21	80	5.5	38	19	130	8.0	55	30
		1,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		10,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		100,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
800	425	0.1	3.8	26	3.2	22	65	...	...	...	...	...	...	...
		0.5	3.0	21	2.4	17	80	...	...	...	...	...	...	...
900	480	...	2.2	15	1.6	11	80	...	...	...	...	...	...	...
1000	540	...	1.6	11	1.2	8.0	65	...	...	...	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension. (b) Greater than values for 0.5 h holding period
Source data are in English units; metric values are converted and rounded.

6061-T6 Sheet and Rolled-and-Drawn Products: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated						At room temperature after heating					
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
°F	°C													
-452	-269	...	74	510	53	365	27	...	...	...	...	...	...	...
-423	-253	...	74	510	53	365	27	...	...	...	...	...	...	...
-320	-196	...	58	400	46	315	23	11.1	77	...	...	...	...	...
-112	-80	...	49	340	42	290	19	10.4	72	...	...	...	...	...
-18	-28	...	47	325	41	285	18	10.1	70	...	...	...	...	...
75	25	...	45	310	40	275	17	9.9	68	45	310	40	275	17
212	100	0.1	41	285	38	260	18	9.5	66	45	310	40	275	17
		0.5	41	285	38	260	18	9.5	66	45	310	40	275	17
		10	41	285	38	260	18	9.5	66	45	310	40	275	17
		100	41	285	38	260	18	9.5	66	45	310	40	275	17
		1,000	42	290	39	270	18	9.5	66	46	315	41	285	17
		10,000	42	290	39	270	18	9.5	66	46	315	42	290	17
		100,000	42	290	39	270	17	9.5	66	45	310	41	285	17
300	150	0.1	38	260	36	250	20	9.1	63	45	310	40	275	17
		0.5	38	260	36	250	20	9.1	63	45	310	40	275	17
		10	38	260	36	250	19	9.1	63	46	315	41	285	16
		100	38	260	36	250	18	9.1	63	45	310	41	285	16
		1,000	38	260	36	250	18	9.1	63	43	295	40	275	16
		10,000	33	230	31	215	19	9.1	63	39	270	35	240	17
		100,000	29	200	27	185	21	9.1	63	35	240	30	205	17
350	177	0.1	36	250	35	240	21	8.9	61	45	310	40	275	17
		0.5	36	250	35	240	21	8.9	61	45	310	40	275	17
		10	36	250	35	240	18	8.9	61	44	305	40	275	16
		100	34	235	32	220	18	8.9	61	41	285	38	260	16
		1,000	30	205	28	195	19	8.9	61	38	260	34	235	16
		10,000	24	165	22	150	22	8.9	61	33	230	27	185	18
		100,000	20	140	17	115	28	8.9	61	28	195	21	145	19
400	205	0.1	33	230	32	220	20	8.6	59	44	305	39	270	18
		0.5	34	235	32	220	19	8.5	59	44	305	40	275	17
		10	30	205	30	205	18	8.6	59	40	275	36	250	16
		100	27	185	25	170	19	8.6	59	35	240	30	205	17
		1,000	22	150	20	140	23	8.6	59	31	215	24	165	17
		10,000	17	115	14	95	28	8.6	59	26	180	18	125	19
		100,000	13	90	9.0	62	40	8.6	59	21	145	11	75	24
450	230	0.1	29	200	28	195	19	8.3	57	43	295	38	260	16
		0.5	29	200	28	195	17	8.3	57	42	290	38	260	16
		10	24	165	23	160	18	8.3	57	34	235	28	195	17
		100	19	130	18	125	23	8.3	57	29	200	21	145	18
		1,000	15	105	13	90	30	8.3	57	25	170	15	105	19
		10,000	12	85	8.5	59	40	8.3	57	20	140	11	75	24
		100,000	9.0	62	6.5	45	70	8.3	57	18	125	8.0	55	30
500	260	0.1	25	170	24	165	17	7.9	54	41	285	36	250	15
		0.5	23	160	22	150	16	7.9	54	39	270	33	230	16
		10	18	125	16	110	20	7.9	54	29	200	20	140	18
		100	13	90	11	75	29	7.9	54	25	170	14	95	20
		1,000	10	70	8.0	55	45	7.9	54	21	145	10	70	24
		10,000	8.0	55	6.0	41	65	7.9	54	18	125	8.0	55	30
		100,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30
600	315	0.1	14	95	13	90	18	6.8	47	32	220	25	170	17
		0.5	12	85	11	75	23	6.8	47	27	185	17	115	19
		10	9.0	62	8.0	55	30	6.8	47	23	160	12	85	22
		100	6.0	41	4.5	31	65	6.8	47	20	140	8.5	59	29
		1,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		10,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
		100,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30
700	370	0.1	8.5	59	8.0	55	35	5.5	38	27	185	17	115	20
		0.5	7.0	48	6.5	45	35	5.5	38	23	160	12	85	22
		10	3.8	26	3.0	21	80	5.5	38	19	130	8.0	55	30
		100	3.6	25	3.0	21	80	5.5	38	19	130	8.0	55	30
		1,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		10,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
		100,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30
800	425	0.1	3.8	26	3.2	22	65	...	...	...	...	...	...	...
		0.5	3.0	21	2.4	17	80	...	...	...	...	...	...	...
900	480	...	2.2	15	1.6	11	80	...	...	...	...	...	...	...
1000	540	...	1.6	11	1.2	8.0	65	...	...	...	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6061-T6 Sheet and Rolled-and-Drawn Products: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	45	310	45	310	44	305	43	295	42	290
		1	45	310	45	310	43	295	42	290	42	290
		10	45	310	44	305	43	295	42	290	42	290
		100	45	310	44	305	42	290	42	290	41	285
		1,000	45	310	43	295	42	290	41	285	41	285
212	100	0.1	41	285	40	275	40	275	39	270	38	260
		1	40	275	39	270	39	270	38	260	37	255
		10	39	270	38	260	38	260	37	255	36	250
		100	38	260	37	255	37	255	...	...	...	...
		1,000	37	255	...	...	...	...	...	...	...	...
300	150	0.1	37	255	36	250	36	250	35	240	34	235
		1	36	250	34	235	34	235	32	220	31	215
		10	34	235	32	220	32	220	30	205	28	195
		100	31	215	30	205	29	200	27	185	24	165
		1,000	27	185	26	180	25	170	21	145	17	115
350	177	0.1	34	235	33	230	33	230	32	220	30	205
		1	32	220	31	215	31	215	29	200	27	185
		10	30	205	29	200	28	195	26	180	23	160
		100	26	180	25	170	24	165	22	150	17	115
		1,000	20	140	19	130	18	125	15	105	12	85
400	205	0.1	31	215	30	205	29	200	28	195	26	180
		1	28	195	27	185	26	180	24	165	22	150
		10	24	165	24	165	23	160	20	140	17	115
		100	20	140	19	130	18	125	15	105	10	70
		1,000	14	95	13	90	12	85	8.5	59	6.5	45
450	230	10,000	10	70	...	...	...	...	...	...	...	...
		0.1	25	170	24	165	24	165	23	160	20	140
		1	22	150	21	145	21	145	19	130	16	110
		10	17	115	16	110	15	105	13	90	11	75
		100	13	90	12	85	11	75	8.5	59	6.0	41
500	260	1,000	9.5	66	8.5	59	7.0	48	...	...	...	...
		0.1	20	140	19	130	19	130	18	125	16	110
		1	17	115	16	110	16	110	14	95	12	83
		10	12	85	11	75	11	75	9.0	62	7.0	48
		100	8.5	59	8.0	55	7.0	48	5.5	38	4.2	29
600	315	1,000	6.5	45	5.5	38	4.7	32	...	...	...	...
		0.1	11	75	10	70	9.5	66	9.0	62	8.0	55
		1	9.5	66	8.0	55	8.0	55	7.0	48	6.0	41
		10	7.0	48	6.0	41	5.5	38	4.5	31	3.2	22
		100	3.6	25	3.0	21	2.8	19	2.2	15	2.0	14
		1,000	2.3	16	2.2	15	2.1	14	1.9	13	1.7	12
		10,000	1.7	12	...	...	...	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6061-T6, -T651, -T6511 (Except for T6 Sheet and Rolled-and-Drawn Products): Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating							
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %			
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa				
°F	°C	Time at temperature, h															
-452	-269	...	74	510	53	365	27	...	...	...	...	...	...	...	...	...	...
-423	-253	...	74	510	53	365	27	...	...	...	...	...	...	...	...	...	...
-320	-196	...	60	415	47	325	22	11.1	77	...	...	...	...	...	...	...	...
-112	-80	...	49	340	42	290	19	10.4	72	...	...	...	...	...	...	...	...
-18	-28	...	47	325	41	285	18	10.1	70	...	...	...	...	...	...	...	...
75	25	...	45	310	40	275	17	9.9	68	45	310	40	275	17	...	...	...
212	100	0.1	41	285	38	260	18	9.5	66	45	310	40	275	17	...	...	...
		0.5	41	285	38	260	18	9.5	66	45	310	40	275	17	...	...	...
		10	41	285	38	260	18	9.5	66	45	310	40	275	17	...	...	...
		100	41	285	38	260	18	9.5	66	45	310	40	275	17	...	...	...
		1,000	42	290	39	270	18	9.5	66	46	315	41	285	17	...	...	...
		10,000	42	290	39	270	18	9.5	66	46	315	42	290	17	...	...	...
		100,000	42	290	39	270	17	9.5	66	45	310	41	285	17	...	...	...
300	150	0.1	38	260	36	250	20	9.1	63	45	310	40	275	17	...	...	...
		0.5	38	260	36	250	20	9.1	63	45	310	40	275	17	...	...	...
		10	38	260	36	250	19	9.1	63	46	315	41	285	16	...	...	...
		100	38	260	36	250	18	9.1	63	45	310	41	285	16	...	...	...
		1,000	38	260	36	250	18	9.1	63	43	295	40	275	16	...	...	...
		10,000	33	230	31	215	19	9.1	63	39	270	35	240	17	...	...	...
		100,000	29	200	27	185	21	9.1	63	35	240	30	205	17	...	...	...
350	177	0.1	36	250	35	240	21	8.9	61	45	310	40	275	17	...	...	...
		0.5	36	250	35	240	21	8.9	61	45	310	40	275	17	...	...	...
		10	36	250	35	240	18	8.9	61	44	305	40	275	16	...	...	...
		100	34	235	32	220	18	8.9	61	41	285	38	260	16	...	...	...
		1,000	30	205	28	195	19	8.9	61	38	260	34	235	16	...	...	...
		10,000	24	165	22	150	22	8.9	61	33	230	27	185	18	...	...	...
		100,000	20	140	17	115	28	8.9	61	28	195	21	145	19	...	...	...
400	205	0.1	33	230	32	220	20	8.6	59	44	305	39	270	18	...	...	...
		0.5	34	235	32	220	19	8.6	59	44	305	40	275	17	...	...	...
		10	30	205	30	205	18	8.6	59	40	275	36	250	16	...	...	...
		100	27	185	25	170	19	8.6	59	35	240	30	205	17	...	...	...
		1,000	22	150	20	140	23	8.6	59	31	215	24	165	17	...	...	...
		10,000	17	115	14	95	28	8.6	59	26	180	18	125	19	...	...	...
		100,000	13	90	9.0	62	40	8.6	59	21	145	11	75	24	...	...	...
450	230	0.1	29	200	28	195	19	8.3	57	43	295	38	260	16	...	...	...
		0.5	29	200	28	195	17	8.3	57	42	290	38	260	16	...	...	...
		10	24	165	23	160	18	8.3	57	34	235	28	195	17	...	...	...
		100	19	130	18	125	23	8.3	57	29	200	21	145	18	...	...	...
		1,000	15	105	13	90	30	8.3	57	25	170	15	105	19	...	...	...
		10,000	12	85	8.5	59	40	8.3	57	20	140	11	75	24	...	...	...
		100,000	9.0	62	6.5	45	70	8.3	57	18	125	8.0	55	30	...	...	...
500	260	0.1	25	170	24	165	17	7.9	54	41	285	36	250	15	...	...	...
		0.5	23	160	22	150	16	7.9	54	39	270	33	230	16	...	...	...
		10	18	125	16	110	20	7.9	54	29	200	20	140	18	...	...	...
		100	13	90	11	75	29	7.9	54	25	170	14	95	20	...	...	...
		1,000	10	70	8.0	55	45	7.9	54	21	145	10	70	24	...	...	...
		10,000	8.0	55	6.0	41	65	7.9	54	18	125	8.0	55	30	...	...	...
		100,000	7.0	48	5.5	38	80	7.9	54	18	125	8.0	55	30	...	...	...
600	315	0.1	14	95	13	90	18	6.8	47	32	220	25	170	17	...	...	...
		0.5	12	85	11	75	23	6.8	47	27	185	17	115	19	...	...	...
		10	9.0	62	8.0	55	30	6.8	47	23	160	12	85	22	...	...	...
		100	6.0	41	4.5	31	65	6.8	47	20	140	8.5	59	29	...	...	...
		1,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30	...	...	...
		10,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30	...	...	...
		100,000	5.0	34	4.2	29	80	6.8	47	18	125	8.0	55	30	...	...	...
700	370	0.1	8.5	59	8.0	55	35	5.5	38	27	185	17	115	20	...	...	...
		0.5	7.0	48	6.5	45	35	5.5	38	23	160	12	85	22	...	...	...
		10	3.8	26	3.0	21	80	5.5	38	19	130	8.0	55	30	...	...	...
		100	3.6	25	3.0	21	80	5.5	38	19	130	8.0	55	30	...	...	...
		1,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30	...	...	...
		10,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30	...	...	...
		100,000	3.6	25	3.0	21	80	5.5	38	18	125	8.0	55	30	...	...	...
800	425	0.1	3.8	26	3.2	22	65	...	...	...	...	...	...	...	...	...	...
		0.5	3.0	21	2.4	17	80	...	...	...	...	...	...	...	...	...	...
900	480	...	2.2	15	1.6	11	80	...	...	...	...	...	...	...	...	...	...
1000	540	...	1.6	11	1.2	8.0	65	...	...	...	...	...	...	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6061-T6, -T651, -T6511 (Except for T6 Sheet and Rolled-and-Drawn Products): Creep and Stress-Relaxation Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep		Stress relaxation	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	Time under strain(a), h	Loss in stress, %
75	25	0.1	45	310	45	310	44	305	43	295	42	290	...	...
		1	45	310	45	310	43	295	42	290	42	290	1	2.0
		10	45	310	44	305	43	295	42	290	42	290	10	2.0
		100	45	310	44	305	42	290	42	290	41	285	100	3.0
		1,000	45	310	43	295	42	290	41	285	41	285	1,000	4.0
212	100	...	...	...	...	...	...	...	...	...	...	...	10,000	5.0
		0.1	41	285	40	275	40	275	39	270	38	260	...	...
		1	40	275	39	270	39	270	38	260	38	260	1	4.0
		10	39	270	38	260	38	260	38	260	37	255	10	7.0
		100	38	260	38	260	38	260	37	255	37	255	100	10
300	150	1,000	37	255	37	255	37	255	37	255	36	250	1,000	14
		...	...	...	...	...	...	...	...	...	...	...	10,000	16
		0.1	37	255	36	250	36	250	35	240	35	240	...	...
		1	36	250	35	240	35	240	35	240	34	235	1	8.0
		10	35	240	34	235	34	235	34	235	33	230	10	12
350	177	100	34	235	34	235	34	235	33	230	32	220	100	18
		1,000	31	215	31	215	31	215	31	215	30	205	1,000	28
		...	...	...	...	...	...	...	...	...	...	...	10,000	43
		0.1	34	235	34	235	34	235	33	230	33	230	...	...
		1	33	230	33	230	33	230	32	220	32	220	1	15
400	205	10	32	220	32	220	32	220	31	215	30	205	10	22
		100	29	200	29	200	29	200	28	195	26	180	100	33
		1,000	25	170	25	170	25	170	24	165	22	150	1,000	47
		...	...	...	...	...	...	...	...	...	...	...	10,000	62
		0.1	32	220	32	220	32	220	31	215	30	205	...	...
450	230	1	30	205	30	205	30	205	29	200	28	195	1	29
		10	27	185	27	185	26	180	25	170	24	165	10	39
		100	23	160	22	150	22	150	21	145	19	130	100	52
		1,000	18	125	18	125	18	125	16	110	14	95	1,000	67
		...	...	...	...	...	...	...	...	...	...	...	10,000	67
500	260	0.1	27	185	27	185	27	185	27	185	26	180	...	...
		1	25	170	25	170	25	170	24	165	23	160	...	...
		10	20	140	20	140	20	140	19	130	17	115	...	...
		100	16	110	16	110	16	110	14	95	12	85	...	...
		1,000	12	85	12	85	11	75	...	...	...	...	...	...
600	315	0.1	21	145	21	145	21	145	21	145	20	140	...	...
		1	19	130	19	130	19	130	18	125	17	115	...	...
		10	14	95	14	95	14	95	13	90	11	75	...	...
		100	11	75	10	70	10	70	8.5	59	6.0	41	...	...
		1,000	7.5	52	7.0	48	6.5	45	...	...	...	...	...	...
600	315	0.1	11	75	10	70	9.5	66	9.5	66	8.5	59	...	...
		1	9.5	66	8.5	59	8.5	59	7.5	52	7.0	48	...	...
		10	7.0	48	7.0	48	6.5	45	5.5	38	4.4	30	...	...
		100	3.6	25	3.0	21	2.8	19	2.2	15	2.0	14	...	...
		1,000	2.3	16	2.2	15	2.1	14	1.9	13	1.7	12	...	...
10,000	1.7	12	...	...	...	...	...	...	...	...	...	...

(a) Stressed in tension to 60% of the tensile yield strength at the stressing temperature. Strain held constant during exposure. Source data are in English units; metric values are converted and rounded.

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6061-T8 Solution Heat Treated, Cold Worked 21%, and Aged 18 h at 320 °F (160 °C): Typical Tensile Properties

Temperature			At temperature indicated						
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)	
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa
°F	°C	Time at temperature, h							
-320	-196	...	...	...	...	...	...	11.1	77
-112	-80	...	...	...	...	...	...	10.4	72
-18	-28	...	...	...	...	...	...	10.1	70
75	25	...	49	340	45	310	16	9.9	68
212	100	0.5	45	310	42	290	16	9.5	66
		10	45	310	42	290	16	9.5	66
		100	45	310	42	290	16	9.5	66
		1,000	45	310	42	290	16	9.5	66
		10,000	45	310	42	290	16	9.5	66
300	150	0.5	41	285	38	260	16	9.1	63
		10	41	285	38	260	16	9.1	63
		100	41	285	38	260	16	9.1	63
		1,000	40	275	37	255	16	9.1	63
		10,000	35	240	32	220	16	9.1	63
350	177	0.5	39	270	35	240	16	8.9	61
		10	38	260	35	240	16	8.9	61
		100	37	255	34	235	16	8.9	61
		1,000	33	230	29	200	18	8.9	61
		10,000	26	180	23	160	18	8.9	61
400	205	0.5	35	240	32	220	16	8.6	59
		10	33	230	30	205	20	8.6	59
		100	30	205	26	180	23	8.6	59
		1,000	24	165	20	140	25	8.6	59
		10,000	17	115	15	105	25	8.6	59
450	230	0.5	29	200	26	180	17	8.3	57
		10	26	180	22	150	23	8.3	57
		100	21	145	15	105	30	8.3	57
		1,000	16	110	10	70	35	8.3	57
		10,000	11	75	7.5	52	35	8.3	57
500	260	0.5	21	145	17	115	20	7.9	54
		10	16	110	12	85	25	7.9	54
		100	12	85	8.0	55	40	7.9	54
		1,000	9.0	62	5.0	34	43	7.9	54
		10,000	7.5	52	4.0	28	45	7.9	54
600	315	0.5	9.0	62	4.8	33	35	6.8	47
		10	7.0	48	4.2	29	45	6.8	47
		100	6.0	41	4.2	29	50	6.8	47
		1,000	5.0	34	4.2	29	50	6.8	47
		10,000	5.0	34	4.2	29	50	6.8	47
700	370	0.5	5.0	34	3.0	21	55	5.5	38
		10	4.0	28	3.0	21	60	5.5	38
		100	3.8	26	3.0	21	65	5.5	38
		1,000	3.6	25	3.0	21	80	5.5	38
		10,000	3.6	25	3.0	21	80	5.5	38

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6063-O Extrusions: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated						At room temperature after heating							
			Tensile strength		Yield strength		Elongation in 4D(a), %	Modulus of elasticity(b)		Tensile strength		Yield strength		Elongation in 4D(a), %		
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa			
°F	°C															
-320	-196	...	26	180	9.0	62	...	...	...	...	...	...	...	...	...	...
-112	-80	...	15	105	8.0	55	...	...	...	...	...	...	...	...	...	...
-18	-28	...	14	95	7.5	52	...	...	...	...	...	...	...	...	...	...
75	25	...	13	90	7.0	48	35	9.9	68	13	90	7.0	48	35	...	...
212	100	0.1	11	75	6.0	41	35	...	...	...	...	...	...	...	...	...
		0.5	11	75	6.0	41	35	...	...	13	90	6.5	45	35	...	...
		10	11	75	6.0	41	35	...	...	13	90	6.5	45	35	...	...
		100	11	75	6.0	41	35	...	...	13	90	6.5	45	35	...	...
		1,000	12	85	6.5	45	30	...	...	14	95	6.5	45	30	...	...
		10,000	13	90	8.0	55	24	...	...	14	95	9.0	62	24	...	...
300	150	0.1	9.5	66	6.0	41	45	...	...	...	...	...	...	...	...	...
		0.5	9.5	66	6.0	41	45	...	...	13	90	6.0	41	35	...	...
		10	10	70	6.5	45	40	...	...	14	95	6.5	45	35	...	...
		100	11	75	7.0	48	35	...	...	14	95	7.0	48	30	...	...
		1,000	12	85	9.5	66	28	...	...	16	110	10	70	28	...	...
		10,000	12	85	9.0	62	28	...	...	15	105	10	70	26	...	...
350	177	0.1	8.5	59	5.5	38	50	...	...	...	...	...	...	...	...	...
		0.5	8.5	59	5.5	38	50	...	...	13	90	5.5	38	35	...	...
		10	9.0	62	6.5	45	50	...	...	14	95	6.5	45	35	...	...
		100	10	70	7.5	52	40	...	...	15	105	9.5	66	25	...	...
		1,000	10	70	8.0	55	30	...	...	15	105	9.0	62	28	...	...
		10,000	9.0	62	7.0	48	40	...	...	14	95	7.5	52	35	...	...
400	205	0.1	7.5	52	5.5	38	65	...	...	...	...	...	...	...	...	...
		0.5	7.5	52	5.5	38	65	...	...	13	90	5.5	38	35	...	...
		10	8.0	55	6.0	41	65	...	...	14	95	7.0	48	35	...	...
		100	8.0	55	6.0	41	65	...	...	14	95	7.5	52	35	...	...
		1,000	8.0	55	6.0	41	65	...	...	13	90	7.0	48	35	...	...
		10,000	7.0	48	5.0	34	65	...	...	12	85	6.0	41	40	...	...
450	230	0.1	6.5	45	4.8	33	75	...	...	...	...	...	...	...	...	...
		0.5	6.5	45	4.8	33	75	...	...	13	90	5.0	34	35	...	...
		10	6.5	45	5.0	34	75	...	...	14	95	7.0	48	35	...	...
		100	6.5	45	5.0	34	75	...	...	13	90	6.0	41	35	...	...
		1,000	6.0	41	4.6	32	75	...	...	12	85	6.0	41	40	...	...
		10,000	5.5	38	4.0	28	75	...	...	11	75	4.8	33	40	...	...
500	260	0.1	5.5	38	4.2	29	80	...	...	...	...	...	...	...	...	...
		0.5	5.5	38	4.2	29	80	...	...	13	90	5.0	34	35	...	...
		10	5.5	38	4.4	30	80	...	...	13	90	6.0	41	35	...	...
		100	5.5	38	4.4	30	80	...	...	12	85	5.5	38	35	...	...
		1,000	4.8	33	3.7	26	80	...	...	12	85	4.9	34	40	...	...
		10,000	4.4	30	3.3	23	80	...	...	11	75	4.2	29	40	...	...
600	315	0.1	3.7	26	3.1	21	90	...	...	...	...	...	...	...	...	...
		0.5	3.7	26	3.1	21	90	...	...	13	90	4.9	34	35	...	...
		10	3.7	26	3.1	21	90	...	...	12	85	4.9	34	40	...	...
		100	3.7	26	3.1	21	90	...	...	12	85	4.6	32	40	...	...
		1,000	3.4	23	2.8	19	90	...	...	11	75	4.1	28	40	...	...
		10,000	3.1	21	2.4	17	90	...	...	10	70	3.6	25	40	...	...
700	370	0.1	2.7	19	2.2	15	100	...	...	...	...	...	...	...	...	...
		0.5	2.7	19	2.2	15	100	...	...	13	90	4.9	34	35	...	...
		10	2.7	19	2.2	15	100	...	...	12	85	4.6	32	40	...	...
		100	2.5	17	2.1	14	100	...	...	12	85	4.2	29	40	...	...
		1,000	2.2	15	2.0	14	100	...	...	11	75	3.7	26	40	...	...
		10,000	2.0	14	1.7	12	100	...	...	10	70	3.2	22	40	...	...
800	425	0.1	1.9	13	1.4	10	110	...	...	...	...	...	...	...	...	...
		0.5	1.9	13	1.4	10	110	...	...	...	...	...	...	...	...	...
900	480	0.1	1.1	8.0	0.8	6.0	120	...	...	...	...	...	...	...	...	...
		0.5	1.1	8.0	0.8	6.0	120	...	...	...	...	...	...	...	...	...
1000	540	0.1	0.7	5.0	0.5	3.0	130	...	...	...	...	...	...	...	...	...
		0.5	0.7	5.0	0.5	3.0	130	...	...	...	...	...	...	...	...	...

(a) Elongation values are actual test results, because no typical values were available. (b) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6063-O Extrusions: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	12	85	12	85	12	85	11	75	11	75
		1	12	85	12	85	12	85	11	75	11	75
		10	12	85	12	85	12	85	11	75	11	75
		100	12	85	12	85	12	85	11	75	11	75
		1000	12	85	12	85	12	85	11	75	11	75
212	100	0.1	11	75	11	75	10	70	9.5	66	9.0	62
		1	11	75	11	75	10	70	9.0	62	8.5	59
		10	11	75	10	70	9.5	66	9.0	62	8.0	55
		100	11	75	10	70	9.0	62	8.0	55	7.5	52
		1000	11	75	10	70	9.0	62	8.0	55	7.0	48
300	150	0.1	9.5	66	8.5	59	8.0	55	7.0	48	6.5	45
		1	9.0	62	8.0	55	7.5	52	7.0	48	6.5	45
		10	9.0	62	8.0	55	7.0	48	6.5	45	6.0	41
		100	9.0	62	8.0	55	7.0	48	6.5	45	6.0	41
		1000	9.0	62	8.0	55	7.0	48	6.5	45	6.0	41
350	177	0.1	8.5	59	7.0	48	6.5	45	6.0	41	5.5	38
		1	8.0	55	6.5	45	6.5	45	5.5	38	5.0	34
		10	7.5	52	6.5	45	6.0	41	5.0	34	4.5	31
		100	7.5	52	6.5	45	6.0	41	5.0	34	4.5	31
		1000	7.5	52	6.5	45	6.0	41	5.0	34	4.5	31
400	205	0.1	7.5	52	6.0	41	5.5	38	4.9	34	4.5	31
		1	6.5	45	5.0	34	4.7	32	4.6	32	4.0	28
		10	6.0	41	4.6	32	4.3	30	4.1	28	3.7	26
		100	6.0	41	4.4	30	4.2	29	3.9	27	3.5	24
		1000	6.0	41	4.4	30	4.1	28	3.8	26	3.4	23
450	230	0.1	6.0	41	4.5	31	4.2	29	3.8	26	3.6	25
		1	5.5	38	3.9	27	3.6	25	3.2	22	3.0	21
		10	4.1	28	3.7	26	3.4	23	3.0	21	...	...
500	260	0.1	4.8	33	3.8	26	...	...	...	...	...	...
		1	4.2	29	...	...	...	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6063-T1 Extrusions: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated					At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D,%	Tensile strength		Yield strength		Elongation in 4D,%
°F	°C	ksi	MPa	ksi	MPa	ksi		MPa	ksi	MPa	ksi		MPa
75	25	...	22	150	12	85	33	22	150	12	85	33
212	100	0.1	21	145	12	85	30	...	...	...	...	...
		0.5	21	145	12	85	30	22	150	12	85	30
		10	22	150	14	95	30	24	165	14	95	30
		100	25	170	18	125	30	28	195	18	125	28
		1,000	30	205	25	170	26	34	235	27	185	22
300	150	10,000	32	220	28	195	20	37	255	33	230	16
		0.1	25	170	12	85	30	...	...	...	...	...
		0.5	25	170	13	90	30	24	165	14	95	30
		10	25	170	20	140	28	29	200	23	160	22
		100	28	195	26	180	20	36	250	32	220	15
350	177	1,000	26	180	24	165	18	32	220	29	200	16
		10,000	21	145	17	115	22	26	180	20	140	20
		0.1	21	145	13	90	29	...	...	...	...	...
		0.5	22	150	14	95	28	25	170	16	110	27
		10	27	185	25	170	20	33	230	31	215	15
400	205	100	23	160	20	140	20	30	205	26	180	17
		1,000	18	125	16	110	23	26	180	19	130	20
		10,000	16	110	12	85	26	22	150	15	105	22
		0.1	20	140	13	90	28	...	...	...	...	...
		0.5	21	145	17	115	26	28	195	23	160	22
450	230	10	20	140	19	130	22	29	200	25	170	18
		100	16	110	14	95	27	24	165	18	125	22
		1,000	14	95	11	75	30	21	145	14	95	23
		10,000	11	75	8.5	59	35	17	115	10	70	24
		0.1	18	125	14	95	27	...	...	...	...	...
500	260	0.5	19	130	18	125	26	27	185	25	170	18
		10	16	110	14	95	30	25	170	18	125	22
		100	13	90	11	75	35	21	145	14	95	23
		1,000	11	75	8.0	55	35	19	130	11	75	24
		10,000	7.5	52	5.5	38	45	13	90	6.5	45	35
600	315	0.1	15	105	14	95	26	...	...	...	...	...
		0.5	15	105	14	95	26	24	165	18	125	21
		10	12	85	10	70	35	21	145	14	95	23
		100	10	70	8.0	55	40	18	125	10	70	24
		1,000	6.5	45	5.0	34	50	13	90	6.5	45	35
700	370	10,000	5.5	38	3.5	24	70	12	85	5.0	34	40
		0.1	9.5	66	8.5	59	40	...	...	...	...	...
		0.5	8.5	59	7.5	52	45	20	140	12	83	23
		10	6.5	45	5.5	38	55	16	110	8.0	55	26
		100	4.2	29	3.5	24	75	13	90	5.5	38	35
800	425	1,000	3.4	23	2.8	19	90	12	85	4.5	31	40
		10,000	3.1	21	2.4	17	90	12	85	4.0	28	40
		0.1	4.5	31	4.0	28	70	...	...	...	...	...
		0.5	4.0	28	3.5	24	75	18	125	9.0	62	25
		10	2.7	19	2.2	15	90	14	95	5.5	38	35
900	480	100	2.5	17	2.1	14	100	12	85	4.2	29	40
		1,000	2.2	15	2.0	14	100	11	75	3.7	26	40
		10,000	2.0	14	1.7	12	100	10	70	3.2	22	40
		0.1	2.1	14	1.8	12	110	...	...	...	...	...
		0.5	1.9	13	1.4	10	110	...	...	...	...	...
1000	540	0.1	1.2	8.0	1.0	7.0	120	...	...	...	...	...
		0.5	1.1	8.0	0.8	6.0	120	...	...	...	...	...
1000	540	0.1	0.7	5.0	0.5	3.0	130	...	...	...	...	...
		0.5	0.7	5.0	0.5	3.0	130	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6063-T5 Extruded Rod: Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-452	-269	...	56	385	36	250	30	...	...	...	...	...	...
75	25	...	32	220	28	195	22	9.9	68	32	220	28	195	22
212	100	0.1	29	200	26	180	22	...	...	...	...	...	...
		0.5	29	200	26	180	22	...	...	32	220	28	195	22
		10	29	200	26	180	22	...	...	32	220	28	195	22
		100	29	200	26	180	22	...	...	32	220	28	195	22
		1,000	29	200	26	180	22	...	...	33	230	29	200	21
		10,000	30	205	27	185	20	...	...	33	230	30	205	20
300	150	0.1	27	185	25	170	23	...	...	...	...	...	...
		0.5	27	185	25	170	23	...	...	32	220	28	195	22
		10	27	185	25	170	23	...	...	33	230	29	200	22
		100	27	185	25	170	23	...	...	33	230	30	205	20
		1,000	26	180	24	165	23	...	...	32	220	28	195	20
		10,000	21	145	17	115	28	...	...	26	180	20	140	23
350	177	0.1	25	170	24	165	23	...	...	...	...	...	...
		0.5	25	170	24	165	23	...	...	32	220	28	195	22
		10	27	185	25	170	24	...	...	33	230	29	200	21
		100	23	160	20	140	25	...	...	30	205	26	180	20
		1,000	18	125	16	110	30	...	...	25	170	19	130	21
		10,000	16	110	12	85	35	...	...	22	150	15	103	24
400	205	0.1	23	160	22	150	24	...	...	...	...	...	...
		0.5	23	160	22	150	24	...	...	32	220	28	195	22
		10	20	140	19	130	26	...	...	29	200	25	170	20
		100	16	110	14	95	27	...	...	24	165	18	125	21
		1,000	14	95	11	75	35	...	...	21	145	14	95	22
		10,000	11	75	8.5	59	45	...	...	17	115	10	70	26
450	230	0.1	20	140	19	130	25	...	...	...	...	...	...
		0.5	19	130	18	125	26	...	...	31	215	26	180	22
		10	16	110	14	95	30	...	...	25	170	18	125	21
		100	13	90	11	75	35	...	...	21	145	14	95	23
		1,000	11	75	8.0	55	45	...	...	18	125	11	75	26
		10,000	7.5	52	5.5	38	55	...	...	13	90	6.5	45	35
500	260	0.1	17	117	16	110	26	...	...	...	...	...	...
		0.5	15	103	14	97	29	...	...	26	180	20	140	22
		10	12	83	10	69	35	...	...	21	145	14	95	24
		100	10	69	8.0	55	45	...	...	18	125	10	70	25
		1,000	6.5	45	5.0	34	60	...	...	13	90	6.5	45	35
		10,000	5.0	34	3.5	24	70	...	...	12	85	5.0	34	40
600	315	0.1	9.5	66	8.5	59	40	...	...	...	...	...	...
		0.5	8.5	59	7.5	52	45	...	...	20	140	12	85	24
		10	6.5	45	5.5	38	55	...	...	16	110	8.0	55	30
		100	4.2	29	3.5	24	80	...	...	13	90	5.5	38	40
		1,000	3.4	23	2.8	19	85	...	...	12	85	4.5	31	40
		10,000	3.1	21	2.4	17	85	...	...	12	85	4.0	28	40
700	370	0.1	4.5	31	4.0	28	70	...	...	...	...	...	...
		0.5	4.0	28	3.5	24	75	...	...	18	125	9.0	62	26
		10	2.7	19	2.2	15	90	...	...	14	95	5.5	38	40
		100	2.5	17	2.1	14	100	...	...	12	85	4.2	29	40
		1,000	2.2	15	2.0	14	100	...	...	11	75	3.7	26	40
		10,000	2.0	14	1.7	12	100	...	...	10	70	3.2	22	40
800	425	0.1	2.1	14	1.8	12	110	...	...	...	...	...	...
		0.5	1.9	13	1.4	10	110	...	...	...	...	...	...
900	480	0.1	1.2	8.0	1.0	7.0	120	...	...	...	...	...	...
		0.5	1.1	8.0	0.8	6.0	120	...	...	...	...	...	...
1000	540	0.1	0.7	5.0	0.5	3.0	130	...	...	...	...	...	...
		0.5	0.7	5.0	0.5	3.0	130	...	...	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6063-T5 Extrusions: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	32	220	32	220	31	215	30	205	29	200
		1	32	220	31	215	30	205	29	200	28	195
		10	32	220	31	215	29	200	28	195	28	195
		100	31	215	30	205	29	200	28	195	27	185
		1,000	30	205	29	200	28	195	27	185	26	180
		10,000	29	200	28	195	27	185	25	170	24	165
212	100	100,000	28	195	27	185	26	180	24	165	23	160
		0.1	29	200	28	195	28	195	27	185	26	180
		1	28	195	27	185	27	185	26	180	24	165
		10	27	185	26	180	25	170	24	165	23	160
		100	26	180	25	170	24	165	23	160	21	145
		1,000	24	165	23	160	22	150	21	145	19	130
300	150	10,000	22	150	21	145	21	145	19	130	17	115
		100,000	19	130	19	130	18	125	16	110	14	95
		0.1	27	185	26	180	25	170	24	165	23	160
		1	25	170	24	165	24	165	23	160	21	145
		10	23	160	22	150	22	150	21	145	19	130
		100	21	145	20	140	20	140	19	130	17	115
350	177	1,000	18	125	17	115	17	115	16	110	13	90
		10,000	13	90	13	90	12	85	10	70	8.0	55
		100,000	9.5	66	9.0	62	8.5	59	7.0	48	5.5	38
		0.1	25	170	24	165	24	165	23	160	22	150
		1	23	160	22	150	22	150	21	145	19	130
		10	20	140	20	140	20	140	19	130	17	115
400	205	100	17	115	17	115	16	110	15	105	12	85
		1,000	12	85	12	85	11	75	9.5	66	7.5	52
		10,000	9.0	62	8.0	55	8.0	55	6.5	45	5.0	34
		100,000	7.0	48	6.5	45	5.5	38	4.5	31	...	...
		0.1	22	150	22	150	21	145	21	145	20	140
		1	20	140	20	140	19	130	19	130	17	115
450	230	10	17	115	16	110	16	110	15	103	13	90
		100	12	85	11	75	11	75	9.5	66	7.5	52
		1,000	9.0	62	8.0	55	7.5	52	6.0	41	4.7	32
		10,000	6.5	45	6.0	41	5.0	34	4.0	28	...	...
		100,000	5.5	38	5.0	34	3.7	26	...	...	...	...
		0.1	19	130	18	125	18	125	17	115	16	110
500	260	1	17	115	16	110	15	105	15	105	14	95
		10	12	85	11	75	11	75	9.5	66	8.0	55
		100	9.0	62	7.5	52	7.5	52	6.5	45	5.0	34
		1,000	6.5	45	6.0	41	5.0	34	4.0	28	...	...
		10,000	5.0	34	5.0	34	...	...	...	...	...	...
		0.1	16	110	15	105	14	95	13	90	12	83
600	315	1	13	90	11	75	11	75	10	70	9.0	62
		10	9.0	62	8.0	55	8.0	55	6.5	45	5.5	38
		100	6.5	45	6.0	41	5.0	34	4.0	28	...	...
		1,000	5.0	34	5.0	34	...	...	...	...	...	...
600	315	0.1	9.0	62	8.0	55	7.5	52	7.0	48	6.5	45
		1	7.5	52	6.0	41	6.0	41	5.0	34	4.8	33
		10	5.0	34	5.0	34	...	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6063-T6: Typical Tensile Properties

Temperature			At temperature indicated					At room temperature after heating						
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-320	-196	...	47	325	36	250	24	...	...	...	...	...	...
-112	-80	...	38	260	33	230	20	...	...	...	...	...	...
-18	-28	...	36	250	32	220	19	...	...	...	...	...	...
75	25	...	35	240	31	215	18	9.9	68	35	240	31	215	18
212	100	0.5	31	215	28	195	20	...	...	35	240	31	215	18
		10	31	215	28	195	20	...	...	35	240	31	215	17
		100	31	215	29	200	20	...	...	36	250	32	220	17
		1,000	32	220	30	205	19	...	...	37	255	33	230	16
		10,000	33	230	31	215	15	...	...	38	260	34	235	15
300	150	0.5	28	195	26	180	22	...	...	35	240	31	215	16
		10	28	195	26	180	20	...	...	37	255	33	230	14
		100	29	200	28	195	18	...	...	37	255	34	235	13
		1,000	28	195	27	185	15	...	...	34	235	30	205	13
		10,000	22	150	20	140	20	...	...	28	195	23	160	20
350	177	0.5	26	180	25	170	19	...	...	35	240	32	220	15
		10	25	170	24	165	17	...	...	36	250	31	215	16
		100	24	165	23	160	16	...	...	31	215	27	185	17
		1,000	20	140	18	125	16	...	...	27	185	21	145	18
		10,000	14	95	11	75	29	...	...	21	145	14	95	26
400	205	0.5	24	165	23	160	18	...	...	36	250	32	220	15
		10	20	140	18	125	18	...	...	29	200	24	165	18
		100	16	110	15	105	24	...	...	25	170	18	125	20
		1,000	13	90	10	70	30	...	...	20	140	13	90	24
		10,000	9.0	62	6.5	45	40	...	...	16	110	8.0	55	34
450	230	0.5	20	140	18	125	20	...	...	36	250	32	220	17
		10	15	105	13	90	22	...	...	25	170	18	125	20
		100	11	75	9.5	66	35	...	...	20	140	13	90	24
		1,000	8.0	55	6.0	41	50	...	...	16	110	8.0	55	30
		10,000	6.0	41	4.5	31	60	...	...	13	90	5.5	38	42
500	260	0.5	14	95	12	85	25	...	...	33	230	30	205	20
		10	10	70	9.0	62	30	...	...	20	140	13	90	22
		100	7.5	52	6.0	41	45	...	...	17	115	9.0	62	27
		1,000	5.0	34	4.0	28	65	...	...	14	95	5.5	38	36
		10,000	4.5	31	3.5	24	75	...	...	12	85	5.0	34	45
600	315	0.5	5.5	38	5.0	34	38	...	...	23	160	17	115	22
		10	4.0	28	3.5	24	55	...	...	14	95	7.0	48	37
		100	3.5	24	3.0	21	70	...	...	12	85	5.5	38	45
		1,000	3.2	22	2.5	17	75	...	...	11	75	4.5	31	45
		10,000	3.2	22	2.5	17	80	...	...	11	75	4.0	28	45
700	370	0.5	2.3	16	2.0	14	90	...	...	15	105	5.0	34	32
		10	2.3	16	2.0	14	100	...	...	13	90	4.5	31	41
		100	2.3	16	2.0	14	105	...	...	12	85	4.0	28	45
		1,000	2.3	16	2.0	14	105	...	...	11	75	4.0	28	45
		10,000	2.3	16	2.0	14	105	...	...	10	70	3.5	24	45

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6063-T6: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	35	240	32	220	29	200	...	...	...	...
		1	35	240	31	215	29	200	...	...	...	...
		10	34	235	30	205	28	195	...	...	...	...
		100	34	235	29	200	28	195	...	...	...	...
212	100	1000	32	220	28	195	28	195	...	...	...	...
		0.1	31	215	29	200	28	195	...	...	...	...
		1	30	205	28	195	27	185	...	...	...	...
		10	28	195	27	185	26	180	...	...	...	...
300	150	100	27	185	25	170	24	165	...	...	...	...
		1000	25	170	24	165	21	145	...	...	...	...
		0.1	27	185	26	180	25	170	19	130	12	85
		1	26	180	25	170	24	165	17	115	10	70
400	205	10	25	170	24	165	23	160	15	105	8.0	55
		100	23	160	22	150	20	140	12	85	...	...
		1000	18	125	17	115	16	110	10	70	...	...
		0.1	22	150	21	145	20	140	14	95	10	70
		1	19	130	18	125	17	115	12	85	8.0	55
		10	16	110	15	105	14	95	9.5	66	5.5	38
		100	12	85	11	75	9.5	66	6.5	45	3.7	26
		1000	7.5	52	6.0	41	4.7	32	3.4	23	...	...

Source data are in English units; metric values are converted and rounded.

6063-T6 Extrusions: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated					At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	ksi	MPa	ksi	MPa	ksi		MPa	ksi	MPa		
75	25	...	36	250	32	220	18	36	250	32	220	18
212	100	0.1	33	230	30	205	19	...	...	...	...	...
		0.5	33	230	30	205	19	36	250	32	220	18
		10	33	230	30	205	19	36	250	32	220	18
		100	33	230	31	215	19	36	250	33	230	18
		1,000	34	235	32	220	18	37	255	34	235	15
300	150	10,000	34	235	32	220	18	37	255	34	235	15
		0.1	30	205	28	195	22	...	...	...	...	...
		0.5	30	205	28	195	22	36	250	32	220	18
		10	31	215	29	200	21	37	255	33	230	17
		100	31	215	29	200	19	37	255	34	235	16
350	177	1,000	28	195	26	180	19	33	230	29	200	16
		10,000	21	145	17	115	24	26	180	20	140	19
		0.1	28	195	27	185	23	...	...	...	...	...
		0.5	28	195	27	185	23	36	250	32	220	17
		10	28	195	27	185	20	36	250	33	230	17
400	205	100	24	165	23	160	21	31	215	26	180	18
		1,000	18	125	16	110	24	26	180	20	140	19
		10,000	16	110	12	85	28	22	150	16	110	20
		0.1	26	180	25	170	23	...	...	...	...	...
		0.5	26	180	25	170	21	35	240	32	220	18
450	230	10	20	140	19	130	25	30	205	26	180	20
		100	16	110	14	95	27	25	170	19	130	21
		1,000	14	95	11	75	30	21	145	14	95	22
		10,000	11	75	8.5	59	35	17	115	10	70	25
		0.1	23	160	22	150	21	...	...	...	...	...
500	260	0.5	22	150	21	145	19	32	220	29	200	20
		10	16	110	14	95	25	25	170	19	130	22
		100	13	90	11	75	29	21	145	15	105	24
		1,000	11	75	8.0	55	35	19	130	11	75	26
		10,000	7.5	52	5.5	38	55	13	90	6.5	45	35
600	315	0.1	18	125	17	115	20	...	...	...	...	...
		0.5	15	105	14	95	21	27	185	22	150	21
		10	12	85	10	70	30	21	145	14	95	23
		100	10	70	8.0	55	40	18	125	10	70	25
		1,000	6.5	45	5.0	34	55	13	90	6.5	45	40
700	370	10,000	5.0	34	3.5	24	70	12	85	5.0	34	40
		0.1	9.5	66	8.5	59	35	...	...	...	...	...
		0.5	8.5	59	7.5	52	40	20	140	12	85	24
		10	6.5	45	5.5	38	55	16	110	8.0	55	30
		100	4.2	29	3.5	24	75	13	90	5.5	38	40
800	425	1,000	3.4	23	2.8	19	90	12	85	4.5	31	40
		10,000	3.1	21	2.4	17	90	12	85	4.0	28	40
		0.1	4.5	31	4.0	28	65	...	...	...	...	...
		0.5	4.0	28	3.5	24	70	18	125	9.0	62	26
		10	2.7	19	2.2	15	90	14	95	5.5	38	40
900	480	100	2.5	17	2.1	14	100	12	85	4.2	29	40
		1,000	2.2	15	2.0	14	100	11	75	3.7	26	40
		10,000	2.0	14	1.7	12	100	10	70	3.2	22	40
		0.1	2.1	14	1.8	12	110	...	...	...	...	...
		0.5	1.9	13	1.4	10	110	...	...	...	...	...
1000	540	0.1	1.2	8.0	1.0	7.0	120	...	...	...	...	...
		0.5	1.1	8.0	0.8	6.0	120	...	...	...	...	...
1000	540	0.1	0.7	5.0	0.5	3.0	130	...	...	...	...	...
		0.5	0.7	5.0	0.5	3.0	130	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

X6064-T81 (Estimated from Data for 6061-T6 and 6061-T8): Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-320	-196	...	67	460	53	365	8	11.2	77	...	...	...	...	...
-112	-80	...	54	370	47	325	6	10.5	72	...	...	...	...	...
-18	-28	...	52	360	46	315	6	10.2	70	...	...	...	...	...
75	25	...	50	345	45	310	6	10.0	69	50	345	45	310	6
212	100	0.5	46	315	42	290	8	9.8	68	50	345	45	310	6
		10	46	315	42	290	8	9.8	68	50	345	45	310	6
		100	46	315	42	290	8	9.8	68	50	345	45	310	6
		1,000	46	315	42	290	8	9.8	68	50	345	45	310	6
		10,000	46	315	42	290	8	9.8	68	50	345	45	310	6
300	150	0.5	42	290	39	270	12	9.4	65	50	345	45	310	6
		10	41	285	38	260	12	9.4	65	49	340	44	305	7
		100	40	275	37	255	12	9.4	65	48	330	43	295	8
		1,000	38	260	36	250	14	9.4	65	46	315	41	285	10
		10,000	34	235	31	215	18	9.4	65	42	290	37	255	15
400	205	0.5	34	235	32	220	14	8.8	61	44	305	39	270	8
		10	31	215	30	205	16	8.8	61	40	275	35	240	10
		100	28	195	25	170	20	8.8	61	36	250	31	215	12
		1,000	23	160	20	140	24	8.8	61	32	220	26	180	14
		10,000	19	130	15	105	28	8.8	61	26	180	19	130	18
500	260	0.5	23	160	22	150	16	8.0	55	35	240	29	200	10
		10	18	125	15	105	18	8.0	55	29	200	21	145	14
		100	14	95	11	75	28	8.0	55	24	165	14	95	17
		1,000	10	70	8.0	55	42	8.0	55	21	145	10	70	25
		10,000	7.5	52	5.0	34	60	8.0	55	18	125	8.0	55	30
600	315	0.5	11	75	10	70	21	7.0	48	27	185	17	115	20
		10	7.5	52	6.0	41	40	7.0	48	24	165	12	85	22
		100	5.5	38	4.5	31	53	7.0	48	20	140	9.0	62	28
		1,000	5.0	34	3.5	24	68	7.0	48	18	125	8.0	55	30
		10,000	4.5	31	2.5	17	85	7.0	48	18	125	8.0	55	30
700	370	0.5	6.0	41	5.0	34	40	6.2	43	23	160	12	85	24
		10	4.0	28	3.5	24	70	6.2	43	20	140	9.0	62	28
		100	3.5	24	2.5	17	85	6.2	43	18	125	8.0	55	30
		1,000	3.0	21	2.0	14	90	6.2	43	18	125	8.0	55	30
		10,000	3.0	21	2.0	14	95	6.2	43	18	125	8.0	55	30

(a) Average of tensile and compressive moduli

Source data are in English units; metric values are converted and rounded.

6066-T6511 Extrusions: Typical Tensile Properties

Temperature			At temperature indicated						
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)	
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa			10 ⁶ psi	GPa
75	25	...	57	395	52	360	12	9.9	68
212	100	0.5	52	360	49	340	15	...	...
		10	52	360	49	340	15	...	...
		100	52	360	49	340	15	...	...
		1,000	52	360	49	340	14	...	...
300	150	10,000	52	360	49	340	13	...	...
		0.5	48	330	46	315	15	...	...
		10	48	330	46	315	15	...	...
		100	48	330	46	315	15	...	...
350	177	1,000	46	315	44	305	14	...	...
		10,000	41	285	38	260	13	...	...
		0.5	46	315	44	305	15	...	...
		10	46	315	44	305	16	...	...
400	205	100	43	295	40	275	16	...	...
		1,000	35	240	33	230	18	...	...
		10,000	25	170	22	150	22	...	...
		0.5	43	295	42	290	15	...	...
450	230	10	38	260	37	255	17	...	...
		100	33	230	31	215	20	...	...
		1,000	23	160	20	140	26	...	...
		10,000	18	125	15	105	32	...	...
500	260	0.5	37	255	36	250	13	...	...
		10	30	205	29	200	17	...	...
		100	24	165	22	150	23	...	...
		1,000	16	110	13	90	28	...	...
600	315	10,000	13	90	10	70	35	...	...
		0.5	30	205	28	195	13	...	...
		10	22	150	20	140	17	...	...
		100	16	110	14	95	25	...	...
600	315	1,000	12	85	9.0	62	30	...	...
		10,000	10	70	7.5	52	50	...	...
		0.5	14	95	13	90	20	...	...
		10	9.5	66	8.0	55	40	...	...
600	315	100	7.0	48	6.0	41	50	...	...
		1,000	6.5	45	5.0	34	50	...	...
		10,000	6.0	41	5.0	34	50	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6070-T6 Extrusions: Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 2 in. (50 mm)(a), %	Modulus of elasticity(b)		Tensile strength		Yield strength		Elongation in 2 in. (50 mm)(a), %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-320	-196	...	70	485	58	400	15	...	...	...	...	...	...
-112	-80	...	58	400	53	365	10	...	...	...	...	...	...
-18	-28	...	57	395	52	360	10	...	...	...	...	...	...
75	25	...	55	380	51	350	10	9.9	68	55	380	51	350	10
212	100	0.5	50	345	47	325	13	...	...	55	380	51	350	10
		10	50	345	47	325	13	...	...	55	380	51	350	10
		100	50	345	47	325	13	...	...	55	380	51	350	10
		1,000	50	345	47	325	13	...	...	55	380	51	350	10
		10,000	50	345	47	325	13	...	...	55	380	51	350	10
300	150	0.5	47	325	45	310	14	...	...	55	380	51	350	10
		10	46	315	45	310	14	...	...	55	380	51	350	10
		100	46	315	44	305	14	...	...	55	380	51	350	10
		1,000	41	285	39	270	14	...	...	50	345	45	310	10
		10,000	34	235	32	220	14	...	...	43	295	38	260	12
350	177	0.5	44	305	43	295	12	...	...	54	370	51	350	10
		10	42	290	40	275	12	...	...	52	360	50	345	10
		100	35	240	34	235	13	...	...	48	330	44	305	10
		1,000	30	205	28	195	15	...	...	41	285	35	240	12
		10,000	20	140	18	125	16	...	...	30	205	24	165	15
400	205	0.5	40	275	38	260	9	...	...	53	365	50	345	10
		10	33	230	31	215	11	...	...	46	315	42	290	11
		100	27	185	25	170	13	...	...	39	270	33	230	12
		1,000	20	140	18	125	17	...	...	30	205	22	150	14
		10,000	12	85	9.0	62	30	...	...	20	140	11	75	20
450	230	0.5	33	230	32	220	8	...	...	49	340	45	310	11
		10	26	180	24	165	11	...	...	40	275	33	230	13
		100	19	130	17	115	18	...	...	32	220	23	160	16
		1,000	13	90	11	75	29	...	...	23	160	11	75	19
		10,000	7.0	48	5.5	38	60	...	...	18	125	7.0	48	25
500	260	0.5	26	180	25	170	9	...	...	42	290	36	250	12
		10	20	140	18	125	15	...	...	33	230	24	165	15
		100	11	75	10	70	40	...	...	26	180	16	110	19
		1,000	7.5	52	6.5	45	60	...	...	20	140	8.5	59	24
		10,000	5.5	38	4.5	31	65	...	...	17	115	6.5	45	28
600	315	0.5	15	105	14	95	14	...	...	30	205	20	140	13
		10	5.5	38	4.9	34	55	...	...	21	145	9.0	62	25
		100	4.5	31	3.8	26	60	...	...	19	130	7.0	48	26
		1,000	4.4	30	3.7	26	65	...	...	18	125	6.5	45	27
		10,000	4.4	30	3.7	26	65	...	...	17	115	6.5	45	28
700	370	0.5	3.2	22	2.8	19	40	...	...	20	140	7.0	48	22

(a) Values for sheet-type specimens. (b) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6101-T6: Typical Tensile Properties

Temperature			At temperature indicated					At room temperature after heating						
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
°F	°C	Time at temperature, h												
-320	-196	...	43	295	33	230	24	...	...	...	...	...	...	...
-112	-80	...	36	250	30	205	20	...	...	...	...	...	...	...
-18	-28	...	34	235	29	200	19	...	...	...	...	...	...	...
75	25	...	32	220	28	195	19	9.9	68	32	220	28	195	19
212	100	0.5	28	195	25	170	20	...	...	32	220	28	195	19
		10	28	195	25	170	20	...	...	32	220	28	195	19
		100	28	195	25	170	20	...	...	32	220	28	195	19
		1,000	28	195	25	170	20	...	...	32	220	28	195	19
		10,000	28	195	25	170	20	...	...	32	220	28	195	19
300	150	0.5	25	170	23	160	20	...	...	32	220	28	195	19
		10	25	170	23	160	20	...	...	32	220	28	195	19
		100	25	170	23	160	20	...	...	32	220	27	185	19
		1,000	24	165	22	150	20	...	...	30	205	25	170	20
		10,000	21	145	19	130	20	...	...	27	185	21	145	20
350	177	0.5	24	165	22	150	20	...	...	32	220	28	195	19
		10	23	160	22	150	20	...	...	31	215	27	185	19
		100	21	145	20	140	21	...	...	30	205	24	165	19
		1,000	19	130	16	110	24	...	...	26	180	20	140	20
400	205	0.5	15	105	12	85	30	...	...	20	140	14	95	24
		10	21	145	20	140	21	...	...	32	220	28	195	19
		100	19	130	18	125	21	...	...	29	200	23	160	20
		1,000	16	110	14	95	24	...	...	25	170	18	125	20
		10,000	13	90	11	75	30	...	...	20	140	13	90	21
450	230	0.5	10	70	7.0	48	40	...	...	15	105	8.0	55	28
		10	18	125	16	110	24	...	...	30	205	25	170	20
		100	15	105	13	90	27	...	...	25	170	18	125	20
		1,000	12	85	9.5	66	35	...	...	20	140	12	85	24
		10,000	8.5	59	6.5	45	45	...	...	15	105	8.0	55	30
500	260	0.5	7.0	48	4.8	33	55	...	...	13	90	6.0	41	35
		10	14	95	12	85	29	...	...	27	185	21	145	20
		100	11	75	8.5	59	35	...	...	20	140	13	90	22
		1,000	8.0	55	6.0	41	50	...	...	15	105	8.0	55	30
		10,000	5.5	38	4.1	28	70	...	...	13	90	5.5	38	40
600	315	0.5	4.8	33	3.3	23	80	...	...	13	90	4.8	33	40
		10	7.0	48	6.0	41	50	...	...	19	130	11	75	22
		100	4.7	32	3.6	25	70	...	...	14	95	6.0	41	35
		1,000	3.8	26	2.9	20	85	...	...	13	90	4.6	32	40
		10,000	3.3	23	2.6	18	90	...	...	12	85	3.8	26	45
700	370	0.5	3.0	21	2.3	16	100	...	...	12	85	3.8	26	45
		10	2.5	17	1.8	12	85	...	...	15	105	6.0	41	30
		100	2.5	17	1.8	12	105	...	...	13	90	4.3	30	40
		1,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45
		10,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6101-T6: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	31	215	30	205	30	205	28	195	27	185
		1	30	205	30	205	29	200	27	185	27	185
		10	30	205	29	200	28	195	27	185	27	185
		100	29	200	29	200	27	185	27	185	26	180
		1000	29	200	28	195	27	185	26	180	26	180
212	100	0.1	27	185	26	180	25	170	24	165	23	160
		1	26	180	25	170	24	165	23	160	22	150
		10	25	170	24	165	23	160	22	150	21	145
		100	23	160	23	160	22	150	20	140	20	140
		1000	22	150	22	150	21	145	19	130	18	125
300	150	0.1	25	170	23	160	23	160	22	150	20	140
		1	23	160	21	145	21	145	20	140	18	125
		10	20	140	19	130	19	130	18	125	17	115
		100	18	125	17	115	17	115	16	110	14	95
		1000	16	110	15	105	15	105	13	90	11	75
350	177	0.1	22	150	21	145	21	145	20	140	18	125
		1	20	140	19	130	19	130	17	115	16	110
		10	17	115	16	110	16	110	14	95	14	95
		100	14	95	14	95	13	90	12	85	9.0	62
		1000	11	75	11	75	10	70	8.0	55	...	...
400	205	0.1	19	130	18	125	18	125	17	115	15	105
		1	17	115	16	110	16	110	14	95	13	90
		10	14	95	13	90	13	90	11	75	10	70
		100	10	70	10	70	9.5	66	8.0	55	5.5	38
		1000	7.0	48	6.5	45	5.5	38	4.0	28	...	...

Source data are in English units; metric values are converted and rounded.

6101-T61: Typical Tensile Properties

Temperature			At temperature indicated						At room temperature after heating					
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-320	-196	...	34	235	23	160	28	...	...	...	...	...	...
-112	-80	...	28	195	21	145	23	...	...	...	...	...	...
-18	-28	...	26	180	20	140	22	...	...	...	...	...	...
75	25	...	25	170	20	140	22	9.9	68	25	170	20	140	22
212	100	0.5	23	160	20	140	22	...	...	25	170	20	140	22
		10	23	160	20	140	22	...	...	25	170	20	140	22
		100	23	160	20	140	22	...	...	25	170	20	140	22
		1,000	23	160	20	140	22	...	...	25	170	20	140	22
		10,000	23	160	20	140	22	...	...	25	170	20	140	22
300	150	0.5	21	145	19	130	22	...	...	25	170	20	140	22
		10	21	145	19	130	22	...	...	25	170	20	140	22
		100	21	145	19	130	22	...	...	25	170	20	140	22
		1,000	21	145	19	130	22	...	...	25	170	20	140	22
		10,000	20	140	18	125	22	...	...	24	165	20	140	22
350	177	0.5	20	140	18	125	22	...	...	25	170	20	140	22
		10	20	140	18	125	22	...	...	25	170	20	140	22
		100	19	130	17	115	22	...	...	25	170	20	140	22
		1,000	18	125	16	110	24	...	...	24	165	19	130	22
		10,000	15	105	12	85	28	...	...	20	140	14	95	22
400	205	0.5	18	125	17	115	22	...	...	25	170	20	140	22
		10	18	125	17	115	22	...	...	25	170	20	140	22
		100	16	110	14	95	24	...	...	24	165	18	125	22
		1,000	13	90	11	75	30	...	...	20	140	13	90	22
		10,000	10	70	7.0	48	40	...	...	15	105	8.0	55	28
450	230	0.5	16	110	16	110	24	...	...	25	170	20	140	22
		10	15	105	13	90	27	...	...	24	165	18	125	22
		100	12	85	9.5	66	35	...	...	20	140	12	85	24
		1,000	8.5	59	6.5	45	45	...	...	15	105	8.0	55	30
		10,000	7.0	48	4.8	33	55	...	...	13	90	6.0	41	35
500	260	0.5	14	95	12	85	29	...	...	25	170	19	130	22
		10	11	75	8.5	59	35	...	...	20	140	13	90	22
		100	8.0	55	6.0	41	50	...	...	15	105	8.0	55	30
		1,000	5.5	38	4.1	28	70	...	...	13	90	5.5	38	40
		10,000	4.8	33	3.3	23	80	...	...	13	90	4.8	33	40
600	315	0.5	7.0	48	6.0	41	50	...	...	19	130	11	75	22
		10	4.7	32	3.6	25	70	...	...	14	95	6.0	41	35
		100	3.8	26	2.9	20	85	...	...	13	90	4.6	32	40
		1,000	3.3	23	2.6	18	90	...	...	12	85	3.8	26	45
		10,000	3.0	21	2.3	16	100	...	...	12	85	3.8	26	45
700	370	0.5	2.5	17	1.8	12	85	...	...	15	105	6.0	41	30
		10	2.5	17	1.8	12	105	...	...	13	90	4.3	30	40
		100	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45
		1,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45
		10,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6101-T61: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	24	165	24	165	23	160	22	150	21	145
		1	24	165	23	160	23	160	21	145	20	140
		10	23	160	23	160	22	150	21	145	20	140
		100	23	160	22	150	22	150	20	140	19	130
212	100	1000	22	150	22	150	21	145	20	140	19	130
		0.1	22	150	21	145	20	140	20	140	20	140
		1	21	145	20	140	20	140	19	130	19	130
		10	20	140	20	140	19	130	18	125	18	125
300	150	100	19	130	19	130	18	125	17	115	16	110
		1000	18	125	18	125	17	115	16	110	15	105
		0.1	20	140	19	130	18	125	18	125	17	115
		1	19	130	18	125	17	115	16	110	16	110
350	177	10	18	125	16	110	15	105	15	105	14	95
		100	16	110	15	105	14	95	14	95	13	90
		1000	14	95	13	90	13	90	12	85	11	75
		0.1	18	125	17	115	17	115	16	110	15	105
400	205	1	17	115	16	110	15	105	15	105	14	95
		10	15	105	14	95	14	95	13	90	12	85
		100	13	90	12	85	12	85	11	75	9.0	62
		1000	11	75	10	70	9.5	66	8.0	55	...	...
400	205	0.1	17	115	16	110	15	105	14	95	14	95
		1	16	110	14	95	14	95	13	90	12	85
		10	13	90	12	85	12	85	11	75	9.5	66
		100	10	70	10	70	9.5	66	8.0	55	5.5	38
		1000	7.0	48	6.5	45	5.5	38	4.0	28	...	...

Source data are in English units; metric values are converted and rounded.

6101-T63: Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
°F	°C	Time at temperature, h												
-320	-196	...	40	275	29	200	26	...	...	...	...	...	...
-112	-80	...	33	230	27	185	21	...	...	...	...	...	...
-18	-28	...	32	220	26	180	20	...	...	...	...	...	...
75	25	...	30	205	25	170	20	9.9	68	30	205	25	170	20
212	100	0.5	27	185	24	165	20	...	...	30	205	25	170	20
		10	27	185	24	165	20	...	...	30	205	25	170	20
		100	27	185	24	165	20	...	...	30	205	25	170	20
		1,000	27	185	24	165	20	...	...	30	205	25	170	20
		10,000	27	185	24	165	20	...	...	30	205	25	170	20
300	150	0.5	25	170	23	160	20	...	...	30	205	25	170	20
		10	25	170	23	160	20	...	...	30	205	25	170	20
		100	25	170	23	160	20	...	...	30	205	25	170	20
		1,000	24	165	22	150	20	...	...	30	205	25	170	20
		10,000	21	145	19	130	20	...	...	27	185	21	145	20
350	177	0.5	23	160	22	150	20	...	...	30	205	25	170	20
		10	23	160	22	150	20	...	...	30	205	25	170	20
		100	21	145	20	140	20	...	...	29	200	24	165	20
		1,000	19	130	16	110	22	...	...	26	180	20	140	20
		10,000	15	105	12	85	26	...	...	20	140	14	95	24
400	205	0.5	21	145	20	140	21	...	...	30	205	25	170	20
		10	19	130	18	125	21	...	...	29	200	23	160	20
		100	16	110	14	95	24	...	...	25	170	18	125	20
		1,000	13	90	11	75	30	...	...	20	140	13	90	21
		10,000	10	70	7.0	48	40	...	...	15	105	8.0	55	28
450	230	0.5	18	125	16	110	24	...	...	30	205	25	170	20
		10	15	105	13	90	27	...	...	25	170	18	125	20
		100	12	85	9.5	66	35	...	...	20	140	12	85	24
		1,000	8.5	59	6.5	45	45	...	...	15	105	8.0	55	30
		10,000	7.0	48	4.8	33	55	...	...	13	90	6.0	41	35
500	260	0.5	14	95	12	85	29	...	...	27	185	21	145	20
		10	11	75	8.5	59	35	...	...	20	140	13	90	22
		100	8.0	55	6.0	41	50	...	...	15	105	8.0	55	30
		1,000	5.5	38	4.1	28	70	...	...	13	90	5.5	38	40
		10,000	4.8	33	3.3	23	80	...	...	13	90	4.8	33	40
600	315	0.5	7.0	48	6.0	41	50	...	...	19	130	11	75	22
		10	4.7	32	3.6	25	70	...	...	14	95	6.0	41	35
		100	3.8	26	2.9	20	85	...	...	13	90	4.6	32	40
		1,000	3.3	23	2.6	18	90	...	...	12	85	3.8	26	45
		10,000	3.0	21	2.3	16	100	...	...	12	85	3.8	26	45
700	370	0.5	2.5	17	1.8	12	85	...	...	15	105	6.0	41	30
		10	2.5	17	1.8	12	105	...	...	13	90	4.3	30	40
		100	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45
		1,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45
		10,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6101-T63: Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	29	200	28	195	28	195	26	180	25	170
		1	28	195	28	195	27	185	25	170	25	170
		10	28	195	27	185	26	180	25	170	25	170
		100	27	185	27	185	25	170	25	170	24	165
		1000	27	185	26	180	25	170	24	165	24	165
212	100	0.1	26	180	25	170	25	170	24	165	23	160
		1	25	170	24	165	24	165	23	160	22	150
		10	24	165	23	160	22	150	22	150	21	145
		100	22	150	22	150	21	145	20	140	20	140
		1000	21	145	21	145	20	140	19	130	18	125
300	150	0.1	25	170	23	160	23	160	22	150	20	140
		1	23	160	21	145	21	145	20	140	18	125
		10	20	140	19	130	19	130	18	125	17	115
		100	18	125	17	115	17	115	16	110	14	95
		1000	16	110	15	105	15	105	13	90	11	75
350	177	0.1	22	150	21	145	21	145	20	140	18	125
		1	20	140	19	130	19	130	17	115	16	110
		10	17	115	16	110	16	110	14	95	14	95
		100	14	95	14	95	13	90	12	85	9.0	62
		1000	11	75	11	75	10	70	8.0	55	...	...
400	205	0.1	19	130	18	125	18	125	17	115	15	105
		1	17	115	16	110	16	110	14	95	13	90
		10	14	95	13	90	13	90	11	75	10	70
		100	10	70	10	70	9.5	66	8.0	55	5.5	38
		1000	7.0	48	6.5	45	5.5	38	4.0	28	...	...

Source data are in English units; metric values are converted and rounded.

6101-T64 (Formerly No. 2 EC): Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating							
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %			
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa				
°F	°C	Time at temperature, h															
-320	-196	...	30	205	11	75	33	...	...	...	...	...	...	...	...	...	...
-112	-80	...	20	140	10	70	26	...	...	...	...	...	...	...	...	...	...
-18	-28	...	18	125	9.5	66	24	...	...	...	...	...	...	...	...	...	...
75	25	...	17	115	9.0	62	24	9.9	68	17	115	9.0	62	24	...	...	...
212	100	0.5	15	105	9.0	62	24	...	...	17	115	9.0	62	24	...	...	...
		10	15	105	9.0	62	24	...	...	17	115	9.0	62	24	...	...	...
		100	15	105	9.0	62	24	...	...	17	115	9.0	62	24	...	...	...
		1,000	15	105	9.0	62	24	...	...	17	115	9.0	62	24	...	...	...
		10,000	15	105	9.0	62	24	...	...	17	115	9.0	62	24	...	...	...
300	150	0.5	14	95	9.0	62	28	...	...	17	115	9.0	62	24	...	...	...
		10	14	95	9.0	62	28	...	...	17	115	9.0	62	24	...	...	...
		100	14	95	9.0	62	28	...	...	17	115	9.0	62	24	...	...	...
		1,000	14	95	9.0	62	28	...	...	17	115	9.0	62	24	...	...	...
		10,000	14	95	9.0	62	28	...	...	17	115	9.0	62	24	...	...	...
350	177	0.5	13	90	9.0	62	30	...	...	17	115	9.0	62	24	...	...	...
		10	13	90	9.0	62	30	...	...	17	115	9.0	62	24	...	...	...
		100	12	85	8.5	59	30	...	...	17	115	9.0	62	24	...	...	...
		1,000	12	85	8.5	59	30	...	...	17	115	9.0	62	24	...	...	...
		10,000	12	85	8.5	59	31	...	...	17	115	9.0	62	24	...	...	...
400	205	0.5	11	75	8.5	59	35	...	...	17	115	9.0	62	24	...	...	...
		10	11	75	8.5	59	35	...	...	17	115	9.0	62	24	...	...	...
		100	11	75	8.0	55	35	...	...	17	115	9.0	62	24	...	...	...
		1,000	11	75	8.0	55	35	...	...	17	115	9.0	62	24	...	...	...
		10,000	10	70	7.0	48	40	...	...	15	105	8.0	55	28	...	...	...
450	230	0.5	10	70	7.5	52	40	...	...	17	115	9.0	62	24	...	...	...
		10	10	70	7.5	52	40	...	...	17	115	9.0	62	24	...	...	...
		100	9.5	66	7.0	48	40	...	...	17	115	9.0	62	25	...	...	...
		1,000	8.5	59	6.5	45	45	...	...	15	105	7.5	52	30	...	...	...
		10,000	7.0	48	4.8	33	55	...	...	13	90	6.0	41	35	...	...	...
500	260	0.5	9.0	62	7.0	48	45	...	...	17	115	9.0	62	24	...	...	...
		10	8.5	59	6.5	45	50	...	...	17	115	9.0	62	24	...	...	...
		100	7.5	52	5.5	38	55	...	...	15	105	8.0	55	30	...	...	...
		1,000	5.5	38	4.1	28	70	...	...	13	90	5.5	38	40	...	...	...
		10,000	4.8	33	3.3	23	80	...	...	13	90	4.8	33	40	...	...	...
600	315	0.5	5.5	38	4.5	31	60	...	...	17	115	8.5	59	25	...	...	...
		10	4.7	32	3.6	25	70	...	...	14	95	6.0	41	35	...	...	...
		100	3.8	26	2.9	20	85	...	...	13	90	4.6	32	40	...	...	...
		1,000	3.3	23	2.6	18	90	...	...	12	85	3.8	26	45	...	...	...
		10,000	3.0	21	2.3	16	100	...	...	12	85	3.8	26	45	...	...	...
700	370	0.5	2.5	17	1.8	12	85	...	...	15	105	6.0	41	30	...	...	...
		10	2.5	17	1.8	12	105	...	...	13	90	4.3	30	40	...	...	...
		100	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45	...	...	...
		1,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45	...	...	...
		10,000	2.5	17	1.8	12	105	...	...	12	85	3.8	26	45	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension.
Source data are in English units; metric values are converted and rounded.

6101-T64 (Formerly No. 2 EC): Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	17	115	17	115	16	110	16	110	14	95
		1	17	115	17	115	16	110	15	105	13	90
		10	16	110	16	110	16	110	14	95	13	90
		100	16	110	16	110	16	110	14	95	12	85
		1000	16	110	16	110	15	105	13	90	12	85
212	100	0.1	15	105	14	95	14	95	12	85	11	75
		1	14	95	13	90	12	85	11	75	9.5	66
		10	14	95	12	85	11	75	9.5	66	8.5	59
		100	13	90	11	75	10	70	8.5	59	8.0	55
		1000	12	85	10	70	9.0	62	8.0	55	7.5	52
300	150	0.1	13	90	11	75	10	70	8.5	59	8.0	55
		1	12	85	10	70	9.0	62	7.5	52	7.0	48
		10	11	75	8.5	59	8.0	55	7.0	48	6.5	45
		100	10	70	7.5	52	7.0	48	6.5	45	6.0	41
		1000	9.0	62	7.0	48	6.5	45	6.0	41	5.5	38
350	177	0.1	12	85	...	...	...	...	...	...	...	...
		1	11	75	...	...	...	...	...	...	...	...
		10	9.5	66	...	...	...	...	...	...	...	...
		100	8.5	59	...	...	...	...	...	...	...	...
		1000	7.5	52	...	...	...	...	...	...	...	...
400	205	0.1	10	70	8.5	59	8.0	55	7.0	48	6.5	45
		1	9.5	66	7.5	52	6.5	45	6.0	41	5.5	38
		10	8.0	55	6.5	45	6.0	41	5.5	38	4.5	31
		100	7.0	48	5.5	38	5.5	38	4.5	31	3.6	25
		1000	6.0	41	5.0	34	4.7	32	...	...	...	...

Source data are in English units; metric values are converted and rounded.

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6101-T8 (Formerly No. 2 EC): Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated							At room temperature after heating					
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %	
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa		
°F	°C														
-320	-196	...	47	325	37	255	23	...	...	...	...	...	...	...	...
-112	-80	...	38	260	34	235	20	...	...	...	...	...	...	...	...
-18	-28	...	36	250	33	230	19	...	...	...	...	...	...	...	...
75	25	...	34	235	31	215	19	9.9	68	34	235	31	215	19	...
212	100	0.5	31	215	29	200	19	...	...	34	235	31	215	19	...
		10	31	215	29	200	19	...	...	34	235	31	215	19	...
		100	31	215	29	200	19	...	...	34	235	31	215	19	...
		1,000	31	215	29	200	19	...	...	34	235	31	215	19	...
		10,000	30	205	28	195	19	...	...	34	235	31	215	19	...
300	150	0.5	28	195	27	185	20	...	...	34	235	31	215	19	...
		10	28	195	27	185	20	...	...	34	235	31	215	19	...
		100	28	195	27	185	20	...	...	33	230	31	215	19	...
		1,000	25	170	24	165	20	...	...	30	205	27	185	19	...
		10,000	21	145	19	130	20	...	...	26	180	22	150	19	...
350	177	0.5	26	180	25	170	22	...	...	34	235	31	215	19	...
		10	25	170	24	165	22	...	...	33	230	30	205	19	...
		100	23	160	22	150	22	...	...	30	205	27	185	19	...
		1,000	20	140	18	125	22	...	...	25	170	21	145	19	...
		10,000	16	110	14	95	23	...	...	20	140	16	110	22	...
400	205	0.5	23	160	21	145	23	...	...	33	230	31	215	19	...
		10	21	145	19	130	24	...	...	29	200	26	180	19	...
		100	18	125	16	110	25	...	...	25	170	21	145	19	...
		1,000	15	105	13	90	26	...	...	20	140	16	110	20	...
		10,000	11	75	9.0	62	28	...	...	15	105	11	75	27	...
450	230	0.5	19	130	16	110	25	...	...	32	220	29	200	19	...
		10	16	110	13	90	27	...	...	25	170	21	145	19	...
		100	13	90	10	70	29	...	...	20	140	16	110	21	...
		1,000	9.5	66	7.0	48	30	...	...	15	105	13	90	23	...
		10,000	7.0	48	4.8	33	35	...	...	13	90	10	70	28	...
500	260	0.5	15	105	12	85	29	...	...	28	195	25	170	19	...
		10	11	75	8.5	59	35	...	...	20	140	17	115	20	...
		100	8.0	55	6.0	41	35	...	...	15	105	12	85	25	...
		1,000	5.5	38	4.1	28	40	...	...	13	90	10	70	27	...
		10,000	4.8	33	3.3	23	45	...	...	13	90	9.5	66	29	...
600	315	0.5	7.0	48	6.0	41	45	...	...	19	130	16	110	20	...
		10	4.7	32	3.6	25	55	...	...	14	95	11	75	26	...
		100	3.8	26	2.9	20	55	...	...	13	90	10	70	29	...
		1,000	3.3	23	2.6	18	55	...	...	12	85	9.0	62	30	...
		10,000	3.0	21	2.3	16	60	...	...	12	85	3.8	26	45	...
700	370	0.5	2.5	17	1.8	12	80	...	...	15	105	11	75	25	...
		10	2.5	17	1.8	12	80	...	...	13	90	7.0	48	35	...
		100	2.5	17	1.8	12	80	...	...	12	85	4.7	32	45	...
		1,000	2.5	17	1.8	12	80	...	...	12	85	3.8	27	45	...
		10,000	2.5	17	1.8	12	80	...	...	12	85	3.8	27	45	...

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6101-T8 (Formerly No. 2 EC): Creep-Rupture and Creep Properties

Temperature		Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C		ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	33	230	33	230	32	220	32	220	31	215
		1	33	230	32	220	32	220	31	215	31	215
		10	32	220	32	220	31	215	31	215	30	205
		100	32	220	31	215	31	215	30	205	29	200
212	100	1000	31	215	31	215	30	205	30	205	29	200
		0.1	30	205	29	200	29	200	28	195	27	185
		1	29	200	28	195	28	195	26	180	23	160
		10	27	185	27	185	26	180	23	160	16	110
300	150	100	26	180	25	170	23	160	18	125	11	75
		1000	24	165	22	150	20	140	12	85	8.0	55
		0.1	27	185	26	180	25	170	23	160	20	140
		1	25	170	24	165	22	150	20	140	14	95
350	177	10	22	150	21	145	19	130	14	95	7.5	52
		100	20	140	18	125	16	110	8.5	59	...	...
		1000	15	105	13	90	9.5	66	...	...	...	...
		0.1	24	165	...	...	...	...	...	...	...	...
400	205	1	21	145	...	...	...	...	...	...	...	...
		10	18	125	...	...	...	...	...	...	...	...
		100	15	105	...	...	...	...	...	...	...	...
		1000	11	75	...	...	...	...	...	...	...	...
400	205	0.1	20	140	18	125	17	115	14	95	9.5	66
		1	16	110	15	105	14	95	9.5	66	4.7	32
		10	13	90	12	85	9.0	62	4.9	34	...	...
		100	11	75	7.5	52	5.0	34	...	...	...	...
		1000	8.5	59	4.3	30	...	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6151-T6: Typical Tensile Properties

Temperature			At temperature indicated						At room temperature after heating					
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
			ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
°F	°C	Time at temperature, h												
-320	-196	...	57	395	50	345	20	...	...	...	...	...	...	...
-112	-80	...	50	345	46	315	17	...	...	...	...	...	...	...
-18	-28	...	49	340	45	310	17	...	...	...	...	...	...	...
75	25	...	48	330	43	295	17	10.1	70	48	330	43	295	17
212	100	0.5	43	295	40	275	17	...	...	48	330	43	295	17
		10	43	295	40	275	17	...	...	48	330	43	295	17
		100	43	295	40	275	17	...	...	48	330	43	295	17
		1,000	43	295	40	275	17	...	...	48	330	43	295	17
		10,000	43	295	40	275	17	...	...	48	330	43	295	17
300	150	0.5	39	270	37	255	15	...	...	48	330	43	295	17
		10	39	270	37	255	16	...	...	48	330	43	295	17
		100	37	255	36	250	17	...	...	47	325	42	290	17
		1,000	33	230	32	220	18	...	...	42	290	38	260	17
		10,000	28	195	27	185	20	...	...	36	250	30	205	17
350	177	0.5	36	250	34	235	15	...	...	47	325	43	295	17
		10	34	235	33	230	16	...	...	46	315	42	290	17
		100	31	215	30	205	17	...	...	43	295	38	260	17
		1,000	27	185	25	170	19	...	...	37	255	30	205	17
400	205	10,000	20	140	18	125	24	...	...	28	195	21	145	18
		0.5	32	220	31	215	15	...	...	46	315	41	285	17
		10	29	200	28	195	16	...	...	42	290	37	255	17
		100	25	170	23	160	17	...	...	37	255	30	205	17
		1,000	20	140	18	125	22	...	...	30	205	21	145	18
450	230	10,000	14	95	12	85	30	...	...	22	150	14	95	19
		0.5	26	180	25	170	15	...	...	42	290	36	250	17
		10	23	160	21	145	16	...	...	36	250	29	200	17
		100	19	130	17	115	18	...	...	28	195	21	145	19
		1,000	13	90	11	75	31	...	...	22	150	13	90	22
500	260	10,000	9.5	66	7.0	48	44	...	...	18	125	10	70	28
		0.5	20	140	19	130	15	...	...	37	255	30	205	17
		10	17	115	15	105	16	...	...	29	200	21	145	18
		100	13	90	11	75	21	...	...	20	140	12	85	23
		1,000	7.0	48	5.5	38	45	...	...	16	110	8.0	55	30
600	315	10,000	6.5	45	5.0	34	50	...	...	16	110	8.0	55	33
		0.5	10	70	9.0	62	19	...	...	27	185	19	130	17
		10	6.0	41	5.0	34	30	...	...	19	130	9.5	66	24
		100	5.0	34	4.5	31	36	...	...	17	115	8.0	55	30
		1,000	5.0	34	3.9	27	40	...	...	16	110	8.0	55	33
700	370	10,000	5.0	34	3.9	27	43	...	...	16	110	8.0	55	33
		0.5	4.2	29	3.5	24	35	...	...	24	165	10	70	19
		10	4.1	28	3.2	22	35	...	...	18	125	8.5	59	27
		100	4.1	28	3.2	22	35	...	...	16	110	8.0	55	31
		1,000	4.1	28	3.2	22	35	...	...	16	110	8.0	55	33
		10,000	4.1	28	3.2	22	35	...	...	16	110	8.0	55	33

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6151-T6: Creep-Rupture and Creep Properties

Temperature			Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C	Time under stress, h	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
300	150	0.1	39	270	...	...	...	...	...	...	35	240
		1	38	260	...	...	...	...	37	255	34	235
		10	35	240	...	...	...	...	34	235	30	205
		100	31	215	...	...	...	...	30	205	26	180
		1000	26	180	...	...	...	...	25	170	22	150
400	205	0.1	26	180	26	180	26	180	26	180	25	170
		1	24	165	24	165	24	165	24	165	23	160
		10	23	160	23	160	23	160	22	150	19	130
		100	21	145	20	140	19	130	17	115	14	95
		1000	16	110	15	105	14	95	13	90	...	...

Source data are in English units; metric values are converted and rounded.

6201-T81 Wire: Typical Tensile Properties

Temperature			At temperature indicated					At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 10 in. (25 cm)(a),%	Tensile strength		Yield strength		Elongation in 10 in. (25 cm)(a),%
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		ksi	MPa	ksi	MPa	
-320	-196	...	68	470	59	405	7	...	...	...	...
-112	-80	...	56	385	51	350	6	...	...	...	...
-18	-28	...	53	365	49	340	6	...	...	...	...
75	25	...	50	345	47	325	6	50	345	47	325	
212	100	0.5	44	305	41	285	6	50	345	47	325	
		10	44	305	41	285	6	50	345	47	325	
		100	44	305	41	285	6	50	345	47	325	
		1,000	43	295	40	275	6	49	340	47	325	
		10,000	38	260	37	255	6	45	310	43	295	
300	150	0.5	39	270	36	250	6	50	345	47	325	
		10	37	255	35	240	6	49	340	46	315	
		100	32	220	30	205	6	45	310	43	295	
		1,000	24	165	22	150	6	33	230	30	205	
		10,000	16	110	13	90	8	22	150	16	110	
350	177	0.5	34	235	31	215	6	49	340	46	315	
		10	29	200	27	185	6	43	295	40	275	
		100	19	130	17	115	6	30	205	26	180	
		1,000	11	75	8.0	55	...	19	130	11	75	
		10,000	7.5	52	4.8	33	...	15	105	6.5	45	
400	205	0.5	26	180	24	165	6	45	310	42	290	
		10	18	125	15	105	7	33	230	29	200	
		100	9.0	62	6.0	41	...	18	125	12	85	
		1,000	6.0	41	4.1	28	...	15	105	7.0	48	
		10,000	6.0	41	3.9	27	...	14	95	6.5	45	
450	230	0.5	19	130	16	110	6	35	240	32	220	
		10	9.0	62	7.5	52	...	23	160	18	125	
		100	...	...	...	...	...	15	105	7.0	48
		1,000	...	...	...	...	...	14	95	6.5	45
500	260	0.5	12	85	8.5	59	6	26	180	21	145	
		10	4.5	31	3.2	22	...	16	110	8.0	55	
		100	...	...	...	...	...	15	105	6.5	45
		1,000	...	...	...	...	...	14	95	6.5	45

(a) Values for elongation apply only to electrical conductor wire 0.1318 to 0.1400 in. (3.30 to 3.50 cm) in diameter. Source data are in English units; metric values are converted and rounded.

6201-T81 Wire: Creep-Rupture and Creep Properties

Temperature			Time under stress, h	Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
				ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	49	340	48	330	47	325	46	315	44	305	
		1	48	330	47	325	46	315	44	305	42	290	
		10	47	325	45	310	44	305	42	290	38	260	
		100	45	310	43	295	42	290	40	275	...	...
		1000	43	295	41	285	40	275	36	250	...	...
212	100	0.1	42	290	41	285	40	275	38	260	36	250	
		1	40	275	39	270	38	260	35	240	27	185	
		10	38	260	36	250	35	240	29	200	23	160	
		100	33	230	30	205	28	195	23	160	21	145	
		1000	26	180	24	165	23	160	21	145	20	140	
300	150	0.1	36	250	34	235	33	230	30	205	24.	165	
		1	32	220	30	205	28	195	23	160	17	115	
		10	25	170	23	160	21	145	16	110	11	75	
		100	18	125	16	110	14	95	9.0	62	6.0	41	
		1000	11	75	9.5	66	7.5	52	4.8	33	4.0	28	

Source data are in English units; metric values are converted and rounded.

6262-T9: Typical Tensile Properties

Temperature			At temperature indicated							At room temperature after heating				
			Tensile strength		Yield strength		Elongation in 4D, %	Modulus of elasticity(a)		Tensile strength		Yield strength		Elongation in 4D, %
°F	°C	Time at temperature, h	ksi	MPa	ksi	MPa		10 ⁶ psi	GPa	ksi	MPa	ksi	MPa	
-320	-196	...	74	510	67	460	14	...	...	...	...	...	...
-112	-80	...	62	425	58	400	11	...	...	...	...	...	...
-18	-28	...	60	415	56	385	10	...	...	...	...	...	...
75	25	...	58	400	55	380	10	9.9	68	58	400	55	380	
212	100	0.5	55	380	52	360	10	9.5	66	58	400	55	380	
		10	55	380	52	360	10	9.5	66	58	400	55	380	
		100	55	380	52	360	10	9.5	66	59	407	56	385	
		1,000	55	380	52	360	10	9.5	66	59	407	56	385	
		10,000	53	365	51	350	11	9.5	66	57	395	54	370	
300	150	0.5	51	350	48	330	10	9.1	63	58	400	55	380	
		10	50	345	47	325	10	9.1	63	57	395	54	370	
		100	47	325	45	310	11	9.1	63	55	380	53	365	
		1,000	43	295	41	285	13	9.1	63	50	345	48	330	
		10,000	35	240	34	235	16	9.1	63	42	290	39	270	
350	177	0.5	46	315	44	305	10	8.9	61	57	395	54	370	
		10	42	290	40	275	12	8.9	61	53	365	51	350	
		100	37	255	35	240	14	8.9	61	47	325	45	310	
		1,000	29	200	28	195	19	8.9	61	38	260	34	235	
		10,000	22	150	21	145	25	8.9	61	30	205	25	170	
400	205	0.5	40	275	38	260	11	8.6	59	53	365	52	360	
		10	32	220	30	205	16	8.6	59	45	310	42	290	
		100	25	170	23	160	21	8.6	59	36	250	32	220	
		1,000	19	130	17	115	26	8.6	59	29	200	24	165	
		10,000	14	95	13	90	35	8.6	59	23	160	18	125	
450	230	0.5	30	205	28	195	12	8.3	57	47	325	44	305	
		10	23	160	20	140	21	8.3	57	36	250	32	220	
		100	16	110	13	90	30	8.3	57	28	195	23	160	
		1,000	13	90	10	70	35	8.3	57	24	165	19	130	
		10,000	11	75	9.0	62	40	8.3	57	21	145	16	110	
500	260	0.5	20	140	18	125	15	7.9	54	39	270	35	240	
		10	15	105	12	85	28	7.9	54	30	205	25	170	
		100	11	75	8.5	59	40	7.9	54	24	165	18	125	
		1,000	9.5	66	7.0	48	45	7.9	54	22	150	16	110	
		10,000	8.5	59	7.0	48	50	7.9	54	20	140	15	105	
600	315	0.5	10	70	7.5	52	21	6.8	47	28	195	23	160	
		10	7.0	48	4.9	34	50	6.8	47	23	160	17	115	
		100	6.0	41	4.3	30	55	6.8	47	21	145	15	105	
		1,000	5.5	38	4.0	28	65	6.8	47	20	140	13	90	
		10,000	5.0	34	3.8	26	70	6.8	47	18	125	12	85	
700	370	0.5	4.3	30	2.7	19	50	5.5	38	24	165	16	110	
		10	3.8	26	2.3	16	75	5.5	38	22	150	13	90	
		100	3.5	24	2.3	16	85	5.5	38	20	140	11	75	
		1,000	3.4	23	2.3	16	90	5.5	38	...	...	...	...
		10,000	3.4	23	2.3	16	90	5.5	38	...	...	...	...

(a) The modulus of elasticity in compression is about 2% greater than in tension. Source data are in English units; metric values are converted and rounded.

6262-T9: Creep-Rupture and Creep Properties

Temperature			Rupture stress		Stress at 1.0% creep		Stress at 0.5% creep		Stress at 0.2% creep		Stress at 0.1% creep	
°F	°C	Time under stress, h	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
75	25	0.1	57	395	57	395	57	395	56	385	55	380
		1	57	395	57	395	56	385	56	385	55	380
		10	56	385	56	385	56	385	55	380	54	370
		100	56	385	56	385	56	385	54	370	52	360
		1000	56	385	55	380	54	370	53	365	48	330
212	100	0.1	53	365	53	365	52	360	51	350	49	340
		1	52	360	51	350	50	345	48	330	44	305
		10	50	345	49	340	48	330	44	305	37	255
		100	48	330	47	325	46	315	39	270	...	...
		1000	42	290	42	290	38	260	...	...	...	...
300	150	0.1	48	330	48	330	47	325	45	310	41	285
		1	45	310	45	310	43	295	39	270	32	220
		10	41	285	40	275	38	260	32	220	24	165
		100	33	230	32	220	30	205	24	165	...	...
		1000	24	165	23	160	22	150	...	...	...	...

Source data are in English units; metric values are converted and rounded.

6351-T5 Extrusions: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated					At room temperature after heating						
			Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %	Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %		
°F	°C		ksi	MPa	ksi	MPa		ksi	MPa	ksi	MPa		ksi	MPa
-320	-196	...	59	405	47	325	17	...	...	...	...	...
-112	-80	...	51	350	44	305	10.5	...	...	...	...	...
-18	-28	...	48	330	43	295	11	...	...	...	...	...
75	25	...	45	310	41	285	11.5	45	310	41	285	11.5		
212	100	0.1	40	275	38	260	13	45	310	41	285	11.5		
		0.5	40	275	38	260	13	45	310	41	285	11.5		
		10	40	275	38	260	14	45	310	41	285	11.5		
		100	41	285	39	270	15	45	310	41	285	11		
		1,000	41	285	39	270	13	46	317	43	295	10		
		10,000	41	285	39	270	12	45	310	42	290	10		
		300	150	0.1	36	250	34	235	15	45	310	41	285	11.5
				0.5	36	250	34	235	15	45	310	41	285	11.5
				10	36	250	35	240	14	45	310	42	290	11
				100	36	250	35	240	14	44	305	41	285	10
1,000	30			205	28	195	15	39	270	34	235	11		
10,000	25			170	22	150	18	33	230	26	180	14		
350	177			0.1	33	230	32	220	15	45	310	41	285	11
				0.5	33	230	32	220	15	45	310	41	285	11
				10	33	230	32	220	14	44	305	40	275	11
				100	28	195	27	185	15	37	255	32	220	12
		1,000	22	150	20	140	19	30	205	24	165	14		
		10,000	17	115	14	95	26	23	160	15	105	19		
		400	205	0.1	30	205	29	200	17	44	305	40	275	11
				0.5	31	215	30	205	14	43	295	39	270	12
				10	25	170	24	165	18	36	250	30	205	12
				100	20	140	18	125	21	30	205	23	160	13
1,000	15			105	13	90	24	23	160	15	105	19		
10,000	9.5			66	7.0	48	35	17	115	8.5	59	30		
450	230			0.1	27	185	27	185	13	42	290	37	255	12
				0.5	25	170	25	170	12	38	260	33	230	12
				10	19	130	19	130	16	31	215	24	165	14
				100	15	105	13	90	25	25	170	16	110	17
		1,000	9.0	62	7.5	52	30	19	130	10	70	24		
		10,000	...	...	...	...	...	15	105	5.0	34	40		
		500	260	0.1	21	145	21	145	16	36	250	30	205	12
				0.5	19	130	18	125	14	33	230	26	180	14
				10	12	85	11	75	22	24	165	15	105	17
				100	8.0	55	6.5	45	29	18	125	8.5	59	28
1,000	5.5			38	4.8	33	40	17	115	7.0	48	35		
600	315			0.1	11	75	11	75	19	30	205	24	165	14
				0.5	10	70	10	70	21	23	160	14	95	16
				10	...	...	...	...	...	17	115	7.0	48	26
				100	...	...	...	...	...	16	110	6.0	41	35
				1,000	...	...	...	...	...	16	110	5.5	38	35
		700	370	0.1	...	...	...	...	...	23	160	12	85	17
				0.5	...	...	...	...	...	20	140	8.0	55	21

Source data are in English units; metric values are converted and rounded.

6351-T6 Extrusions: Typical Tensile Properties

Temperature		Time at temperature, h	At temperature indicated			At room temperature after heating								
			Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %	Tensile strength		Yield strength		Elongation in 2 in. (50 mm), %		
°F	°C	ksi	MPa	ksi	MPa	ksi		MPa	ksi	MPa				
-320	-196	...	63	435	53	365	14	...	...	...	...	...
-112	-80	...	54	370	48	330	10.5	...	...	...	...	...
-18	-28	...	51	350	47	325	10.5	...	...	...	...	...
75	25	...	48	330	45	310	11	48	330	45	310	11		
212	100	0.1	43	295	42	290	13	48	330	45	310	11		
		0.5	43	295	42	290	13	48	330	45	310	11		
		10	43	295	42	290	14	48	330	45	310	11		
		100	43	295	42	290	15	48	330	46	315	11		
		1,000	43	295	42	290	13	50	345	47	325	10		
		10,000	43	295	42	290	12	48	330	45	310	10		
		300	150	0.1	39	270	38	260	15	48	330	45	310	11
				0.5	39	270	38	260	15	48	330	45	310	11
				10	39	270	38	260	14	49	340	46	315	11
				100	38	260	37	255	14	48	330	45	310	10
1,000	32			220	31	215	15	41	285	38	260	11		
10,000	27			185	24	165	18	35	240	30	205	14		
350	177	0.1	36	250	36	250	15	48	330	45	310	11		
		0.5	36	250	36	250	15	48	330	45	310	11		
		10	35	240	35	240	14	47	325	44	305	11		
		100	30	205	29	200	15	41	285	37	255	12		
		1,000	25	170	24	165	19	35	240	30	205	14		
		10,000	...	...	...	...	...	28	195	21	145	19
400	205	0.1	33	230	33	230	17	48	330	45	310	11		
		0.5	33	230	33	230	14	47	325	44	305	12		
		10	26	180	26	180	18	40	275	35	240	12		
		100	22	150	20	140	21	34	235	28	195	13		
		1,000	17	115	15	105	24	28	195	21	145	19		
		10,000	...	...	...	...	...	20	140	11	75	30
450	230	0.1	29	200	29	200	13	46	315	44	305	12		
		0.5	28	195	28	195	12	42	290	39	270	12		
		10	21	145	20	140	16	34	235	29	200	14		
		100	17	115	15	105	25	28	195	21	145	17		
		1,000	...	...	...	...	...	20	140	12	85	24
		10,000	...	...	...	...	...	17	115	7.0	48	34
500	260	0.1	23	160	23	160	16	40	275	36	250	12		
		0.5	21	145	20	140	14	36	250	30	205	14		
		10	16	110	14	95	22	28	195	20	140	17		
		100	12	85	10	70	29	21	145	12	85	28		
		1,000	...	...	...	...	...	17	115	7.0	48	34
		10,000	...	...	...	...	...	19	130	9.0	62	26
600	315	0.1	...	...	...	...	...	34	235	28	195	14
		0.5	11	75	11	75	21	30	205	22	150	16		
		10	...	...	...	...	...	19	130	9.0	62	26
700	370	100	...	...	...	...	...	18	125	7.0	48	35
		0.1	...	...	...	...	...	26	180	16	110	17
		0.5	...	...	...	...	...	21	145	9.5	66	21

Source data are in English units; metric values are converted and rounded.

6951-O (Estimated from Results of Tests of Similar Alloys): Typical Tensile Properties

Temperature		Time at temperature, h	Tensile strength		Yield strength	
°F	°C		ksi	MPa	ksi	MPa
75	25	...	17	115	7.0	48
212	100	0.5	16	110	6.5	45
		10,000	16	110	6.5	45
300	150	0.5	14	95	6.0	41
		10,000	14	95	6.0	41
400	205	0.5	8.5	59	5.0	34
		10,000	8.5	59	5.0	34
500	260	0.5	5.5	38	4.0	28
		10,000	5.5	38	4.0	28
600	315	0.5	4.0	28	3.0	21
		10,000	4.0	28	3.0	21
700	370	0.5	3.0	21	2.0	14
		10,000	3.0	21	2.0	14
800	425	0.5	2.5	17	1.8	12
		10,000	2.5	17	1.8	12
900	480	0.5	2.0	14	1.6	11
		10,000	2.0	14	1.6	11
1000	540	0.5	1.6	11	1.2	8.0
		10,000	1.6	11	1.2	8.0
1100	595	0.5	1.1	8.0	0.8	6.0
		10,000	1.1	8.0	0.8	6.0

Source data are in English units; metric values are converted and rounded.

6951-T4 (Estimated from Results of Tests of Similar Alloys): Typical Tensile Properties

Temperature		Time at temperature, h	Tensile strength		Yield strength	
°F	°C		ksi	MPa	ksi	MPa
75	25	...	29	200	18	125
212	100	0.5	32	220	22	150
		10,000	36	250	32	220
300	150	0.5	31	215	26	180
		10,000	23	160	20	140
400	205	0.5	28	195	25	170
		10,000	9.0	62	7.0	48
500	260	0.5	16	110	14	95
		10,000	5.5	38	4.0	28
600	315	0.5	6.5	45	5.5	38
		10,000	4.0	28	3.0	21
700	370	0.5	3.0	21	2.0	14
		10,000	3.0	21	2.0	14
800	425	0.5	2.5	17	1.8	12
		10,000	2.5	17	1.8	12
900	480	0.5	2.0	14	1.6	11
		10,000	2.0	14	1.6	11
1000	540	0.5	1.6	11	1.2	8.0
		10,000	1.6	11	1.2	8.0
1100	595	0.5	1.1	8.0	0.8	6.0
		10,000	1.1	8.0	0.8	6.0

Source data are in English units; metric values are converted and rounded.

6951-T6 (Estimated from Results of Tests of Similar Alloys): Typical Tensile Properties

Temperature		Time at temperature, h	Tensile strength		Yield strength	
°F	°C		ksi	MPa	ksi	MPa
75	25		42	290	36	250
212	100	0.5	37	255	33	230
		10,000	37	255	33	230
300	150	0.5	33	230	30	205
		10,000	23	160	20	140
400	205	0.5	28	195	25	172
		10,000	9.0	62	7.0	48
500	260	0.5	16	110	14	95
		10,000	5.5	38	4.0	28
600	315	0.5	6.5	45	5.5	38
		10,000	4.0	28	3.0	21
700	370	0.5	3.0	21	2.0	14
		10,000	3.0	21	2.0	14
800	425	0.5	2.5	17	1.8	12
		10,000	2.5	17	1.8	12
900	480	0.5	2.0	14	1.6	11
		10,000	2.0	14	1.6	11
1000	540	0.5	1.6	11	1.2	8.0
		10,000	1.6	11	1.2	8.0
1100	595	0.5	1.1	8.0	0.8	6.0
		10,000	1.1	8.0	0.8	6.0

Source data are in English units; metric values are converted and rounded.

Wrought Alloys: 7xxx Al-Zn Alloys

Principal characteristics and applications of the 7xxx series of aluminum alloys include:

- Heat treatable
- Very high strength; special high toughness versions
- Aerospace, automotive applications
- Representative alloys: 7005, 7075, 7475, 7150
- Typical ultimate tensile strength range: 32 to 88 ksi (220 to 605 MPa)

The 7xxx alloys are heat treatable and, among the Al-Zn-Mg-Cu versions, provide the highest strengths of all aluminum alloys. Several alloys in the series are produced especially for high toughness, notably 7150 and 7475, and these alloys have controlled impurity level to maximize the combination of strength and fracture toughness.

The widest application of the 7xxx alloys has historically been in the aircraft industry, where fracture-critical design concepts have provided the impetus for the high-toughness alloy development. These alloys are not consid-

ered weldable by routine commercial processes, and they are regularly used in riveted construction.

The atmospheric corrosion resistance of the 7xxx alloys is not as high as that of the 5xxx and 6xxx alloys; therefore, in such service, they are usually coated or, for sheet and plate, used in an alclad version. The use of special tempers, such as the T73 type, is required in place of T6 tempers whenever stress-corrosion cracking may be a problem.