

Cu Zn40

Common names: **60/40 Brass (Lead-Free)**
Muntz Metal
Yellow Metal

A copper-zinc alloy with a duplex alpha-plus-beta phase structure and excellent hot-working properties. Service environment must be considered to predict corrosion behaviour. Cu Zn40 has somewhat better cold-working and joining properties, but is less readily machined, than the similar low-leaded alloy Cu Zn40 Pb. The most commonly used wrought forms are plate, rod and sections/shapes.

COMPOSITION (weight %)

Cu . . . 59.0-62.0
Zn . . . rem.

1 SOME TYPICAL USES**Architectural**

Extruded sections including angles, channels and trim; heavy-gauge panels and sheets.

Chemical and Marine

Condenser and heat exchanger tubeplates.

Mechanical

Hot forgings and "upset" products requiring limited cold bending or riveting.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C 68 °F	8.40 g/cm ³	0.305 lb/in ³
2.2 Melting range	895-900 °C	1 645-1 650 °F
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C 68 to 212 °F	0.000 020 per °C	0.000 011 per °F
20 to 300 °C 68 to 572 °F	0.000 021 " "	0.000 012 " "
2.4 Specific heat (thermal capacity) at:		
20 °C 68 °F	0.09 cal/g °C	0.09 Btu/lb °F
2.5 Thermal conductivity at:		
-200 °C -328 °F	0.15 cal cm/cm ² s °C	37 Btu ft/ft ² h °F
20 °C 68 °F	0.30 " "	73 " "
200 °C 392 °F	0.34 " "	82 " "
2.6 Electrical conductivity (volume) at:		
20 °C 68 °F (annealed)	16 m/ohm mm ²	28 % IACS
200 °C 392 °F (")	12 " "	21 " "
2.7 Electrical resistivity (volume) at:		
20 °C 68 °F (annealed)	0.062 ohm mm ² /m	37 ohms (circ mil/ft)
	6.2 microhm cm	2.4 microhm in
200 °C 392 °F (")	0.082 ohm mm ² /m	49 ohms (circ mil/ft)
	8.2 microhm cm	3.2 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C 68 °F (annealed)	0.002 0 per °C (28% IACS)	0.001 1 per °F (28% IACS)
applicable over range from 0 to 100 °C 32 to 212 °F		
2.9 Modulus of elasticity (tension) at 20 °C 68 °F		
annealed	10 400 kg/mm ²	14 800 000 lb/in ²
cold worked	9 600-10 400 kg/mm ²	13 650 000-14 800 000 lb/in ²
2.10 Modulus of rigidity (torsion) at 20 °C 68 °F		
annealed	3 900 kg/mm ²	5 550 000 lb/in ²
cold worked	3 500-3 900 kg/mm ²	5 000 000-5 550 000 lb/in ²

N.B.: The values shown in Section 2, which have been appropriately rounded in view of the composition range involved, are based on selected literature references.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 12); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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Cu Zn40
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3 FABRICATION PROPERTIES

The information given in this table is for general guidance only, since many factors influence fabrication techniques.

The values shown are approximate only, since those used in practice are dependent upon form and size of metal, equipment available, techniques adopted and properties required in the material.

	Metric Units	English Units
3.1 Casting temperature range	1 010-1 050 °C	1 850-1 920 °F
3.2 Annealing temperature range	450- 650 °C	840-1 200 °F
Stress relieving temperature range	250- 350 °C	480- 660 °F
3.3 Hot working temperature range	650- 750 °C	1 200-1 380 °F
3.4 Hot formability		Excellent
3.5 Cold formability		Limited
3.6 Cold reduction between anneals		40% max.
3.7 Machinability :		See General Data Sheet No. 2
Machinability rating (free-cutting brass = 100)		45
3.8 Joining methods :		See General Data Sheet No. 3.4
Soldering		Excellent
Brazing		Good
Oxy-acetylene welding		Good
Carbon-arc welding		Not recommended
Gas-shielded arc welding		Fair
Coated metal-arc welding		Not recommended
Resistance welding: spot and seam		Fair
butt		Good

5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE^(a)

5.1.1 Typical Tensile Properties and Hardness Values—Metric Units

This table is representative of practice in many European countries. For British and American practices, see tables 5.1.2 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper	Tensile Strength kg/mm ²	Proof Stress 0.2% offset kg/mm ²	Elongation		Hardness		Shear Strength kg/mm ²	Typical Size Related to Properties Shown ^(b)
				%	gauge length	Brinell	Vickers		
Plate Sheet Strip	Annealed	38	16	40	5.65√S ₀	85	89	29	—
	Hot Rolled	38	16	30	5.65√S ₀	85	89	29	30–80 mm thick
	Typical Cold Worked Tempers	45 52	32 45	25 8	5.65√S ₀ 5.65√S ₀	125 145	130 150	32 34	0.5–20 mm thick 0.5–5 mm thick
Rod	Annealed	38	16	40	5.65√S ₀	85	89	29	—
	Hot Worked	38	16	30	5.65√S ₀	85	89	29	10–80 mm diam. or equivalent area
	Typical Cold Worked Tempers	43 50	32 45	28 10	5.65√S ₀ 5.65√S ₀	120 135	125 140	30 33	6–40 mm diam. or equivalent area 6–12 mm diam. or equivalent area
Wire	Annealed	42	—	35	100 mm	—	—	32	1.5–6 mm diam.
	Typical Cold Drawn Tempers	48 60	— —	15 4	100 mm 100 mm	— —	— —	31 33	1.5–6 mm diam. "
Tube	Annealed	40	18	40	5.65√S ₀	85	89	30	—
	Typical Cold Drawn Tempers	45 50	33 40	20 8	5.65√S ₀ 5.65√S ₀	125 140	130 145	32 33	10–50 mm O.D. over 2 mm wall up to 25 mm O.D. up to 2 mm wall
Sections Shapes	Annealed	38	16	40	5.65√S ₀	85	89	29	—
	Hot Worked ^(c)	38	16	30	5.65√S ₀	85	89	29	—
Sections Shapes	Typical Cold Worked Temper ^(c)	42	25	28	5.65√S ₀	100	105	29	—
	Hot Worked ^(c)	38	16	30	5.65√S ₀	85	89	29	—

(a) It will be noted that tables 5.1.1, 5.1.2 and 5.1.3, giving typical tensile properties and hardness values in Metric, English and American units, respectively, are not directly comparable. This is because the properties quoted reflect to some extent the metalworking techniques, specification practices, and testing procedures in the countries concerned, and in view of the different sizes of products referred to in these tables. Individual manufacturers of semi-fabricated products can, however, normally meet the requirements of any national standard.

(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.

(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.1.2 Typical Tensile Properties and Hardness Values—English Units

This table is based on British practice. For other European and American practices, see tables 5.1.1 and 5.1.3, respectively.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper ^(a)	Tensile Strength ton/in ²	Proof Stress 0.1% offset ton/in ²	Elongation		Vickers Hardness	Shear Strength ton/in ²	Typical Size Related to Properties Shown ^(b)
				%	gauge length			
Rod	Annealed	23	8	45	$5.65\sqrt{S_o}$	90	17	—
	Hot Worked	24	9	40	$5.65\sqrt{S_o}$	100	18	0.5–2 in. diam. or equivalent area
	Cold Worked	25	10	40	$5.65\sqrt{S_o}$	110	19	1–2 in. diam. or equivalent area
	As Manufactured	27	14	35	$5.65\sqrt{S_o}$	125	20	0.375–1 in. diam. or equivalent area
		30	18	25	$5.65\sqrt{S_o}$	140	21	0.125–0.375 in. diam. or equivalent area
Sections (extruded)	Hot Worked ^(c)	24	9	40	$5.65\sqrt{S_o}$	100	18	—
	Cold Drawn As Manufactured ^(c)	26	12	35	$5.65\sqrt{S_o}$	120	19	—
Forgings	Hot Worked ^(c)	24	9	40	$5.65\sqrt{S_o}$	100	18	—

^(a) The recognised temper designations used in the relevant or nearest British Standards are also given, to clarify the cold-worked tempers shown.

^(b) It is possible to obtain sizes outside the ranges given in this column, but information on their mechanical properties should be obtained from the metal manufacturers.

^(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Elongation		Reduction of Area %	Impact Strength		
		°C	°F	kg/mm ²	ton/in ²	psi	%	gauge length		kg m/cm ²	ft lb	
Plate⁽¹⁾ 12.7—19 mm 0.5—0.75 in.	— ^(a)	20	68	29.5 ^(b)	18.6^(b)	41 500 ^(b)	14	2 in.	26.5	6.0 ^(c)	34.5^(c)	
		-50	-58	—	—	—	—	—	—	6.6 ^(c)	38^(c)	
		-100	-148	—	—	—	—	—	—	6.6 ^(c)	38^(c)	
		-120	-184	33.5 ^(b)	21.4^(b)	48 000 ^(b)	15	2 in.	27.0	—	—	
		-150	-238	35.5 ^(b)	22.5^(b)	50 500 ^(b)	15	2 in.	26.5	6.3 ^(c)	36.5^(c)	
		-196	-321	39 ^(b)	24.9^(b)	56 000 ^(b)	14	2 in.	24.5	6.7 ^(c)	39^(c)	
Rod⁽²⁾	Annealed	20	68	40.5	25.5	57 500	51.3	11.3√S _o	75.5	8.55^(d)	30.9 ^(d)	
		-78	-108	43.0	27.5	61 000	53.0	11.3√S _o	74.6	8.57^(d)	31.0 ^(d)	
		-183	-297	53.3	34	76 000	55.3	11.3√S _o	71.0	8.30^(d)	30.0 ^(d)	
	Cold Worked 17%	20	68	—	—	—	—	—	—	—	5.08^(d)	18.4 ^(d)
		-78	-108	—	—	—	—	—	—	—	5.29^(d)	19.1 ^(d)
		-183	-297	—	—	—	—	—	—	—	5.27^(d)	19.0 ^(d)
	Cold Worked 25%	20	68	56.0	35.5	79 500	19.8	11.3√S _o	65.5	—	—	
		-78	-108	58.3	37	83 000	21.0	11.3√S _o	67.7	—	—	
		-183	-297	69.2	44	98 500	24.4	11.3√S _o	64.1	—	—	
— ^{(3)(e)}	Annealed	20	68	36	23	51 000	51	5.65√S _o	—	—		
		-80	-112	38	24	54 000	53	5.65√S _o	—	—		
		-195	-319	47	30	67 000	55	5.65√S _o	—	—		
	Cold Worked ^(f)	20	68	50	31.5	71 000	20	5.65√S _o	—	—		
		-80	-112	52	32.5	72 500	21	5.65√S _o	—	—		
		-195	-319	61	38.5	87 000	24	5.65√S _o	—	—		

(a) Temper not stated in original document; probably annealed.

(b) Tipper notched tensile test; section of notch 19 × 15 mm (0.750 × 0.610 in.). (c) Charpy test; 10 × 10 × 100 mm specimen; 45° V-notch, 2 mm deep; cross-sectional area at the notch 0.8 cm². (d) Charpy test; 10 × 8 × 100 mm specimen; 45° V-notch, 3 mm deep; cross-sectional area at the notch 0.5 cm². (e) Form not stated in original document. (f) Quoted as "hard" in original document but amount of cold work not defined.

N.B.—Original values are printed in **bold type**; other values are converted.

—All converted values for impact strength are to be taken as indicative only; the impact energy has been converted from ft lb into kg m/cm² (and vice versa) taking into account the actual cross-sectional area of the specimen at the notch.

—Data not available:

Proof stress 0.1% and 0.2% offset,
Yield strength 0.5% extension under load.

5.2.2 Navy Tear Test

Form	Temper	Testing Temperature		Maximum Load			Corrected Energy Values						Reduction of Plate Thickness at Fracture		
		°C	°F	kg	ton	lb	initiation		propagation		total		mm	in.	%
							kg m	ft lb	kg m	ft lb	kg m	ft lb			
Plate⁽¹⁾ 12.7—19 mm 0.5—0.75 in.	— ^(a)	20	68	9 195	9.05	20 270	15.5	112	80.5	582	95.9	694	3.8	0.150	20.0
		-120	-184	10 975	10.8	24 190	30.1	218	94.7	685	124.8	903	4	0.160	21.5
		-196	-321	13 410	13.2	29 570	33.7	244	117.7	851	151.4	1 095	3.8	0.150	20.0

(a) Temper not stated in original document; probably annealed.

N.B.: Original values are printed in **bold type**; other values are converted.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress			Elongation		Impact Strength		
		°C	°F	kg/mm ²	ton/in ²	psi	0.2% offset kg/mm ²	0.1% offset ton/in ²	Yield Strength 0.5% extension under load psi	%	gauge length	kg m cm ²	ft lb	
Plate ⁽⁴⁾	Annealed	20	68	34	21.5	48 000	10.1 ^(a)	6.2	—	62	2 in.	—	—	
		66	150	34.5	21.8	49 000	10.1 ^(a)	6.2	—	65	2 in.	—	—	
		121	250	32	20.2	45 000	10.1 ^(a)	6.2	—	62	2 in.	—	—	
		177	350	30.5	19.4	43 500	10.5 ^(a)	6.5	—	63	2 in.	—	—	
		204	400	30	19.2	43 000	11.2 ^(a)	6.8	—	62	2 in.	—	—	
Rod ⁽⁵⁾ 3.2 mm diam. 0.125 in. diam.	Annealed	24	75	38.5	24.5	54 700	13.1 ^(b)	—	18 600	51.0	2 in.	—	—	
		149	300	—	—	—	12.9 ^(b)	—	18 500	—	—	—	—	
		204	400	—	—	—	12.9 ^(b)	—	18 500	—	—	—	—	
		260	500	—	—	—	12.4 ^(b)	—	17 900	—	—	—	—	
Rod ⁽²⁾	Annealed	19	66	—	—	—	—	—	—	—	—	8.55 ^(c)	30.9 ^(c)	
		20	68	40.5	25.5	57 500	—	—	—	51.3	11.3√S ₀	—	—	
		51	124	—	—	—	—	—	—	—	—	—	8.26 ^(c)	29.9 ^(c)
		55	131	39.7	25	56 500	—	—	—	51.0	11.3√S ₀	—	—	
		100	212	38.8	24.5	55 000	—	—	—	50.8	11.3√S ₀	7.56 ^(c)	27.3 ^(c)	
		151	304	—	—	—	—	—	—	—	—	—	6.94 ^(c)	25.0 ^(c)
		154	309	35.2	22.5	50 000	—	—	—	50.3	11.3√S ₀	—	—	
		200	392	—	—	—	—	—	—	—	—	—	6.27 ^(c)	22.7 ^(c)
		206	403	34.4	22	49 000	—	—	—	49.8	11.3√S ₀	—	—	
		250	482	31.5	20	45 000	—	—	—	48.7	11.3√S ₀	5.17 ^(c)	18.7 ^(c)	
		283	541	30.6	19.5	43 500	—	—	—	47.8	11.3√S ₀	—	—	
		300	572	—	—	—	—	—	—	—	—	2.38 ^(c)	8.6 ^(c)	
		327	621	—	—	—	—	—	—	—	—	—	2.13 ^(c)	7.7 ^(c)
		336	637	26.9	17	38 500	—	—	—	33.2	11.3√S ₀	—	—	
		351	664	—	—	—	—	—	—	—	—	—	1.08 ^(c)	3.9 ^(c)
		355	671	25.3	16	36 000	—	—	—	37.2	11.3√S ₀	—	—	
		400	752	21.2	13.5	30 000	—	—	—	41.6	11.3√S ₀	0.81 ^(c)	2.9 ^(c)	
		450	842	—	—	—	—	—	—	—	—	—	0.92 ^(c)	3.3 ^(c)
		454	849	16.7	10.5	23 500	—	—	—	34.7	11.3√S ₀	—	—	
		500	932	9.6	6	13 500	—	—	—	33.3	11.3√S ₀	—	—	
550	1022	—	—	—	—	—	—	—	—	—	0.77 ^(c)	2.8 ^(c)		
550	1022	—	—	—	—	—	—	—	—	—	1.14 ^(c)	4.1 ^(c)		
599	1110	—	—	—	—	—	—	—	—	—	1.37 ^(c)	5.0 ^(c)		
650	1202	—	—	—	—	—	—	—	—	—	7.18 ^{(c)(d)}	26.0 ^{(c)(d)}		
704	1299	—	—	—	—	—	—	—	—	—	4.82 ^{(c)(d)}	17.4 ^{(c)(d)}		
Rod ⁽²⁾	Cold Worked 17%	19	66	—	—	—	—	—	—	—	—	5.08 ^(c)	18.4 ^(c)	
		53	127	—	—	—	—	—	—	—	—	—	5.09 ^(c)	18.4 ^(c)
		100	212	—	—	—	—	—	—	—	—	—	4.85 ^(c)	17.7 ^(c)
		152	306	—	—	—	—	—	—	—	—	—	4.41 ^(c)	17.4 ^(c)
		201	394	—	—	—	—	—	—	—	—	—	4.11 ^(c)	14.9 ^(c)
		250	482	—	—	—	—	—	—	—	—	—	3.27 ^(c)	11.8 ^(c)
		301	574	—	—	—	—	—	—	—	—	—	2.06 ^(c)	7.5 ^(c)
		351	664	—	—	—	—	—	—	—	—	—	1.06 ^(c)	3.8 ^(c)
		400	752	—	—	—	—	—	—	—	—	—	0.96 ^(c)	3.5 ^(c)
		450	842	—	—	—	—	—	—	—	—	—	1.68 ^(c)	6.1 ^(c)
		500	932	—	—	—	—	—	—	—	—	—	1.59 ^(c)	5.8 ^(c)
		550	1022	—	—	—	—	—	—	—	—	—	2.07 ^(c)	7.5 ^(c)
		600	1112	—	—	—	—	—	—	—	—	—	2.84 ^(c)	10.3 ^(c)
650	1202	—	—	—	—	—	—	—	—	—	7.93 ^{(c)(d)}	28.7 ^{(c)(d)}		
700	1292	—	—	—	—	—	—	—	—	—	5.10 ^{(c)(d)}	18.4 ^{(c)(d)}		

continued on opposite page

5.3.1 Short-Time Tensile Properties—Impact Properties (continued)

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress			Elongation		Impact Strength	
		°C	°F	kg/mm ²	ton/in ²	psi	0.2% offset kg/mm ²	0.1% offset ton/in ²	Yield Strength 0.5% extension under load psi	%	gauge length	kg m cm ²	ft lb
Rod ^(a)	Cold Worked 25%	21	70	56.0	35.5	79 500	—	—	—	19.8	11.3√S _o	—	—
		50	122	54.2	34.5	77 000	—	—	—	19.6	11.3√S _o	—	—
		100	212	53.0	33.5	75 500	—	—	—	19.4	11.3√S _o	—	—
		156	313	49.3	31.5	70 000	—	—	—	19.2	11.3√S _o	—	—
		194	381	45.1	28.5	64 000	—	—	—	20.0	11.3√S _o	—	—
		253	487	43.2	27.5	61 500	—	—	—	19.6	11.3√S _o	—	—
		296	565	38.4	24.5	54 500	—	—	—	16.5	11.3√S _o	—	—
		325	617	36.7	23.5	52 000	—	—	—	14.2	11.3√S _o	—	—
		365	689	22.7	14.5	32 500	—	—	—	14.7	11.3√S _o	—	—
		396	745	20.7	13	29 500	—	—	—	23.4	11.3√S _o	—	—
		450	842	13.6	8.5	19 500	—	—	—	32.5	11.3√S _o	—	—
505	941	5.5	3.5	8 000	—	—	—	31.8	11.3√S _o	—	—		
Rod ^(b) 19 mm diam. 0.75 in. diam.	Hot Worked (grain size 0.020 mm)	24	75	39	24.5	55 350	—	—	—	51.0	2 in.	—	—
		204	400	33.5	21.5	45 750	—	—	—	50.5	2 in.	—	—
		316	600	17.5	11	25 150	—	—	—	40.0	2 in.	—	—
		427	800	6	4	8 700	—	—	—	18.0	2 in.	—	—
Tube ^(c)	Annealed	Room	Room	28	18	40 000	—	—	20 000	—	—	—	—
		66	150	28	18	40 000	—	—	20 000	—	—	—	—
		121	250	31.5	20	45 000	—	—	20 000	—	—	—	—
		149	300	30	19	43 000	—	—	20 000	—	—	—	—
		177	350	28	18	40 000	—	—	20 000	—	—	—	—
		204	400	26	16.5	37 000	—	—	20 000	—	—	—	—
		232	450	24	15	34 000	—	—	18 000	—	—	—	—

(a) This value was originally reported in ton/in²; in this table it is given in kg/mm² to 3 significant figures.

(b) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.

(c) Charpy test, 10 × 8 × 100 mm specimen, 45° V-notch, 3 mm deep; cross-sectional area at the notch 0.5 cm².

(d) Unbroken specimen.

N.B.—Original values are printed in **bold type**; other values are converted.

—All converted values for impact strength are to be taken as indicative only; the impact energy has been converted from kg m/cm² into ft lb taking into account the actual cross-sectional area of the specimen at the notch.

5.3.2 Creep Properties

5.3.2.1 Original Creep Data

Form	Temper	Testing Temperature		Stress			Duration h	Total Extension % ^(a)	Intercept %	Minimum Creep Rate % per 1000 h
		°C	°F	kg/mm ²	ton/in ²	psi				
Rod ⁽⁵⁾ 3.2 mm diam. 0.125 in. diam.	Annealed	149	300	3.5	2.2	5 000	6 430	0.053 5	0.009 5	0.001 1
				5.2	3.3	7 450	6 430	0.099	0.029	0.002 3
				7.0	4.4	10 000	6 430	0.158	0.039	0.006
				10.5	6.7	15 000	6 430	0.313	0.084	0.011 5
				14.0	8.9	19 900	6 430	3.580	1.265	0.20
		204	400	0.74	0.47	1 050	7 700	0.048	0.013 2	0.002 9
				1.4	0.92	2 050	7 700	0.090	0.025	0.005 8
				2.8	1.8	4 050	2 280	0.18	0.010	0.022
				4.3	2.7	6 100	7 680	1.975	0.053	0.246

^(a) Total extension = Initial extension + Total creep = Initial extension + Intercept + (Minimum creep rate × Duration).

N.B.: Original values are printed in **bold type**; other values are converted.

5.3.2.2 Stress for Designated Creep Data

Form	Temper	Testing Temperature		Stress for Designated Creep Rate								
		°C	°F	0.001% per 1 000 h			0.01% per 1 000 h			0.1% per 1 000 h		
				kg/mm ²	ton/in ²	psi	kg/mm ²	ton/in ²	psi	kg/mm ²	ton/in ²	psi
Rod ⁽⁵⁾ 3.2 mm diam. 0.125 in. diam.	Annealed	149	300	3.3	2.1	4 700	9.7	6.2	13 800	13.6	8.6	19 300
Rod ⁽⁶⁾ 19 mm diam. 0.75 in. diam.	Hot Rolled (alpha grain size 0.020 mm)	149	300	—	—	—	6.3	4.0	9 000	8.4	5.4	12 000
		204	400	—	—	—	1.4	0.89	2 000	3.3	2.1	4 750

N.B.: Original values are printed in **bold type**; other values are converted.

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

Form	Temper	Number of Cycles $\times 10^6$	Metric Units kg/mm ²		English Units ton/in ²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Rod⁽⁹⁾ 19 mm diam. 0.75 in. diam.	Annealed	50	42	15 ^(a)	26.5	9.5 ^(a)	59 500	21 500^(a)
	Cold Worked 25%	50	54.5	19.5 ^(a)	34.5	12.5 ^(a)	77 600	27 700^(a)
	Cold Worked 25% and Stress Relieved ^(e)	50	51.5	21.5 ^(a)	32.5	13.5 ^(a)	73 200	30 400^(a)
Rod⁽¹⁰⁾ 25.4 mm diam. 1 in. diam.	Hot Worked ^(b)	100	54	11 ^(a)	34	7 ^(a)	76 600	16 000^(a)
	Hot Worked ^(c)	100	55.5	13 ^(a)	35.5	8.5 ^(a)	79 200	18 500^(a)
	Hot Worked ^(d)	100	46	12.5 ^(a)	29.5	8 ^(a)	65 600	18 000^(a)

(a) Rotating-beam test. (b) Drawn at 249 °C (480 °F). (c) Drawn at 343 °C (650 °F). (d) Drawn at 450 °C (840 °F). (e) Stress relieved at 275 °C (527 °F).

N.B.—Original values are printed in **bold type**; other values are converted.

—Further data can be obtained from the following paper:

- Frost, N.E. and Greenan, A.F. Further Experiments on the Propagation of Edge Cracks in Plate Specimens. National Engineering Laboratory, East Kilbride, Glasgow: NEL Report No. 132 (1964), Feb.