

Cu Co2 Be

**Common names: Cobalt-Beryllium Copper
Low-Beryllium Copper
Cobalt-Beryllium Bronze**

A copper alloy containing cobalt and beryllium, with small amounts of nickel and/or iron, that can be strengthened by heat treatment. Material solution heat treated at high temperature has a soft supersaturated alpha-phase structure, and subsequent precipitation hardening at lower temperature precipitates a finely dispersed cobalt- and beryllium-rich phase in the matrix. In this condition, the alloy exhibits high strength and hardness, combined with good conductivity. Cold working, performed before precipitation hardening, can further improve strength and hardness. The improved properties are retained at moderately elevated temperatures. The most commonly used wrought forms are strip, rod and forgings.

COMPOSITION (weight %)

Co	2.0-2.8
Be	0.4-0.7
Ni+Fe	0.5 max.
Cu	rem.

1 SOME TYPICAL USES**Electrical**

Current-carrying springs, contacts and connectors; clips; circuit-breaker parts.

Mechanical

Resistance-welding electrodes and holders; nozzles for gas and oil burners; plunger tips for pressure die-casting machines; bushings and bearings; soldering iron tips.

2 PHYSICAL PROPERTIES

The "solution heat treated" and "precipitation hardened" conditions referred to in this section relate to material with or without cold work. When no specific condition is quoted, the value shown is applicable to material in all conditions of heat treatment and working.

	Metric Units	English Units
2.1 Density at 20 °C 68 °F (solution heat treated or precipitation hardened)	8.75 g/cm ³	0.315 lb/in ³
2.2 Melting range	1 000-1 075 °C	1 830-1 965 °F
2.3 Coefficient of thermal expansion (linear) at:		
—246 to 25 °C —410 to 78 °F	0.000 014 per °C	0.000 008 per °F
—76 to 25 °C —104 to 78 °F	0.000 015 " "	0.000 008 " "
20 to 100 °C 68 to 212 °F	0.000 018 " "	0.000 010 " "
20 to 200 °C 68 to 392 °F	0.000 018 " "	0.000 010 " "
20 to 300 °C 68 to 572 °F	0.000 019 " "	0.000 011 " "
2.4 Specific heat (thermal capacity) at:		
20 °C 68 °F	0.10 cal/g °C	0.10 Btu/lb °F
2.5 Thermal conductivity at:		
20 °C 68 °F (solution heat treated)	~0.30 cal cm/cm ² s °C	~73 Btu ft/ft ² h °F
20 °C 68 °F (precipitation hardened)	0.50-0.60 "	121-145 "
200 °C 392 °F (precipitation hardened)	0.52-0.62 "	127-152 "
2.6 Electrical conductivity (volume) at:		
20 °C 68 °F (solution heat treated)	~13 m/ohm mm ²	~22 % IACS
20 °C 68 °F (precipitation hardened)	26-30 "	45-52 " "
200 °C 392 °F (precipitation hardened)	17-21 "	30-37 " "
2.7 Electrical resistivity (volume) at:		
20 °C 68 °F (solution heat treated)	~0.078 ohm mm ² /m	~47 ohms (circ mil/ft)
	~7.8 microhm cm	~3.1 microhm in
20 °C 68 °F (precipitation hardened)	0.038-0.033 ohm mm ² /m	23-20 ohms (circ mil/ft)
	3.8-3.3 microhm cm	1.5-1.3 microhm in
200 °C 392 °F (precipitation hardened)	0.057-0.047 ohm mm ² /m	35-28 ohms (circ mil/ft)
	5.7-4.7 microhm cm	2.3-1.8 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C 68 °F (solution heat treated)	~0.000 9 per °C (22% IACS)	~0.0005 per °F (22% IACS)
applicable over range from 0 to 100 °C 32 to 212 °F		
20 °C 68 °F (precipitation hardened)	0.001 8 " " (45 " ")	0.001 0 " " (45 " ")
	0.002 0 " " (52 " ")	0.001 1 " " (52 " ")
applicable over range from 0 to 100 °C 32 to 212 °F		
2.9 Modulus of elasticity (tension) at 20 °C 68 °F:		
solution heat treated	12 000 kg/mm ²	17 100 000 lb/in ²
precipitation hardened	14 000 kg/mm ²	19 900 000 lb/in ²
2.10 Modulus of rigidity (torsion) at 20 °C 68 °F:		
solution heat treated	4 400 kg/mm ²	6 300 000 lb/in ²
precipitation hardened	5 200 kg/mm ²	7 400 000 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; the melting range covers the highest liquidus and lowest solidus temperatures over the composition range quoted.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 10); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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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.

For further information on heat treatment and the related properties of this alloy, see General Data Sheet No. 4.

		Metric Units	English Units
3.1	Casting temperature range ^(a)	1 120–1 200 °C	2 050–2 190 °F
3.2	Heat treatment conditions		
3.2.1	Solution heat treatment		
3.2.1.1	Temperature range	900– 960 °C	1 650–1 760 °F
3.2.1.2	Time at temperature		60–15 min.
3.2.1.3	Type of furnace		Muffle
3.2.1.4	Cooling		Water quench
3.2.2	Interstage annealing temperature range	750– 825 °C	1 380–1 515 °F
3.2.3	Precipitation hardening		
3.2.3.1	Temperature range	450– 490 °C	840– 915 °F
3.2.3.2	Time at temperature		3 – 1 h
3.2.3.3	Type of furnace		Muffle or salt bath
3.2.3.4	Cooling		Air
3.3	Hot working temperature range	700– 900 °C	1 290–1 650 °F
3.4	Hot formability		Good
3.5	Cold formability		
	Solution heat treated		Good
	Precipitation hardened		Fair
3.6	Cold reduction		
	Solution heat treated		50% max.
	Precipitation hardened		30% max.
3.7	Machinability:		See General Data Sheet No. 2
	Machinability rating (free-cutting brass = 100)		
	Solution heat treated and cold worked		30%
	Precipitation hardened		30%
3.8	Joining methods: ^(a) ^(b)		See General Data Sheet No. 3.3
	Soldering		Good
	Brazing		Good
	Oxy-acetylene welding		Not recommended
	Carbon-arc welding		Not recommended
	Gas-shielded arc welding		Fair
	Coated metal-arc welding		Fair
	Resistance welding: spot		Good
	seam		Fair
	butt		Fair

^(a) Adequate fume extraction must be ensured during melting, casting, and welding to avoid risk of toxicity from beryllium oxide.

^(b) These processes, involving the application of heat, are generally restricted to solution-heat-treated material, but soldering must be carried out after precipitation hardening to avoid melting of the joint.

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

and ISO Recommendation

Country	Designation of Standards	Designation of Material in Standards	Specification for Chemical Composition (a)	Plate Sheet Strip	Rod	Wire	Tube	Sections / Shapes	Forgings
Australia	SAA	—	—	—	—	—	—	—	—
Belgium	NBN	—	—	—	—	—	—	—	—
Canada	CSA	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	Cu Co2 Be Ni	252 of. 68	—	—	—	259 of. 70	—	—
France	NF	—	—	—	—	—	—	—	—
Germany	DIN	CuCoBe	17 666	17 670	17 672	17 677	—	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	—	—	—	—	—	—	—	—
Netherlands	N or NEN (b)	—	—	—	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	A3/1	—	—	4577	—	—	—	4577
United States (c)	ASTM	No. 175	—	B 441 B 534	B 441	—	—	—	—
International Organisation for Standardization	ISO	Cu Co2 Be	R 1187	—	—	—	—	—	—

(a) Applicable when the chemical composition is not given in the specifications for wrought forms.

(b) Older specifications bear prefix N; for new specifications the NEN prefix is used

(c) In the United States, bar is covered under the Plate-Sheet-Strip column

5 MECHANICAL PROPERTIES

5.1 Mechanical properties at room temperature

Tensile properties	see tables 5.1.1/2/3.1/3.2
Hardness	„ „ 5.1.1/2/3.1/3.2
Shear strength	„ „ 5.1.1/2/3.1/3.2
Modulus of elasticity (tension)	see 2.9
Modulus of rigidity (torsion)	„ 2.10

5.2 Mechanical properties at low temperature

Tensile properties	see tables 5.2.1.1/2
Impact properties	„ „ 5.2.1.2

5.3 Mechanical properties at elevated temperature

Short-time tensile properties	see table 5.3.1
Creep properties	„ „ 5.3.2.2

5.4 Fatigue properties

Fatigue strength at room temperature	see tables 5.4.1.1/2
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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.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4.

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 Strip	Solution Heat Treated	31	12	25	11.3√S ₀	56	60	22	—
	Solution Heat Treated and Cold Worked to Typical Tempers	36	28	5	11.3√S ₀	105	110	25	0.2–3 mm thick 0.2–1 mm thick
		45	40	4	50 mm	135	140	29	
	Precipitation Hardened after Solution Heat Treatment	63	58	3	11.3√S ₀	180	190	33	0.2–5 mm thick
Precipitation Hardened after Cold Working to Typical Tempers	68	59	12	11.3√S ₀	190	200	30	0.2–5 mm thick 0.2–3 mm thick 0.2–1 mm thick	
	72	60	10	50 mm	200	210	35		
	80	70	3	50 mm	220	230	44		
Rod ^(c)	Solution Heat Treated	31	12	25	11.3√S ₀	56	60	22	—
	Solution Heat Treated and Cold Worked to Typical Tempers	37	28	5	11.3√S ₀	105	110	25	25–50 mm diam. or equivalent area up to 25 mm diam. or equivalent area
		54	48	3	11.3√S ₀	145	150	35	
	Precipitation Hardened after Solution Heat Treatment	65	58	3	11.3√S ₀	185	195	34	50–120 mm diam. or equivalent area 2–50 mm diam. or equivalent area
67		55	16	5.65√S ₀	190	200	35		
Precipitation Hardened after Cold Working to Typical Tempers	70	60	14	5.65√S ₀	190	200	31	25–50 mm diam. or equivalent area	
	80	70	10	5.65√S ₀	220	230	44		
Wire	Solution Heat Treated	32	15	25	100 mm	—	—	22	—
	Solution Heat Treated and Cold Drawn to Typical Tempers	38	28	10	100 mm	—	—	26	0.2–3 mm diam. "
		55	45	1	100 mm	—	—	36	
	Precipitation Hardened after Solution Heat Treatment	65	53	15	100 mm	—	—	34	0.2–10 mm diam.
Precipitation Hardened after Cold Drawing to Typical Tempers	70	60	12	100 mm	—	—	31	0.2–5 mm diam. " 0.2–3 mm diam. "	
	75	65	10	100 mm	—	—	42		
	85	76	7	100 mm	—	—	44		
	90	80	6	100 mm	—	—	50		
Forgings ^(c)	Precipitation Hardened after Solution Heat Treatment	75	60	15	5.85√S ₀	210	220	43	—

(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, SI and 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—SI and 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.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4.

Form	Temper	Tensile Strength		Proof Stress 0.1% Offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown ^(b)
		hbar	ton/in ²	hbar	ton/in ²	%	gauge length		hbar	ton/in ²	
Strip	Solution Heat Treated	32	21	15	10	25	50 mm (2 in.)	85	22	14	0.15–4 mm (0.006–0.16 in.) thick
	Solution Heat Treated and Cold Worked to Typical Tempers	48	31	39	25	10	50 mm (2 in.)	125	32	21	0.15–3 mm (0.006–0.12 in.) thick
		54	35	46	30	8	50 mm (2 in.)	140	36	23	0.15–1 mm (0.006–0.04 in.) thick
	Precipitation Hardened after Solution Heat Treatment	70	45	59	38	10	50 mm (2 in.)	210	37	24	0.15–4 mm (0.006–0.16 in.) thick
	Precipitation Hardened after Cold Working to Typical Tempers ^(a)	76	49	65	42	10	50 mm (2 in.)	225	36	23	0.15–3 mm (0.006–0.12 in.) thick
82		53	70	45	8	50 mm (2 in.)	240	37	24	0.15–1 mm (0.006–0.04 in.) thick	
Rod ^(c)	Solution Heat Treated	32	21	15	10	20	$5.65\sqrt{S_0}$	85	22	14	6–25 mm (0.25–1 in.) diam. or equivalent area
	Solution Heat Treated and Cold Drawn to Typical Temper	48	31	39	25	10	$5.65\sqrt{S_0}$	125	32	21	6–25 mm (0.25–1 in.) diam. or equivalent area
	Precipitation Hardened after Solution Heat Treatment	70	45	59	38	10	$5.65\sqrt{S_0}$	210	37	24	6–25 mm (0.25–1 in.) diam. or equivalent area
	Precipitation Hardened after Cold Drawing to Typical Temper ^(a)	77	50	68	44	8	$5.65\sqrt{S_0}$	230	36	23	6–25 mm (0.25–1 in.) diam. or equivalent area
Wire	Solution Heat Treated	32	21	—	—	20	100 mm (4 in.)	—	22	14	0.5–3 mm (0.02–0.125 in.) diam.
	Solution Heat Treated and Cold Drawn to Typical Temper	54	35	—	—	5	100 mm (4 in.)	—	36	23	0.5–3 mm (0.02–0.125 in.) diam.
	Precipitation Hardened after Solution Heat Treatment	70	45	—	—	7	100 mm (4 in.)	—	37	24	0.5–3 mm (0.02–0.125 in.) diam.
	Precipitation Hardened after Cold Drawing to Typical Temper ^(a)	85	55	—	—	5	100 mm (4 in.)	—	37	24	0.5–3 mm (0.02–0.125 in.) diam.
Forgings ^(c)	Solution Heat Treated	32	21	15	10	20	$5.65\sqrt{S_0}$	85	22	14	—
	Precipitation Hardened after Solution Heat Treatment	70	45	59	38	10	$5.65\sqrt{S_0}$	210	39	25	—
	Precipitation Hardened after Cold Working ^(a)	77	50	68	44	8	$5.65\sqrt{S_0}$	230	36	23	—

(a) Solution heat treated, cold worked and finally precipitation hardened.

(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.

5.1.3 Typical Tensile Properties and Hardness Values—American Units

This table is based on American practice and the temper designations shown are those referred to in ASTM and other American Standards. For British and other European countries' practices, see tables 5.1.2 and 5.1.1, 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.

The mechanical properties of this alloy are largely dependent upon heat treatment conditions. For further information, see General Data Sheet No. 4.

5.1.3.1 Solution-Heat-Treated Material

Form	Temper	Tensile Strength psi	Yield Strength 0.2% offset psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown ^(a)
				%	gauge length	F	B	30 T		
Flat Products (Plate, Strip, Bar and Flat Wire)	Solution Heat Treated	45 000 43 000	25 000 22 000	25 30	2 in. 2 in.	77 74	35 30	40 36	32 000 31 000	0.032 in. thick 0.250 in. thick
	Solution Heat Treated and Cold Worked									
	Half Hard Hard	68 000 78 000	60 000 70 000	7 5	2 in. 2 in.	97 —	70 83	64 72	49 000 58 000	0.032 in. thick "
	Half Hard Hard	65 000 75 000	56 000 67 000	10 5	2 in. 2 in.	96 —	68 80	62 70	48 000 55 000	0.250 in. thick "
Rod ^(b)	Solution Heat Treated	43 000	24 000	30	2 in.	74	30	36	31 000	0.250 in. diam.
	Solution Heat Treated and Cold Worked									
	Half Hard Hard	65 000 80 000	57 000 75 000	15 10	2 in. 2 in.	91 —	60 80	56 70	48 000 59 000	0.250 in. diam. "
Wire	Solution Heat Treated	48 000	27 000	25	10 in.	—	—	—	34 000	0.080 in. diam.
	Solution Heat Treated and Cold Worked									
	Half Hard Three Quarter Hard	70 000 78 000	63 000 71 000	10 8	10 in. 10 in.	— —	— —	— —	51 000 58 000	0.080 in. diam. "

5.1.3.2 Precipitation-Hardened Material

Form	Temper	Tensile Strength psi	Yield Strength 0.2% offset psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown ^(a)
				%	gauge length	F	B	30 T		
Flat Products (Plate, Strip, Bar and Flat Wire)	Precipitation Hardened	110 000 100 000	90 000 80 000	10 12	2 in. 2 in.	— —	96 92	80 78	78 000 73 000	0.032 in. thick 0.250 in. thick
	Precipitation Hardened after Cold Working									
	Half Hard Hard	115 000 120 000	100 000 105 000	10 8	2 in. 2 in.	— —	100 100	82 82	82 000 88 000	0.032 in. thick "
	Half Hard Hard	113 000 118 000	97 000 102 000	12 10	2 in. 2 in.	— —	98 98	81 81	80 000 86 000	0.250 in. thick "
Rod ^(b)	Precipitation Hardened	100 000	85 000	17	2 in.	—	92	78	73 000	0.250 in. diam.
	Precipitation Hardened after Cold Working									
	Half Hard Hard	115 000 120 000	105 000 110 000	15 12	2 in. 2 in.	— —	98 98	81 81	82 000 88 000	0.250 in. diam. "
Wire	Precipitation Hardened	100 000	80 000	8	10 in.	—	—	—	73 000	0.080 in. diam.
	Precipitation Hardened after Cold Working									
	Three Quarter Hard Hard Drawn	120 000 130 000	110 000 125 000	5 2	10 in. 10 in.	— —	— —	— —	88 000 99 000	0.080 in. diam. "

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

^(b) 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

5.2.1.1. Solution-Heat-Treated Material

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm ²	Elongation % on 2 in.
		°C	°F	kg/mm ²	ton/in ²	psi		
Sheet ⁽¹⁾ 3 mm 0.125 in.	Solution Heat Treated and Cold Worked 12%	27	80	42	27	60 000	35.9 ^(a)	10
		−78	−108	47	30	67 000	40.8 ^(a)	19
		−197	−323	57.5	36.5	82 000	45.0 ^(a)	32
		−253	−424	67	42.5	95 000	49.2 ^(a)	49

5.2.1.2 Precipitation-Hardened Material

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm ²	Elongation % on 1 in.	Reduction of Area %	Impact Strength	
		°C	°F	kg/mm ²	ton/in ²	psi				kg m/cm ²	ft lb
Rod ⁽²⁾ 19 mm diam. 0.75 in. diam.	Precipitation Hardened ^(c)	−61	78	93.5	59.5	133 000	81.6 ^(a)	15.0	30.0	—	—
		−61	78	77.5	49	110 000	71.0 ^(a)	15.0	37.5	—	—
		−76	−104	76.5	48.5	109 100	70.9 ^(a)	17.0	44.0	—	—
		−76	−104	84	53.5	119 500	77.7 ^(a)	18.0	43.5	—	—
		−196	−320	92	58.5	131 000	80.1 ^(a)	21.0	48.0	—	—
		−196	−320	111	70.5	158 000	97.7 ^(a)	21.0	41.0	—	—
		−253	−423	123.5	78.5	176 000	99.8 ^{(a)(d)}	25.0	41.0	—	—
		−253	−423	122.5	78	174 500	103 ^{(a)(d)}	24.0	42.5	—	—
Rod ⁽³⁾ 14 mm diam. 0.560 in. diam.	Precipitation Hardened after Cold Working	27	80	87	55	123 600	75.2 ^(a)	13	24	3.0 ^(b)	11 ^(b)
		−59	−75	89.5	56.5	127 000	75.9 ^(a)	14	24	3.2 ^(b)	11.5 ^(b)
		−129	−200	91.5	58	130 500	80.8 ^(a)	15	23	3.3 ^(b)	12 ^(b)
		−184	−300	96.5	61	137 000	78.7 ^(a)	15	22	3.6 ^(b)	13 ^(b)

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

(b) Charpy Keyhole-notch specimen; cross-sectional area at the notch 0.5 cm².

(c) 8 h at 850 °F (454 °C) and air cooled.

(d) Quoted as "yield point" in original document, but offset strain 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 taking into account the actual cross-sectional area of the specimen at the notch.

—The 0.1% offset proof stress and the yield strength 0.5% ext. under load values are not available.

—Further data can be obtained from the following paper:

■ Brechna, H. Materials in Electromagnets and Their Properties. Proc. 2nd Internat. Conf. on Magnet Technology, Oxford, England, (1967). Rutherford Lab. (1967), pp. 305-329. (Table 4 includes tensile data at temperatures down to 4.2 K for precipitation-hardened alloy containing 0.55% Be).

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm ²	Elongation	
		°C	°F	kg/mm ²	ton/in ²	psi		%	gauge length
Strip ⁽⁵⁾ 0.5 mm 0.020 in.	Precipitation Hardened	20	68	74.5	47.5	106 000	57.6 ^(a)	18	2 in.
		93	200	73	46.5	104 000	54.1 ^(a)	17	2 in.
		149	300	70.5	44.5	100 000	50.6 ^(a)	16	2 in.
		204	400	62	39.5	88 000	47.1 ^(a)	13	2 in.
		260	500	50.5	32	72 000	40.8 ^(a)	9	2 in.
		316	600	41	26	58 000	35.9 ^(a)	3	2 in.
		371	700	35	22.5	50 000	30.9 ^(a)	2	2 in.
		427	800	33	21	47 000	26.0 ^(a)	2	2 in.
		482	900	29	18.5	41 000	21.8 ^(a)	3	2 in.
		538	1 000	24.5	15.5	35 000	19.7 ^(a)	3	2 in.
		593	1 100	18.5	11.5	26 000	15.5 ^(a)	4	2 in.
		649	1 200	13.5	8.5	19 000	12.0 ^(a)	11	2 in.
Rod ⁽⁴⁾ 8 mm diam. 0.32 in. diam.	Precipitation Hardened ^(b)	20	68	87	55	123 500	72	9	11.3√S ₀
		100	212	83	52.5	118 000	65	10	11.3√S ₀
		200	392	80	51	114 000	66	7	11.3√S ₀
		300	572	77	49	109 500	69	3	11.3√S ₀
		400	752	71	45	101 000	61	2	11.3√S ₀
		500	932	60	38	85 500	55	1	11.3√S ₀
		600	1 112	41	26	58 500	40	1	11.3√S ₀
		700	1 292	19	12	27 000	18	9	11.3√S ₀
		800	1 472	6	4	8 500	4	33	11.3√S ₀
		900	1 652	2	1.5	3 000	1	37	11.3√S ₀
950	1 742	1	0.5	1 500	0	22	11.3√S ₀		
Rod ⁽⁶⁾ 76 mm diam. 3 in. diam.	Precipitation Hardened	20	68	77	49	109 600	56.9 ^(a)	22	2 in.
		93	200	73	46.5	104 000	56.2 ^(a)	17	2 in.
		149	300	73	46.5	104 000	56.2 ^(a)	20	2 in.
		204	400	68	43.5	97 000	55.5 ^(a)	10	2 in.
		260	500	62	39.5	88 000	56.2 ^(a)	—	—
Rod ⁽⁷⁾	Precipitation Hardened	20	68	73	46.5	104 000	61.9 ^(a)	18	2 in.
		93	200	72.5	46	103 000	60.5 ^(a)	13	2 in.
		149	300	71	45	101 000	58.3 ^(a)	9	2 in.
		204	400	68	43.5	97 000	56.9 ^(a)	6	2 in.
		260	500	64.5	41	92 000	54.1 ^(a)	3	2 in.
		316	600	59	37.5	84 000	51.3 ^(a)	2	2 in.
		371	700	50.5	32	72 000	47.5 ^(a)	1	2 in.
		427	800	43.5	27.5	62 000	40.1 ^(a)	1	2 in.
		482	900	36.5	23	52 000	33.7 ^(a)	1	2 in.
		538	1 000	29.5	18.5	42 000	26.7 ^(a)	1	2 in.
		593	1 100	24.5	15.5	35 000	23.2 ^(a)	2	2 in.
		649	1 200	19.5	12.5	28 000	18.3 ^(a)	6	2 in.

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

(b) Precipitation hardened to maximum hardness.

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

—Data on short-time tensile properties at elevated temperatures are available only for precipitation hardened material.

—Data not available

Proof Stress, 0.1% offset,
Yield strength, 0.5% extension under load.

5.3.2 Creep Properties

5.3.2.1 Original Creep Data

At the date of publication of this sheet, no data relating to this material have been traced. The following paper includes creep data for a copper—0.37% beryllium alloy:-

- McLean, D. and Farmer, M. H. The Relation During Creep Between Grain-Boundary Sliding, Sub-Crystal Size, and Extension. J. Inst. Metals, Vol. 85 (1956-57), pp. 41-50.

5.3.2.2 Stress for Rupture

Form	Temper	Testing Temperature		Stress for Rupture in Time Indicated					
				10 h			100 h		
		°C	°F	kg/mm ²	ton/in ²	psi	kg/mm ²	ton/in ²	psi
—(7) (a)	Precipitation Hardened	149	300	91.4	58.0	130 000	89.3	56.7	127 000
		204	400	85.8	54.5	122 000	77.3	49.1	110 000
		260	500	77.3	49.1	110 000	61.9	39.3	88 000
		316	600	56.2	35.7	80 000	45.0	28.6	64 000
		371	700	38.7	24.6	55 000	31.6	20.1	45 000
		427	800	29.5	18.7	42 000	21.1	13.4	30 000
		482	900	20.4	12.9	29 000	13.4	8.5	19 000
		538	1 000	12.7	8.0	18 000	7.7	4.9	11 000

(a) Form not stated in original document.

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

- Data on stress-rupture properties are available only for precipitation-hardened material.
- Data not available.

Stress for rupture in 1 000 h.

- Further data can be obtained from the following paper:

■Parker, E. R. and Ferguson, C. Rupture Tests at 200 Degrees Cent. on Some Copper Alloys. Trans. ASM, Vol. 31 (1943), pp. 699-715 (stress-rupture data at 200° and 350°C for alloy containing 2.59% Co, 0.46% Be; 0.048 in. diam. wire, precipitation hardened for 4 h at 500 °C after cold working 40%).

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

5.4.1.1 Solution-Heat-Treated Material

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
Strip ⁽⁸⁾	Solution Heat Treated and Cold Worked	100	52.5	21 ^(a)	33.5	13.5 ^(a)	75 000	30 000 ^(a)

5.4.1.2 Precipitation-Hardened Material

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
Strip ⁽⁹⁾ 1 mm diam. 0.040 in. diam.	Precipitation Hardened	100	77.5	21 ^(a)	49	13.5 ^(a)	110 000	30 000 ^(a)
	Precipitation Hardened after Cold Working 37%	100	84.5	24.5 ^(a)	53.5	15.5 ^(a)	120 000	35 000 ^(a)
Rod ⁽⁸⁾	Precipitation Hardened ^(c)	100	81	21 ^(b)	51.5	13.5 ^(b)	115 000	30 000 ^(b)
	Precipitation Hardened after Cold Working ^(c)	100	91.5	24.5 ^(b)	58	15.5 ^(b)	130 000	35 000 ^(b)
Wire ⁽⁴⁾	Precipitation Hardened	100	75	22 ^(d)	47.5	14 ^(d)	106 500	31 500 ^(d)

(a) Reversed bending test.

(b) Rotating beam test.

(c) 2-3 h at 900 °F (482 °C).

(d) Bending fatigue test.

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

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MECHANICAL PROPERTIES (SECTION 5)

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- (3) Richards, J. T. and Brick, R. M. Mechanical Properties of Beryllium Copper at Subzero Temperatures. Trans. AIME (Inst. Met. Divn.), Vol. 200 (1954), pp. 574-580.
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- (9) Bulow, C. L. Which Alloy and Which Temper for Current-Carrying Springs. Prod. Engng., Vol. 34 (1963), No. 1, pp. 60-67.