Cu Sn10

Common names: 10% Phosphor Bronze
Phosphor Bronze, 10% D

A copper-tin alloy with a duplex alpha-plus-delta phase structure. The high tin content and the phosphorus addition impart to the alloy excellent wear resistance, fatigue strength and bearing properties. The alloy exhibits the highest strength and hardness in the copper-tin series. The most commonly used wrought forms are strip and wire.

COMPOSITION (weight %)

Sn	9.0 –11.0
P	0.02– 0.40
Cu	rem.

1 SOME TYPICAL USES

Chemical
Components for the papermaking industry.

Mechanical
Heavy-duty springs and washers; bridge bearing plates.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.80 g/cm³	0.320 lb/in³
2.2 Melting range [a]	830–1 020 °C	1 525–1 870 °F
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C *68 to 212 °F*	0.000 017 per °C	0.000 009 per °F
20 to 300 °C *68 to 572 °F*	0.000 018 ,, ,,	0.000 010 ,, ,,
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:		
20 °C *68 °F*	0.10–0.12 cal cm/cm² s °C	24–29 Btu ft/ft² h °F
2.6 Electrical conductivity (volume) at:		
20 °C *68 °F* (annealed)	5.8–7.0 m/ohm mm²	10–12% IACS
2.7 Electrical resistivity (volume) at:		
20 °C *68 °F* (annealed)	0.17–0.14 ohm mm²/m 17–14 microhm cm	100–86 ohms (circ mil/ft) 6.8–5.7 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C *68 °F* (annealed) applicable over range from 0 to 100 °C *32 to 212 °F*	0.000 6 per °C (10–12% IACS)	0.000 3 per °F (10–12% IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*		
annealed	11 000 kg/mm²	15 600 000 lb/in²
cold worked [b]	8 400–10 000 kg/mm²	11 900 000–14 200 000 lb/in²
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F*:		
annealed	4 100 kg/mm²	5 800 000 lb/in²
cold worked [b]	3 100–3 700 kg/mm²	4 400 000–5 300 000 lb/in²

(a) For high phosphorus contents, the temperatures, especially at the bottom of the range, will be lower.

(b) The modulus values progressively decrease, within the ranges shown, as the amount of cold work increases.

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 8); 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.

	Metric Units	English Units
3.1 Casting temperature range	1 060–1 130 °C	1 940–2 065 °F
3.2 Annealing temperature range	500– 725 °C	930–1 335 °F
Stress relieving temperature range	200– 350 °C	390–660 °F
3.3 Hot working temperature range	—	—
3.4 Hot formability	Very limited (Not recommended)	
3.5 Cold formability	Fair	
3.6 Cold reduction between anneals	40% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	20	
3.8 Joining methods:	See General Data Sheet No. 3.7	
Soldering	Excellent	
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 and seam	Good	
butt	Excellent	

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	HC. TJ100 524	—	HC.4.5	HC.5.5	HC.5.23	—	HC.5.5	—
Chile	INDITECNOR	Cu Sn10 P	NCh248.of.68	—	—	—	—	—	—
France	NF	U-E9 P	—	A53-607	—	—	—	—	—
Germany	DIN	—	—	—	—	—	—	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	—	—	—	—	—	—	—	—
Netherlands	N or NEN[b]	Cu-Sn9	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Sn10	—	37 103	—	37 103	—	—	—
Sweden	SIS	54 31	—	14 54 31	14 54 31	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	—	—	—	—	—	—	—	—
United States[c]	ASTM	No. 524	—	B 103 B 139	B 139	B 159	—	B 139	—
International Organization for Standardization	ISO	Cu Sn10	R 427	—	—	—	—	—	—

(a) Applicable when the chemical composition is not given in the specification for wrought forms.
(b) Older specifications bear prefix N; for new specifications the NEN prefix is used.
(c) In the United States, bar and flat wire are covered under the Plate-Sheet-Strip column.

5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE [*]

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/mm²	Proof Stress 0.2% offset kg/mm²	Elongation		Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [a]
				%	gauge length	Brinell	Vickers		
Sheet Strip	Annealed	44	19	65	50 mm	95	100	33	0.2–3 mm thick
	Typical Cold Worked Tempers	70 83 88	64 80 85	17 3 —	50 mm 50 mm —	195 235 245	205 245 255	44 48 48	0.5–3 mm thick up to 1 mm thick up to 0.5 mm thick
Wire	Annealed	46	—	60	100 mm	—	—	34	0.2–1 mm diam.
	Typical Cold Drawn Temper	100	—	—	—	—	—	49	up to 1 mm diam.

(a) 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.

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.

Form	Temper [a]	Tensile Strength		Proof Stress 0.1% offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown [b]
		hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Strip	Annealed (grain size∼0.03 mm)	43	28	17	11	70	50 mm (2 in.)	100	32	21	0.2–3 mm (0.008–0.125 in.) thick
	Cold Worked Extra Spring Hard	87	56	74	48	4	50 mm (2 in.)	250	48	31	0.2–0.5 mm (0.008–0.02 in.) thick

(a) The recognised temper designations used in the nearest British Standards are also given.

(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.

(*) 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.

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.

Form	Temper	Tensile Strength psi	Yield Strength 0.5% extension under load psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown [a]
				%	gauge length	F	B	30 T		
Flat Products (Plate, Sheet, Strip and Bar)	Annealed (grain size 0.025 mm)	65 000	28 000	68	2 in.	84	—	—	48 000	0.040 in. thick
	Cold Worked									
	Half Hard	83 000	60 000	34	2 in.	—	91	74	57 000	0.040 in. thick
	Hard	100 000	79 000	12	2 in.	—	96	80	64 000	"
	Spring	121 000	93 000	4	2 in.	—	101	83	68 000	"
	Extra Spring	128 000	—	3	2 in.	—	103	84	70 000	"
Wire	Annealed	66 000	—	—	—	—	—	—	48 000	0.080 in. diam.
	Cold Worked									
	Quarter Hard	93 000	—	—	—	—	—	—	61 000	0.080 in. diam.
	Half Hard	118 000	—	—	—	—	—	—	67 000	"
	Hard	146 000	—	—	—	—	—	—	70 000	"

(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.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Impact Properties

Form	Temper	Testing Temperature		Impact Strength	
		°C	°F	kg m/cm²	ft lb
Rod (1) (a)	Cold Worked 37%	23 —78 —196 —246	73 —108 —321 —411	8.3 (b) 4.8 (b) 3.1 (b) 3.5 (b)	**48** (b) **28** (b) **18** (b) **20** (b)

(a) Form not reported in original document, but probably rod.

(b) Standard Charpy specimen, V-notch; cross-sectional area at the notch 0.8 cm².

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.

— Data not available: Tensile strength,
Proof stress, 0.2% and 0.1% offset,
Yield strength, 0.5% extension under load,
Elongation,
Reduction of area.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Elongation % on 2 in.
		°C	°F	kg/mm²	ton/in²	psi	
Rod (3) (a)	Annealed (b)	25 75 125 175 225 275 325	77 167 257 347 437 527 617	41.5 42 43 42 — 27.5 22.5	26.5 27 27 27 — 17.5 14.5	**59 000** **60 000** **61 000** **60 000** — **39 000** **32 000**	**64** **68** **70** **68** **36** **17** **10**
Rod (2)	Cold Worked (c)	27 149 260 371	80 300 500 700	74 71.5 64.5 33.5	47 45.5 41 21.5	**105 000** **102 000** **92 000** **48 000**	**18.0** **18.0** **10.0** **22.0**
Wire (4) 6.35 mm diam. 0.25 in. diam.	Cold Worked (c)	16 100 125 150 185 200 225 250 300 350 400 500 600	61 212 257 302 365 392 437 482 572 662 752 932 1 112	69.5 68.5 69 68 68 68 67.5 66 61.5 53.5 45 17 8	**44.21** **43.35** **43.93** **43.30** **43.21** **43.21** **42.98** **41.94** **38.96** **33.86** **28.71** **10.73** **5.14**	99 000 97 000 98 500 97 000 97 000 97 000 96 500 94 000 87 500 76 000 64 500 24 000 11 500	**22** **14.5** **17** **20** **19** **18** **20** **18** **12** **7** **6.5** **73** **52**

(a) Form not reported in original document, but probably rod.

(b) Temper not reported in original document but probably annealed.

(c) Amount of cold work not defined in original document.

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

— Data not available: Proof stress, 0.2% and 0.1% offset.
Yield Strength, 0.5% extension under load.

— Further data can be obtained from the following papers:-

- Köster, W. and Speidel, M. O. Der Einfluss der Temperatur und der Korngrösse auf die ausgeprägte Streckgrenze von Kupferlegierungen. Z. Metallkunde, vol. 56 (1965), pp. 585–598.
- Crowe, C. H. Properties of Some Copper Alloys at Elevated Temperatures. ASTM Bulletin, No. 250, December, (1960), pp. 30–31.

5.3.2 Creep Properties

At the date of publication of this sheet no data relating to this material have been traced.

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

Form	Temper	Number of Cycles $\times 10^6$	Metric Units kg/mm² Tensile Strength	Metric Units kg/mm² Fatigue Strength	English Units ton/in² Tensile Strength	English Units ton/in² Fatigue Strength	American Units psi Tensile Strength	American Units psi Fatigue Strength
Strip (5) 1 mm 0.04 in.	Annealed (grain size 0.035 mm)	100	44.5	17.5 (a)	28	11 (a)	**63 000**	**25 000** (a)
	Annealed (grain size 0.015 mm)	100	48.5	22.5 (a)	31	14.5 (a)	**69 000**	**32 000** (a)
	Cold Worked 21 % (b)	100	57.5	20.5 (a)	36.5	13 (a)	**82 000**	**29 000** (a)
	Cold Worked 21 % (c)	100	60	22.5 (a)	38	14.5 (a)	**85 000**	**32 000** (a)
	Cold Worked 37 % (b)	100	69.5	22 (a)	44	14 (a)	**99 000**	**31 000** (a)
	Cold Worked 37 % (c)	100	71	22 (a)	45	14 (a)	**101 000**	**31 000** (a)
	Cold Worked 50 % (b)	100	75	20.5 (a)	48	13 (a)	**107 000**	**29 000** (a)
	Cold Worked 50 % (c)	100	77.5	21 (a)	49	13.5 (a)	**110 000**	**30 000** (a)
	Cold Worked 60.5 % (b)	100	81	21 (a)	51.5	13.5 (a)	**115 000**	**30 000** (a)
	Cold Worked 60.5 % (c)	100	82.5	21 (a)	52	13.5 (a)	**117 000**	**30 000** (a)
	Cold Worked 69 % (b)	100	85	20.5 (a)	54	13 (a)	**121 000**	**29 000** (a)
	Cold Worked 69 % (c)	100	86.5	20.5 (a)	55	13 (a)	**123 000**	**29 000** (a)
Rod (6) 13 mm diam. 0.5 in. diam.	Annealed (grain size 0.016 mm)	1 000	48	24.5 (d)	30.5	15.5 (d)	**68 000**	**35 000** (d)
	Annealed (grain size 0.065/0.070 mm)	1 000	43.5	17.5 (d)	28	11 (d)	**62 200**	**25 000** (d)
	Cold Worked 15.2 %	1 000	54	21 (d)	34	13.5 (d)	**76 600**	**30 000** (d)
	Cold Worked 30.1 %	1 000	65	15 (d)	41	9.5 (d)	**92 100**	**21 000** (d)
	Cold Worked 50.1 %	1 000	89.5	16 (d)	57	10.5 (d)	**127 500**	**23 000** (d)
Rod (7) 25.4 mm diam. 1 in. diam.	Annealed	100 (f)	45	14 (d)	28.5	9 (d)	**64 300**	**20 000** (d)
	Cold Worked and Stress Relieved (e)	100 (f)	61	12 (d)	38.5	7.5 (d)	**86 700**	**17 000** (d)
		100 (f)	64	12 (d)	41	7.5 (d)	**91 300**	**17 000** (d)
Rod (8)	Annealed	30	47.5	19 (d)	30	12 (d)	**67 500**	**27 000** (d)
	Cold Worked (g)	15	58.5	19 (d)	37	12 (d)	**83 000**	**27 000** (d)

(a) Reversed-bending test.
(b) Ready-to-finish grain size 0.035 mm.
(c) Ready-to-finish grain size 0.015 mm.
(d) Rotating-beam test.
(e) Stress relieved 3h at 204°C *(400°F)* and furnace-cooled.
(f) Extrapolated value.
(g) Amount of cold work not defined in original document.

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

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