Cu Zn38 Pb1

Common names: Free-cutting Muntz Metal
Engraving Brass

A copper–zinc–lead alloy with a duplex alpha-plus-beta phase structure containing a dispersion of fine lead particles. The alloy has good hot working and machining properties and is mainly supplied as tube for the manufacture of machined tubular parts.

COMPOSITION (weight %)

Cu	59.0 - 63.0
Pb	0.5 - 1.5
Zn	rem.

1 SOME TYPICAL USES

Mechanical

Numerous types of machined tubular components; sections requiring limited ductility. Swiss clock, watch and instrument parts are mainly produced from a similar alloy of higher lead content (up to 3%).

Miscellaneous

Eyelets; printers' rules; mechanical engraved work.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.4 g/cm^3	0.305 lb/in^3
2.2 Melting range	885–900 °C	1 625–1 650 °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:		
20 °C *68 °F*	0.29 cal cm/cm^2 s °C	70 Btu ft/ft^2 h °F
2.6 Electrical conductivity (volume) at:		
20 °C *68 °F* (annealed)	16 m/ohm mm^2	27% IACS
2.7 Electrical resistivity (volume) at:		
20 °C *68 °F* (annealed)	0.064 ohm mm^2/m 6.4 microhm cm	38 ohms (circ mil/ft) 2.5 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C *68 °F* (annealed)	0.001 6 per °C (27% IACS)	0.000 9 per °F (27% 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 or cold worked)	9 900 kg/mm^2	14 100 000 lb/in^2
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F* (annealed or cold worked)	3 700 kg/mm^2	5 300 000 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 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	1 010 –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	700 – 800 °C	1 290 –1 470 °F
3.4 Hot formability	Good	
3.5 Cold formability	Fair	
3.6 Cold reduction between anneals	25% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	70	
3.8 Joining methods:	See General Data Sheet No. 3.5	
Soldering	Excellent	
Brazing	Good	
Oxy-acetylene welding	Not recommended	
Carbon-arc welding	Not recommended	
Gas-shielded arc welding	Not recommended	
Coated metal-arc welding	Not recommended	
Resistance welding: spot and seam	Not recommended	
butt	Fair	

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/mm²	Proof Stress 0.2% offset kg/mm²	Elongation		Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [b]
				%	gauge length	Brinell	Vickers		
Plate[c] Sheet Strip	Annealed	38	18	40	$5.65\sqrt{S_o}$	80	84	29	—
	Typical Cold Worked Tempers	47	38	15	$5.65\sqrt{S_o}$	120	125	33	0.3–2 mm thick
		58	52	8	$5.65\sqrt{S_o}$	150	160	41	"
Rod	Annealed	38	18	40	$5.65\sqrt{S_o}$	75	79	29	—
	Typical Cold Worked Tempers	45	33	28	$5.65\sqrt{S_o}$	110	115	32	6–40 mm diam. or equivalent area
		52	44	12	$5.65\sqrt{S_o}$	135	140	35	6–12 mm diam. or equivalent area
Wire	Annealed	40	—	25	100 mm	—	—	30	1.5–6 mm diam.
	Typical Cold Drawn Temper	50	—	12	100 mm	—	—	34	over 1.5 mm diam.
Tube	Annealed	39	18	40	$5.65\sqrt{S_o}$	75	79	29	—
	Typical Cold Drawn Tempers	42	30	30	$5.65\sqrt{S_o}$	105	110	31	over 3 mm wall
		50	42	15	$5.65\sqrt{S_o}$	130	135	34	up to 3 mm wall

(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) These forms can be obtained in Cu Zn38 Pb1 alloy although they are generally produced in a similar alloy of higher lead content (up to 3%).

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/in²	Proof Stress 0.1% offset ton/in²	Elongation		Vickers Hardness	Shear Strength ton/in²	Typical Size Related to Properties Shown[b]
				%	gauge length			
Sheet Strip	Annealed	23	9	45	2 in.	90	17	—
	Cold Worked							
	Half Hard	30	20	25	2 in.	140	21	0.02–0.20 in. thick
	Hard	34	25	15	2 in.	160	22	0.02–0.125 in. thick
Rod	Annealed	23	8	40	$5.65\sqrt{S_o}$	90	17	—
	Hot Worked	24	9	35	$5.65\sqrt{S_o}$	100	18	0.5–2 in. diam. or equivalent area
	Cold Worked							
		25	10	35	$5.65\sqrt{S_o}$	110	18	1–2 in. diam. or equivalent area
	As-Manufactured	27	14	30	$5.65\sqrt{S_o}$	125	19	0.375–1 in. diam. or equivalent area
		30	18	20	$5.65\sqrt{S_o}$	140	20	0.125–0.375 in. diam. or equivalent area
Sections (extruded)	Hot Worked[c]	24	9	35	$5.65\sqrt{S_o}$	100	18	—
	Cold Drawn As-Manufactured[c]	26	12	30	$5.65\sqrt{S_o}$	120	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 [a]			Elongation % on $11.3\sqrt{S_o}$	Reduction of Area %	Impact Strength [b]	
		°C	°F	kg/mm²	ton/in²	psi			kg m/cm²	ft lb
Rod[1]	Annealed	20	68	**37.1**	23.5	53 000	**50.2**	**62.5**	**4.40**	15.9
		– 78	–108	**38.4**	24.5	54 500	**49.8**	**64.0**	**4.91**	17.8
		–183	–297	**48.5**	31	69 000	**50.6**	**62.1**	**4.61**	16.7
	Cold Worked 12%	20	68	**44.8**	28.5	63 500	**28.2**	**57.0**	**2.23**	8.1
		– 78	–108	**49.5**	31.5	70 500	**27.0**	**59.0**	**2.48**	9.0
		–183	–297	**60.8**	38.5	86 500	**30.8**	**57.0**	**2.19**	7.9

(a) 5 mm (0.2 in.) diam. test specimen.

(b) Charpy test, 10 × 8 × 100 mm specimen, 45° V-notch, 3 mm deep; cross sectional area at the notch 0.5 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 kg m/cm² into ft lb 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.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm²	Elongation	
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length
Rod[2](a) 16 mm diam. 0.625 in. diam.	—(b)	17	63	42.5	27	**60 700**	—	**41**	2 in.
		150	302	36.5	23.5	**52 200**	**21.4**(c)	**55**	2 in.
		250	482	28	18	**39 900**	**18.3**(c)	**21.5**	2 in.
		350	662	14	9	**20 160**	**6.94**(c)	**42**	2 in.
		500	932	4	2.5	**5 380**	**1.89**(c)	**30**	2 in.
Rod[1]	Annealed	20	68	**37.1**	23.5	53 000	—	**50.2**	$11.3\sqrt{S_o}$
		53	127	**36.2**	23	51 500	—	**49.1**	$11.3\sqrt{S_o}$
		109	228	**36.1**	23	51 500	—	**46.2**	$11.3\sqrt{S_o}$
		150	302	**33.6**	21.5	48 000	—	**45.5**	$11.3\sqrt{S_o}$
		200	392	**31.7**	20	45 000	—	**42.2**	$11.3\sqrt{S_o}$
		248	478	**30.0**	19	42 500	—	**37.4**	$11.3\sqrt{S_o}$
		301	574	**26.9**	17	38 500	—	**28.1**	$11.3\sqrt{S_o}$
		354	669	**22.9**	14.5	32 500	—	**17.5**	$11.3\sqrt{S_o}$
		400	752	**16.6**	10.5	23 500	—	**25.4**	$11.3\sqrt{S_o}$
		450	842	**11.5**	7.5	16 500	—	**24.8**	$11.3\sqrt{S_o}$
		496	925	**5.9**	3.5	8 500	—	**21.8**	$11.3\sqrt{S_o}$
		555	1 031	**4.1**	2.5	6 000	—	**22.6**	$11.3\sqrt{S_o}$
		610	1 130	**3.1**	2	4 500	—	**22.5**	$11.3\sqrt{S_o}$
		650	1 202	**1.5**	1	2 000	—	**24.0**	$11.3\sqrt{S_o}$
		700	1 292	**1.1**	0.7	1 500	—	**26.7**	$11.3\sqrt{S_o}$
	Cold Worked 12%	22	72	**44.8**	28.5	63 500	—	**28.2**	$11.3\sqrt{S_o}$
		51	124	**44.8**	28.5	63 500	—	**27.1**	$11.3\sqrt{S_o}$
		116	241	**43.9**	28	62 500	—	**24.5**	$11.3\sqrt{S_o}$
		150	302	**41.8**	26.5	59 500	—	**22.0**	$11.3\sqrt{S_o}$
		200	392	**39.2**	25	56 000	—	**17.6**	$11.3\sqrt{S_o}$
		250	482	**36.1**	23	51 500	—	**8.5**	$11.3\sqrt{S_o}$
		301	574	**30.4**	19.5	43 000	—	**5.2**	$11.3\sqrt{S_o}$
		354	669	**22.8**	14.5	32 500	—	**5.3**	$11.3\sqrt{S_o}$
		416	781	**16.1**	10	23 000	—	**10.9**	$11.3\sqrt{S_o}$
		450	842	**10.9**	7	15 500	—	**21.7**	$11.3\sqrt{S_o}$
		504	939	**4.8**	3	7 000	—	**22.1**	$11.3\sqrt{S_o}$

(a) Alloy containing 0.34% Sn.

(b) Not stated in original document.

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

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

—Data not available:
Proof stress, 0.1% offset,
Yield strength, 0.5% extension under load.
Impact strength

5.3.2 Creep Properties

Form	Temper	Testing Temperature °C	Testing Temperature °F	Stress kg/mm²	Stress ton/in²	Stress psi	Duration h	Total Creep % (a)	Intercept %	Min. Creep Rate % per 1 000 h
Rod[2] (b) 16 mm diam. 0.625 in. diam.	— (c)	150	302	15.7 18.9	10.0 12.0	**22 400** **26 880**	**1 000** **500**	**0.239** **0.56**	**0.082** **0.22**	**0.16** (d) **0.68** (d)
		250	482	1.6 3.1	1.0 2.0	**2 240** **4 480**	**250** **150**	**0.082** **0.32**	**0.018** **0.06**	**0.26** (d) (e) **1.7** (d) (e)
		350	662	0.20 0.34	0.13 0.22	**291** **483**	**500** **500**	**0.50** **3.2**	**0** **0**	**0.76** (d) **6.1** (d)

(a) Total creep; does not include the initial elastic extension.
(b) Alloy containing 0.34% Sn.
(c) Not stated in original document.
(d) Creep rate at end of test (tangent to creep curve).
(e) Increasing at end of test.
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/mm²		English Units ton/in²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Rod [3]	As Received	50	41.5	16 (a)	26.5	10.5 (a)	**59 000**	**23 000** (a)

(a) Rotating-beam test.
N.B.: Original values are printed in **bold type**; other values are converted.

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