WROUGHT MATERIALS

COPPER-ZINC-LEAD ALLOYS
Leaded Brasses

Cu Zn36 Pb3

Common names: Free-Cutting Brass
American Free-Machining Brass
Extra-High-Leaded Brass

A copper–zinc–lead alloy with a duplex alpha-plus-beta phase structure containing a dispersion of fine lead particles. This alloy is the standard American-type free-cutting brass, generally supplied as rod. It is widely used where extensive machining is required, especially on automatic machines.

COMPOSITION (weight %)

Cu	60.0–63.0
Pb	2.5– 3.7
Zn	rem.

1 SOME TYPICAL USES

Mechanical

Wide variety of machined components usually made on high-speed automatic lathes, including nuts, bolts, screws, bushings, bearings, pins, washers, and tubular products with open or closed ends; hollow extrusions; machined and lightly riveted parts.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.5 g/cm³	0.305 lb/in³
2.2 Melting range	885 - 900 °C	1 625 - 1 650 °F
2.3 Coefficient of thermal expansion (linear) at:		
—170 °C *—275 °F*	0.000 013 per °C	0.000 007 per °F
— 70 °C *— 95 °F*	0.000 017 ,, ,,	0.000 009 ,, ,,
20 to 100 °C *68 to 212 °F*	0.000 019 ,, ,,	0.000 011 ,, ,,
20 to 300 °C *68 to 572 °F*	0.000 020 ,, ,,	0.000 011 ,, ,,
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*	0.28 cal cm/cm² s °C	68 Btu ft/ft² h °F
2.6 Electrical conductivity (volume) at: 20 °C *68 °F* (annealed)	15 m/ohm mm²	26% IACS
2.7 Electrical resistivity (volume) at: 20 °C *68 °F* (annealed)	0.066 ohm mm²/m 6.6 microhm cm	40 ohms (circ mil/ft) 2.6 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*	0.001 5 per °C (26% IACS)	0.000 8 per °F (26% IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F* (annealed or cold worked)	10 100 kg/mm²	14 400 000 lb/in²
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F* (annealed or cold worked)	3 700 kg/mm²	5 300 000 lb/in²

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 6); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

Prepared by
CONSEIL INTERNATIONAL POUR LE DEVELOPPEMENT DU CUIVRE (CIDEC)
100, rue du Rhône - 1204 GENEVE

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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	1 020–1 070 °C	1 870–1 960 °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– 775 °C	1 290–1 425 °F
3.4 Hot formability	Fair	
3.5 Cold formability	Limited	
3.6 Cold reduction between anneals	35% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	100	
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		
Rod	Annealed	36	15	40	$5.65\sqrt{S_o}$	75	79	27	—
Rod	Typical Cold Worked Tempers	44	30	25	$5.65\sqrt{S_o}$	105	110	31	6–40 mm diam. or equivalent area
Rod	Typical Cold Worked Tempers	52	45	12	$5.65\sqrt{S_o}$	135	140	34	6–12 mm diam. or equivalent area
Sections / Shapes	Annealed[c]	36	15	40	$5.65\sqrt{S_o}$	75	79	27	—
Sections / Shapes	Typical Cold Worked Temper[c]	42	30	25	$5.65\sqrt{S_o}$	100	105	30	—

(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/in²	Proof Stress 0.1% offset ton/in²	Elongation		Vickers Hardness	Shear Strength ton/in²	Typical Size Related to Properties Shown[b]
				%	gauge length			
Rod	Annealed	22	8	40	$5.65\sqrt{S_o}$	80	17	—
Rod	Cold Worked	23	10	35	$5.65\sqrt{S_o}$	90	17	1–2 in. diam. or equivalent area
Rod	Half Hard	26	16	25	$5.65\sqrt{S_o}$	120	18	0.25–1 in. diam. or equivalent area
Rod	Hard	32	22	10	$5.65\sqrt{S_o}$	160	21	0.2–0.3 in. diam. or equivalent area
Rod	Hard	36	25	—	—	—	23	0.125–0.2 in. diam. or equivalent area
Sections (extruded)	Hot Worked[c]	23	10	35	$5.65\sqrt{S_o}$	90	17	—
Sections (extruded)	Cold Drawn As-Manufactured[c]	25	12	30	$5.65\sqrt{S_o}$	110	18	—

(a) The recognised temper designations used in the relevant or nearest British Standard 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			Yield Strength psi	Elongation % on 2 in.	Reduction of Area %	Impact Strength [b]	
		°C	°F	kg/mm²	ton/in²	psi				kg m/cm²	ft lb
Rod [1]	Cold Rolled	20 −183	68 −310	25 30	16 19	**35 600** **42 800**	**24 400** [a] **32 100** [a]	**17.0** **13.0**	**22.2** **19.0**	— —	— —
Rod [2]	Annealed	27 − 23 − 73 −123 −173 −223 −253	81 − 9 − 99 −189 −279 −369 −423	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	3.9 4.0 4.4 4.7 4.8 4.7 3.8	**14** **14.5** **16** **17** **17.5** **17** **13.5**
	Cold Worked [c]	27 − 23 − 73 −123 −173 −223 −253	81 − 9 − 99 −189 −279 −369 −423	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	— — — — — — —	2.4 2.8 3.0 3.0 3.1 3.3 3.5	**8.5** **10** **11** **11** **11.5** **12** **13**

(a) Quoted as yield point, but offset strain not defined.
(b) Charpy test, keyhole notch; cross-sectional area at the notch 0.5 cm².
(c) Quoted as "Half 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 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—Impact Properties

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

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 × 10⁶	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] 12.7 mm diam. 0.5 in. diam.	Cold Worked 21%	300	37	9.5 [a]	23.5	6 [a]	**52 800**	**13 500** [a]
Rod [4] 16 mm diam. 0.625 in. diam.	Cold Worked 20%	100	38.5	14 [a]	24.5	9 [a]	**55 000**	**20 000** [a]
Rod [5] 51 mm diam. 2 in. diam.	Cold Worked 18%	300	38.5	10 [a]	24.5	6.5 [a]	**55 000**	**14 000** [a]

(a) Rotating-beam test.
N.B.:—Original values are printed in **bold type**; other values are converted.
—Further data can be obtained from the following paper:
■ Shives, T.R. and Bennett, J.A. The Effect of Environment on the Fatigue Properties of Selected Engineering Alloys. J. Materials, Vol. 3 (1968), pp. 695-715.

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