UDC 669.35'5'4

Cu Zn39 Pb2

Common names: Forging Brass
Clock Brass

A copper–zinc–lead alloy with a duplex alpha-plus-beta phase structure containing a dispersion of fine lead particles. It is mainly supplied as rod for forging stock. The alloy exhibits an excellent combination of hot-working and machining properties and is widely used for hot pressed components.

COMPOSITION (weight %)

Cu	57.0–60.0
Pb	1.0– 2.5
Zn	rem.

1 SOME TYPICAL USES

Mechanical and General

Wide variety of hot forged and pressed components including sanitary appliances, door furniture, window fittings, taps, valves and valve parts, automobile components, decorative items, parts for mechanical handling equipment, brackets, clamps, housings, gears, cams, nuts, unions and miscellaneous machine components. Clock, watch and instrument parts (UK only), especially gears and plates requiring high degree of precision machining.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.4 g/cm³	0.305 lb/in³
2.2	Melting range	880–895 °C	1 615–1 645 °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*	0.28 cal cm/cm² s °C	68 Btu ft/ft² h °F
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed)	16 m/ohm mm²	27% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed)	0.064 ohm mm²/m	38 ohms (circ mil/ft)
		6.4 microhm cm	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)	9 800 kg/mm²	13 900 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F* (annealed or cold worked)	3 600 kg/mm²	5 200 000 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 8): INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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DATA SHEET No. E7
Cu Zn39 Pb2

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	1 000–1 050 °C	1 830–1 920 °F
3.2 Annealing temperature range	450– 600 °C	840–1 110 °F
Stress relieving temperature range	250– 350 °C	480– 660 °F
3.3 Hot working temperature range	650– 775 °C	1 200–1 425 °F
3.4 Hot formability	Excellent	
3.5 Cold formability	Limited	
3.6 Cold reduction between anneals	20% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	85	
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	

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	—	—	—	—	—	—	AS-H11	AS-H11
Belgium . . .	NBN	Lt 58 Pb2	—	—	266.12	—	—	266.12	266.12
Canada . . .	CSA	HC.ZP 382 (or 377)	—	—	HC.5.10	—	—	HC.5.10	HC.8.1
Chile	INDITECNOR	Cu Zn39 Pb2	247 n./68	—	—	—	—	—	—
France . . .	NF	U-Z39 Pb1	EN A 53-013	A 53-603	A 53-303 FDA 53-403	—	—	A 53-303 FDA 53-403	—
Germany . . .	DIN	Cu Zn39 Pb2 (2.0380)	17 660	17 670	17 672	17 672	—	—	17673 Bl.3
India	IS	Cu Zn42 Pb2	—	—	3488	—	—	3488	
Italy	UNI	P-Cu Zn39 Pb2	5706	5706	5706	—	—	5706	5706
Japan	JIS	Pb BsP 13 Pb BsR 13 Pb BsW 1	—	H3202 H3322	—	H3523	—	—	—
Netherlands .	N or NEN [b]	Cu-Zn39 Pb2	NEN 6030	NEN 6033	—	—	—	—	—
South Africa .	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden . . .	SIS	51 68	—	14 51 68	—	—	—	14 51 68	14 51 68
Switzerland . .	VSM	Cu Zn39 Pb2	10 822	—	11 854	—	—	11 854	—
United Kingdom	BS	CZ120 CZ122	—	2785 2870	218 250 2872 2874	—	—	250 2874	218 2872
United States .	ASTM	No.377	—	B124	B124	—	—	B124	B283 B124
International Organization for Standardization	ISO	R426	—	—	—	—	—	—	—

(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.

5 MECHANICAL PROPERTIES

5.1 Mechanical properties at room temperature

Tensile properties — see tables 5.1.1/2/3
Hardness — " " 5.1.1/2/3
Shear strength — " " 5.1.1/2/3
Modulus of elasticity (tension) — see 2.9
Modulus of rigidity (torsion) — " 2.10

5.2 Mechanical properties at low temperature
Tensile properties — see table 5.2.1
Impact properties — " " 5.2.1

5.3 Mechanical properties at elevated temperature
Short-time tensile properties — see table 5.3.1
Impact properties — " " 5.3.1
Creep properties — " " 5.3.2

5.4 Fatigue properties
Fatigue strength at room temperature — see table 5.4.1

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	40	22	35	$5.65\sqrt{S_o}$	90	95	30	—
	Hot Worked	42	23	30	$5.65\sqrt{S_o}$	95	100	32	10–60 mm diam. or equivalent area
	Typical Cold Worked Tempers	45	30	20	$5.65\sqrt{S_o}$	120	125	34	6–40 mm diam. or equivalent area
		56	48	15	$5.65\sqrt{S_o}$	140	145	38	6–12 mm diam. or equivalent area
Sections / Shapes	Hot Worked [c]	42	22	30	$5.65\sqrt{S_o}$	95	100	31	—
	Typical Cold Worked Temper [c]	45	30	20	$5.65\sqrt{S_o}$	115	120	34	—
Forgings	Hot Worked [c]	38	18	28	$5.65\sqrt{S_o}$	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/in²	Proof Stress 0.1% offset ton/in²	Elongation %	Elongation gauge length	Vickers Hardness	Shear Strength ton/in²	Typical Size Related to Properties Shown[b]
Strip	Cold Worked							
	Half Hard	28	17	25	2 in.	130	20	0.01–0.20 in. thick
	Hard	34	25	10	2 in.	160	22	0.01–0.125 in. thick
	Extra Hard	38	32	5	2 in.	185	23	"
Rod	Hot Worked	27	11	30	$5.65\sqrt{S_o}$	110	20	0.5–2 in. diam. or equivalent area
	Cold Worked	28	13	30	$5.65\sqrt{S_o}$	120	20	1–2 in. diam. or equivalent area
	As-Manufactured	30	16	25	$5.65\sqrt{S_o}$	140	21	0.375–1 in. diam. or equivalent area
		32	18	20	$5.65\sqrt{S_o}$	160	22	0.125–0.375 in. diam. or equivalent area
	Hard	32	18	20	$5.65\sqrt{S_o}$	160	22	0.25–1.5 in. diam. or equivalent area
Sections (extruded)	Hot Worked[c]	27	11	30	$5.65\sqrt{S_o}$	110	20	—
	Cold Drawn As-Manufactured[c]	29	14	25	$5.65\sqrt{S_o}$	130	21	—
Forgings	Hot Worked[c]	26	11	35	$5.65\sqrt{S_o}$	100	20	—

[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.

5.1.3 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 %	Elongation gauge length	Rockwell Hardness F	Rockwell Hardness B	Rockwell Hardness 30 T	Shear Strength psi	Typical Size Related to Properties Shown[a]
Rod	As Extruded	52 000	20 000	45	2 in.	78	—	—	39 000	1.0 in. diam.
Shapes	As Extruded	52 000	20 000	45	2 in.	78	—	—	39 000	1.0 in. thick

[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 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Elongation		Reduction of Area %	Impact Strength [b]	
		°C	°F	kg/mm²	ton/in²	psi	%	gauge length		kg m/cm²	ft lb
Sheet [1] **8–10 mm 0.3–0.4 in.**	— [c]	17	68	**45**	28.5	64 000	**32**	—	**35**	—	—
		–196	–321	**59**	37.5	84 000	**37**	—	**38**	—	—
		–253	–423	**68**	43	96 500	**34**	—	**35**	—	—
Rod [2] [d]	Annealed	20	68	**37.1** [a]	23.5 [a]	53 000 [a]	**50.2**	$11.3\sqrt{S_o}$	**62.5**	**4.40**	15.9
		– 78	–108	**38.4** [a]	24.5 [a]	54 500 [a]	**49.8**	$11.3\sqrt{S_o}$	**64.0**	**4.91**	17.8
		–183	–297	**48.5** [a]	31 [a]	69 000 [a]	**50.6**	$11.3\sqrt{S_o}$	**62.1**	**4.61**	16.7
	Cold Worked 12%	20	68	**44.8** [a]	28.5 [a]	63 500 [a]	**28.2**	$11.3\sqrt{S_o}$	**57.0**	**2.23**	8.1
		– 78	–108	**49.5** [a]	31.5 [a]	70 500 [a]	**27.0**	$11.3\sqrt{S_o}$	**59.0**	**2.48**	9.0
		–183	–297	**60.8** [a]	38.5 [a]	86 500 [a]	**30.8**	$11.3\sqrt{S_o}$	**57.0**	**2.19**	7.9
—[3] [c]	Cold Worked [e]	20	68	**57**	36	81 000	**27**	$5.65\sqrt{S_o}$	—	—	—
		– 30	– 22	**58**	37	82 500	**27**	$5.65\sqrt{S_o}$	—	—	—
		– 80	–112	**61**	38.5	87 000	**27**	$5.65\sqrt{S_o}$	—	—	—
		–120	–184	**64**	40.5	91 000	**26**	$5.65\sqrt{S_o}$	—	—	—
		–195	–319	**75**	47.5	106 500	**26**	$5.65\sqrt{S_o}$	—	—	—

[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.

[c] Not stated in original document.

[d] Alloy containing Zn 40%, Pb 1.3%, Cu rem.

[e] 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 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—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Elongation		Impact Strength [a]	
		°C	°F	kg/mm²	ton/in²	psi	%	gauge length	kg m/cm²	ft lb
Rod [2]	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**	$11.3\sqrt{S_o}$	—	—
Rod [4]	— [b]	20	68	**36**	23	51 000	**41**	$5.65\sqrt{S_o}$	**15**	86.8
		100	212	**32**	20.5	45 500	**38**	$5.65\sqrt{S_o}$	**13**	75.2
		200	392	**28**	18	40 000	**31**	$5.65\sqrt{S_o}$	**9**	52.1
		300	572	**22**	14	31 500	**18**	$5.65\sqrt{S_o}$	**5**	28.9
		400	752	**18**	11.5	25 500	**8**	$5.65\sqrt{S_o}$	**2**	11.6
		500	932	**13**	8.5	18 500	**10**	$5.65\sqrt{S_o}$	**2.5**	14.5
		600	1 112	**11**	7	15 500	**14**	$5.65\sqrt{S_o}$	**3**	17.4
		700	1 292	**8**	5	11 500	**57**	$5.65\sqrt{S_o}$	**4**	27.1
		800	1 472	**3**	2	4 500	**4**	$5.65\sqrt{S_o}$	**1**	5.8

(a) Izod specimen: cross-sectional area at the notch 0.8 cm².

(b) Not stated in original document.

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.

5.3.2 Creep Properties

Form	Temper	Testing Temperature		Stress			Duration h	Total Creep %[a]	Min. Creep Rate % per 1 000 h
		°C	°F	kg/mm²	ton/in²	psi			
Rod [5] **18 mm diam. 0.708 in. diam.**	Hot Worked [b]	204	400	0.79	**0.5**	1 100	**10 000**	**0.052**	**0.002**
				1.6	**1**	2 200	**10 000**	**0.230**	**0.02**
				3.1	**2**	4 500	**10 000**	**0.950**	**0.08**
				6.3	**4**	9 000	**500**	**0.564**	—
				9.4	**6**	13 400	**500**	**5.42**	—
	Hot Worked [c]	204	400	0.79	**0.5**	1 100	**10 000**	**0.024**	**0.001**
				1.6	**1**	2 200	**10 000**	**0.85**[d]	**0.003**
				3.1	**2**	4 500	**10 000**	**0.530**	**0.04**
				6.3	**4**	9 000	**500**	**0.492**	—
				9.4	**6**	13 400	**144**	**0.558**	—

[a] Does not include the initial elastic extension.

[b] Hot-stamped at 680–700 °C (*1 255–1 290 °F*).

[c] Hot-stamped at 790–820 °C (*1 455–1 510 °F*).

[d] Extrapolated value.

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

—Data not available:
Intercept.

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 [6] **12.7 mm diam. 0.5 in. diam.**	Cold Worked 21%	300	53	15.5 [a]	33.5	10 [a]	**75 500**	**22 000** [a]

[a] Rotating-beam test.

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

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