Cu Zn33

Common names: 67/33 Brass
2/1 Brass
67/33 Yellow Brass

A copper–zinc alloy with an alpha phase structure. The alloy exhibits a good combination of strength and ductility, and is commonly selected whenever excellent cold-working properties and relatively low cost are desirable. Service environment must be considered to predict corrosion behaviour. The alloy is often used for a variety of deep-drawn components.

COMPOSITION (weight %)

Cu . .	65.5–68.5
Zn . .	rem.

1 SOME TYPICAL USES

Architectural
Grillwork

Electrical
Lamp caps and lampholder components.

Hardware
General coppersmithing work; chain, eyelets, fasteners, hinges, locks and fingerplates.

Mechanical
Wide variety of deep-drawn and spun components; automobile radiator tanks, tubes and fins; general industrial pressings formed from sheet and strip, including clock, watch and instrument cases; cold-headed or "upset" products such as rivets, pins and screws; torch and flashlight cases; reflectors; etched and chemically engraved work; springs.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.50 g/cm³	0.305 lb/in³
2.2 Melting range	902–940 °C	1 655–1 725 °F
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C *68 to 212 °F*	0.000 019 per °C	0.000 011 per °F
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
200 °C *392 °F*	0.11 ,,	0.11 ,,
2.5 Thermal conductivity at:		
−200 °C *−328 °F*	0.12 cal cm/cm² s °C	30 Btu ft/ft² h °F
20 °C *68 °F*	0.29 ,,	70 ,,
200 °C *392 °F*	0.34 ,,	82 ,,
2.6 Electrical conductivity (volume) at:		
−196 °C *−321 °F* (annealed)	24 m/ohm mm²	41 % IACS
20 °C *68 °F* (,,)	16 ,,	27 ,, ,,
200 °C *392 °F* (,,)	12 ,,	21 ,, ,,
2.7 Electrical resistivity (volume) at:		
−196 °C *−321 °F* (annealed)	0.042 ohm mm²/m 4.2 microhm cm	25 ohms (circ mil/ft) 1.7 microhm in
20 °C *68 °F* (,,)	0.064 ohm mm²/m 6.4 microhm cm	38 ohms (circ mil/ft) 2.5 microhm in
200 °C *392 °F* (,,)	0.082 ohm mm²/m 8.2 microhm cm	49 ohms (circ mil/ft) 3.2 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 6 per °C (27% IACS)	0.000 9 per °F (27% IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*		
annealed	11 400 kg/mm²	16 200 000 lb/in²
cold worked	9 700–11 400 kg/mm²	13 800 000–16 200 000 lb/in²
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F*		
annealed	4 050 kg/mm²	5 750 000 lb/in²
cold worked	3 600–4 050 kg/mm²	5 100 000–5 750 000 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 10); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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DATA SHEET No. D 6
Cu Zn33
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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	990–1 020 °C	1 815–1 870 °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	750– 850 °C	1 380–1 560 °F
3.4 Hot formability	Fair	
3.5 Cold formability	Excellent	
3.6 Cold reduction between anneals	85% max.	
3.7 Machinability:	See General Data Sheet No. 2	
Machinability rating (free-cutting brass = 100)	30	
3.8 Joining methods:	See General Data Sheet No. 3.4	
Soldering	Excellent	
Brazing	Excellent	
Oxy-acetylene welding	Good	
Carbon-arc welding	Not recommended	
Gas-shielded arc welding	Fair	
Coated metal-arc welding	Not recommended	
Resistance welding: spot and seam	Fair	
butt	Good	

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 Sheet Strip	Annealed grain size 0.035 mm	34	13	58	$5.65\sqrt{S_o}$	65	68	26	0.2–5 mm thick
	grain size 0.025 mm	36	14	55	50 mm	80	84	27	0.2–2.5 mm thick
	grain size 0.015 mm	38	16	52	50 mm	85	89	28	0.2–1.5 mm thick
	Typical Cold Worked Tempers	39	25	38	50 mm	100	105	28	0.2–3 mm thick
		43	33	30	50 mm	120	125	29	"
		49	41	15	50 mm	135	140	31	0.2–2 mm thick
		53	48	8	50 mm	145	150	32	"
		58	55	3	50 mm	155	160	33	0.2–1.5 mm thick
		63	—	—	—	165	170	34	0.2–1 mm thick
Rod	Annealed	34	14	60	$5.65\sqrt{S_o}$	65	68	26	—
	Typical Cold Worked Tempers	38	23	42	$5.65\sqrt{S_o}$	95	100	28	—
		41	32	32	$5.65\sqrt{S_o}$	115	120	29	6–40 mm diam. or equivalent area
		47	41	16	$5.65\sqrt{S_o}$	130	135	31	6–12 mm diam. or equivalent area
Wire	Annealed	37	—	45	100 mm	—	—	27	1.5–6 mm diam.
		39	—	35	100 mm	—	—	28	0.5–1.5 mm diam.
		43	—	20	100 mm	—	—	29	up to 0.5 mm diam.
	Typical Cold Drawn Tempers	41	—	32	100 mm	—	—	28	1.5–6 mm diam.
		56	—	8	100 mm	—	—	31	"
		66	—	—	—	—	—	36	1.5–3 mm diam.
		79	—	—	—	—	—	40	"
		45	—	15	100 mm	—	—	30	0.5–1.5 mm diam.
		59	—	2	100 mm	—	—	33	"
		71	—	—	—	—	—	36	"
		86	—	—	—	—	—	44	"
Tube	Annealed	35	13	55	$5.65\sqrt{S_o}$	80	84	26	—
	Typical Cold Drawn Tempers	42	33	30	$5.65\sqrt{S_o}$	110	115	29	10–50 mm O.D. over 2 mm wall
		49	44	12	$5.56\sqrt{S_o}$	135	140	32	up to 25 mm O.D. up to 2 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.

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							
	grain size 0.070 mm	20	6	67	2 in.	60	15	—
	grain size 0.050 mm	21	7	65	2 in.	65	16	—
	grain size 0.035 mm	21	7	60	2 in.	70	16	—
	grain size 0.025 mm	22	8	58	2 in.	80	17	—
	grain size 0.015 mm	23	9	55	2 in.	90	17	0.01–0.125 in. thick
	Cold Worked							
	Quarter Hard	23	15	50	2 in.	95	17	0.01–0.375 in. thick
	Half Hard	26	19	38	2 in.	125	18	0.01–0.25 in. thick
	Hard	31	25	18	2 in.	150	20	0.01–0.1 in. thick
	Extra Hard	37	31	8	2 in.	175	21	,,
Rod	Annealed	21	7	55	$5.65\sqrt{S_o}$	70	16	—
	Cold Worked							
	As Manufactured	23	14	45	$5.65\sqrt{S_o}$	90	17	0.25–1 in. diam. or equivalent area
		25	18	35	$5.65\sqrt{S_o}$	110	18	
Wire	Annealed	22	—	65	2 in.	—	17	0.10–0.25 in. diam.
		23	—	60	2 in.	—	17	0.02–0.10 in. diam.
	Cold Drawn							
	Quarter Hard	27	—	35	2 in.	—	19	0.10–0.25 in. diam.
	Half Hard	35	—	12	2 in.	—	25	,,
	Hard	43	—	—	—	—	28	,,
	Extra Hard	48	—	—	—	—	29	,,
	Half Hard	37	—	10	2 in.	—	26	0.02–0.10 in. diam.
	Hard	45	—	—	—	—	29	,,
	Extra Hard	50	—	—	—	—	30	,,
Tube[c]	Annealed	21	7	55	$5.65\sqrt{S_o}$	70	16	—
	Cold Drawn							
	As Drawn	31	25	15	$5.65\sqrt{S_o}$	160	20	0.25–2 in. O.D., 0.02–0.08 in. wall

(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) Drawn tubes are usually stress relieved after the final draw. Tubes for heat exchangers are mainly supplied in the two tempers whose representative mechanical properties are shown.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Elongation % on $11.3\sqrt{S_o}$	Reduction of Area %	Impact Strength	
		°C	°F	kg/mm²	ton/in²	psi			kg m/cm²	ft lb
Rod[1]	Annealed	20	68	—	—	—	—	—	**14.35**[a][b]	51.9[a][b]
		23	73	**40.0**	25.5	57 000	**50.4**	**72.0**	—	—
		– 78	–108	**43.0**	27.5	61 000	**49.8**	**76.6**	**16.89**[a][b]	61.1[a][b]
		–183	–297	**53.7**	34	76 500	**50.8**	**70.7**	**14.15**[a]	51.2[a]
	Cold Worked 12%	20	68	—	—	—	—	—	**8.12**[a]	29.4[a]
		– 78	–108	—	—	—	—	—	**9.2**[a]	33.3[a]
		–183	–297	—	—	—	—	—	**9.4**[a]	34.0[a]
	Cold Worked 40%	23	73	**60.0**	38	85 500	**6.3**	**66.5**	—	—
		– 78	–108	**65.0**	41.5	92 500	**7.8**	**71.5**	—	—
		–183	–297	**72.3**	46	103 000	**10.1**	**66.5**	—	—
Square Rod[2] 12.7 mm 0.5 in.	Annealed	21	70	—	—	—	—	—	3.9[c]	**14**[c]
		– 83	–117	—	—	—	—	—	4.4[c]	**16**[c]
		–200	–328	—	—	—	—	—	5.0[c]	**18**[c]
		–243	–405	—	—	—	—	—	3.9[c]	**14**[c]
	Soft	21	70	—	—	—	—	—	3.0[c]	**11**[c]
		– 83	–117	—	—	—	—	—	3.3[c]	**12**[c]
		–200	–328	—	—	—	—	—	3.9[c]	**14**[c]

(a) Charpy test, 10 × 8 × 100 mm specimen, 45° V-notch, 3 mm deep; cross-sectional area at the notch 0.5 cm².

(b) Unbroken specimen.

(c) Charpy test, 10 × 10 × 50 mm specimen, keyhole notch; 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 (and vice versa) 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	
		°C	°F	kg/mm²	ton/in²	psi	%	gauge length	kg m/cm²	ft lb
Rod[1]	Annealed	20	68	—	—	—	—	—	**14.35**[a][b]	51.9[a][b]
		23	73	**40.0**	25.5	57 000	**50.4**	$11.3\sqrt{S_o}$	—	—
		46	115	—	—	—	—	—	**12.1**[a]	43.8[a]
		106	223	—	—	—	—	—	**11.1**[a]	40.1[a]
		108	226	**38.2**	24.5	54 500	**49.7**	$11.3\sqrt{S_o}$	—	—
		150	302	—	—	—	—	—	**10.9**[a]	39.4[a]
		200	392	**35.6**	22.5	50 500	**45.3**	$11.3\sqrt{S_o}$	—	—
		203	397	—	—	—	—	—	**10.6**[a]	38.3[a]
		251	484	—	—	—	—	—	**9.52**[a]	34.4[a]
		298	568	**32.7**	21	46 500	**34.8**	$11.3\sqrt{S_o}$	—	—
		301	574	—	—	—	—	—	**3.37**[a]	12.2[a]
		350	662	—	—	—	—	—	**1.55**[a]	5.6[a]
		352	666	**30.6**	19.5	43 500	**26.9**	$11.3\sqrt{S_o}$	—	—
		400	752	**22.6**	14.5	32 000	**20.7**	$11.3\sqrt{S_o}$	—	—
		401	754	—	—	—	—	—	**1.30**[a]	4.7[a]
		450	842	—	—	—	—	—	**1.01**[a]	3.7[a]
		498	928	—	—	—	—	—	**1.08**[a]	3.9[a]
		500	932	**10.9**	7	15 500	**16.8**	$11.3\sqrt{S_o}$	—	—
		550	1 022	—	—	—	—	—	**0.86**[a]	3.1[a]
		598	1 108	—	—	—	—	—	**0.80**[a]	2.9[a]
		617	1 143	**4.2**	3	6 000	**17.3**	$11.3\sqrt{S_o}$	—	—
		646	1 195	—	—	—	—	—	**0.97**[a]	3.5[a]
		695	1 283	—	—	—	—	—	**0.96**[a]	3.5[a]
		697	1 287	**2.7**	1.5	4 000	**16.3**	$11.3\sqrt{S_o}$	—	—
	Cold Worked 12%	20	68	—	—	—	—	—	**8.12**[a]	29.4[a]
		50	122	—	—	—	—	—	**8.44**[a]	30.5[a]
		100	212	—	—	—	—	—	**8.10**[a]	29.3[a]
		152	306	—	—	—	—	—	**7.10**[a]	25.7[a]
		200	392	—	—	—	—	—	**7.03**[a]	25.4[a]
		250	482	—	—	—	—	—	**5.91**[a]	21.4[a]
		302	576	—	—	—	—	—	**3.70**[a]	13.4[a]
		350	662	—	—	—	—	—	**1.82**[a]	6.6[a]
		401	754	—	—	—	—	—	**1.01**[a]	3.7[a]
		450	842	—	—	—	—	—	**0.93**[a]	3.4[a]
		500	932	—	—	—	—	—	**0.79**[a]	2.9[a]
		550	1 022	—	—	—	—	—	**0.60**[a]	2.2[a]
		600	1 112	—	—	—	—	—	**1.01**[a]	3.7[a]
		650	1 202	—	—	—	—	—	**1.20**[a]	4.3[a]
		700	1 292	—	—	—	—	—	**0.99**[a]	3.6[a]
	Cold Worked 40%	23	73	**60.0**	38	85 500	**6.3**	$11.3\sqrt{S_o}$	—	—
		109	228	**58.6**	37	83 500	**6.3**	$11.3\sqrt{S_o}$	—	—
		200	392	**56.3**	35.5	80 000	**5.2**	$11.3\sqrt{S_o}$	—	—
		306	583	**52.8**	33.5	75 000	**4.0**	$11.3\sqrt{S_o}$	—	—
		347	657	**44.9**	28.5	64 000	**4.3**	$11.3\sqrt{S_o}$	—	—
		378	712	**28.5**	18	40 500	**19.6**	$11.3\sqrt{S_o}$	—	—
		396	745	**23.6**	15	33 500	**21.8**	$11.3\sqrt{S_o}$	—	—
Rod[3] 12.8 mm diam. 0.505 in. diam.	Cold Worked 50%	25	77	58.5	37	**83 000**	**11**	2 in.	—	—
		250	482	49.5	31.5	**70 700**	**3**	2 in.	—	—
		375	707	19.5	12	**27 400**	**35**	2 in.	—	—
		500	932	6.5	4	**9 300**	**28**	2 in.	—	—
		625	1 157	3	2	**4 200**	**19**	2 in.	—	—
		750	1 382	1.5	0.9	**2 100**	**17**	2 in.	—	—
		875	1 607	0.6	0.4	**900**	**10**	2 in.	—	—

(a) Charpy test, 10 × 8 × 100 mm specimen, 45° V-notch, 3 mm deep; cross-sectional area at the notch 0.5 cm².
(b) Unbroken specimen.

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

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
Flat Products[4] **1 mm 0.04 in.**	Annealed (grain size 0.070 mm)	100	32.5	8.5[a]	20.5	5.5[a]	**46 000**	**12 000**[a]
	Cold Worked[b]	100	52	10[a]	33	6.5[a]	**74 000**	**14 000**[a]
	Cold Worked[c]	100	64	14[a]	40.5	9[a]	**91 000**	**20 000**[a]
Strip[5] **1 mm 0.04 in.**	Cold Worked[d]	100	67	10.5[a]	42.5	6.5[a]	**95 500**	**15 000**[a]
Wire[4] **2 mm diam. 0.08 in.diam.**	Cold Worked[e]	300	49	15.5[f]	31.5	10[f]	**70 000**	**22 000**[f]

[a] Reversed-bending test. [b] Quoted as "hard" in original document, but amount of cold work not defined. [c] Quoted as "spring" in original document, but amount of cold work not defined. [d] Quoted as "extra spring" in original document, but amount of cold work not defined. [e] Quoted as "quarter hard" in original document, but amount of cold work not defined. [f] 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:

■Walker, H.L. and Craig, W.J. Effect of Grain Size on Tensile Strength, Elongation and Endurance Limit of Deep-Drawing Brass. Trans. AIME, Vol. 180 (1949), pp. 42–51.