WROUGHT MATERIALS

COPPER-ALUMINIUM ALLOYS
Aluminium Bronzes

Cu Al9 Mn2

A copper–aluminium–manganese alloy with an alpha-plus-beta phase structure. Manganese is added to improve hot-working properties and weldability; the alloy may also contain small amounts of iron and/or nickel. The most commonly used wrought forms are plate, sheet, rod and forgings.

COMPOSITION (weight %)

Al	8.0–10.0
Mn	1.5– 3.0
Fe	0 – 1.5
Ni	0 – 0.8
Cu	rem.

1 SOME TYPICAL USES

Chemical
Cryogenic equipment; strainers, screens and perforated plates; components for food machinery.

Mechanical
Worm gears; fasteners; machine slides; moulding dies for plastics; slow-moving bearings (e.g. lock gates and sluices); shafts.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	7.6 g/cm³	0.275 lb/in³
2.2 Melting range	1 045–1 100 °C	1 915–2 010 °F
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C *68 to 212 °F*	0.000 016 per °C	0.000 009 per °F
20 to 300 °C *68 to 572 °F*	0.000 017 ,, ,,	0.000 009 ,, ,,
2.4 Specific heat (thermal capacity) at: 20 °C *68 °F*	0.10 cal/g °C	0.10 Btu/lb °F
2.5 Thermal conductivity at: 20 °C *68 °F*	0.14–0.16 cal cm/cm² s °C	34–39 Btu ft/ft² h °F
2.6 Electrical conductivity (volume) at: 20 °C *68 °F* (annealed or cold worked)	7.0–8.1 m/ohm mm²	12–14% IACS
2.7 Electrical resistivity (volume) at: 20 °C *68 °F* (annealed or cold worked)	0.14–0.12 ohm mm²/m 14–12 microhm cm	86–74 ohms (circ mil/ft) 5.7–4.8 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 8 per °C (12%–14% IACS)	0.000 4 per °F (12%–14% IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*: annealed or cold worked	10 500 kg/mm²	14 900 000 lb/in²
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F*: annealed or cold worked	3 900 kg/mm²	5 500 000 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; the melting range covers the highest liquidus and lowest solidus temperatures over the composition range quoted.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 6); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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3 FABRICATION PROPERTIES

Fabrication characteristics, corrosion resistance and mechanical properties of this copper–aluminium alloy are markedly influenced by composition and by heat treatment which is usually performed by the metal manufacturer.
If thermal treatment, including hot forming and joining processes, is to be undertaken by the end user, the advice of the metal supplier should be requested.

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	1 140–1 200 °C	2 085–2 190 °F
3.2	Annealing temperature range Stress relieving temperature range	600– 800 °C 300– 400 °C	1 110–1 470 °F 570– 750 °F
3.3	Hot working temperature range	800– 925 °C	1 470–1 695 °F
3.4	Hot formability	Good	
3.5	Cold formability	Fair	
3.6	Cold reduction between anneals	25% max.	
3.7	Machinability: Machinability rating (free cutting brass = 100)	See General Data Sheet No. 2 20	
3.8	Joining methods:	See General Data Sheet No. 3.8	
	Soldering	Not recommended	
	Brazing (with special fluxes)	Fair	
	Oxy-acetylene welding	Not recommended	
	Carbon-arc welding	Fair	
	Gas-shielded arc welding	Good	
	Coated metal-arc welding	Good	
	Resistance welding: spot and seam	Good	
	butt	Good	

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	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	Cu Al9 Mn2	NCh 249 of. 68	—	—	—	—	—	—
France . . .	NF	—	—	—	—	—	—	—	—
Germany . .	DIN	Cu Al9 Mn	17 665	—	17 672	—	17 671	—	17 673
India . . .	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan . . .	JIS	—	—	—	—	—	—	—	—
Netherlands .	N or NEN [(b)]	—	—	—	—	—	—	—	—
South Africa .	SABS	—	—	—	—	—	—	—	—
Spain . . .	UNE	—	—	—	—	—	—	—	—
Sweden . . .	SIS	—	—	—	—	—	—	—	—
Switzerland .	VSM	—	—	—	—	—	—	—	—
United Kingdom .	BS	—	—	—	—	—	—	—	—
United States .	ASTM	—	—	—	—	—	—	—	—
International Organisation for Standardization	ISO	Cu Al9 Mn2	R428	—	—	—	—	—	—

(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 table	5.1.1
Hardness	,, ,,	5.1.1
Shear strength	,, ,,	5.1.1
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
Creep properties	see table	5.3.2.2

5.4 Fatigue properties

Fatigue strength at room temperature	see table	5.4.1

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.

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		
Plate Sheet	Annealed	50	20	35	$5.65\sqrt{S_o}$	120	125	38	3–30 mm thick
Rod[b]	Hot Worked	52	25	25	$5.65\sqrt{S_o}$	130	135	39	15–80 mm diam. or equivalent area
	Typical Cold Worked Temper	65	40	15	$5.65\sqrt{S_o}$	160	170	42	10–40 mm diam. or equivalent area
Forgings[b]	Hot Worked	55	28	25	$5.65\sqrt{S_o}$	135	140	41	—

(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.

(b) 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—SI and English Units

Tensile properties and hardness values in SI and English units are omitted from this data sheet, since alloys within the composition range concerned are not normally produced by British manufacturers.

5.1.3 Typical Tensile Properties and Hardness Values—American Units

Tensile properties and hardness values in American units are omitted from this data sheet, since alloys within the composition range concerned are not supplied by American manufacturers.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.2% offset kg/mm²	Elongation		Impact Strength [a]
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length	kg m/cm²
Plate [1] [2] **5 mm 0.2 in.**	Annealed	20 —165	68 —265	**54.6** **64**	34.5 40.5	77 500 91 000	**23.3** —	**35.5** **40**	[c] [c]	**9.2–11.0** **9.2–11.0**
[3] [b]	Annealed	20 — 78 —183	68 —108 —297	**53** **55** **63**	33.5 35 40	75 500 78 000 89 500	— — —	**36** **36** **33**	[c] [c] [c]	— — —

[a] Charpy test; KUF specimen; cross-sectional area at the notch not stated in original document, therefore impossible to give conversion from kg m/cm² to ft. lb.

[b] Form not stated in original document.

[c] Gauge length not stated in original document.

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.

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
Flat Products [4] (Bar) **12 mm 0.5 in.**	Hot Rolled	20 600 800	68 1 112 1 472	**42** **9** **0.8**	26.5 5.5 0.5	59 500 13 000 1 000	— — —	**25** **17** **70**	$5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$
Rod [5] **25 mm diam. 1 in. diam.**	Forged	20 100 200 300 400	68 212 392 572 752	**56** **52** **51** **51** **38**	35.5 33 32.5 32.5 24	79 500 74 000 72 500 72 500 54 000	**35** **32** **32** **31** **28**	**40** **30** **40** **36** **55**	$5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$ $5.65\sqrt{S_o}$

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.

—Further data can be obtained from the following paper:

- Rosenhain, W. and Lantsberry, F.C.A.H. On the Properties of Some Alloys of Copper, Aluminium and Manganese. Excerpt Minutes Proc. Inst. Mech. Engrs., London (1910), pp. 119-286.

5.3.2 Creep Properties

5.3.2.2 Stress for Designated Creep Rate

Form	Temper	Testing Temperature		Stress for Designated Creep Rate		
		°C	°F	1% per 1000 h		
				kg/mm²	ton/in²	psi
(6) (a)	(b)	300	572	**9.8**	6.2	13 900
		350	662	**4.6** (c)	2.9 (c)	6 500 (c)

(a) Form not stated in original document.
(b) Temper not stated in original document.
(c) Extrapolated value.
N.B.—Original values are printed in **bold type**; other values are converted.
—The stresses for 0.001%, 0.01% and 0.1% per 1 000 h creep rate values are not available.

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
Plate (5)	Forged	40	**52**	>**12** (a)	33	> 7.5 (a)	74 000	>17 000 (a)
Rod (5) **25 to 50 mm diam. 1 to 2 in. diam.**	Cold Worked	50	**65.5**	>**24** (a)	41.5	>15 (a)	93 000	>34 000 (a)
Rod (5) **50 mm diam. 2 in. diam.**	Forged	50	**74**	**26** (a)	47	16.5 (a)	105 500	37 000 (a)
Rod (5) **80 mm diam. 3.2 in. diam.**	Forged	20 20	**55** **50**	**19** (a) **18** (a)	35 31.5	12 (a) 11.5 (a)	78 500 71 000	27 000 (a) 25 500 (a)

(a) Rotating-bending test.
N.B.:—Original values are printed in **bold type**; other values are converted.
—Further data can be obtained from the following papers:

- Heubner, U., Jung-König, W. and Wincierz, P. Beitzag zur Biegewechselfestigkeit und Kerbempfindlichkeit von Kupferlegierungen — Teil 2. Metall, Vol. 21 (1967), pp. 1250-1254.
- Rosenhain, W. and Lantsberry, F.C.A.H. On the Properties of Some Alloys of Copper, Aluminium and Manganese. Excerpt Minutes Proc. Inst. Mech. Engrs., London (1910), pp. 119-286.

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(1) Weill-Couly, M. P. Comportamento delle Lamiere di Lega Inoxyda Saldate e non Saldate alla Temperatura dell'Azoto Liquido (—196°C). Simposio AIM, Napoli (Settembre, 1962).

(2) Weill-Couly, M. P. I Cupro Allumini e le Bassissime Temperature-Scelta di una Gradazione Criogenica – Comportamento di questi Materiali e loro Applicazioni. Simposio ATI, Milano (Dicembre, 1963).

(3) Propriétés des Alliages Cuivreux aux Basses Températures (The Properties of Copper Alloys at Low Temperatures). Cuivre, Laitons, Alliages, No. 74 (1963), July-August, pp. 41-43.

(4) Luzhnikov, L. P. Werkstoffe in Maschinenbau – Vol. 1: NE – Metalle und Legierungen. Izdatelstvo Mashinostroenie, Moskva (1967), 304 pp.

(5) Private communication from Fürstlich Hohenzollernsche Hüttenverwaltung Laucherthal, Hohenzollern, Germany.

(6) Vosskühler, H. Das Zeitstandverhalten der geknoteten Aluminiumbronzen und Mehrstoff-Aluminiumbronzen (Literaturübersicht V). Metall, Vol. 13, (1959), pp. 1017-1024.