WROUGHT MATERIALS

COPPER-NICKEL-ZINC ALLOYS
Nickel Silvers

Cu Ni12 Zn24

Common names: 12% Nickel Silver
Nickel Silver 65–12

A copper-nickel-zinc alloy with an alpha phase structure. The alloy has good corrosion resistance to rural, industrial and marine atmospheres and to fresh water. Since it has good cold formability and an attractive soft ivory-white colour, the material is often used for decorative applications. The most commonly used wrought forms are sheet, strip, rod, tube and wire.

COMPOSITION (weight %)

Cu	62.0–66.0
Ni	11.0–13.0
Mn	0– 0.5
Zn	rem.

1 SOME TYPICAL USES

Decorative
Holloware, flatware (spoons and forks), pressed, spun and deep-drawn articles usually silver plated; watch cases; jewellery; "objets d'art".

Electrical
Relay and contact springs, wiper blades, cross-bar switches, control parts and uniselector components, in telecommunications equipment (for less arduous service conditions); resistance wire and strip for moderately elevated temperatures; contacts, connectors, connector pins and terminals.

Mechanical
Springs and clips; rivets; Bourdon tubing.

Miscellaneous
Instrument and camera parts; slide fasteners; etching stock, nameplates and dials; musical instruments; fishing tackle.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.65 g/cm³	0.315 lb/in³
2.2	Melting range	1 000–1 060 °C	1 830–1 940 °F
2.3	Coefficient of thermal expansion (linear) at:		
	20 to 100 °C *68 to 212 °F*	0.000 015 per °C	0.000 008 per °F
	20 to 300 °C *68 to 572 °F*	0.000 016 „ „	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*	0.08 cal cm/cm² s °C	19 Btu ft/ft² h °F
	200 °C *392 °F*	0.09 „	22 „
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	4.6 m/ohm mm²	8% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	0.22 ohm mm²/m 22 microhm cm	130 ohms (circ mil/ft) 8.5 microhm in
2.8	Temperature coefficient of electrical resistance at:		
	20 °C *68 °F* (annealed or cold worked) applicable over range from 0 to 100 °C *32 to 212 °F*	0.000 4 per °C (8% IACS)	0.000 2 per °F (8% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68°F*:		
	annealed	12 300 kg/mm²	17 500 000 lb/in²
	cold worked	13 100 kg/mm²	18 600 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	annealed	4 600 kg/mm²	6 500 000 lb/in²
	cold worked	4 900 kg/mm²	6 900 000 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 7); 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	1 150–1 225 °C	2 100–2 235 °F
3.2	Annealing temperature range	600– 750 °C	1 110–1 380 °F
	Stress relieving temperature range	250– 350 °C	480– 660 °F
3.3	Hot working temperature range	850– 925 °C	1 560– 1 695 °F
3.4	Hot formability	Very limited	
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)	25	
3.8	Joining methods:	See General Data Sheet No. 3.10	
	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	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	NS104	—	H77 H83	—	—	—	—	—
Belgium	NBN	Cu63 Ni12 Zn	—	266.41	266.41	266.41	—	—	—
Canada	CSA	HC. ZN2312 757	—	—	HC.5.4	HC.5.22	—	—	—
Chile	NCh (INDITECNOR)	—	NCh 251 of. 68	—	—	—	—	—	—
France	NF	—	—	—	—	—	—	—	—
Germany	DIN	Cu Ni12 Zn24	17 663	17 670	17 672	17 677 17 682	17 671	—	—
India	IS	Cu Ni12 Zn25 NS 12	—	3332 2283	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	NSP 3 NSB 3 NSR 3 NSW 3	—	H3701	H3711	H3721	—	—	—
Netherlands	N or NEN [b]	Cu-Ni12 Zn24	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Zn Ni12	—	37 103	—	—	—	—	—
Sweden	SIS	52 43 Cu Ni12 Zn24	—	14 52 43	14 52 43	14 52 43	—	—	—
Switzerland	VSM	Cu Ni12 Zn24	10 804	10 804	10 804	10 804	10 804	—	—
United Kingdom	BS	NS104	—	1824 2870	—	2873	—	—	—
United States [c]	ASTM	No. 757	—	B151	B151	B206	—	—	—
International Organisation for Standardization	ISO	Cu Ni12 Zn24	R430	—	—	—	—	—	—

(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.

(c) In the United States, bar and flat wire are covered under the Plate-Sheet-Strip column.

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	no data
Impact properties	,, ,,

5.3 Mechanical properties at elevated temperature

Short-time tensile properties	see table 5.3.1
Impact properties	no data
Creep properties	,, ,,

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		
Sheet Strip	Annealed (grain size 0.035 mm)	39	16	48	50 mm	80	85	29	0.2–2 mm thick
Sheet Strip	Annealed (grain size 0.015 mm)	44	21	45	50 mm	90	95	33	0.2–2 mm thick
Sheet Strip	Typical Cold Worked Tempers	45	32	32	50 mm	120	125	32	0.5–2 mm thick
		50	42	22	50 mm	145	150	35	0.2–2 mm thick
		60	54	10	50 mm	165	175	36	0.1–1 mm thick
		70	67	5	50 mm	190	200	38	0.1–1 mm thick
Rod [c]	Annealed	38	15	50	$5.65\sqrt{S_o}$	85	90	28	5–25 mm diam. or equivalent area
Rod [c]	Typical Cold Worked Temper	50	43	16	$5.65\sqrt{S_o}$	140	145	35	5–15 mm diam. or equivalent area
Wire	Annealed	38	—	50	100 mm	—	—	28	0.5–3 mm diam.
Wire	Typical Cold Drawn Temper	85	—	1	100 mm	—	—	42	0.2–1 mm diam.
Tube	Annealed	39	15	50	$5.65\sqrt{S_o}$	80	85	29	10–30 mm O.D., 1–3 mm wall
Tube	Typical Cold Drawn Temper	48	38	18	$5.65\sqrt{S_o}$	140	145	33	10–30 mm O.D., 1–3 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, SI and 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—SI and 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		Proof Stress 0.1% offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown (b)
		hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Sheet Strip	Annealed (grain size 0.040 mm)	39	25	14	9	45	50 mm (2 in.)	85	29	19	0.2–3 mm (0.008–0.12 in.) thick
	Grade 5 (soft) (c)	—	—	—	—	—	—	100	—	—	0.2–1 mm (0.008–0.04 in.) thick
	Cold Worked Half Hard	48	31	32	21	20	50 mm (2 in.)	145	31	20	0.2–3 mm (0.008–0.12 in.) thick
	Grade 4 (c)	—	—	—	—	—	—	155	—	—	0.2–1 mm (0.008–0.04 in.) thick
	Hard	56	36	45	29	8	50 mm (2 in.)	170	34	22	0.2–3 mm (0.008–0.12 in.) thick
	Grade 3 (c)	—	—	—	—	—	—	180	—	—	0.2–1 mm (0.008–0.04 in.) thick
	Extra Hard	66	43	57	37	~3	50 mm (2 in.)	195	37	24	0.2–3 mm (0.008–0.12 in.) thick
	Grade 2 (c)	—	—	—	—	—	—	210	—	—	0.2–1 mm (0.008–0.04 in.) thick
Rod (d)	Annealed	37	24	12	8	45	$5.65\sqrt{S_o}$	85	28	18	—
	Typical Cold Worked Temper	51	33	37	24	13	$5.65\sqrt{S_o}$	155	36	23	4–12 mm (0.16–0.5 in.) diam. or equivalent area
Wire	Annealed	39	25	—	—	40	100 mm (4 in.)	—	29	19	0.5–2.5 mm (0.02–0.10 in.) diam.
	Cold Drawn Half Hard	59	38	—	—	~5	100 mm (4 in.)	—	—	—	0.5–2.5 mm (0.02–0.10 in.) diam.
	Hard	74	48	—	—	—	—	—	—	—	0.5–2.5 mm (0.02–0.10 in.) diam.

(a) The recognised temper designations used in the relevant British Standards are also given.
(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) Strip for the telecommunications industry; the material is similar to but harder than the corresponding annealed, half hard, hard and extra hard tempers defined for general-purpose sheet and strip in the relevant British Stanadard.
(d) 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		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown [(a)]
				%	gauge length	F	B	30 T		
Flat Products (Sheet, Strip, Bar and Flat Wire)	Annealed									
	(grain size 0.070 mm)	52 000	18 000	48	2 in.	69	22	27	39 000	0.040 in. thick
	(grain size 0.050 mm)	54 000	19 000	45	2 in.	73	30	33	41 000	0.040 in. thick
	(grain size 0.035 mm)	56 000	21 000	42	2 in.	78	37	38	42 000	0.040 in. thick
	(grain size 0.025 mm)	59 000	24 000	38	2 in.	82	45	44	44 000	0.040 in. thick
	(grain size 0.015 mm)	61 000	28 000	35	2 in.	88	55	51	45 000	0.040 in. thick
	Cold Worked									
	Eighth Hard	60 000	35 000	32	2 in.	—	60	55	42 000	0.040 in. thick
	Quarter Hard	65 000	45 000	23	2 in.	—	70	63	43 000	0.040 in. thick
	Half Hard	73 000	60 000	11	2 in.	—	80	70	44 000	0.040 in. thick
	Hard	85 000	75 000	4	2 in.	—	89	75	51 000	0.040 in. thick
	Extra Hard	93 000	79 000	2	2 in.	—	92	77	52 000	0.040 in. thick
Rod [(b)]	Annealed	55 000	20 000	45	2 in.	—	35	—	42 000	1.0 in. diam.
	Cold Worked	80 000	65 000	12	2 in.	—	80	—	52 000	1.0 in. diam.
Wire	Annealed									
	(grain size 0.070 mm)	50 000	—	50	10 in.	—	—	—	38 000	0.080 in. diam.
	(grain size 0.050 mm)	52 000	—	48	10 in.	—	—	—	39 000	0.080 in. diam.
	(grain size 0.035 mm)	56 000	—	45	10 in.	—	—	—	42 000	0.080 in. diam.
	(grain size 0.025 mm)	58 000	—	40	10 in.	—	—	—	43 000	0.080 in. diam.
	(grain size 0.015 mm)	63 000	—	35	10 in.	—	—	—	47 000	0.080 in. diam.
	Cold Worked									
	Eighth Hard (10%)	65 000	—	25	10 in.	—	—	—	45 000	0.080 in. diam.
	Quarter Hard (20%)	72 000	—	10	10 in.	—	—	—	47 000	0.080 in. diam.
	Half Hard (37%)	85 000	—	7	10 in.	—	—	—	55 000	0.080 in. diam.
	Hard (60%)	105 000	—	5	10 in.	—	—	—	63 000	0.080 in. diam.
	Extra Hard (75%)	120 000	—	3	10 in.	—	—	—	66 000	0.080 in. diam.
	Spring (84%)	130 000	—	1	10 in.	—	—	—	71 000	0.080 in. diam.

(a) It is possible to obtain sizes different from those given in this column, but information on their mechanical properties should be obtained from metal manufacturers.

(b) 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

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

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	Elongation	
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	%	gauge length
Strip [1]	Cold worked [a]	20 100 200	68 212 392	**67** **67** **65**	42.5 42.5 41.5	95 500 95 500 92 500	**63** **65** **63**	**2** — —	50 mm — —

[a] Quoted as "hard, 205 HV" in original document, but amount of cold work not defined.

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 × 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
Strip [b] [2] 0.74 mm 0.029 in.	Cold Worked 50%	100	72	22.5 [a]	45.5	14.5 [a]	**102 300**	**32 000** [a]
Strip [b] [2] 0.81 mm 0.032 in.	Cold Worked 37.2%	100	72	19.5 [a]	46	12.5 [a]	**102 700**	**28 000** [a]
Strip [b] [2] 0.91 mm 0.036 in.	Cold Worked 20.7%	100	68	18.5 [a]	43	11.5 [a]	**96 700**	**26 000** [a]
Strip [b] [2] 1.1 mm 0.043 in.	Cold Worked 10.9%	100	60	17.5 [a]	38	11 [a]	**85 100**	**25 000** [a]

[a] Reversed-bending test.

[b] Alloy composition: Cu 60.08%; Ni 10.89%; Zn 29.05%; Fe 0.20%.

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

— Further data can be obtained from the following paper:

■ Weldon, B.A., Towers, J.A. and Patton, A.M. Nickel Silver as an Engineering Material. Metals & Materials, Vol. 4 (1970), pp. 299-303; also Copper and Its Alloys. Inst. Metals Monograph and Report Series No. 34 (1970), pp. 298-302. (data for 1 mm strip, hardness 195-200 HV, deflected to maximum and returned to zero position).

REFERENCE

MECHANICAL PROPERTIES (SECTION 5)

(1) Weldon, B.A., Towers, J.A. and Patton, A.M. Nickel Silver as an Engineering Material. Metals & Materials, Vol. 4 (1970), pp. 299-303.

(2) Gohn, G.R., Guerard, J.P. and Herbert, G.J. The Mechanical Properties of Some Nickel Silver Alloy Strips. Proc. ASTM. Vol. 54 (1954), pp. 229-256

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