WROUGHT MATERIALS

COPPER-NICKEL-ZINC ALLOYS
Nickel Silvers

Cu Ni10 Zn27

Common names: 10% Nickel Silver
Nickel Silver 65–10

A copper-nickel-zinc alloy with an alpha phase structure. The material, which is slightly yellow in colour, has good corrosion resistance to rural and marine atmospheres and to fresh water. The alloy has good cold-working properties. The most commonly used wrought forms are sheet and strip.

COMPOSITION (weight %)

Cu	61.0–65.0
Ni	9.0–11.0
Mn	0– 0.5
Zn	rem.

1 SOME TYPICAL USES

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

Electrical
Resistance wire and strip for moderately elevated temperatures; contacts; connectors, connector pins and terminals.

Mechanical
Rivets and clips.

Miscellaneous
Instrument and camera parts; slide fasteners; etching stock, nameplates and dials.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.60 g/cm³	0.310 lb/in³
2.2	Melting range	980–1 035 °C	1 795–1 895 °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*	0.09 cal cm/cm² s °C	22 Btu ft/ft² h °F
	200 °C *392 °F*	0.11 „	27 „
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	4.9 m/ohm mm²	8.5% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	0.20 ohm mm²/m 20 microhm cm	122 ohms (circ mil/ft) 8.0 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 (8.5% IACS)	0.000 2 per °F (8.5% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*:		
	annealed	12 000 kg/mm²	17 100 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	annealed	4 400 kg/mm²	6 300 000 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. 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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DATA SHEET No. L 1
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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	1 125–1 200 °C	2 055–2 190 °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	Good	
3.6	Cold reduction between anneals	70% 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	NS103	—	H 77	—	—	—	—	—
Belgium	NBN	—	—	—	—	—	—	—	—
Canada	CSA	HC. ZN2140 745	—	HC. 4.4	—	—	—	—	—
Chile	NCh (INDITECNOR)	—	NCh 251 of. 68	—	—	—	—	—	—
France	NF	U-Z28 N9	—	A53-605	—	—	—	—	—
Germany	DIN	—	—	—	—	—	—	—	—
ndia	IS	NS 10	—	2283	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	NSP 4 NSR 4 NSW 4	—	H3701	—	H3721	—	—	—
Netherlands	N or NEN [b]	Cu-Ni10 Zn27	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Zn Ni10	37 103	37 103	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	NS103	—	2870	—	2873	—	—	—
United States [c]	ASTM	No. 745	—	B122 B151	B151	B206	—	—	—
International Organisation for Standardization	ISO	Cu Ni10 Zn27	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	no data
Impact properties	,, ,,
Creep properties	,, ,,

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. 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 % on 50 mm	Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [a]
					Brinell	Vickers		
Sheet Strip	Annealed (grain size 0.035 mm)	39	15	52	80	85	29	0.2–2 mm thick
	(grain size 0.015 mm)	43	20	48	90	95	32	0.2–2 mm thick
	Typical Cold Worked Tempers	46	32	25	120	125	32	0.5–2 mm thick
		52	45	12	145	150	34	0.2–2 mm thick
		60	56	6	170	180	36	0.2–1 mm thick

(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.

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)	37	24	14	9	50	50 mm (2 in.)	80	28	18	0.2–3 mm (0.008–0.12 in.) thick
	(grain size 0.025 mm)	40	26	19	12	47	50 mm (2 in.)	90	29	19	0.2–3 mm (0.008–0.12 in.) thick
	Cold Worked Half Hard	46	30	31	20	22	50 mm (2 in.)	140	29	19	0.2–3 mm (0.008–0.12 in.) thick
	Hard	54	35	43	28	10	50 mm (2 in.)	170	32	21	0.2–3 mm (0.008–0.12 in.) thick
	Extra Hard	65	42	56	36	~3	50 mm (2 in.)	190	32	21	0.2–3 mm (0.008–0.12 in.) thick
Rod [c]	Annealed	36	23	12	8	50	$5.65\sqrt{S_o}$	80	26	17	—
	Typical Cold Worked Temper	49	32	36	23	15	$5.65\sqrt{S_o}$	150	32	21	4–12 mm (0.16–0.5 in.) diam. or equivalent area
Wire	Annealed	37	24	—	—	45	100 mm (4 in.)	—	28	18	0.5–2.5 mm (0.02–0.10 in.) diam
	Cold Drawn Half Hard	57	37	—	—	~5	100 mm (4 in.)	—	—	—	0.5–2.5 mm (0.02–0.10 in.) diam.
	Hard	73	47	—	—	—	—	—	—	—	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 meta manufacturers.
(c) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

* 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.

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 Flat Wire)	Annealed									
	(grain size 0.070 mm)	49 000	18 000	49	2 in.	67	22	30	37 000	0.040 in. thick
	(grain size 0.050 mm)	51 000	19 000	46	2 in.	71	28	34	38 000	0.040 in. thick
	(grain size 0.035 mm)	53 000	20 000	43	2 in.	76	35	38	40 000	0.040 in. thick
	(grain size 0.025 mm)	56 000	23 000	40	2 in.	80	42	44	42 000	0.040 in. thick
	(grain size 0.015 mm)	60 000	28 000	36	2 in.	85	52	51	45 000	0.040 in. thick
	Cold Worked									
	Eighth Hard	60 000	35 000	34	2 in.	—	60	55	42 000	0.040 in. thick
	Quarter Hard	65 000	45 000	25	2 in.	—	70	63	43 000	0.040 in. thick
	Half Hard	73 000	60 000	12	2 in.	—	80	70	44 000	0.040 in. thick
	Hard	86 000	75 000	4	2 in.	—	89	76	51 000	0.040 in. thick
	Extra Hard	95 000	76 000	3	2 in.	—	92	78	53 000	0.040 in. thick
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.	—	—	—	50 000	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.

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

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 $\times 10^6$	Metric Units kg/mm²		English Units ton/in²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Strip [f] [1] **0.56 mm 0.022 in.**	Cold Worked 30.9%	100	62	19.5 [a]	39.5	12.5 [a]	**88 000**	**28 000** [a]
Strip [f] [1] **0.64 mm 0.025 in.**	Cold Worked 17.2%	100	53.5	17 [a]	34	10.5 [a]	**76 000**	**24 000** [a]
Strip [f] [1] **0.71 mm 0.028 in.**	Cold Worked 10.9%	100	48.5	19 [a]	31	12 [a]	**69 000**	**27 000** [a]
Strip [f] [1] **0.81 mm 0.032 in.**	Annealed	100	43	14 [a]	27	9 [a]	**61 000**	**20 000** [a]
—[b] [c] [2]	Cold Drawn	100 [d]	41.5	12 [e]	26	7.5 [e]	**58 700**	**17 000** [e]

[a] Reversed-bending test.
[b] Alloy composition: Cu 60.08%; Ni 10.89%; Zn 29.05%; Fe 0.20%.
[c] Form not stated in original document, but probably rod.
[d] Estimated.
[e] Rotating-cantilever test.
[f] Alloy composition: Cu 60.7%; Ni 9.5%; Mn 0.07% Fe 0.10%; Pb 0.02%; Zn rem.

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

REFERENCES

MECHANICAL PROPERTIES (SECTION 5)

(1) 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.
(2) McAdam, D.J., Jr. Fatigue and Corrosion-Fatigue of Spring Material. Trans. ASME., No. 51, (1929), pp. 45-58.

Printed by James Upton Ltd., Birmingham and London

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) (grain size 0.015 mm)	39 44	16 21	48 45	50 mm 50 mm	80 90	85 95	29 33	0.2–2 mm thick 0.2–2 mm thick
	Typical Cold Worked Tempers	45 50 60 70	32 42 54 67	32 22 10 5	50 mm 50 mm 50 mm 50 mm	120 145 165 190	125 150 175 200	32 35 36 38	0.5–2 mm thick 0.2–2 mm thick 0.1–1 mm thick 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
	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.
	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
	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 × 10⁶	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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WROUGHT MATERIALS

COPPER-NICKEL-ZINC ALLOYS
Nickel Silvers

Cu Ni15 Zn21

Common names: 15% Nickel Silver
Nickel Silver 65–15

A copper-nickel-zinc alloy with an alpha phase structure. The alloy has good corrosion resistance in many environments, and on account of its pleasing silver-white colour, is selected for many decorative applications. The material has excellent cold formability. The most commonly used wrought forms are sheet, strip, rod and wire.

COMPOSITION (weight %)

Cu	62.0–66.0
Ni	14.0–16.0
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; medals and medallions; jewellery and fancy buttons; architectural panels and trim; "objets d'art".

Electrical
Contacts, connectors, connector pins and terminals; resistance wire and strip for moderately elevated temperatures.

Mechanical
Springs and clips; rivets.

Miscellaneous
Instrument and camera parts; etching stock, nameplates and dials; musical instruments; slide fasteners; deep-drawn products.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.70 g/cm³	0.315 lb/in³
2.2	Melting range	1 040–1 090 °C	1 905–1 995 °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*	0.07 cal cm/cm² s °C	17 Btu ft/ft² h °F
	200 °C *392 °F*	0.08 ,,	19 ,,
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	4.1 m/ohm mm²	7% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	0.25 ohm mm²/m 25 microhm cm	148 ohms (circ mil/ft) 9.7 microhm in
2.8	Temperature coefficient of electrical resistance at:		
	20 °C *68 °F* (annealed or cold worked)	0.000 3 per °C (7% IACS)	0.000 2 per °F (7% 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	12 700 kg/mm²	18 100 000 lb/in²
	cold worked	13 200 kg/mm²	18 800 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	annealed	4 700 kg/mm²	6 700 000 lb/in²
	cold worked	4 900 kg/mm²	7 000 000 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.

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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	1 175–1 250 °C	2 145–2 280 °F
3.2 Annealing temperature range	625– 775 °C	1 155–1 425 °F
Stress relieving temperature range	250– 350 °C	480– 660 °F
3.3 Hot working temperature range	900– 975 °C	1 650–1 785 °F
3.4 Hot formability	Very limited	
3.5 Cold formability	Excellent	
3.6 Cold reduction between anneals	80% 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	NS105	—	H77	—	—	—	—	—
Belgium . . .	NBN	—	—	—	—	—	—	—	—
Canada . . .	CSA	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	—	—	—	—	—	—	—	—
France . . .	NF	U-Z22 N15	—	A53-605	—	—	—	—	—
Germany . . .	DIN	—	—	—	—	—	—	—	—
India	IS	NS15	—	2283	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	NSP 3 NSB 3 NSR 3 NSW 3	—	H3701	H3711	H3721	—	—	—
Netherlands .	N or NEN [(b)]	—	—	—	—	—	—	—	—
South Africa .	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Zn Ni15	—	37 103	—	—	—	—	—
Sweden . . .	SIS	—	—	—	—	—	—	—	—
Switzerland . .	VSM	—	—	—	—	—	—	—	—
United Kingdom . .	BS	NS105	—	2870	—	2873	—	—	—
United States .	ASTM	—	—	—	—	—	—	—	—
International Organisation for Standardization	ISO	Cu Ni15 Zn21	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.

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
Modulis 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	no data
Impact properties	,, ,,
Creep properties	,, ,,

5.4 Fatigue properties

Fatigue strength at room temperature	no data

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)	41	16	45	50 mm	85	90	31	0.2–2 mm thick
	Annealed (grain size 0.015 mm)	45	22	38	50 mm	100	105	34	0.2–2 mm thick
	Typical Cold Worked Tempers	47	36	25	50 mm	125	130	33	0.5–2 mm thick
		53	47	15	50 mm	150	155	34	0.2–2 mm thick
		61	57	8	50 mm	170	180	36	0.1–1 mm thick
Rod[c]	Annealed	40	16	45	$5.65\sqrt{S_o}$	85	90	30	5–25 mm diam. or equivalent area
	Typical Cold Worked Temper	52	43	16	$5.65\sqrt{S_o}$	145	150	34	5–15 mm diam. or equivalent area
Wire	Annealed	41	—	40	100 mm	—	—	31	0.5–3 mm diam.
	Typical Cold Drawn Temper	63	—	6	100 mm	—	—	38	0.2–2 mm diam.

(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)	40	26	15	10	45	50 mm (2 in.)	90	29	19	0.2–3 mm (0.008–0.12 in.) thick
	(grain size 0.025 mm)	42	27	20	13	42	50 mm (2 in.)	100	31	20	0.2–3 mm (0.008–0.12 in.) thick
	Cold Worked										
	Half Hard	49	32	37	24	15	50 mm (2 in.)	150	34	22	0.2–3 mm (0.008–0.12 in.) thick
	Hard	57	37	48	31	6	50 mm (2 in.)	175	37	24	0.2–3 mm (0.008–0.12 in.) thick
	Extra Hard	68	44	59	38	~2	50 mm (2 in.)	200	40	26	0.2–3 mm (0.008–0.12 in.) thick
Rod [c]	Annealed	39	25	14	9	45	$5.65\sqrt{S_o}$	90	29	19	—
	Typical Cold Worked Temper	53	34	42	27	10	$5.65\sqrt{S_o}$	160	37	24	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	62	40	—	—	<5	100 mm (4 in.)	—	—	—	0.5–2.5 mm (0.02–0.10 in.) diam.
	Hard	76	49	—	—	—	—	—	—	—	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) 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)	Annealed									
	(grain size 0.070 mm)	53 000	18 000	43	2 in.	69	22	27	40 000	0.040 in. thick
	(grain size 0.050 mm)	55 000	19 000	42	2 in.	73	31	33	42 000	0.040 in. thick
	(grain size 0.035 mm)	57 000	21 000	40	2 in.	79	39	41	43 000	0.040 in. thick
	(grain size 0.025 mm)	59 000	24 000	37	2 in.	82	46	46	44 000	0.040 in. thick
	(grain size 0.015 mm)	61 000	28 000	34	2 in.	89	55	53	45 000	0.040 in. thick
	Cold Worked									
	Eighth Hard	60 000	35 000	30	2 in.	—	60	55	42 000	0.040 in. thick
	Quarter Hard	65 000	49 000	21	2 in.	—	70	63	43 000	0.040 in. thick
	Half Hard	74 000	62 000	10	2 in.	—	80	70	44 000	0.040 in. thick
	Hard	85 000	75 000	3	2 in.	—	87	75	51 000	0.040 in. thick
	Extra Hard	92 000	79 000	2	2 in.	—	90	77	53 000	0.040 in. thick
	Spring	97 000	—	—	—	—	92	—	58 000	0.040 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 metal manufacturers.

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

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

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

Printed in Engle ' by James Upton Ltd., Birmingham and London

WROUGHT MATERIALS

COPPER-NICKEL-ZINC ALLOYS
Nickel Silvers

Cu Ni18 Zn20

Common names: 18% Nickel Silver
Nickel Silver 65–18

A copper-nickel-zinc alloy with an alpha phase structure. The alloy has good corrosion resistance to many organic products, waters and corrosive atmospheres. The material has good cold formability and spring properties and is widely used for telecommunications equipment in European practice; because of its attractive silver-blue-white colour, it is also widely used for decorative applications. The most commonly used wrought forms are sheet, strip, rod and wire.

COMPOSITION (weight %)

Cu	60.0–64.0
Ni	17.0–19.0
Mn	0– 0.7
Zn	rem.

1 SOME TYPICAL USES

Decorative
Holloware, flatware (spoons and forks), pressed, spun and deep-drawn articles usually silver plated; lighting fittings; medals and medallions; jewellery; architectural panels and trim (including marine service); "objets d'art".

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

Mechanical
Springs and clips; rivets; bellows and pressure-sensitive devices.

Miscellaneous
Instrument and camera parts; etching stock, nameplates and dials; musical instruments; side wires of spectacle frames; slide fasteners; medical instruments; model construction.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.75 g/cm³	0.315 lb/in³
2.2	Melting range	1 060–1 110 °C	1 940–2 030 °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*	0.06 cal cm/cm² s °C	15 Btu ft/ft² h °F
	200 °C *392 °F*	0.07 ,,	17 ,,
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	3.5 m/ohm mm²	6% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	0.29 ohm mm²/m 29 microhm cm	173 ohms (circ mil/ft) 11 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 3 per °C (6% IACS)	0.000 2 per °F (6% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*:		
	annealed	13 300 kg/mm²	18 900 000 lb/in²
	cold worked	13 700 kg/mm²	19 500 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	annealed	4 900 kg/mm²	7 000 000 lb/in²
	cold worked	5 000 kg/mm²	7 200 000 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. The melting range covers the highest liquidus and lowest solidus temperatures over the composition range quoted.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 8); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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CONSEIL INTERNATIONAL POUR LE DEVELOPPEMENT DU CUIVRE (CIDEC)
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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	1 175–1 250 °C	2 145–2 280 °F
3.2	Annealing temperature range	625– 775 °C	1 155–1 425 °F
	Stress relieving temperature range	250– 350 °C	480– 660 °F
3.3	Hot working temperature range	900– 975 °C	1 650–1 785 °F
3.4	Hot formability	Very limited	
3.5	Cold formability	Good	
3.6	Cold reduction between anneals	70% 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	Very good	
	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	NS106	—	H77	—	—	—	—	—
Belgium	NBN	—	—	—	—	—	—	—	—
Canada	CSA	HC.ZN 1817 752	—	HC.4.4	—	—	—	—	—
Chile	NCh (INDITECNOR)	—	NCh 251 of. 68	—	—	—	—	—	—
France	NF	U-Z22 N18	—	A53-605	—	—	—	—	—
Germany	DIN	Cu Ni18 Zn20	17 663	1780 17 670	17 672	17 677 17 682	17 671	—	—
India	IS	NS18	—	2283	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	NSP 2 NSB 2 NSR 2 NSW 2	—	H3701	H3711	H3721	—	—	—
Netherlands	N or NEN [(b)]	Cu-Ni18 Zn20	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Zn Ni18	—	37 103	—	—	—	—	—
Sweden	SIS	52 46 Cu Ni18 Zn20	—	14 52 46	—	—	—	—	—
Switzerland	VSM	Cu Ni18 Zn20	10 804	10 804	10 804	10 804	10 804	—	—
United Kingdom	BS	NS106	—	2870	—	2873	—	—	—
United States [(c)]	ASTM	No. 752	—	B 122 B 151	B 151	B 206	—	—	—
International Organization for Standardization	ISO	Cu Ni18 Zn20	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	see table 5.2.1
Impact properties	no data

5.3 Mechanical properties at elevated temperature

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

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)	42	19	45	50 mm	90	95	32	0.2–2 mm thick
	(grain size 0.015 mm)	45	22	40	50 mm	100	110	34	0.2–2 mm thick
	Typical Cold Worked Tempers	48	36	25	50 mm	125	130	33	0.5–2 mm thick
		54	46	15	50 mm	155	165	35	0.2–2 mm thick
		62	55	9	50 mm	185	195	37	0.1–1 mm thick
		70	67	3	50 mm	200	210	38	0.1–1 mm thick
Rod [c]	Annealed	41	17	43	$5.65\sqrt{S_o}$	85	90	31	5–25 mm diam. or equivalent area
	Typical Cold Worked Tempers	50	38	25	$5.65\sqrt{S_o}$	140	145	35	5–25 mm diam. or equivalent area
		60	55	10	$5.65\sqrt{S_o}$	175	185	36	5–15 mm diam. or equivalent area
Wire	Annealed	42	—	38	100 mm	—	—	32	0.5–3 mm diam.
	Typical Cold Drawn Tempers	58	—	9	100 mm	—	—	35	0.5–3 mm diam.
		70	—	2	100 mm	—	—	38	0.2–1 mm diam.

(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 0.030 mm)	42	27	17	11	40	50 mm (2 in.)	100	31	20	0.2–3 mm (0.008–0.12 in.) thick
	(grain size 0.015 mm)	45	29	23	15	35	50 mm (2 in.)	105	34	22	0.2–3 mm (0.008–0.12 in.) thick
	Cold Worked										
	Half Hard	51	33	37	24	12	50 mm (2 in.)	155	36	23	0.2–3 mm (0.008–0.12 in.) thick
	Hard	59	38	48	31	6	50 mm (2 in.)	180	39	25	0.2–3 mm (0.008–0.12 in.) thick
	Extra Hard	68	44	59	38	~2	50 mm (2 in.)	205	45	29	0.2–3 mm (0.008–0.12 in.) thick
Rod [(c)]	Annealed	40	26	15	10	40	$5.65\sqrt{S_o}$	95	29	19	—
	Typical Cold Worked Temper	54	35	42	27	8	$5.65\sqrt{S_o}$	165	37	24	4–12 mm (0.16–0.5 in.) thick or equivalent area
Wire	Annealed	42	27	—	—	35	100 mm (4 in.)	—	31	20	0.5–2.5 mm (0.02–0.10 in.) diam.
	Cold Drawn										
	Half Hard	63	41	—	—	<5	100 mm (4 in.)	—	—	—	0.5–2.5 mm (0.02–0.10 in.) diam.
	Hard	77	50	—	—	—	—	—	—	—	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) 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 Flat Wire)	Annealed									
	(grain size 0.035 mm)	58 000	25 000	40	2 in.	85	40	—	44 000	0.040 in. thick
	(grain size 0.015 mm)	60 000	30 000	32	2 in.	90	55	—	45 000	0.040 in. thick
	Cold Worked									
	Quarter Hard	65 000	50 000	20	2 in.	—	73	65	43 000	0.040 in. thick
	Half Hard	74 000	62 000	8	2 in.	—	83	72	44 000	0.040 in. thick
	Hard	85 000	74 000	3	2 in.	—	87	75	51 000	0.040 in. thick
	Extra Hard	92 000	—	—	—	—	92	—	55 000	0.020 in. thick
	Spring	97 000	—	—	—	—	94	—	58 000	0.020 in. thick
Rod [b]	Annealed (grain size 0.035 mm)	56 000	25 000	42	2 in.	—	40	—	42 000	0.50 in. diam.
	Cold Worked Half Hard	70 000	60 000	20	2 in.	—	78	—	47 000	0.50 in. diam.
Wire	Annealed									
	(grain size 0.035 mm)	58 000	25 000	45	10 in.	—	—	—	44 000	0.080 in. diam.
	(grain size 0.015 mm)	60 000	30 000	35	10 in.	—	—	—	45 000	0.080 in. diam.
	Cold Worked									
	Quarter Hard	73 000	65 000	16	10 in.	—	—	—	47 000	0.080 in. diam.
	Half Hard	86 000	80 000	7	10 in.	—	—	—	55 000	0.080 in. diam.
	Hard	103 000	90 000	3	10 in.	—	—	—	61 000	0.080 in. diam.
Tube	Annealed	60 000	24 000	40	2 in.	—	45	—	45 000	1.0 in. O.D. × 0.065 in. wall
	Cold Worked Hard Drawn	80 000	65 000	5	2 in.	—	88	—	52 000	1.0 in. O.D. × 0.065 in. wall

(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

Form	Temper	Testing Temperature °C	Testing Temperature °F	Tensile Strength kg/mm²	Tensile Strength ton/in²	Tensile Strength psi	Yield Strength psi	Elongation % on 2 in.	Reduction of Area %
Rod [1]	Annealed	20	68	45.5	29	**64 900**	**29 500** [a]	**46.8**	**62.3**
		—183	—297	58.5	37	**83 100**	**38 200** [a]	**56.8**	**69.5**
	Cold Rolled	20	68	52	33	**73 800**	**69 300** [a]	**21.5**	**54.3**
		—183	—297	66	42	**93 700**	**80 500** [a]	**35.5**	**62.6**

(a) Quoted as yield point, but offset strain not defined.

N.B.: Original values are printed in **bold type**; other values are converted.
Data not available:
Proof stress, 0.1% and 0.2% offset and yield strength (0.5% extension under load).
Impact Strength.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties—Impact Properties

Form	Temper	Testing Temperature °C	Testing Temperature °F	Tensile Strength kg/mm²	Tensile Strength ton/in²	Tensile Strength psi	Proof Stress 0.2% offset kg/mm²	Elongation %	Elongation gauge length	Reduction of Area %	Impact Strength [b] kg m/cm²	Impact Strength [b] ft lb
Strip [2]	Cold Worked [a]	20	68	**71**	45	101 000	**65**	**5**	50 mm	—	—	—
		100	212	**70**	44.5	99 500	**65**	—	—	—	—	—
		200	392	**68**	43	96 500	**63**	—	—	—	—	—
Rod [3] 6 mm diam. 0.24 in. diam.	Annealed	20	68	**38.0**	24	54 000	—	**40**	30 mm	**79**	**17.3**	93.8
		250	482	**37.5**	24	53 500	—	**38**	30 mm	**69**	**13.3**	72.1
		300	572	**37.0**	23.5	52 500	—	**38**	30 mm	**64**	**12.4**	67.2
		330	626	—	—	—	—	—	—	—	**12.3**	66.7
		340	644	**35.0**	22	50 000	—	**36**	30 mm	**65**	—	—
		380	716	—	—	—	—	—	—	—	**12.1**	65.6
		450	842	**29.0**	18.5	41 000	—	**50**	30 mm	**73**	—	—

(a) Quoted as "hard, 208 HV" in original document, but amount of cold work not defined.

(b) Charpy test, V notch; cross sectional area at the notch 0.75 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 to ft lb taking into account the cross-sectional area of the specimen at the notch.
Data not available: Proof stress, 0.1% offset.
Yield Strength, 0.5% extension under load.

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 [4] **0.30–0.35 mm 0.012–0.014 in.**	Cold Rolled 50%	10	**68**	**19** [f]	43	12 [f]	96 500	27 000 [f]
Strip [5] **1 mm 0.04 in.**	Cold Worked [g] 37% 60.5%	100 100	64.5 70.5	19.5 [h] 22 [h]	41 44.5	12.5 [h] 14 [h]	**92 000** **100 000**	**28 000** [h] **31 000** [h]
Rod [6] [d] **13 mm diam. 0.5 in. diam.**	Cold Worked 21% [c]	300	51.5	16	32.5	10.5	**72 900**	**23 000**
— [e] [7]	Cold Drawn	100 [a]	44	15.5 [b]	28	10 [b]	**62 400**	**22 000** [b]

(a) Estimated.
(b) Rotating-cantilever test.
(c) Ready-to-finish grain size 0.030 mm.
(d) Composition: Cu 64.64%; Zn 16.22%; Ni 18.90%,; Mn 0.21%; Fe 0.03%.
(e) Form not stated in original document but probably rod (Composition: Cu 65.30%, Ni 17.63%, Zn 17.15%, Fe 0.23%).
(f) Flexural-alternating test.
(g) Ready-to-finish grain size 0.015 mm.
(h) Reversed-bending test.

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 (data for 1 mm strip, hardness 205 HV, deflected to maximum and returned to zero position).

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WROUGHT MATERIALS

COPPER-NICKEL-ZINC ALLOYS Nickel Silvers

Cu Ni18 Zn27

Common names: 18% Nickel Silver
Nickel Silver 55–18

A copper-nickel-zinc alloy with an alpha phase structure. The material, which is silver-white in colour, has good corrosion resistance to many organic products, waters and corrosive atmospheres. It is essentially a spring alloy widely used in the telecommunications field. The most commonly used wrought forms are sheet and strip.

COMPOSITION (weight %)

Cu	53.0–56.0
Ni	17.0–19.0
Mn	0– 0.5
Zn	rem.

1 SOME TYPICAL USES

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

Mechanical
Springs and clips.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.70 g/cm³	0.315 lb/in³
2.2	Melting range	1 000–1 070 °C	1 830–1 960 °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*	0.09 cal/g °C	0.09 Btu/lb °F
2.5	Thermal conductivity at:		
	20 °C *68 °F*	0.06 cal cm/cm² s °C	15 Btu ft/ft² h °F
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	3.2 m/ohm mm²	5.5% IACS
2.7	Electrical resistivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	0.31 ohm mm²/m 31 microhm cm	189 ohms (circ mil/ft) 12 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 3 per °C (5.5% IACS)	0.000 2 per °F (5.5% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*:		
	annealed	13 400 kg/mm²	19 100 000 lb/in²
	cold worked	14 000 kg/mm²	19 900 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*:		
	annealed	5 000 kg/mm²	7 100 000 lb/in²
	cold worked	5 200 kg/mm²	7 400 000 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

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	650– 800 °C	1 200–1 470 °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	Good	
3.6	Cold reduction between anneals	65% 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. 3.10	
	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	NS107	—	H 83	—	—	—	—	—
Belgium	NBN	Cu55 Ni18 Zn	—	266.41	266.41	266.41	—	—	—
Canada	CSA	HC. ZN2718 770	—	HC.4.4	—	—	—	—	—
Chile	NCh (INDITECNOR)	—	NCh 251 of. 68	—	—	—	—	—	—
France	NF	U-Z27 N18 × 85	—	A53-605	—	—	—	—	—
Germany	DIN	—	—	—	—	—	—	—	—
India	IS	Cn Ni18 Zn27	—	3332	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	NSSP NSBS NSSR NSWS NSSPS NSSRS	—	H3702	H3711	H3721	—	—	—
Netherlands	N or NEN [b]	Cu-Ni18 Zn27	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cn Zn Ni54-18	—	37 103	37 103	37 103	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	Cu Ni18 Zn27	10 804	10 804	—	—	—	—	—
United Kingdom	BS	NS107	—	1824 2870	—	2873	—	—	—
United States [c]	ASTM	No. 770	—	B 122 B 151	B 151	B 206	—	—	—
International Organisation for Standardization	ISO	Cu Ni18 Zn27	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 *

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 % on 50 mm	Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [(a)]
					Brinell	Vickers		
Sheet Strip	Annealed	44	21	48	100	105	33	0.2–2 mm thick
	Typical Cold Worked Tempers	65 74 80	58 68 75	6 4 2	190 215 225	200 225 235	42 44 45	0.2–2 mm thick 0.1–1 mm thick 0.1–1 mm thick

(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.

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	
Strip [(c)]	Annealed Grade 5—Soft (grain size 0.030 mm)	42	27	19	12	45	50 mm (2 in.)	100	31	20	0.2–1 mm (0.008–0.04 in.) thick
	Cold Worked Grade 4 Grade 3 Grade 2 Grade 1—extra hard	53 57 63 77	34 37 41 50	37 45 54 68	24 29 35 44	25 15 8 ~2	50 mm (2 in.) 50 mm (2 in.) 50 mm (2 in.) 50 mm (2 in.)	155 180 210 240	— — — 46	— — — 30	0.2–1 mm (0.008–0.04 in.) thick 0.2–1 mm (0.008–0.04 in.) thick 0.2–1 mm (0.008–0.04 in.) thick 0.2–1 mm (0.008–0.04 in.) thick
Rod [(d)]	Annealed	40	26	17	11	45	$5.65\sqrt{S_o}$	95	29	19	—
	Typical Cold-Worked Temper	60	39	48	31	10	$5.65\sqrt{S_o}$	190	42	27	4–12 mm (0.16–0.5 in.) diam. or equivalent area
Wire	Annealed	42	27	—	—	40	100 mm (4 in.)	—	31	20	0.5–2.5 mm (0.02–0.10 in.) diam.
	Cold Drawn Half Hard Hard	68 80	44 52	— —	— —	<5 —	100 mm (4 in.) —	— —	— —	— —	0.5–2.5 mm (0.02–0.10 in.) diam. 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) Material for the telecommunications industry.

(d) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

* 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.

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, Bar and Strip, Flat Wire)	Annealed (grain size 0.035 mm)	60 000	27 000	40	2 in.	90	55	—	45 000	0.040 in. thick
	Cold Worked									
	Quarter Hard	78 000	—	—	—	—	72	—	54 000	0.040 in. thick
	Half Hard	90 000	—	—	—	—	83	—	62 000	0.040 in. thick
	Hard	100 000	85 000	3	2 in.	—	91	77	65 000	0.040 in. thick
	Extra Hard	108 000	90 000	2.5	2 in.	—	96	80	70 000	0.040 in. thick
	Spring	115 000	—	2.5	2 in.	—	99	81	74 000	0.040 in. thick
Rod[b]	Annealed	60 000	24 000	45	2 in.	—	50	—	45 000	1.0 in. diam.
	Cold Worked Hard	80 000	60 000	15	2 in.	—	80	—	56 000	1.0 in. diam.
Wire	Annealed (grain size 0.035 mm)	60 000	—	40	10 in.	—	—	—	45 000	0.080 in. diam.
	Cold Worked									
	Extra Hard	120 000	—	2	10 in.	—	—	—	78 000	0.080 in. diam.
	Spring (68%)	145 000	—	1.5	10 in.	—	—	—	87 000	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 kg/mm²	Elongation % on 50 mm
		°C	°F	kg/mm²	ton/in²	psi		
Strip [1]	Cold Worked [a]	20 100 200	68 212 392	**80** **81** **78**	51 51.5 49.5	114 000 115 000 111 000	**69** **73** **77**	**2** — —

[a] Quoted as "hard, 240 HV" in original document, but amount of cold work not defined.

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.

5.4 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
Strip [2] 0.51 mm 0.02 in.	Annealed	100	43.5	11 [a]	28	7 [a]	**62 200**	**16 000** [a]
	Cold Worked 37.2% 50% [b] 60.5% [c] 68%	 100 100 100 100	 67 76.5 79 83	 14.5 [a] 16 [a] 16.5 [a] 17.5 [a]	 42.5 48.5 50 52.5	 9 [a] 10.5 [a] 10.5 [a] 11 [a]	 **95 400** **108 500** **112 400** **117 700**	 **20 500** [a] **23 000** [a] **23 750** [a] **25 000** [a]
Strip [2] 0.64 mm 0.025 in.	Cold Worked 20.7%	100	56	16 [a]	35.5	10.5 [a]	**79 300**	**23 000** [a]
Strip [3] 1 mm 0.04 in.	Cold Worked [d] 37% 60.5%	 100 100	 76 82.5	 20.5 [a] 22.5 [a]	 48 52	 13 [a] 14.5 [a]	 **108 000** **117 000**	 **29 000** [a] **32 000** [a]

[a] Reversed-bending test.
[b] Ready-to-finish grain size 0.022 mm.
[c] Ready-to-finish grain size 0.090 mm.
[d] Ready-to-finish grain size 0.015 mm.

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.

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MECHANICAL PROPERTIES (SECTION 5)

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(3) France, W.D. and Trout, D.E. Selecting Copper Alloys for Fatigue Applications. Metal Progress, Vol. 101 (1972), No. 6, pp. 69, 71-72.

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