

Cu Ni44 Mn1Common names: 55/45 Copper-Nickel
"Constantan"

A copper-nickel alloy with an alpha phase structure. The alloy usually contains small amounts of iron and manganese. It is characterised by fairly high electrical resistivity and a very low temperature coefficient of electrical resistance. The material is easily fabricated and readily weldable. The most commonly used wrought forms are strip and wire.

COMPOSITION (weight %)

Ni	43.0-45.0
Mn	0.5- 2.0
Fe	0 - 0.5
Cu	rem.

1 SOME TYPICAL USES**Electrical**

Precision instrument and control resistors operating at moderately elevated temperatures; thermocouple wires and compensating leads; components for thermionic valves; heating elements; bimetal thermostats and switches.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C 68 °F	8.90 g/cm ³	0.320 lb/in ³
2.2 Melting range (a)	1 225-1 300 °C	2 235-2 370 °F
2.3 Coefficient of thermal expansion (linear) at:		
-183 to 20 °C -297 to 68 °F	0.000 012 per °C	0.000 007 per °F
20 to 300 °C 68 to 572 °F	0.000 015 " "	0.000 008 " "
20 to 500 °C 68 to 932 °F	0.000 016 " "	0.000 009 " "
20 to 1 000 °C 68 to 1 832 °F	0.000 019 " "	0.000 010 " "
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	0.05 cal cm/cm ² s °C	12 Btu ft/ft ² h °F
2.6 Electrical conductivity (volume) at:		
-269 °C -452 °F (annealed)	2.0 m/ohm mm ²	3.5% IACS
20 °C 68 °F (annealed or cold worked)	2.0 " "	3.5 " "
200 °C 392 °F (" " " ")	2.0 " "	3.5 " "
2.7 Electrical resistivity (volume) at:		
-269 °C -452 °F (annealed)	0.49 ohm mm ² /m 49 microhm cm	296 ohms (circ mil/ft) 19 microhm in
20 °C 68 °F (annealed or cold worked)	0.49 ohm mm ² /m 49 microhm cm	296 ohms (circ mil/ft) 19 microhm in
200 °C 392 °F (" " " ")	0.49 ohm mm ² /m 49 microhm cm	296 ohms (circ mil/ft) 19 microhm in
2.8 Temperature coefficient of electrical resistance at:		
20 °C 68 °F (annealed or cold worked)	± 0.000 04 per °C (3.5% IACS)	± 0.000 02 per °F (3.5% 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	16 800 kg/mm ²	23 900 000 lb/in ²
cold worked ^(b)	16 000 kg/mm ²	22 800 000 lb/in ²
2.10 Modulus of rigidity (torsion) at 20 °C 68 °F		
annealed	6 200 kg/mm ²	8 800 000 lb/in ²
cold worked ^(b)	5 900 kg/mm ²	8 400 000 lb/in ²

(a) The melting range covers the highest liquidus and lowest solidus temperatures over the composition range quoted. The values are based on: Hansen, M. and Anderko, K. Constitution of Binary Alloys. 2nd ed. (1958) McGraw-Hill, London, New York; more recent work (Feest, E.A. and Doherty, R.D. The Cu-Ni Equilibrium Phase Diagram. J. Inst. Metals, Vol. 99 (1971), pp. 102-103) indicates that the solidus temperature may be slightly higher.

(b) Approximately 50% cold work.

N.B.: The values shown in Section 2, which have been appropriately rounded in view of the composition range involved, are based on selected literature references.

INDEX NUMBERS RELATE TO LITERATURE REFERENCES (see page 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	1 350–1 425 °C	2 460–2 595 °F
3.2 Annealing temperature range	700– 875 °C	1 290–1 605 °F
Stress relieving temperature range	300– 400 °C	570– 750 °F
3.3 Hot working temperature range	950–1 050 °C	1 740–1 920 °F
3.4 Hot formability		Good
3.5 Cold formability		Good
3.6 Cold reduction between anneals		50% max.
3.7 Machinability:		See General Data Sheet No. 2
Machinability rating (free cutting brass = 100)		20
3.8 Joining methods:		See General Data Sheet No. 3.9
Soldering		Excellent
Brazing		Excellent
Oxy-acetylene welding		—
Carbon-arc welding		Not recommended
Gas-shielded arc welding		Excellent
Coated metal-arc welding		—
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	Cu Ni44 Fe Mn	—	266.31	—	266.31	—	—	—
Canada	CSA	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	Cu Ni44 Fe Mn	NCh 250. of 68	—	—	—	—	—	—
France	—	Cu Ni44 Fe Mn	—	—	—	—	—	—	—
Germany	DIN	Cu Ni44	17 664	17 670	—	17 471 17 672 46 460	—	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	—	—	—	—	—	—	—	—
Netherlands	N or NEN ^(b)	—	—	—	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	Cu Ni44 Mn	—	10 803	—	10 803	—	—	—
United Kingdom	BS	—	—	—	—	—	—	—	—
United States	ASTM	—	—	—	—	—	—	—	—
International Organization for Standardization	ISO	Cu Ni44 Mn1	R 429	—	—	—	—	—	—

(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 temperatures

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

5.2 Mechanical properties at low temperature

Tensile properties	see table 5.2.1
Impact properties	„ „ 5.2.1

5.3 Mechanical properties at elevated temperature

Short-time tensile properties	see table 5.3.1
Creep properties	see tables 5.3.2.2

5.4 Fatigue properties

Fatigue strength at room temperature	see table 5.4.1
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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/mm ²	Proof Stress 0.2% offset kg/mm ²	Elongation		Hardness		Shear Strength kg/mm ²	Typical Size Related to Properties Shown ^(a)
				%	gauge length	Brinell	Vickers		
Strip	Annealed	48	20	45	50 mm	95	100	36	0.5–3 mm thick
	Typical Cold Worked Temper	68	55	5	50 mm	165	175	44	0.5–2 mm thick
Wire	Annealed	48	—	32	100 mm	—	—	36	0.5–3 mm diam.
	Typical Cold Drawn Temper	70	—	6	100 mm	—	—	45	0.5–2 mm diam.

(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	Tensile Strength		Proof Stress 0.1% offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown ^(a)
		hbar	ton/in ²	hbar	ton/in ²	%	gauge length		hbar	ton/in ²	
Strip	Annealed ^(b)	46	30	19	12	45	50 mm (2 in.)	120	36	23	—
	Typical Cold Worked Temper	65	42	53	34	5	50 mm (2 in.)	180	42	27	0.2–3 mm (0.008–0.125 in.) thick
Wire	Annealed ^(b)	45	29	—	—	40	100 mm (4 in.)	—	34	22	2.5–5 mm (0.1–0.2 in.) diam.
		48	31	—	—	35	100 mm (4 in.)	—	37	24	0.5–2 mm (0.02–0.08 in.) diam.
		51	33	—	—	30	100 mm (4 in.)	—	39	25	0.2–0.4 mm (0.008–0.016 in.) diam.

(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) This alloy is usually supplied in the annealed condition, for applications involving its important electrical resistance characteristics.

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 (Strip)	Annealed	65 000	28 000	40	2 in.	—	78	—	49 000	0.040 in. thick
	Cold Worked 37%	95 000	82 000	4	2 in.	—	90	—	62 000	0.040 in. thick
Wire	Annealed	65 000	—	25	20 in.	—	—	—	—	up to 0.039 in. diam. over 0.039 in. diam.
		65 000	—	35	4 in.	—	—	—	—	
	Cold Worked	78 000	—	6	8 in.	—	—	—	—	0.040–0.118 in. diam.
		93 000	—	4	8 in.	—	—	—	—	0.021–0.039 in. diam.
		115 000	—	3	8 in.	—	—	—	—	0.004–0.02 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 the metal manufacturers.

(*) 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.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress 0.1% offset ton/in ²	Elongation		Reduction of Area %	Impact ^(b) Strength	
		°C	°F	kg/mm ²	ton/in ²	psi		%	gauge length		kg m/cm ²	ft lb
Rod ⁽¹⁾ 25 mm diam. 1 in. diam.	Annealed ^(a)	20	68	42	26.8	60 000	8.74	40.2	2 in.	77.0	13.9	80.5
		— 10	14	46.5	29.5	66 000	8.21	46.9	2 in.	78.0	—	—
		— 40	— 40	47.5	30.2	67 500	9.38	42.6	2 in.	77.5	14.7	85.0
		— 80	—112	51	32.25	72 000	9.86	48.4	2 in.	75.0	14.0	81.0
		—120	—184	54	34.4	77 000	10.74	48.0	2 in.	74.0	14.3	83.0
		—180	—292	63	40.0	89 500	11.73	57.4	2 in.	76.0	14.9	86.0
	Annealed ^(c)	20	68	43	27.2	61 000	9.35	49.0	2 in.	77.0	13.9	80.5
		—180	—292	62	39.4	88 500	24.0 ^(d)	60.0	2 in.	74.0	14.9	86.0

(a) Tensile specimen 6.35 mm (0.25 in.) diam.

(b) Izod specimen; cross-sectional area at the notch 0.8 cm².

(c) Tensile specimen 12.8 mm (0.505 in.) diam.

(d) Quoted as "yield point" in original document, but offset strain not defined.

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

— All converted values for impact strength are to be taken as indicative only; the impact energy has been converted from ft lb into kg m/cm² taking into account the actual cross-sectional area of the specimen at the notch.

— Data not available: Proof stress, 0.2% 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			Elongation	
		°C	°F	kg/mm ²	ton/in ²	psi	%	gauge length
Wire ⁽²⁾ 1 mm diam. 0.04 in. diam.	Annealed	20	68	50	31.5	71 000	30	100 mm
		400	752	41	26	58 500	19	100 mm
Wire ⁽³⁾ 1 mm diam. 0.04 in. diam.	Cold Drawn ^(a)	20	68	74	47	105 500	1	100 mm
		100	212	70	44.5	99 500	1	100 mm
		200	392	65	41.5	92 500	1	100 mm
		300	572	59	37.5	84 000	1	100 mm
		400	752	53	33.5	75 500	1	100 mm
		500	932	43	27.5	61 000	1	100 mm
		600	1 112	33	21	47 000	3	100 mm
		700	1 292	12.5	8	18 000	6	100 mm
800	1 472	8.5	5.5	12 000	8	100 mm		

(a) Quoted as "hard drawn" 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% and 0.2% offset,
Yield strength, 0.5% extension under load.

5.3.2 Creep Properties

5.3.2.1 Original Creep Data

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

5.3.2.2 Stress for Rupture

Form	Temper	Testing Temperature		Stress			Time for Rupture h
		°C	°F	kg/mm ²	ton/in ²	psi	
— ⁽⁴⁾	Annealed	452	845	24.6	15.6	35 000	498
				28.1	17.9	40 000	67.6
				31.6	20.1	45 000	9.3
				35.2	22.3	50 000	1.06

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 $\times 10^6$	Metric Units kg/mm ²		English Units ton/in ²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Rod ⁽⁵⁾ 25 mm diam. 1 in. diam.	Hot Rolled	80	49.5	24.5 ^(a)	31.5	15.5 ^(a)	70 500	34 500 ^(a)
Rod ⁽⁶⁾	Annealed	80	49	19.5 ^(a)	31	12.5 ^(a)	69 500	28 000 ^(a)
	Cold Worked and Stress Relieved ^(b)	100	68	29 ^(a)	43	18.5 ^(a)	96 500	41 000 ^(a)
	Cold Worked	40	73	30 ^(a)	46	19 ^(a)	103 500	43 000 ^(a)
Wire ⁽²⁾ 3 mm diam. 0.12 in. diam.	Annealed	10	50	21 ^(c)	31.5	13.5 ^(c)	71 000	30 000 ^(c)
— ^(d) ⁽⁷⁾	Annealed	^(g)	44	17.5 ^(c)	28	11 ^(c)	62 500	25 000 ^(c)
	Cold Worked ^(f)	^(g)	54	22 ^(c)	34.5	14 ^(c)	77 000	31 500 ^(c)
— ^(d) ⁽⁸⁾	— ^(e)	20	41.4	17	26.5	11	59 000	24 000

(a) Rotating cantilever test.

(b) Stress relieved for 3h at 399°C (750°F).

(c) Bending-fatigue test.

(d) Form not stated in original document.

(e) Temper not stated in original document, but probably annealed.

(f) Quoted as "half hard" in original document, but amount of cold work not defined.

(g) Number of cycles not stated in original document.

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

REFERENCES

MECHANICAL PROPERTIES (Section 5)

- (1) Colbeck, E.W. and MacGillivray, W.E. The Mechanical Properties of Metals at Low Temperatures. Part 2: Non-Ferrous Materials. Trans. Instn. Chem. Engrs, Vol. 11 (1933), pp. 107-123.
- (2) Private communication from Siemens, A.G., Germany.
- (3) Schulze, A. Über metallische elektrische Widerstandswerkstoffe für technische Widerstände und Heizwiderstände. Elektrotechnik, Vol. 2 (1948), No. 1, pp. 17-24.
- (4) Blucher, J.T. and Grant, N.J. Recrystallization, Tensile and Stress-Rupture Properties of Nickel-Copper Alloys. Proc. ASTM, Vol. 62 (1962), pp. 593-601.
- (5) McAdam, Jr., D.J. Endurance Properties of Alloys of Nickel and of Copper - Part 1. Trans. ASST, Vol. 7 (1925), pp. 54-81.
- (6) Wilkins, R.A. and Bunn, E.S. Copper and Copper-Base Alloys. McGraw-Hill Book Co., New York (1943).
- (7) Hempel, M. Dauerschwingverhalten der Werkstoffe. VDI-Z., Vol. 104 (1962), No. 27, pp. 1362-1377.
- (8) Weller, J. and Weissgerber, R. Festigkeitseigenschaften von Cu Ni Fe Mn - Werkstoffen. Institut für Leichtbau IFL - Mitteilungen, Dresden, Vol. 7 (1968), pp. 288-296.