UDC 669.35'24'1'74

Cu Ni5 Fe1 Mn

Common names: 95/5 Copper-Nickel-Iron
95/5 Cupro-nickel
Cupro-nickel, 95/5

A copper-nickel alloy with an alpha phase structure. Small amounts of iron and manganese are added to improve corrosion resistance in slow-moving clean seawater. The alloy is relatively insensitive to stress corrosion and has good cold- and hot-working properties. The most commonly used wrought forms are plate, sheet and tube.

COMPOSITION (weight %)

Ni	4.5–6.0
Fe	1.0–1.5
Mn	0.3–0.8
Cu	rem.

1 SOME TYPICAL USES

Marine
Tubes carrying seawater for fire mains, cooling-water circuits and sanitary services on board ship.

Mechanical
Shell bands.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.90 g/cm³	0.320 lb/in³
2.2 Melting range [a]	1 090–1 125 °C	1 995–2 055 °F
2.3 Coefficient of thermal expansion (linear) at:		
−183 to 10 °C *−297 to 50 °F*	0.000 014 per °C	0.000 008 per °F
20 ,, 300 °C *68 ,, 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*	0.15 cal cm/cm² s °C	36 Btu ft/ft² h °F
2.6 Electrical conductivity (volume) at:		
20 °C *68 °F* (annealed or cold worked)	8.1 m/ohm mm²	14% IACS
200 °C *392 °F* (,, ,, ,, ,,)	6.4 ,,	11 ,, ,,
2.7 Electrical resistivity (volume) at:		
20 °C *68 °F* (annealed or cold worked)	0.12 ohm mm²/m 12 microhm cm	74 ohms (circ mil/ft) 4.8 microhm in
200 °C *392 °F* (,, ,, ,, ,,)	0.16 ohm mm²/m 16 microhm cm	94 ohms (circ mil/ft) 6.2 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*	0.001 2 per °C (14% IACS)	0.000 7 per °F (14% IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*		
annealed	13 500 kg/mm²	19 200 000 lb/in²
cold worked [b]	12 400 kg/mm²	17 600 000 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 [b]	4 600 kg/mm²	6 500 000 lb/in²

[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 8); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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DATA SHEET No. K 1
© Cu Ni5 Fe1 Mn
1972 Edition

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	1 200–1 275 °C	2 190–2 325°F
3.2	Annealing temperature range	600– 825 °C[(a)]	1 110–1 515 °F[(a)]
	Stress relieving temperature range	275– 400 °C	525– 750 °F
3.3	Hot working temperature range	825– 950 °C	1 515–1 740 °F
3.4	Hot formability	Good	
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)	20	
3.8	Joining methods:	See General Data Sheet No. 3.9	
	Soldering	Excellent	
	Brazing	Good [(b)]	
	Oxy-acetylene welding	Good [(b)]	
	Carbon-arc welding	Not recommended	
	Gas-shielded arc welding	Good [(b)]	
	Coated metal-arc welding	Good [(b)]	
	Resistance welding: spot and seam	Good [(b)]	
	butt	Good [(b)]	

(a) To preserve optimum corrosion resistance, annealing temperature should be within the range 750–825°C *(1 380 – 1 515°F)*.

(b) Post-welding heat treatment above 750°C *(1 380°F)* is necessary to preserve optimum corrosion resistance at joints; accordingly, brazing operations are not always practicable.

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

and ISO Recommendation

Country	Designation of Standards	Designation of Material in Standards	Specification for Chemical Composition [a]	Plate Sheet Strip	Rod	Wire	Tube	Sections / Shapes	Forgings
Australia	SAA	—	—	—	—	—	—	—	—
Belgium	NBN	—	—	—	—	—	—	—	—
Canada	CSA	HC.NF52	—	—	—	—	HC.7.3 HC.7.4	—	—
Chile	NCh (INDITECNOR)	Cu Ni5 Fe1 Mn	NCh 250. of 68	—	—	—	—	—	—
France	—	Cu Ni5 Fe1 Mn	—	—	—	—	—	—	—
Germany	DIN	CuNi5 Fe	17 664	17 670	—	—	17 671	—	—
India	IS	—	—	—	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	—	—	—	—	—	—	—	—
Netherlands	N or NEN [b]	Cu Ni5 Fe1 Mn	NEN 6030	—	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	CN101	—	1541 2870 2875	—	—	2871 [c]	—	—
United States	ASTM	No. 704	—	—	—	—	B111 B359 B395 B466	—	—
International Organization for Standardization	ISO	Cu Ni5 Fe1 Mn	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.
(c) Included in imperial units edition (1957) but deleted from metricated revision (1972).

5 MECHANICAL PROPERTIES

5.1 Mechanical properties at room temperature

- Tensile properties — see tables 5.1.1/3
- Hardness — „ „ 5.1.1/3
- Shear Strength — „ „ 5.1.1/3
- 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 5.3.2.2/3

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 American practice, see table 5.1.3.

The values shown represent reasonable approximations for general engineering use, taking account of variations in composition and manufacturing procedures. For design purposes, national specifications should be consulted.

For a given temper, individual elongation values may show some variation above or below the typical values indicated.

Form	Temper	Tensile Strength kg/mm²	Proof Stress 0.2% offset kg/mm²	Elongation		Hardness		Shear Strength kg/mm²	Typical Size Related to Properties Shown [a]
				%	gauge length	Brinell	Vickers		
Plate Sheet Strip	Annealed	28	9	40	$5.65\sqrt{S_o}$	60	63	21	1–20 mm thick
	Typical Cold Worked Temper	38	35	10	$5.65\sqrt{S_o}$	100	105	27	1–10 mm thick
Tube [b]	Annealed (grain size 0.025 mm)	32	13	35	$5.65\sqrt{S_o}$	65	68	24	10–30 mm O.D. 1–3 mm wall

[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] Tubes for condensers and heat exchangers are generally supplied in the annealed temper whose representative mechanical properties are shown.

5.1.2 Typical Tensile Properties and Hardness Values—SI and English Units

Tensile properties and hardness values in SI and English units are omitted from this data sheet, since alloys within the composition range concerned are no longer in regular production by British manufacturers.

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 practice in European countries, see table 5.1.1.

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 (Plate, Sheet, Strip)	As Hot Rolled	35 000	15 000	40	2 in.	—	48	—	28 000	2 in. thick
	Annealed	38 000	12 000	41	2 in.	—	8	—	30 000	0.040 in. thick
	Cold Worked 37%	62 000	59 000	6	2 in.	—	71	—	40 000	0.040 in. thick
Tube [b]	Annealed (grain size 0.025 mm)	41 000	14 000	46	2 in.	58	—	—	31 000	1.0 in. O.D. × 0.065 in. wall
	Cold Worked Light Drawn	48 000	36 000	18	2 in.	—	67	—	34 000	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 the metal manufacturers.

[b] Tubes for condensers and heat exchangers are generally supplied in the annealed or light-drawn tempers whose representative mechanical properties are shown.

[*] It will be noted that tables 5.1.1, and 5.1.3, giving typical tensile properties and hardness values in Metric, 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 ton/in² [(a)]	Elongation		Reduction of Area %	Impact Strength [(b)]	
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length		kg m/cm²	ft lb
Plate [(c) (1)] 13–19 mm 0.5–0.75 in.	[(d)]	14	57	29	**18.3**	41 000	**15.3**	**37**	1.5 in.	**70.5**	37.1	**134**
		− 20	− 4	29	**18.4**	41 000	**15.1**	**38**	1.5 in.	**71.0**	—	—
		− 50	− 58	31	**19.6**	44 000	**15.9**	**40**	1.5 in.	**70.0**	37.1	**134**
		−100	−148	32.5	**20.5**	46 000	**15.9**	**40**	1.5 in.	**69.0**	42.3	**153**
		−150	−238	35	**22.2**	49 500	**16.5**	**40**	1.5 in.	**62.0**	46.5	**168**
		−196	−321	39.5	**25.1**	56 000	**17.2**	**51**	1.5 in.	**55.0**	42.9	**155**

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

(b) Charpy test; V notch; cross-sectional area at the notch 0.5 cm².

(c) Results of Navy tear tests on this alloy are also included in ref. (1)

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

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% and 0.1% offset,
Yield strength, 0.5% extension under load.

5.3 MECHANICAL PROPERTIES AT ELEVATED TEMPERATURE

5.3.1 Short-Time Tensile Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress			Elongation	
		°C	°F	kg/mm²	ton/in²	psi	0.2% offset kg/mm²	0.1% offset ton/in²	Yield Strength 0.5% ext. under load psi	%	gauge length
Plate [2]	Annealed	20	68	30.5	**19.5**	43 500	**17.2** [a]	**10.2**	—	**40**	2 in.
		66	150	29	**18.3**	41 000	**16.9** [a]	**9.9**	—	**41**	2 in.
		121	250	27	**17.2**	38 500	**16.4** [a]	**9.6**	—	**40**	2 in.
		177	350	26	**16.5**	37 000	**15.0** [a]	**8.7**	—	**38**	2 in.
		232	450	25	**15.8**	35 500	**15.4** [a]	**9.1**	—	**35**	2 in.
		288	550	24	**15.2**	34 000	**15.1** [a]	**9.0**	—	**34**	2 in.
		316	600	23.5	**14.9**	33 500	**14.3** [a]	**8.6**	—	**34**	2 in.
Rod [3] **29 mm diam. 1.125 in. diam.**	Annealed (grain size 0.045 mm)	20	68	29	**18.3**	41 000	**15.4** [a]	**9.2**	—	**52**	$4\sqrt{S_0}$
		200	392	25.5	**16.3**	36 500	**15.3** [a]	**9.0**	—	**46**	$4\sqrt{S_0}$
		450	842	21.5	**13.6**	30 500	**15.6** [a]	**9.2**	—	**8**	$4\sqrt{S_0}$
		500	932	19.5	**12.3**	27 500	**14.3** [a]	**8.3**	—	**6**	$4\sqrt{S_0}$
		550	1 022	16	**10.3**	23 000	**13.2** [a]	**7.9**	—	**4**	$4\sqrt{S_0}$
— [b] [c] [4]	Cold Worked 37%	200	392	40	25.5	**57 100**	—	—	—	**15.0**	2 in.
		300	572	37	23.5	**52 300**	—	—	**51 500**	**11.0**	2 in.
		400	752	32	20	**45 200**	—	—	**44 200**	**6.5**	2 in.
		500	932	27	17	**38 600**	—	—	**37 700**	**5.5**	2 in.
		600	1 112	21	13.5	**30 200**	—	—	**29 800**	**6.5**	2 in.
		700	1 292	9.5	6	**13 800**	—	—	**12 300**	**27.0**	2 in.

(a) This value was originally reported in ton/in²; in this table it is given in kg/mm² to 3 significant figures.
(b) Form not stated in original document.
(c) Alloy containing 1.60% Fe.

N.B. : — Original values are printed in **bold type**; other values are converted.
— Further data can be obtained from the following papers:

- Simakovskii, A. P. Properties of Cu-Cr and Cu-Ni Alloys at Elevated Temperatures. Metalloved i Obrabotka Met. (1958), No. 6, pp. 41–47 (tests up to 350°C *(662°F)* on 20 mm sheet, hot rolled or annealed).
- Kuz'mina, N. S. Experiments in the Production of Tubes from a Copper-Nickel Alloy with Iron and Manganese (Alloy MN5). Izvest. Vyssh. Ucheb. Zaved. MVO, Razdel Tsvet. Met., (1958), No. 1, pp. 153–163 (tests on extruded material).

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 Designated Creep Rate

Form	Temper	Testing Temperature		Stress for Designated Creep Rate					
				0.01% per 1 000 h			0.1% per 1 000 h		
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi
Rod (3) **29 mm diam.** **1.125 in. diam.**	Annealed (grain size 0.045 mm)	450 500	842 932	1.6 0.32 (a)	**1.0** **0.2** (a)	2 200 450 (a)	4.3 1.7	**2.7** **1.1**	6 000 2 500

(a) Extrapolated value.

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

5.3.2.3 Stress for Rupture

Form	Temper	Testing Temperature		Stress for Rupture								
				in 10 h			in 100 h			in 10 000 h		
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi
Tube (5)	Annealed	279 321 349	535 610 660	— — —	— — —	— — —	— — —	— — —	— — —	12.0 9.6 5.0	7.6 6.1 3.2	**17 000** **13 600** **7 100**
(a) (4)	Cold Worked 37%	300 400 500	572 752 932	28.2 16.0 9.1	17.9 10.2 5.8	**40 100** **22 800** **12 900**	24.5 11.5 5.2	15.6 7.3 3.3	**34 900** **16 300** **7 400**	— — —	— — —	— — —

(a) Form not stated in original document.

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

— Further data can be obtained from the following papers:

- Simakovskii, A.P. Properties of Cu–Cr and Cu–Ni Alloys at Elevated Temperatures. Metalloved i Obrabotka Met. (1958), No. 6, pp. 41–47.
- Kuz'mina, N.S. Experiments in the Production of Tubes from a Copper-Nickel Alloy with Iron and Manganese (Alloy MN5). Izvest. Vyssh. Ucheb. Zaved. MVO, Razdel Tsvet. Met., (1958), No. 1, pp. 153–163. (creep tests up to 1 000°C *(1 830°F)* on as-extruded tube).
- Bearham, J.H. and Parker, R.J. Elevated-Temperature Tensile, Stress-Rupture and Creep Data for Six Copper-Base Materials. Metallurgia (Manchr), Vol. 78 (1968), pp. 9–14. (stress-rupture properties of annealed rod).
- Parker, R.J. Estimation of Stress-Rupture Properties from Hot Hardness Tests, Metallurgia (Manchr.), Vol. 67 (1963), pp. 219–223 (stress-rupture tests at 450°C *(842°F)*).

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
Sheet [6] **5 mm 0.2 in.**	Annealed	2	**24.5**	**11.5** [e]	15.5	7.5 [e]	35 000	16 500 [e]
	Cold Worked	2	**28**	**13** [e]	18	8.5 [e]	40 000	18 500 [e]
Strip [7] **6 mm 0.25 in.**	Cold Worked 25%	100	—	~ 9.5 [a]	—	**~ 6** [a]	—	~13 500 [a]
Rod [8] **23 mm diam. 0.9 in. diam.**	Annealed	100	31	13.5 [b]	**19.7**	**8.5** [b]	44 000	19 000 [b]
	Cold Worked 25%	100	41	17.5 [b]	**26.0**	**11.2** [b]	58 000	25 000 [b]
	Cold Worked 50%	100	47.5	19 [b]	**30.2**	**12.1** [b]	67 500	27 000 [b]
— [c] [9]	— [d]	20	**33.6**	**17**	21.5	11	48 000	24 000

[a] Reversed-bending test.
[b] Rotating-beam test.
[c] Form not stated in original document.
[d] Temper not stated in original document.
[e] Alternating-bending test.
N.B.: Original values are printed in **bold type**; other values are converted.

REFERENCES

MECHANICAL PROPERTIES (Section 5)

(1) Lismer, R.E. The Properties of Some Metals and Alloys at Low Temperatures. J. Inst. Metals, Vol. 89 (1960–61), pp. 145–161.
(2) Ashbolt, D. and Bowers, J.E. The Properties of Copper and Copper Alloys at Elevated Temperatures. BNFMRA Research Report A1550 (1965).
(3) Bearham, J.H. and Parker, R.J. Elevated-Temperature Tensile, Stress-Rupture and Creep Data for Six Copper-Base Materials. Metallurgia (Manchr), Vol. 78 (1968), pp. 9–14.
(4) Pels, A.R. Elevated-Temperature Properties of Copper-Base Alloys. Wire and Wire Products, Vol. 37 (1962), pp. 1398–1404, 1502–1503.
(5) Alloy Digest. Engineering Alloys Digest, Inc., New Jersey (1967).
(6) Abramovich, V.R. The Mechanical Properties of Welded and Brazed Joints of Copper and Copper-Nickel Alloys. Svarochnoe Proizvodstvo, (1959), No. 2, pp. 31–33.
(7) Bale, E.S. Fatigue Tests at Room Temperature on Copper - Nickel - Iron Alloys. BNFMRA Tech. Memo TM94 (1952).
(8) Bidmead, G.F. Wöhler Fatigue Test Data on "Kunifer 5" Rod. Imperial Metal Industries, Ltd., England. Research Dept. Rept. MD/RR/87/54 (1954).
(9) Weller, J. and Weissgerber, R. Festigkeitseigenschaften von Cu Ni Fe Mn – Werkstoffen. Institut für Leichtbau IfL – Mitteilungen, Dresden, Vol. 7 (1968), pp. 288–296.

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