UDC 669.35'24

Cu Ni20

Common names: **80/20 Copper-Nickel**
80/20 Cupro-nickel
Cupro-nickel, 80/20

A copper-nickel alloy with an alpha phase structure. The material has good corrosion resistance in slow-moving water and is relatively insensitive to stress corrosion. It has excellent cold-and good hot-working properties and is readily weldable. The most commonly used wrought forms are sheet and strip.

COMPOSITION (weight %)

Ni	19.0–21.0
Mn	0 – 0.5
Cu	rem.

1 SOME TYPICAL USES

Electrical
Resistors; transistor cans; radar waveguides.

Mechanical
Bullet envelopes (clad on steel); corrosion-resistant deep-drawn and spun components.

Plumbing
Domestic water heaters.

Coinage
Coins, medals, and medallions.

2 PHYSICAL PROPERTIES

		Metric Units	English Units
2.1	Density at 20 °C *68 °F*	8.95 g/cm³	0.325 lb/in³
2.2	Melting range [a]	1 130–1 190 °C	2 065–2 175 °F
2.3	Coefficient of thermal expansion (linear) at:		
	−183 to 10 °C *−297 to 50 °F*	0.000 013 per °C	0.000 007 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*	0.09 cal/g °C	0.09 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
2.6	Electrical conductivity (volume) at:		
	20 °C *68 °F* (annealed or cold worked)	3.5 m/ohm mm²	6% IACS
	200 °C *392 °F* („ „ „ „)	3.5 „	6 „ „
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
	200 °C *392 °F* („ „ „ „)	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 4 per °C (6% IACS)	0.000 2 per °F (6% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*		
	annealed	14 900 kg/mm²	21 200 000 lb/in²
	cold worked [b]	13 600 kg/mm²	19 300 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*		
	annealed	5 500 kg/mm²	7 800 000 lb/in²
	cold worked [b]	5 050 kg/mm²	7 200 000 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 worked.

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 3

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	1 250–1 325 °C	2 280–2 415 °F
3.2	Annealing temperature range	625– 825 °C	1 155–1 515 °F
	Stress relieving temperature range	300– 400 °C	570– 750 °F
3.3	Hot working temperature range	875– 975 °C	1 605–1 785 °F
3.4	Hot formability	Good	
3.5	Cold formability	Good	
3.6	Cold reduction between anneals	75% 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	Fair	
	Carbon-arc welding	Not recommended	
	Gas-shielded arc welding	Excellent	
	Coated metal-arc welding	Good	
	Resistance welding: spot and seam	Good	
	butt	Good	

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

and ISO Recommendation

Country	Designation of Standards	Designation of Material in Standards	Specification for Chemical Composition [a]	Plate Sheet Strip	Rod	Wire	Tube	Sections / Shapes	Forgings
Australia	SAA	—	—	—	—	—	—	—	—
Belgium	NBN	Cu Ni20	—	266.31	—	266.31	266.31	—	—
Canada	CSA	—	—	—	—	—	—	—	—
Chile	NCh (INDITECNOR)	Cu Ni20	NCh 250. of 68	—	—	—	—	—	—
France	—	Cu Ni20	—	—	—	—	—	—	—
Germany	DIN	—	—	—	—	—	—	—	—
India	IS	NS20	—	2283	—	—	—	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Japan	JIS	—	—	—	—	—	—	—	—
Netherlands	N or NEN [b]	Cu Ni20	NEN 6030	NEN 6033	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	Cu Ni20	—	37 103	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	—	—	—	—	—	—	—	—
United Kingdom	BS	CN104	—	374 1541 2870 2875 [c]	—	—	—	—	—
United States	ASTM	—	—	—	—	—	—	—	—
International Organization for Standardization	ISO	Cu Ni20	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 (1963), but deleted from metricated revision (1969).

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	„ „ 5.2.1

5.3 Mechanical properties at elevated temperature

Short-time tensile properties	see table 5.3.1
Creep properties	see tables 5.3.2.1/2

5.4 Fatigue properties

Fatigue strength at room temperature	see table 5.4.1

5.1 MECHANICAL PROPERTIES AT ROOM TEMPERATURE (*)

5.1.1 Typical Tensile Properties and Hardness Values—Metric Units

This table is representative of practice in many European countries. 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 (a)
				%	gauge length	Brinell	Vickers		
Plate Sheet Strip	Annealed	34	15	40	$5.65\sqrt{S_o}$	80	84	25	1–10 mm thick
	Typical Cold Worked Tempers	40	34	25	$5.65\sqrt{S_o}$	115	120	28	1–10 mm thick
		46	42	12	$5.65\sqrt{S_o}$	135	140	32	1– 5 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	Tensile Strength		Proof Stress 0.1% offset		Elongation		Vickers Hardness	Shear Strength		Typical Size Related to Properties Shown (a)
		hbar	ton/in²	hbar	ton/in²	%	gauge length		hbar	ton/in²	
Sheet Strip	Annealed	34	22	12	8	40	50 mm (2 in.)	85	25	16	—
	Typical Cold Worked Tempers	40	26	31	20	25	50 mm (2 in.)	120	28	18	0.2–3 mm (0.008–0.125 in.) thick
		45	29	39	25	15	50 mm (2 in.)	140	29	19	"
		56	36	49	32	4	50 mm (2 in.)	165	31	20	"
Rod (b)	Typical Cold Worked Temper (c)	45	29	37	24	12	$5.65\sqrt{S_o}$	130	29	19	6–25 mm (0.25–1 in.) diam. or equivalent area
Wire	Annealed (c)	32	21	—	—	35	100 mm (4 in.)	—	25	16	2.5–5 mm (0.1–0.2 in.) diam.
		36	23	—	—	30	100 mm (4 in.)	—	26	17	0.5–2 mm (0.02–0.08 in.) diam.
		39	25	—	—	25	100 mm (4 in.)	—	29	19	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) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.

(c) The principal application for rod and wire of this composition is as a material of controlled electrical resistance; rod is usually supplied in an appropriate cold-worked temper and wire in the annealed condition.

(*) 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 (Plate, Sheet, Strip)	As Hot Rolled	48 000 40 000	36 000 18 000	35 35	2 in. 2 in.	— —	48 48	— —	36 000 30 000	0.75 in. thick 2 in. thick
	Annealed	41 000	14 000	45	2 in.	—	—	—	31 000	0.040 in. thick
	Cold Worked Hard	63 000	52 000	17	2 in.	102	78	69	40 000	1.0 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 the metal manufacturers.

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/in²	Elongation		Reduction of Area %	Impact Strength	
		°C	°F	kg/mm²	ton/in²	psi		%	gauge length		kg m/cm²	ft lb
Rod [1] **25 mm diam. 1 in. diam.**	Annealed [a]	20	68	36	**23.0**	51 500	**12.36**	**25.5**	2 in.	**77.5**	13.3 [b]	**77.0** [b]
		− 10	− 14	39.5	**25.1**	56 000	**12.79**	**28.2**	2 in.	**77.0**	—	—
		− 40	− 40	42	**26.6**	59 500	**12.96**	**28.9**	2 in.	**77.0**	14.0 [b]	**81.0** [b]
		− 80	−112	43.5	**27.5**	61 500	**12.91**	**28.7**	2 in.	**76.0**	13.6 [b]	**79.0** [b]
		−114	−173	46.5	**29.5**	66 000	**13.04**	**28.2**	2 in.	**75.0**	—	—
		−120	−184	—	—	—	—	—	—	—	14.5 [b]	**84.0** [b]
		−180	−292	52	**32.9**	73 500	**14.49**	**35.6**	2 in.	**72.0**	14.7 [b]	**85.0** [b]
	Annealed [c]	20	68	38.5	**24.3**	54 500	**14.7**	**34.0**	2 in.	**76.0**	13.3 [b]	**77.0** [b]
		−180	−292	57	**36.35**	81 500	**21.65** [d]	**44.0**	2 in.	**71.0**	14.7 [b]	**85.0** [b]
Plate [2] [f] **13–19 mm 0.5–0.75 in.**	[g]	16	61	—	—	—	—	—	—	—	12 [e]	**44** [e]
		22	72	31	**19.7**	44 000	—	**56**	1.5 in.	**70.0**	—	—
		− 20	− 4	33.5	**21.3**	47 500	—	**57**	1.5 in.	**68.5**	—	—
		− 50	− 58	34.5	**21.9**	49 000	—	**57**	1.5 in.	**66.0**	9.7 [e]	**35** [e]
		−100	−148	37.5	**23.9**	53 500	—	**55**	1.5 in.	**63.0**	9.4 [e]	**34** [e]
		−150	−238	40	**25.5**	57 000	—	**56**	1.5 in.	**57.0**	9.7 [e]	**35** [e]
		−196	−321	48.5	**30.9**	69 000	—	**62**	1.5 in.	**57.0**	8.3 [e]	**30** [e]

(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.
(e) Charpy test; V notch; cross-sectional area at the notch 0.5 cm².
(f) Results of Navy tear tests on this alloy are also included in ref. (2).
(g) 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% 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	%	gauge length
Plate [3]	Hot Rolled	20	68	30.5	**19.5**	43 500	**10.6** [a]	**6.3**	**53**	2 in.
		66	150	29	**18.3**	41 000	**10.1** [a]	**6.0**	**53**	2 in.
		121	250	27	**17.2**	38 500	**10.3** [a]	**5.8**	**50**	2 in.
		177	350	25.5	**16.2**	36 500	**9.76** [a]	**5.6**	**49**	2 in.
		232	450	24.5	**15.5**	34 500	**9.45** [a]	**5.5**	**49**	2 in.
		288	550	23.5	**14.9**	33 500	**9.61** [a]	**5.5**	**46**	2 in.
		343	650	22.5	**14.3**	32 000	**8.66** [a]	**5.1**	**45**	2 in.
		371	700	22.5	**14.2**	32 000	**8.19** [a]	**4.8**	**42**	2 in.
Strip [4] **2 mm 0.08 in.**	Annealed	20	68	31	**19.7**	44 000	—	**5.3**	**45**	2 in.
		100	212	28	**17.9**	40 000	—	**4.8**	**41**	2 in.
		200	392	25.5	**16.3**	36 500	—	**4.3**	**37**	2 in.
		300	572	22.5	**14.4**	32 500	—	**4.0**	**34**	2 in.
		400	752	21	**13.2**	29 500	—	**3.7**	**29**	2 in.
		500	932	16.5	**10.4**	23 500	—	**3.4**	**20**	2 in.
Rod [5] **22 mm diam. 0.875 in. diam.**	Annealed	20	68	31.5	**20.1**	45 000	—	**3.1** [b]	**48.5**	$4\sqrt{S_o}$
		250	482	24.5	**15.5**	34 500	—	**2.0** [b]	**34.5**	$4\sqrt{S_o}$
		500	932	16	**10.2**	23 000	—	—	**11.5**	$4\sqrt{S_o}$
		750	1 382	5	**3.3**	7 500	—	—	**6.5**	$4\sqrt{S_o}$

[a] This value was originally reported in ton/in²; in this table it is given in kg/mm² to 3 significant figures.

[b] Quoted as "proportional limit" in original document but offset strain not defined.

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

— The 0.5% yield strength values are not available.

— Further data can be obtained from the following paper:

■ Volkogon, G.M. Velocity of the Deformation Occurring in Testing Affecting the Measured Mechanical Properties of Cupronickel MN19 and Monel NMZHMTS28–2.5–1.5. Tsvetnye Metally (1961) May, pp. 62–64. (tensile data up to 1 000°C *(1 832°F)* for alloy containing 19.2% Ni; 0.24% Fe; 0.46% Mn).

5.3.2 Creep Properties

5.3.2.1 Original Creep Data

Form	Temper	Testing Temperature		Stress			Duration h	Total Extension % [a]	Intercept %	Minimum Creep Rate % per 1 000 h
		°C	°F	kg/mm²	ton/in²	psi				
Rod [6] [b] **3 mm diam. 0.125 in. diam.**	Annealed (grain size 0.025 mm)	149	300	7.0	4.5	**10 000**	**6 260**	**0.085**	**0.004 5**	**0.000 1**
				10.5	6.7	**15 000**	**6 260**	**0.155 5**	**0.010**	**0.000 1**
				14.1	8.9	**20 000**	**6 260**	**1.226**	**0.104**	**0.000 4**
				17.5	11.1	**24 900**	**6 260**	**3.483**	**1.100**	**0.000 4**
		260	500	7.0	4.5	**10 000**	**6 260**	**0.117**	**0.013**	**0.000 6**
				10.5	6.7	**15 000**	**6 200**	**0.481**	**0.008**	**0.000 4**
				14.1	8.9	**20 000**	**6 260**	**1.685**	**0.086**	**0.006**
				15.5	9.9	**22 100**	**6 200**	**2.174**	**0.369**	**0.001 2**
				17.6	11.2	**25 000**	**6 260**	**3.130**	**0.012 5**	**0.001 1**

[a] Total Extension = Initial Extension + Total Creep = Initial Extension + Intercept + (Minimum creep rate × Duration).

[b] Alloy containing: 0.60% Mn; 0.19% Fe; 0.76% Zn; 19.95% Ni.

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

— Further data can be obtained from the following paper:

■ Marin, J. Interpretation of Creep and Long-Time Test Data. Proc. Soc. Exptl. Stress Anal., Vol. 11 (1954), pp. 207–212.

5.3.2.2 Stress for Designated Creep Rate

Form	Temper	Testing Temperature		Stress for Designated Creep Rate					
				0.001% per 1 000 h			0.01% per 1 000 h		
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi
Rod [6] [b] **3 mm diam. 0.125 in. diam.**	Annealed (grain size 0.025 mm)	149 260	300 500	>17.6 [a] 12.0	>11.2 [a] 7.6	**>25 000** [a] **17 000**	— >21.1	— >13.4	— **>30 000**

(a) Extrapolated value.

(b) Alloy containing 0.60% Mn; 0.19% Fe; 0.76% Zn; 19.95% Ni.

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

5.4 FATIGUE PROPERTIES

5.4.1 Fatigue Strength at Room Temperature

Form	Temper	Number of Cycles × 10^6	Metric Units kg/mm²		English Units ton/in²		American Units psi	
			Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength	Tensile Strength	Fatigue Strength
Strip [7] **1 mm 0.04 in.**	Annealed	[f]	36	12	23	7.5	**51 000**	**17 000**
	Cold Worked	[f]	55.5	19	35.5	12	**79 000**	**27 000**
Rod [8] [g] **25 mm diam. 1 in. diam.**	Cold Rolled	80	35	12.5 [a]	22.5	8 [a]	**49 900**	**18 000** [a]
Rod [9] [e]	— [c]	20	35.5	13 [d]	**22.5**	**8.1** [d]	50 500	18 000 [d]
Wire [10] **2 mm diam. 0.072 in. diam.**	Cold Worked 88%	100	59.5	24 [b]	37.5	15 [b]	**84 300**	**34 000** [b]

(a) Rotating-cantilever test.

(b) Rotating-wire-arc test.

(c) Temper not stated in original document.

(d) Direct-stress test.

(e) Alloy containing 0.19% Fe.

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

(g) Alloy containing 0.27% Fe.

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

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