Cu Ni30 Mn1 Fe

Common names: 70/30 Copper-Nickel-Iron
70/30 Cupro-nickel
Cupro-nickel, 70/30

A copper-nickel alloy with an alpha phase structure. Small amounts of iron and manganese are added to improve corrosion resistance in high-velocity (from 1.5 to about 4.5 m/s) waters, including polluted seawater. The alloy is almost insensitive to stress corrosion. It retains its strength well at moderately elevated temperatures, has good cold- and hot-working properties and is readily weldable. The most commonly used wrought forms are plate, sheet, rod and tube.

COMPOSITION (weight %)

Ni	29.0–32.0
Mn	0.5– 1.5
Fe	0.4– 1.0
Cu	rem.

1 SOME TYPICAL USES

Chemical & Marine*
Tubes and tubeplates for heavy-duty condensers, feedwater heaters and evaporators, including desalination plant.

Mechanical
Fasteners.

*Several varieties of this alloy, with higher iron and manganese contents, are used in tube form under severe conditions of impingement and erosion.

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]	1 170–1 240 °C	2 140–2 265 °F
2.3	Coefficient of thermal expansion (linear) at:		
	−183 to 10 °C *−297 to 50 °F*	0.000 012 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*	0.07 cal cm/cm² s °C	17 Btu ft/ft² h °F
2.6	Electrical conductivity (volume) at:		
	−269 °C *−452 °F* (annealed)	3 m/ohm mm²	5% IACS
	20 °C *68 °F* (annealed or cold worked)	3 ,,	5 ,, ,,
	200 °C *392 °F* (,, ,, ,, ,,)	3 ,,	5 ,, ,,
2.7	Electrical resistivity (volume) at:		
	−269 °C *−452 °F* (annealed)	0.34 ohm mm²/m 34 microhm cm	207 ohms (circ mil/ft) 14 microhm in
	20 °C *68 °F* (annealed or cold worked)	0.34 ohm mm²/m 34 microhm cm	207 ohms (circ mil/ft) 14 microhm in
	200 °C *392 °F* (,, ,, ,, ,,)	0.34 ohm mm²/m 34 microhm cm	207 ohms (circ mil/ft) 14 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 05 per °C (5% IACS)	0.000 03 per °F (5% IACS)
2.9	Modulus of elasticity (tension) at 20 °C *68 °F*		
	annealed	15 500 kg/mm²	22 000 000 lb/in²
	cold worked [b]	14 600 kg/mm²	20 800 000 lb/in²
2.10	Modulus of rigidity (torsion) at 20 °C *68 °F*		
	annealed	5 750 kg/mm²	8 200 000 lb/in²
	cold worked [b]	5 400 kg/mm²	7 700 000 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 10); INDEX LETTERS RELATE TO FOOTNOTES AT END OF TABLE

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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	1 325–1 400 °C	2 415–2 550 °F
3.2 Annealing temperature range	650– 850 °C	1 200–1 560 °F
Stress relieving temperature range	300– 400 °C	570– 750 °F
3.3 Hot working temperature range	925–1 025 °C	1 695–1 875 °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	Good	
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	—	—	—	—	—	—	—	—
Canada . .	CSA	HC.NF301	—	HC.4.6	—	—	HC.7.3 HC.7.4	—	—
Chile	NCh (INDITECNOR)	Cu Ni30 Mn1 Fe	NCh 250. of 68	—	—	—	—	—	—
France . . .	NF	Cu Ni30 Mn1 Fe	—	—	—	—	A51-102	—	—
Germany . .	DIN	Cu Ni30 Fe	17 664	17 670	17 672	17 672	1785 17 671	—	—
India . . .	IS	—	—	—	—	—	—	—	—
Italy . . .	UNI	Pt-Cu Ni30 Mn 1Fe	—	—	—	—	6785	—	—
Japan . . .	JIS	CNP 3 CNTF 3 CNTF 3 S	—	H 3251	—	—	H 3635	—	—
Netherlands .	N or NEN[b]	—	—	—	—	—	—	—	—
South Africa .	SABS	—	—	—	—	—	—	—	—
Spain . . .	UNE	—	—	—	—	—	—	—	—
Sweden . .	SIS	—	—	—	—	—	—	—	—
Switzerland .	VSM	Cu Ni30 Fe Mn	—	10 803	—	—	10 803 11 557	—	—
United Kingdom . .	BS	CN107	—	1541 2870[d] 2875	—	—	378 1464 2579 (Part1) 2871	—	—
United States[c] . .	ASTM	No. 715	—	B 122 B 151 B 171 B 402	B 151	—	B 111 B 359 B 395 B 466 B 467 B 543	—	—
International Organization for Standardization	ISO	Cu Ni30 Mn1 Fe	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) In the United States, bar is covered under the Plate-Sheet-Strip column.

(d) In metricated revision (1968); not in imperial units edition (1962).

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 5.3.2.1/2/3

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 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	36	15	42	$5.65\sqrt{S_o}$	85	89	27	1–20 mm thick
	Hot Rolled	38	16	38	$5.65\sqrt{S_o}$	90	95	28	10–50 mm thick
	Typical Cold Worked Temper	50	43	16	$5.65\sqrt{S_o}$	140	145	35	1–5 mm thick
Rod (c)	Annealed	40	17	40	$5.65\sqrt{S_o}$	95	100	30	6–40 mm diam. or equivalent area
	Typical Cold Worked Temper	50	42	18	$5.65\sqrt{S_o}$	130	135	35	6–25 mm diam. or equivalent area
Tube (b)	Annealed (grain size 0.025 mm)	42	17	42	$5.65\sqrt{S_o}$	90	95	31	10–30 mm O.D. 1–3 mm wall
	Typical Cold Drawn Temper	52	45	18	$5.65\sqrt{S_o}$	145	150	36	10–30 mm O.D. 1–2 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.
(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	
Plate	Annealed	39	25	15	10	42	$5.65\sqrt{S_o}$	95	29	19	—
	Hot Rolled As-Manufactured	40	26	17	11	40	$5.65\sqrt{S_o}$	105	31	20	12–50 mm (0.5–2 in.) thick
Sheet Strip	Annealed	39	25	15	10	45	50 mm (2 in.)	95	29	19	—
	Hot Rolled As-Manufactured	43	28	20	13	40	50 mm (2 in.)	120	32	21	3–10 mm (0.125–0.375 in.) thick
Tube (c)	Annealed (grain size 0.025 mm)	**42**	**27**	**17**	**11**	**42**	$5.65\sqrt{S_o}$	**105**	**31**	**20**	—
	Cold Drawn or Temper Annealed										
	As-Drawn (hard)	51	33	37	24	25	$5.65\sqrt{S_o}$	150	32	21	50–255 mm (2–10 in.) O.D. 2–5 mm (0.08–0.2 in.) wall
	Temper Annealed	**43**	**28**	**20**	**13**	**40**	$5.65\sqrt{S_o}$	**120**	**32**	**21**	
	Temper Annealed	**49**	**32**	**34**	**22**	**30**	$5.65\sqrt{S_o}$	**140**	**37**	**24**	6–50 mm (0.25–2 in.) O.D. 0.5–2 mm (0.02–0.08 in.) wall
	As-Drawn	**56**	**36**	**46**	**30**	**15**	$5.65\sqrt{S_o}$	**170**	**39**	**25**	
	As-Drawn (hard)	**66**	**43**	**57**	**37**	**7**	$5.65\sqrt{S_o}$	**190**	**37**	**24**	

(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) Intermediate tube tempers are generally obtained by temper annealing. Drawn tubes are usually stress relieved after the final draw. Tubes for condensers and heat exchangers are mainly supplied in the tempers whose representative mechanical properties are printed in **bold type.**
(*) 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	55 000	20 000	45	2 in.	—	35	—	41 000	1.0 in. thick
		50 000	20 000	35	2 in.	—	—	—	37 000	2.0 in. thick
	Annealed	55 000	18 000	36	2 in.	—	40	—	41 000	0.040 in. thick
		54 000	22 000	40	2 in.	—	35	—	40 000	1.0 in. thick
	Cold Worked									
	Half Hard	73 000	67 000	4	2 in.	—	80	—	51 000	0.040 in. thick
	Hard	81 500	76 000	3	2 in.	—	85	—	52 000	,,
	Extra Hard	86 000	79 000	3	2 in.	—	87	—	52 000	,,
	Spring	89 000	80 000	3	2 in.	—	88	—	48 000	,,
Rod [b]	Annealed	55 000	20 000	45	2 in.	—	37	—	41 000	1.0 in. diam.
	Cold Worked									
	Half Hard	75 000	70 000	15	2 in.	—	80	—	52 000	1.0 in. diam.
	Hard	85 000	78 000	15	2 in.	—	81	—	55 000	,,
Tube [c]	Annealed									
	(grain size 0.025 mm)	60 000	25 000	45	2 in.	80	45	—	45 000	1.0 in. O.D. × 0.065 in. wall
	(grain size 0.025 mm)	54 000	—	45	2 in.	77	36	—	40 000	4.5 in. O.D. × 0.109 in. wall
	Cold Worked									
	Light Drawn	75 000	68 000	15	2 in.	—	80	—	52 000	1.0 in. O.D. × 0.065 in. wall
	Hard Drawn	84 000	—	4	2 in.	—	—	—	55 000	0.75 in. O.D. × 0.049 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) The mechanical properties will be largely dependent upon the size and cross-sectional area or complexity of the product.
(c) Tubes for condensers and heat exchangers are generally supplied in annealed or drawn and stress-relieved tempers.

5.2 MECHANICAL PROPERTIES AT LOW TEMPERATURE

5.2.1 Tensile Properties—Impact Properties

Form	Temper	Testing Temperature		Tensile Strength			Proof Stress		Elongation		Reduction of Area %	Impact Strength	
		°C	°F	kg/mm²	ton/in²	psi	0.2% offset kg/mm²	Yield Strength 0.5% ext. under load psi	%	gauge length		kg m/cm²	ft lb
Rod [1] 12 mm diam. 0.47 in. diam.	Cold Worked	20	68	**65**	41.5	92 500	—	56 900 [a]	**12**	16 mm	—	—	—
		0	32	**65**	41.5	92 500	—	61 200 [a]	**13**	16 mm	—	—	—
		−100	−148	**70**	44.5	99 500	—	76 800 [a]	**17**	16 mm	—	—	—
		−196	−321	**80**	51	114 000	—	99 600 [a]	**24**	16 mm	—	—	—
		−224	−371	**83**	52.5	118 000	—	107 000 [a]	**22**	16 mm	—	—	—
		−247	−413	**90**	57	128 000	—	114 000 [a]	**20**	16 mm	—	—	—
		−269	−452	**95**	60.5	135 000	—	121 000 [a]	**18**	16 mm	—	—	—
Rod [d] [2] 19 mm diam. 0.75 in. diam.	Annealed	22	72	40.5	26	**57 800**	—	**18 700**	**47**	$4.52\sqrt{S_o}$	**68**	19.9 [b]	**115** [b]
		− 78	−108	48	30.5	**68 000**	—	**22 200**	**48**	$4.52\sqrt{S_o}$	**70**	19.7 [b]	**114** [b]
		−197	−323	63	40	**89 800**	—	**31 600**	**52**	$4.52\sqrt{S_o}$	**70**	19.7 [b]	**114** [b]
		−253	−423	72.5	46	**103 100**	—	**38 100**	**51**	$4.52\sqrt{S_o}$	**66**	19.7 [b]	**114** [b]
		−269	−452	73.5	46.5	**104 600**	—	**40 100**	**48**	$4.52\sqrt{S_o}$	**65**	—	—
Rod [3] [4] 22 mm diam. 0.875 in. diam.	Annealed	24	75	38	24.5	**54 400**	**15.1** [c]	—	**52**	2 in.	**80.5**	—	—
		− 30	− 22	41	26	**58 600**	**15.5** [c]	—	**49.5**	2 in.	**79**	—	—
		− 78	−108	45	28.5	**64 300**	**16.9** [c]	—	**56**	2 in.	**77.5**	—	—
		−140	−220	50.5	32	**71 900**	**19.3** [c]	—	**57.5**	2 in.	**77.5**	—	—
		−196	−320	59	37.5	**83 700**	**21.7** [c]	—	**61.5**	2 in.	**77.5**	—	—

(a) This value was originally reported in kg/mm²; in this table it is given in psi to 3 significant figures.
(b) Charpy test; 10 × 10 × 55 mm specimen; 45° V notch 2 mm deep; cross-sectional area at the notch 0.8 cm².
(c) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.
(d) Tensile specimen 6.35 mm (0.25 in.) diam.
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, 0.1% offset.

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 [5]	Hot Rolled	20	68	37.5	**23.9**	53 500	**12.4** [a]	**7.4**	—	**50**	2 in.
		66	150	35.5	**22.7**	51 000	**12.4** [a]	**7.5**	—	**49**	2 in.
		121	250	33.5	**21.4**	48 000	**11.5** [a]	**6.7**	—	**48**	2 in.
		177	350	32.5	**20.5**	46 000	**10.4** [a]	**6.3**	—	**48**	2 in.
		232	450	31	**19.7**	44 000	**10.6** [a]	**6.2**	—	**46**	2 in.
		288	550	30	**19.0**	42 500	**10.2** [a]	**6.0**	—	**55**	2 in.
		343	650	29	**18.5**	41 500	**9.29** [a]	**5.2**	—	**54**	2 in.
		371	700	29	**18.3**	41 000	**9.45** [a]	**5.6**	—	**63**	2 in.
Plate [6]	Hot Worked	20	68	**38**	24	54 000	**13.5**	—	—	—	—
		100	212	**38**	24	54 000	**13.5**	—	—	—	—
		200	392	**35.5**	22.5	50 500	**12**	—	—	—	—
		300	572	**33**	21	47 000	**11.5**	—	—	—	—
		400	752	**30**	19	42 500	**10**	—	—	—	—
Strip [7] 2 mm 0.08 in.	Annealed	20	68	40.5	**25.8**	58 000	—	**7.9**	—	**44**	2 in.
		100	212	37.5	**23.8**	53 500	—	**7.5**	—	**40**	2 in.
		200	392	34.5	**21.9**	49 000	—	**6.6**	—	**37**	2 in.
		300	572	32.5	**20.5**	46 000	—	**6.1**	—	**34**	2 in.
		400	752	30.5	**19.4**	43 500	—	**5.8**	—	**31**	2 in.
		500	932	26	**16.4**	36 500	—	**5.4**	—	**20**	2 in.
Rod [8] 14 mm diam. 0.55 in. diam.	Annealed	20	68	**44**	28	62 500	**16**	—	—	**38**	$11.3\sqrt{S_o}$
		100	212	**41**	26	58 500	**11**	—	—	**36**	$11.3\sqrt{S_o}$
		200	392	**38**	24	54 000	**11**	—	—	**33**	$11.3\sqrt{S_o}$
		300	572	**35**	22	50 000	**11**	—	—	**32**	$11.3\sqrt{S_o}$
		390	734	**33.5**	21.5	47 500	**11**	—	—	**29**	$11.3\sqrt{S_o}$
		500	932	**28**	18	40 000	**11**	—	—	**22**	$11.3\sqrt{S_o}$
		600	1 112	**19**	12	27 000	**9**	—	—	**16**	$11.3\sqrt{S_o}$
		700	1 292	**11**	7	15 500	**8**	—	—	**6**	$11.3\sqrt{S_o}$
		790	1 454	**6.5**	4	9 000	**5.5**	—	—	**3**	$11.3\sqrt{S_o}$
Rod [3] 22 mm diam. 0.875 in. diam.	Cold Worked 25%	24	75	52.5	33.5	**74 500**	**50.9** [b]	—	—	**19**	2 in.
		149	300	48	30.5	**68 600**	**45.7** [b]	—	—	**17**	2 in.
		371	700	40.5	25.5	**57 600**	**39.0** [b]	—	—	**13**	2 in.
		482	900	30.5	19.5	**43 600**	**27.1** [b]	—	—	**11.5**	2 in.
		649	1 200	12	7.5	**16 900**	**6.82** [b]	—	—	**26**	2 in.
		816	1 500	5	3	**7 200**	**2.88** [b]	—	—	**16**	2 in.
		927	1 700	3	2	**4 110**	**1.16** [b]	—	—	**22**	2 in.
	Cold Worked 70%	24	75	67	42.5	**95 200**	**65.0** [b]	—	—	**16**	2 in.
		149	300	61.5	39	**87 500**	**56.8** [b]	—	—	**16**	2 in.
		371	700	51.5	33	**73 600**	**50.0** [b]	—	—	**11**	2 in.
		482	900	40	25.5	**56 900**	**37.0** [b]	—	—	**14**	2 in.
		649	1 200	12	7.5	**16 900**	**6.89** [b]	—	—	**29**	2 in.
		816	1 500	5	3	**6 990**	**2.60** [b]	—	—	**19**	2 in.
		927	1 700	2.5	1.5	**3 680**	**1.12** [b]	—	—	**22.5**	2 in.
Rod [9] [c] 25 mm diam. 1.0 in. diam.	Annealed	28	82	45	28.5	**64 100**	—	—	**32 000**	**34.5**	2 in.
		260	500	37.5	24	**53 300**	—	—	**26 300**	**31.5**	2 in.
		343	650	34.5	22	**49 200**	—	—	**25 000**	**27.0**	2 in.
		427	800	33	21	**46 700**	—	—	**22 500**	**25.6**	2 in.
		510	950	26	16.5	**37 250**	—	—	**21 500**	**16.2**	2 in.
		593	1 100	18.5	12	**26 550**	—	—	**20 000**	**12.3**	2 in.
Rod [10] 27 mm diam. 1.1 in. diam.	Annealed (grain size 0.025–0.035 mm)	20	68	41.5	**26.5**	59 500	**13.7** [a]	**8.6**	—	**56**	$4\sqrt{S_o}$
		250	482	35	**22.2**	49 500	**10.9** [a]	**6.8**	=	**45**	$4\sqrt{S_o}$
		350	662	34	**21.6**	48 500	**10.4** [a]	**6.5**	—	**39**	$4\sqrt{S_o}$
		450	842	31.5	**20.0**	45 000	**10.7** [a]	**6.6**	—	**42**	$4\sqrt{S_o}$
		550	1 022	26.5	**16.7**	37 500	**11.8** [a]	**6.8**	—	**33**	$4\sqrt{S_o}$
Condenser [11] Tube	Annealed	20	68	**43**	27.5	61 000	**16**	—	—	**38**	$11.3\sqrt{S_o}$
		100	212	**39**	25	55 500	**14.5**	—	—	**35**	$11.3\sqrt{S_o}$
		200	392	**36**	23	51 000	**13.5**	—	—	**36**	$11.3\sqrt{S_o}$
		300	572	**34.5**	22	49 000	**12.0**	—	—	**28**	$11.3\sqrt{S_o}$
		400	752	**33**	21	47 000	**11.0**	—	—	**30**	$11.3\sqrt{S_o}$
		500	932	**24**	15	34 000	**10**	—	—	**25**	$11.3\sqrt{S_o}$
		600	1 112	**17**	11	24 000	**8**	—	—	**25**	$11.3\sqrt{S_o}$

(a) This value was originally reported in ton/in²; in this table it is given in kg/mm² to 3 significant figures.
(b) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.
(c) Alloy containing 0.40% Mn.

N.B.: — Original values are printed in **bold type**; other values are converted.
— Further data can be obtained from the following papers:
■ Simmons, W.F., Sirois, B.J.; Williams, D.N. & Jaffee, R.I. Properties of 70–30 Copper-Nickel Alloy at Temperatures Ranging up to 1 050°F. Proc. ASTM. Vol. 59 (1959), pp. 1035–1051. (data for cold drawn and stress relieved rod; alloy containing 0.35% Mn).
■ Reference [3].

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 [12] [b] 3 mm diam. 0.125 in. diam.	Annealed (grain size 0.020 mm)	149	300	3.2	2.0	**4 550**	**2 600**	**0.033**	**0.010**	**< 0.000 1**
				10.6	6.7	**15 100**	**2 600**	**0.109**	**0.022**	**<0.000 1**
				14.0	8.9	**19 900**	**4 400**	**0.884**	**0.022**	**0.000 4**
				20.0	12.7	**28 450**	**5 200**	**3.230**	**0.025**	**0.001 0**
				23.0	14.6	**32 700**	**3 700**	**4.532**	**0.030**	**0.000 6**
		204	400	3.5	2.2	**4 980**	**2 880**	**0.026**	**0.004**	**<0.000 1**
				11.2	7.1	**15 950**	**4 100**	**0.167**	**0.006**	**<0.000 2**
		260	500	3.5	2.2	**4 980**	**2 780**	**0.031**	**0.001**	**<0.000 1**
				7.2	4.6	**10 250**	**5 000**	**0.075**	**0.012**	**<0.000 5**
				11.0	7.0	**15 650**	**5 000**	**0.310**	**0.015**	**0.000 9**
				14.9	9.4	**21 150**	**5 000**	**1.498**	**0.030**	**0.003 7**
				18.6	11.8	**26 500**	**5 100**	**2.775**	**0.028**	**0.005 3**
				21.5	13.7	**30 650**	**5 100**	**4.671**	**0.048**	**0.008 4**
	Cold Worked 84%	149	300	14.0	8.9	**19 900**	**3 600**	**0.108**	**0.018**	**<0.000 1**
				24.5	15.6	**34 900**	**3 700**	**0.174**	**0.016**	**<0.000 1**
				34.9	22.1	**49 600**	**5 150**	**0.259**	**0.024**	**0.000 5**
				42.1	26.8	**59 950**	**4 650**	**0.345**	**0.036**	**0.000 9**
		260	500	3.5	2.2	**4 960**	**2 760**	**0.036**	**0.012**	**0.000 7**
				7.1	4.5	**10 100**	**4 980**	**0.074**	**0.024**	**0.001 1**
				14.6	9.3	**20 800**	**4 800**	**0.124**	**0.023**	**0.001 6**
				28.7	18.2	**40 800**	**4 800**	**0.243**	**0.049**	**0.002 4**
				34.6	21.9	**49 150**	**5 100**	**0.322**	**0.066**	**0.003 0**
				42.1	26.7	**59 850**	**5 750**	**0.648**	**0.267**	**0.012**
Rod [13] 19 mm diam. 0.75 in. diam.	Cold Worked and Stress relieved	316	600	28.1	17.8	**40 000**	**500**	**0.255** [c]	—	**0.015** [d]
				35.1	22.3	**50 000**	**500**	**0.426**	—	**0.02** [d]
				38.6	24.5	**55 000**	**500**	**0.940**	—	**0.08** [d]
		399	750	12.6	8.0	**18 000**	**2 500**	**0.219**	—	**0.015**
				17.6	11.1	**25 000**	**2 500**	**0.319** [c]	—	**0.032**
				21.1	13.4	**30 000**	**1 500**	**0.359** [c]	—	**0.055**
				24.6	15.6	**35 000**	**1 000**	**0.490** [c]	—	**0.17**
				28.1	17.8	**40 000**	**1 000**	**0.818**	—	**0.40**
				31.6	20.1	**45 000**	**1 500**	**3.25**	—	**1.0**
		454	850	4.9	3.1	**7 000**	**2 500**	**0.142**	—	**0.019**
				9.8	6.2	**14 000**	**1 500**	**0.339**	—	**0.072**
				17.6	11.1	**25 000**	**1 000**	**0.993**	—	**0.61**
				21.1	13.4	**30 000**	**1 500**	**9.80**	—	**2.2**
		510	950	1.4	0.89	**2 000**	**1 500**	**0.096**	—	**0.032**
				4.2	2.7	**6 000**	**1 000**	**0.292**	—	**0.18**
				12.6	8.0	**18 000**	**1 500**	**11.2**	—	**3.4**
		566	1 050	1.0	0.67	**1 500**	**500**	**0.185**	—	**0.3**
				7.3	4.4	**10 000**	**500**	**7.20**	—	**7**
Rod [14] [e]	Annealed	149	300	30	19	**42 670**	**2 370**	**13.16**	**13.16**	**0** [f]
				32.3	20.5	**46 000**	**2 182**	**19.84**	**19.84**	**0** [f]
				33	21	**47 000**	**2 340**	**20.42**	**20.42**	**0** [f]
		482	900	13	8.3	**18 670**	**2 752**	**49.0**	**2.3**	**9.5** [f]
Rod [15] [e]	Cold Worked 40%	371	700	30	19	**42 670**	**8 490**	**3**	**0.27**	**0.33** [f]
		482	900	11.2	7.1	**16 000**	**14 044**	**46**	**0.32**	**0.39** [f]
				15	9.5	**21 330**	**4 190**	**23**	**0.45**	**1.5** [f]
		649	1 200	1	0.64	**1 450**	**5 002**	**28.5**	**0.40**	**2.65** [f]

(a) Total Extension = Initial Extension + Total creep = Initial extension + Intercept + (Minimum Creep Rate × Duration).
(b) Fe content 0.03%.
(c) Extrapolated value.
(d) Lowest creep rate within duration of test.
(e) Creep specimen 0.505 in. diam.
(f) Average second-stage creep rate.

N.B.: — Original values are printed in **bold type**; other values are converted.
— Further data can be obtained from refs. [14] and [15].

5.3.2.2 Stress for Designated Creep Rate

Form	Temper	Testing Temperature		Stress for Designated Creep Rate											
				0.000 4% per 1 000 h			0.001% per 1 000 h			0.01% per 1 000 h			0.1% per 1 000 h		
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi
Rod [b] [12] **3 mm diam. 0.125 in. diam.**	Annealed (grain size 0.020 mm)	149	300	—	—	—	16.9	10.7	**24 000**	24.6 [a]	15.6 [a]	**35 000**[a]	—	—	—
		260	500	—	—	—	11.2	7.1	**16 000**	21.1 [a]	13.4 [a]	**30 000**[a]	—	—	—
	Cold Worked 84%	260	500	—	—	—	5.6	3.6	**8 000**	—	—	—	—	—	—
Rod [13] **19 mm diam. 0.75 in. diam.**	Cold Worked and Stress relieved	316	600	—	—	—	—	—	—	33.7	21.4	**48 000**	—	—	—
		371	700	—	—	—	—	—	—	18.6	11.8	**26 500**	—	—	—
		399	750	—	—	—	—	—	—	10.5	6.7	**15 000**	—	—	—
		454	850	—	—	—	—	—	—	3.5	2.2	**5 000**	—	—	—
		510	950	—	—	—	—	—	—	0.56	0.36	**800**	—	—	—
Rod [10] **27 mm diam. 1.1 in. diam.**	Annealed (grain size 0.025–0.035 mm)	350	662	—	—	—	—	—	—	25.2	**16.0**	35 800	14.2	**9.0**	20 200
		450	842	—	—	—	—	—	—	10.2	**6.5**	14 600	5.7	**3.6**	8 100
		550	1 022	—	—	—	—	—	—	1.6	**1.0**	2 200	0.47 [a]	**0.3** [a]	670[a]
Rod [16]	Annealed	399	750	6.3	4.0	**9 000**	—	—	—	—	—	—	—	—	—
	Cold Worked [c]	399	750	—	—	—	—	—	—	6.4	4.1	**9 100**	—	—	—

(a) Extrapolated value.
(b) Fe content 0.03%.
(c) Tensile strength of material at 85°F *(29°C)* quoted as 64 700 psi in original document but amount of cold work not defined.

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

5.3.2.3 Stress for Rupture

Form	Temper	Testing Temperature		Stress for Rupture			Time for Rupture h
		°C	°F	kg/mm²	ton/in²	psi	
Rod [13] **19 mm diam. 0.75 in. diam.**	Cold Worked and Stress relieved	399	750	31.6	20.1	**45 000**	**2 124.4**
				35.2	22.3	**50 000**	**467.9**
				38.7	24.6	**55 000**	**22.9**
		454	850	21.1	13.4	**30 000**	**1 539.7**
				24.6	15.6	**35 000**	**469.4**
				28.1	17.9	**40 000**	**96.7**
				31.6	20.1	**45 000**	**29.2**
		510	950	12.7	8.0	**18 000**	**1 839.6**
				19.0	12.1	**27 000**	**117.9**
				24.6	15.6	**35 000**	**11.8**
		566	1 050	7.0	4.5	**10 000**	**968.6**
				13.4	8.5	**19 000**	**82.6**
				16.9	10.7	**24 000**	**25.5**
Rod [9] **25 mm diam. 1 in. diam.**	Annealed	260	500	36.9	23.4	**52 500**	**>3 000** [a]
				35.2	22.3	**50 000**	**14 322**
		343	650	33.4	21.2	**47 500**	**121.0**
				31.6	20.1	**45 000**	**106.1**
				28.1	17.9	**40 000**	**4 016**
		427	800	24.6	15.6	**35 000**	**7.6**
				22.8	14.5	**32 500**	**12.8**
				21.1	13.4	**30 000**	**48.5**
				17.6	11.2	**25 000**	**167.2**
				15.8	10.0	**22 500**	**3 767**
		510	950	15.8	10.0	**22 500**	**3.3**
				14.8	9.4	**21 000**	**10.1**
				14.1	8.9	**20 000**	**35.8**
				12.7	8.0	**18 000**	**38.3**
				10.5	6.7	**15 000**	**1 048.0**

(a) Test stopped after 3 000 h.

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

- 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.
- Blucher, J. T. and Grant, N. J. Recristallization, Tensile and Stress-Rupture Properties of Nickel- Copper Alloys. Proc. ASTM, Vol. 62 (1962), pp. 593–601.
- Parker, R. J. Estimation of Stress-Rupture Properties from Hot Hardness Tests. Metallurgia (Manchr), Vol. 67 (1963), pp. 219–223.

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
Plate [17]	Annealed	100	~41	~14 [a]	~26	~ 9 [a]	**~58 000**	**~20 000** [a]
Rod [18] **14 mm diam. 0.56 in. diam.**	Cold Drawn 33%	100	57.5	24.5 [b]	36.5	15.5 [b]	**81 700**	**34 500** [b]
Rod [19] **20 mm diam. 0.8 in. diam.**	Cold Worked	50	**55**	**20** [a]	35	12.5 [a]	78 500	28 500 [a]
Rod [20] **25 mm diam. 1 in. diam.**	Annealed	[e]	38.5	15.5	24.5	10	**55 000**	**22 000**
	Cold Drawn 50%	[e]	60	22.5	38	14.5	**85 000**	**32 000**
Tube [21] **280 mm I.D., 10 mm wall 11 in. I.D., 0.375 in. wall**	Annealed	100	41	14.5 [c]	**26.1**	**9.2** [c]	58 500	20 500 [c]
Tube [22]	Soft	100	**35**	**15**	22	9.5	50 000	21 500
	Cold Worked and Stress Relieved	100	**45**	**18** [d]	28.5	11.5 [d]	64 000	25 500 [d]

[a] Rotating-cantilever test.

[b] Rotating-beam test.

[c] Direct-stress test.

[d] Bending fatigue test.

[e] Number of cycles 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:

- Tewes, W.A. and Gross, M.R. Investigation of the Low-Cycle Fatigue Behavior of Non-Ferrous Metals for Heat Exchangers and Salt-Water Piping. U.S. Naval EES Rept. 910 196A (1962).
- Czyryca, E.J. and Gross, M.R. Low-Cycle Fatigue of Non-Ferrous Alloys for Heat Exchangers and Salt-Water Piping. U.S. Navy MEL Rept. 26/66 (1966).
- Gross, M.R. Low-Cycle Fatigue of Materials for Submarine Construction. U.S. Naval EES Rept. 91-197D (1963); also paper 690B at SAE-ASNE National Aero-Nautical Meeting, Washington, 8-11 April, 1963.
- Gibbons, W.G. Strain-Cycle Fatigue of 70-30 Copper-Nickel. Trans. ASME, Ser. D, Vol. 88 (1966), No. 2, pp. 552-554.
- Blomfield, J.A. and Jackson, P.B.M. Fatigue Tests on Some Cupro-Nickel Pipe Bends and a Comparison of Some Failure Prediction Methods. First Int. Conf. Pressure Vessels Technology, Part 2: Materials and Fabrication. ASME (1969), pp. 1221-1231.
- Gross, M.R. and Czyryca, E.J. Correlation Between Flexural and Direct-stress Low-Cycle Fatigue Tests. Naval Ship Research and Development Center, Annapolis, Maryland, U.S.A. Rept. No. 2460 (1967) (AD 656746).
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(8) Private communication from Wieland-Werke, AG, Germany.

(9) Donachie Jr., M.J., Steele, R.K. and Shepheard, R.G. Elevated-Temperature Behavior of Annealed 70–30 Copper-Nickel. Proc. ASTM, Vol. 63 (1963), pp. 598–604.

(10) 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.

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