COPPER-TELLURIUM

Cu Te

Common name: Tellurium Copper

A free-machining copper with a small tellurium addition. The material has relatively high conductivity and is available in both phosphorus-bearing and 'tough-pitch' varieties, the first being free from risk of hydrogen embrittlement.

COMPOSITION (weight %)

Cu (+ Ag) + Te	99.90 min.
Te	0.30–0.80

1 SOME TYPICAL USES

Electrical

Transformer and circuit-breaker terminals; contacts, connectors, clamps and other high-conductivity current-carrying components requiring free-machining properties.

Mechanical

Bolts, nuts, studs and a wide variety of other components requiring free-machinability and in most cases good conductivity, often for production on automatic screw machines.

2 PHYSICAL PROPERTIES

	Metric Units	English Units
2.1 Density at 20 °C *68 °F*	8.9 g/cm³	0.321 lb/in³
2.2 Melting range	870–1 081 °C [a] 1 051–1 081 °C [b]	1 600–1 978 °F [a] 1 924–1 978 °F [b]
2.3 Coefficient of thermal expansion (linear) at:		
20 to 100 °C *68 to 212 °F*	0.000 017 per °C	0.000 009 3 per °F
20 to 300 °C *68 to 572 °F*	0.000 018 ,, ,,	0.000 009 8 ,, ,,
2.4 Specific heat (thermal capacity) at:		
20 °C *68 °F*	0.092 cal/g °C	0.092 Btu/lb °F
2.5 Thermal conductivity at:		
−240 °C *−400 °F*	1.9 [b] cal cm/cm² s °C	462 [b] Btu ft/ft² h °F
−173 °C *−280 °F*	0.98 [b] ,,	237 [b] ,,
20 °C *68 °F* [c]	0.91 [a] ,, 0.88 [b] ,,	220 [a] ,, 214 [b] ,,
2.6 Electrical conductivity (volume) at:		
20 °C *68 °F* (annealed)	56.8 [a] m/ohm mm² 54.5 [b] ,,	98 [a] % IACS 94 [b] ,, ,,
20 °C *68 °F* (fully cold worked)	55.7 [a] ,, 53.4 [b] ,,	96 [a] ,, ,, 92 [b] ,, ,,
2.7 Electrical resistivity (volume) at:		
20 °C *68 °F* (annealed)	0.017 6 [a] ohm mm²/m 1.76 [a] microhm cm 0.018 3 [b] ohm mm²/m 1.83 [b] microhm cm	10.6 [a] ohms (circ mil/ft) 0.693 [a] microhm in 11.0 [b] ohms (circ mil/ft) 0.722 [b] microhm in
20 °C *68 °F* (fully cold worked)	0.018 0 [a] ohm mm²/m 1.80 [a] microhm cm 0.018 7 [b] ohm mm²/m 1.87 [b] microhm cm	10.8 [a] ohms (circ mil/ft) 0.707 [a] microhm in 11.3 [b] ohms (circ mil/ft) 0.738 [b] microhm in

continued overleaf

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. B 5
Cu Te

2 PHYSICAL PROPERTIES (continued)

	Metric Units	English Units
2.8 Temperature coefficient of electrical resistance at: [d] 20 °C *68 °F* (annealed) applicable over range from 0 to 100 °C *32 to 212 °F*	0.003 9 [a] per °C (98 % IACS) 0.003 7 [b] „ „ (94 % IACS)	0.002 1 [a] per °F (98 % IACS) 0.002 0 [b] „ „ (94 % IACS)
20 °C *68 °F* (fully cold worked) applicable over range from 0 to 100 °C *32 to 212 °F*	0.003 8 [a] „ „ (96 % IACS) 0.003 6 [b] „ „ (92 % IACS)	0.002 1 [a] „ „ (96 % IACS) 0.002 0 [b] „ „ (92 % IACS)
2.9 Modulus of elasticity (tension) at 20 °C *68 °F*:		
annealed	12 000 kg/mm²	17 000 000 lb/in²
cold worked	12 000–13 500 „	17 000 000–19 000 000 „
2.10 Modulus of rigidity (torsion) at 20 °C *68 °F*:		
annealed	4 500 kg/mm²	6 400 000 lb/in²
cold worked	4 500– 5 000 „	6 400 000– 7 000 000 „

(a) Oxygen-bearing ('tough-pitch') tellurium copper.
(b) Phosphorus-deoxidised tellurium copper.
(c) Deduced from electrical conductivity values for annealed material.
(d)—The temperature coefficients of resistance given can be used for calculating resistances within the temperature range shown, but these relate only to calculations based on a reference temperature of 20°C *(68°F)*.
—The temperature coefficient of resistance of this low-alloyed copper can be assumed to be directly proportional to the conductivity value and the figures given above have been calculated on the basis that copper of 100% IACS conductivity at 20°C *(68°F)* has a temperature coefficient of resistance of 0.003 93 per °C *(0.002 18 per °F)*.

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.

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 [a]	1 120–1 200 °C	2 050–2 190 °F
3.2 Annealing temperature range [b]	425– 650 °C	800–1 200 °F
Stress relieving temperature range [b]	225– 275 °C	440– 530 °F
3.3 Hot working temperature range [b]	725– 825 °C	1 340–1 520 °F
3.4 Hot formability [b]	Good	
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)	85	
3.8 Joining methods [b]	See General Data Sheet No. 3.2	
Soldering	Excellent	
Brazing [c]	Good	
Oxy-acetylene welding	Not recommended	
Carbon-arc welding	Not recommended	
Gas-shielded arc welding	Fair	
Coated metal-arc welding	Not recommended	
Resistance welding: spot and seam	Not recommended	
butt	Fair	

(a) Optimum casting temperature range for 'tough-pitch' variety 1 120–1 150 °C *(2 050–2 100 °F)*.
(b) Embrittlement will occur if the 'tough-pitch' variety is heated in atmospheres containing an excess of hydrogen.
(c) For 'tough-pitch' variety, care should be taken to avoid melting of ternary eutectic which occurs at 870 °C *(1 600 °F)*.

4 NATIONAL SPECIFICATIONS FOR MANUFACTURED FORMS

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 Te	—	—	266.02	—	—	—	—
Canada	CSA	—	—	—	—	—	—	—	—
Chile	INDITECNOR	Cu-Te	245 n.68	—	—	—	—	—	—
France	NF	—	—	—	—	—	—	—	—
Germany	DIN	E-CuTe (2.1545)	17 666	—	17 672	17 672	17 671	17 674	—
		SE-CuTe (2.1546)	17 666	—	17 672	17 672	17 671	—	—
Italy	UNI	—	—	—	—	—	—	—	—
Netherlands	N or NEN [b]	—	—	—	—	—	—	—	—
South Africa	SABS	—	—	—	—	—	—	—	—
Spain	UNE	—	—	—	—	—	—	—	—
Sweden	SIS	—	—	—	—	—	—	—	—
Switzerland	VSM	Cu-OFTE	10826	—	11852	—	—	—	—
United Kingdom	BS	C109	—	—	2874	—	—	2874	—
United States	ASTM	No. 145 or DPTE or OFTE or OFPTE	—	—	B301	—	—	—	—

(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
Modulus of rigidity (torsion)	„ 2.10

5.2 Mechanical properties at low temperature

Tensile properties	no data traced
Impact properties	„ „ „

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

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 %	Elongation gauge length	Hardness Brinell	Hardness Vickers	Shear Strength kg/mm²	Typical Size Related to Properties Shown [a]
Rod	Annealed	23	6	40	$5.65\sqrt{S_o}$	50	55	14	—
	Typical Cold Worked Tempers	27	23	15	$5.65\sqrt{S_o}$	80	85	17	6–40 mm diam. or equivalent area
		32	29	8	$5.65\sqrt{S_o}$	90	100	18	6–20 mm diam. or equivalent area
		35	32	4	$5.65\sqrt{S_o}$	100	110	19	up to 6 mm diam. or equivalent area
Tube	Annealed	23	6	40	$5.65\sqrt{S_o}$	50	55	14	—
	Typical Cold Drawn Tempers	27	23	15	$5.65\sqrt{S_o}$	80	85	17	10–50 mm O.D. up to 6 mm wall
		32	29	8	$5.65\sqrt{S_o}$	90	100	18	10–25 mm O.D. up to 2 mm wall
Sections / Shapes	Hot Worked [b]	23	6	40	$5.65\sqrt{S_o}$	55	60	15	—
	Typical Cold Worked Temper [b]	30	26	12	$5.65\sqrt{S_o}$	85	95	18	—

(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.

5.1.2 Typical Tensile Properties and Hardness Values - English Units

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 ton/in²	Proof Stress 0.1 % offset ton/in²	Elongation %	Elongation gauge length	Vickers Hardness	Shear Strength ton/in²	Typical Size Related to Properties Shown [a]
Rod	Annealed	15	3	45	$5.65\sqrt{S_o}$	50	9	—
	Typical Cold Worked Tempers	18	15	20	$5.65\sqrt{S_o}$	85	11	0.25–1 in. diam. or equivalent area
		20	17	10	$5.65\sqrt{S_o}$	100	12	"
Sections (extruded)	Typical Cold Drawn Temper [b]	18	15	20	$5.65\sqrt{S_o}$	85	11	—
Forgings	Hot Worked [b]	15	6	30	$5.65\sqrt{S_o}$	60	10	—

(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.

* 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, English and American units respectively, are not directly comparable. This is because the properties quoted reflect to some extent the metalworking techniques and specification practices of the countries concerned.

5.1.3 Typical Tensile Properties and Hardness Values - American Units

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 psi	Yield Strength, 0.5 % extension under load psi	Elongation		Rockwell Hardness			Shear Strength psi	Typical Size Related to Properties Shown [b]
				%	gauge length	F	B	30 T		
Flat Products (Bar)	As Hot Rolled [c]	33 000	8 000	45	2 in.	40	—	—	23 000	—
	Annealed	33 000	8 000	47	2 in.	32	—	—	23 000	—
	Cold Worked									
	Half Hard	42 000	38 000	20	2 in.	80	40	24	26 000	0.125–0.250 in. thick
	Hard	54 000	51 000	11	2 in.	85	50	31	29 000	"
	Quarter Hard	37 000	32 000	30	2 in.	72	25	13	24 000	0.250–0.50 in. thick
	Half Hard	42 000	38 000	20	2 in.	77	35	20	26 000	"
	Hard	50 000	47 000	15	2 in.	83	45	28	28 000	"
	Half Hard	42 000	36 000	25	2 in.	79	38	23	26 000	over 0.50 in. thick
	Hard	48 000	43 000	15	2 in.	85	50	32	27 000	"
Rod	As Hot Rolled [c]	33 000	8 000	45	2 in.	40	—	—	23 000	—
	Annealed-Soft	33 000	8 000	47	2 in.	32	—	—	23 000	—
	Cold Worked									
	Hard	54 000	50 000	9	2 in.	85	50	32	29 000	0.125 in. diam.
	Quarter Hard	37 000	32 000	30	2 in.	69	20	10	24 000	0.250 in. diam.
	Half Hard	43 000	38 000	20	2 in.	79	38	23	26 000	"
	Hard	53 000	49 000	10	2 in.	87	52	33	28 000	"
	Quarter Hard	37 000	32 000	30	2 in.	75	30	16	24 000	0.50 in. diam.
	Half Hard	42 000	38 000	20	2 in.	80	40	24	26 000	"
	Hard	48 000	45 000	15	2 in.	83	45	28	27 000	"
	Half Hard	42 000	36 000	25	2 in.	75	35	22	26 000	1.0 in. diam.
	Hard	48 000	42 000	15	2 in.	80	42	27	27 000	"
	Half Hard	41 000	35 000	30	2 in.	75	35	22	25 000	2.0 in. diam.
	Hard	46 000	40 000	20	2 in.	80	42	27	27 000	"
Shapes	As Hot Rolled [c]	33 000	8 000	45	2 in.	40	—	—	23 000	—
	Annealed [c]	33 000	8 000	47	2 in.	32	—	—	23 000	—
	Cold Worked [c]									
	Half Hard	42 000	36 000	25	2 in.	75	35	22	26 000	—
	Hard	48 000	42 000	15	2 in.	80	42	27	27 000	—
Forgings	As Forged [c]	33 000	8 000	40	2 in.	40	—	—	23 000	—

(a) The tempers listed are those referred to in ASTM and other American Standards.
(b) 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.
(c) 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		Elongation % on 2 in.
		°C	°F	kg/mm²	ton/in²	psi	0.2 % offset kg/mm²	Yield Strength 0.5 % ext. under load psi	
Rod [1] 3.2 mm diam. 0.125 in. diam.	Annealed (grain size 0.025 mm)	24	75	24.5	15.5	**34 800**	**5.35** [a]	**8 400**	**48**
		149	300	—	—	—	**4.50** [a]	**7 300**	—
		204	400	—	—	—	**4.22** [a]	**6 800**	—
		260	500	—	—	—	**4.07** [a]	**6 600**	—
	Cold Worked 37 %	24	75	34.5	22	**49 200**	**31.4** [a]	**45 000**	**8.5**
		149	300	—	—	—	**27.7** [a]	**40 000**	—
		204	400	—	—	—	**24.8** [a]	**36 000**	—
		260	500	—	—	—	**22.6** [a]	**32 800**	—
Rod [1] 19 mm diam. 0.75 in. diam.	Cold Worked 21 %	20	68	35.5	22.5	**50 400**	—	—	**12.5**
		260	500	28.5	18.5	**40 900**	—	—	**9**
		288	550	27	17	**38 600**	—	—	**9**
		315	600	25	16	**35 400**	—	—	**7**
		343	650	23	14.5	**32 700**	—	—	**8**
		371	700	22.5	14.5	**32 200**	—	—	**8**
		399	750	18	11.5	**25 600**	—	—	**8**
		426	800	15.5	10	**22 100**	—	—	**11**
	Cold Worked [b]	27	80	37	23.5	**52 400**	**35.6** [a]	—	**12.8**
		260	500	27	17	**38 600**	**27.1** [a]	—	**4.7**

(a) This value was originally reported in psi; in this table it is given in kg/mm² to 3 significant figures.
(b) Quoted as 'Rockwell hardness 56B' in original document, but amount of cold work not defined.
N.B.: — Original values are printed in **bold type**; other values are converted.
— The 0.1% offset proof stress values are not available.

5.3.2 Creep Properties

5.3.2.1 Original Creep Data

Form	Temper	Testing Temperature		Stress			Duration 1 000 h	Total Extension % (a)	Intercept %	Min. Creep Rate % per 1 000 h
		°C	°F	kg/mm²	ton/in²	psi				
Rod (1) 3.2 mm diam. 0.125 in. diam.	Annealed (grain size 0.025 mm)	149	300	2	1	**3 050**	**6.00**	**0.134 4**	**0.077**	**0.001 4**
				3.5	2	**5 200**	**6.00**	**0.251 5**	**0.121**	**0.007 8**
				6	3.5	**8 550**	**6.00**	**1.553**	**0.737**	**0.022 3**
	Cold Worked 37 %	149	300	4.5	3	**6 900**	**6.00**	**0.089 5**	**0.034 4**	**0.000 85**
				7	4	**10 000**	**6.00**	**0.149 4**	**0.068 1**	**0.001 9**
				10.5	6.5	**15 000**	**6.00**	**0.223 4**	**0.088**	**0.005 23**
				14	8.5	**19 950**	**6.00**	**0.390 5**	**0.155 5**	**0.011 5**
				20.5	13	**29 200**	**6.00**	**1.133**	**0.479**	**0.080**
Rod (1) 19 mm diam. 0.75 in. diam.	Cold Worked (b)	260	500	5.5	3.5	**8 000**	**>4.368**	**0.420**	**0.219**	**0.046**
		315	600	2	1	**3 000**	**>3.60**	**0.084**	**0.065**	**0.005**

(a) Total extension = Initial extension + Total creep = Initial extension + Intercept + (Minimum creep rate × Duration).
(b) Quoted as 'Rockwell hardness 56B' in original document, but amount of cold work not defined.
N.B.: Original values are printed in **bold type**; other values are converted.

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			0.1 % per 1 000 h		
		°C	°F	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi	kg/mm²	ton/in²	psi
Rod (1) 3.2 mm diam. 0.125 in. diam.	Cold Worked 37 %	149	300	5	3	**7 400**	13	8	**19 000**	21.5	13.5	**31 000**

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
Rod [2] **7.6 mm diam. 0.3 in. diam.**	Cold Worked 17 %	100	28	11.5 [a]	17.5	7.5 [a]	**39 500**	**16 500** [a]
Rod [3]	Hot Worked	10	25	8.5 [a]	**16**	**5.5** [a]	36 000	12 500 [a]
	Cold Worked 25 %	10	31.5	11 [a]	**20**	**7** [a]	45 000	15 500 [a]

[a] Rotating-beam test.
N.B.: Original values are printed in **bold type**; other values are converted.

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MECHANICAL PROPERTIES (SECTION 5)

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