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CONFIRMED AUGUST 1985

SPECIFICATION FOR

COPPER FOR ELECTRICAL PURPOSES

WIRE FOR GENERAL ELECTRICAL PURPOSES AND FOR INSULATED CABLES AND FLEXIBLE CORDS

BRITISH STANDARDS INSTITUTION

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THIS BRITISH STANDARD, having been approved by the Non-ferrous Metals Industry Standards Committee, was published under the authority of the Executive Board on 25 June, 1970.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over 9,000, fully indexed and with a note of the contents of each, will be found in the BSI Catalogue which may be purchased from BSI Sales Department. The Catalogue may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 18. Methods for tensile testing of metals. Part 1. Non-ferrous metals.
BS 205. Glossary of terms used in electrical engineering.
BS 1036. Electrolytic tough pitch high conductivity copper.
BS 1037. Fire refined tough pitch high conductivity copper.
BS 1420. Glossary of terms applicable to wrought products in copper, zinc and their alloys.
BS 1559. Reels and wooden drums for bare wire, stranded conductors and trolley wire, for use in the United Kingdom.
BS 1861. Oxygen-free high conductivity copper.
BS 3239. Determination of resistivity of metallic electrical conductor materials.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee reference NFE/12 Draft for comment 69/11310

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CO-OPERATING ORGANIZATIONS

The Non-ferrous Metals Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments, and scientific and industrial organizations:

Aluminium Federation
Association of Bronze and Brass Founders
Association of Consulting Engineers, Incorporated
Board of Trade
British Bronze and Brass Ingot Manufacturers' Association
*British Electrical and Allied Manufacturers' Association
British Lead Manufacturers' Association
*British Non-ferrous Metals Federation
*British Non-ferrous Metals Research Association
*Copper Development Association
Crown Agents for Oversea Governments and Administrations
*Electric Cable Makers' Confederation
Institute of British Foundrymen
*Institute of Metals
Institution of Mechanical Engineers (Automobile Division)
Institution of Mining and Metallurgy
Institution of Production Engineers
Institution of Structural Engineers
Lead Development Association
Light Metal Founders' Association
London Metal Exchange
Magnesium Industry Council
Ministry of Defence (Army Dept)
Ministry of Defence (Navy Dept)
National Brassfoundry Association
*Non-ferrous Metal Stockists
*Post Office
Royal Institute of British Architects
*Society of Motor Manufacturers and Traders Limited
Tin Research Institute
Zinc Development Association
Individual manufacturers

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Railways Board
Electricity Supply Industry in England and Wales
Institute of Sheet Metal Engineering
Ministry of Technology
Ministry of Technology (National Physical Laboratory)

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BRITISH STANDARD SPECIFICATION FOR

COPPER FOR ELECTRICAL PURPOSES WIRE FOR GENERAL ELECTRICAL PURPOSES AND FOR INSULATED CABLES AND FLEXIBLE CORDS

FOREWORD

This British Standard is one of a series of standards for copper for electrical purposes, the others in the series being as follows:

BS 1432 Copper for electrical purposes.	Strip with drawn or rolled edges.
BS 1433 Copper for electrical purposes.	Rod and bar
BS 1434 Copper for electrical purposes.	Commutator bars.
BS 1977 Copper for electrical purposes.	Tubes.
BS 4608 Copper for electrical purposes	Rolled sheet, strip and foil.

This British Standard is a revision in metric terms of a standard published in 1967. It was then intended to bring together in a single standard requirements for copper wires used in insulated cables and flexible cords and to replace BS 128 issued in 1929. With the publication of this metric revision, the 1967 edition in imperial units is withdrawn.

In this revision due regard has been given to the work of the International Organization for Standardization (ISO) on testing requirements, properties, etc. and wherever possible and appropriate their recommendations or expected recommendations have been followed.

This standard is not intended to apply to wires which are to be enamelled or textile covered, nor to wires for mineral insulated cables, nor to telecommunication wires or cables. Neither does it apply to wires *taken from* the conductors in insulated cables and flexible cords which are covered by BS 6360, ' Copper conductors in insulated cables and cords '.

The wording and general arrangement of clauses have been aligned as far as possible with BS 2873, ' Copper and copper alloys. Wire'.

NOTE. Attention is drawn to certification facilities offered by SSI; see the back cover of this standard.

SPECIFICATION

1. SCOPE

This British Standard specifies requirements for bare high conductivity, plain or tinned, annealed or hard copper wire in diameters from 0·05 mm up to and including 6·0 mm for general electrical purposes and for use in insulated cables and flexible cords.

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2. GENERAL

The wire shall comply with the general requirements specified in Clauses 5 to 10, with the requirements of the tests specified in Clauses 12 to 15, if appropriate, and with the appropriate requirements of Tables 1 to 10.

3. DEFINITIONS

For the purposes of this British Standard the definitions in BS 205* and BS 1420† apply.

4. INFORMATION TO BE SUPPLIED BY THE PURCHASER

The purchaser shall supply the following information when placing the order:

(1) The chemical composition of the material (see Clause 6).
(2) The condition of the material (see Clause 7).
(3) Whether a tinned finish is required (see Clause 8).
(4) Whether a certificate of compliance is required (see Clause 16).
(5) Whether it is the purchaser's intention to inspect the material at the supplier's works (see Clause 17).

5. FREEDOM FROM DEFECTS

The wire shall be bright, clean, smooth and free from harmful defects.

6. CHEMICAL COMPOSITION

The wire shall be manufactured from copper complying with the requirements of BS 1036‡ (designated C101), BS 1037§ (designated C102) or BS 1861‖ (designated C103) as specified by the purchaser.

If no British Standard is stipulated by the purchaser, the supplier shall be at liberty to supply at his discretion material complying with the requirements of any one of the above standards.

7. CONDITION

The wire shall be supplied in either of the following conditions, as specified by the purchaser:

Annealed	O
Hard	H

in accordance with the mechanical properties specified in this standard.

* BS 205, 'Glossary of terms used in electrical engineering'.
† BS 1420, 'Glossary of terms applicable to wrought products in copper, zinc and their alloys'.
‡ BS 1036, 'Electrolytic tough pitch high conductivity copper'.
§ BS 1037, 'Fire refined tough pitch high conductivity copper'.
‖ BS 1861, 'Oxygen-free high conductivity copper'.

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8. FINISH

When specified to be tinned the wire shall be coated with a smooth, uniform layer of tin, free from deleterious impurities.

9. JOINTS

There shall be no joints in the wire except those made in the base rod or wire before final drawing.

10. DIMENSIONS AND TOLERANCES

The diameter of wire determined by means of a suitable micrometer and by taking the mean of two measurements at right angles made at the same cross section of a sample taken from any part of a coil, reel or drum, shall be within the limits stated in Table 1. (See also Columns 2 and 3 of Tables 8 to 10.)

TABLE 1. TOLERANCE ON DIAMETER

Diameter		Tolerance
over	up to and including	
mm	mm	mm
—	0·125	± 0·002
0·125	0·400	± 0·004
0·400	4·00	± 1 % of standard diameter
4·00	—	± 0·05

The difference between the maximum and minimum measurements, taken at the same cross section shall not exceed the limits stated in Table 2. (See also Column 4 of Tables 8 to 10).

TABLE 2. DIFFERENCE BETWEEN MAXIMUM AND MINIMUM MEASUREMENTS

Diameter		Difference between maximum and minimum measurements
over	up to and including	
mm	mm	mm
0·315	0·400	0·004
0·400	4·00	1 % of standard diameter
4·00	—	0·05

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11. SELECTION OF TEST SAMPLES

When tests are specifically called for by the purchaser the selection of test samples and the number of tests to be made shall be agreed between the supplier and the purchaser.

12. MECHANICAL TESTS

The following tests shall be made on test pieces selected as specified in Clause 11.

The mechanical properties shall comply with the appropriate requirements of Table 7.

12.1 Tensile test. This test applies only to wire in the H condition and shall be made in accordance with the methods described in BS 18 Part 1*. The load shall be applied gradually and uniformly.

12.2 Elongation test. This test applies only to wire in the O condition and shall be made in accordance with the methods described in BS 18 Part 1*. The load shall be applied gradually and uniformly to a straightened length of wire, having an original gauge length of 200 mm. Alternatively a gauge length of 250 mm may be used. The elongation shall be measured on the gauge length after the fractured ends have been fitted together. The determination shall be valid, whatever the position of the fracture, if the specified value is reached. If the specified value is not reached, the determination shall be valid only if the fracture occurs between the gauge marks and not closer than 25 mm to either mark.

12.3 Wrapping test. This test applies only to wire in the H condition. The wire shall be wrapped round a wire of its own diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again closely re-wrapped in the same direction as the first wrapping. To comply with the requirements of the test the wire shall not break when thus tested.

13. ELECTRICAL RESISTIVITY TEST

The resistivity shall be determined by direct measurement on the wire in accordance with the routine method given in BS 3239†.

The values obtained using the factors given in Tables 11 and 12 in Appendix B as appropriate shall not exceed the values given in Table 3, except that for tinned wire in the O and H conditions increases in resistivity as shown in Table 4 shall be permitted.

* BS 18, 'Methods for tensile testing of metals' Part 1. Non-ferrous metals.
† BS 3239, 'Determination of resistivity of metallic electrical conductor materials'.

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TABLE 3. RESISTIVITY VALUES

Condition	Resistivity at 20 °C max.	Conductivity*
	microhm metre	%
O	0·017 241	100
H	0·017 77	97

Maximum resistances for plain wire based on these standard resistivity values and calculated on the minimum diameter listed in Column 3 of Tables 8 to 10 are given in Column 8 of Tables 8 to 10.

TABLE 4. PERMITTED INCREASE IN RESISTIVITY FOR TINNED WIRE

Diameter		Permitted increase	
over	up to and including	O condition	H condition
mm	mm	%	%
—	1·0	2	1·5
1·0	—	1	0·5

Maximum resistances for tinned wire in the O and H conditions are given in Column 9 of Tables 8 to 10.

14. TINNING TEST

The following test shall apply only to tinned wires of diameter over 0·09 mm up to and including 3·2 mm.

14.1 Preparation of test specimens

14.1.1 Test specimens shall be cut from the test samples referred to in Clause 11, to the total length shown in Column 3 of Table 5 and then marked 40 mm from each end by means of a grease pencil or in some other manner which will not cause damage to the coating, thus providing the length between marks shown in Column 4 of Table 5.

NOTE. Long test specimens may be split up into a number of separate test pieces.

* Expressed as a percentage of the value for standard annealed copper as laid down by the International Electrotechnical Commission. Copper having a resistivity at 20 °C of 0·017 241 microhm metre is said to have a conductivity of 100 % (IEC Publication No. 28).

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TABLE 5. TEST SPECIMENS FOR TINNING TEST

1	2	3	4
Diameter		Length of test specimen	
over	up to and including	Total	Between marks
mm	mm	m	m
0·09	0·15	10·08	10
0·15	0·30	5·08	5
0·30	0·67	2·08	2
0·67	3·2	1·08	1

14.1.2 Each test specimen shall be wound into a helix upon a smooth mandrel in such a manner as to ensure no twisting movement being imparted to the wire.

Such portions of the test specimen as are necessary to lead up to the 40 mm ends and provide for their projection above the surface of the testing solution in which the specimen is to be immersed shall not be formed to the mandrel but shall be suitably bent for the purpose. Such bending, however, shall not entail a radius of less than half the diameter of the mandrel used to produce the helix.

The diameters of the mandrels to be used shall comply with those given in Table 6.

TABLE 6. MANDREL DIAMETERS FOR TINNING TEST

1	2	3
Diameter of wire		Diameter of mandrel
above	up to and including	
mm	mm	mm
0·09	0·14	15
0·14	0·41	20
0·41	0·67	25
0·67	0·85	30
0·85	1·13	35
1·13	1·53	45
1·53	1·78	55
1·78	2·25	65
2·25	2·52	75
2·52	2·85	85
2·85	3·20	95

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14.1.3 The helix shall be removed from the mandrel by slipping it off endwise without further distortion of the wire.

14.1.4 A cleaning operation shall be carried out after the test helix has been removed from the mandrel and immediately before its immersion in the test solution, and the part to be immersed shall not be handled.

The method of cleaning shall consist of the immersion of the test helix for a period of ten seconds in a suitable solvent, e.g. chloroform or methylated ether, contained in one vessel, followed by a similar period of immersion in solvent contained in a second vessel, the helix to be agitated during each immersion and allowed to dry before immersion in the test solution.

Should the coloration of the solvent by dissolved material become discernible, the solvent shall be renewed, care being taken to ensure that the vessel containing the cleaner liquid is used for the second (and final) wash.

14.2 Preparation of testing solutions. The testing solutions shall be prepared as follows:

14.2.1 Ammonium persulphate solution. Dissolve 10 g of fresh crystalline ammonium persulphate in distilled water, add 20 ml of ammonia solution (sp. gr. 0·880-0·91) and make up to 1 litre with distilled water.

14.2.2 Standard colour reagent. (1 ml-0·001 g of copper). Dissolve 3·927 grammes of pure copper sulphate ($CuSO_4\ 5H_2O$) in distilled water with 50 ml of ammonia solution (sp. gr. 0·880-0·91). Make up to 1 litre with distilled water.

14.3 Immersion for test. After cleaning, the helix shall be immersed for ten minutes in a vessel containing the ammonium persulphate solution (see 14.2.1) in such a manner that the surface of the wire between the marks (see Column 4 of Table 5) is exposed to the testing solution and the 40 mm ends project above the surface.

The test shall be carried out under normal room temperature conditions.

The volume of the solution shall be as follows:

(1) diameters up to and including 1·8 mm—75 ml

(2) diameters over 1·8 mm—200 ml

14.4 Determination of weight of copper dissolved. The weight of copper dissolved from the wire by the ammonium persulphate solution shall be determined colorimetrically by comparison with the standard colour reagent (14.2.2). The weight of copper dissolved shall not exceed 1 g/m² of surface area of wire immersed.

15. RETESTS

Arrangements for retesting shall be made between the supplier and the purchaser.

Where one test is required per batch the following shall apply:

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Should any one of the test pieces first selected fail to pass any of the prescribed tests, two further samples from the same batch shall be selected for testing, one of which shall be from the piece from which the original test sample was taken unless that piece has been withdrawn by the supplier.

Should the test pieces from both these additional samples pass, the batch represented by the test samples shall be deemed to comply with this standard. Should the test pieces from either of these additional samples fail, the batch represented by the test samples shall be deemed not to comply with this standard.

16. CERTIFICATE OF COMPLIANCE

The supplier shall, if required, certify that the material complies with the requirements of this standard appropriate to the material ordered.

17. INSPECTION

The purchaser shall notify the supplier when placing the order if it is his intention to inspect the material at the supplier's works. The supplier shall afford the purchaser all reasonable facilities to satisfy himself that the material is in accordance with this standard. For this purpose the purchaser or his representative may by prior arrangement attend to inspect the material, to select and identify the test sample for testing and to witness the tests being made.

The purchaser shall be at liberty to take samples from the material selected in accordance with Clause 11 and have them analysed. The cost of such analysis shall be borne by the purchaser and the results shall be communicated to the supplier if they are not in accordance with the requirements specified in Clause 6.

18. FACILITIES FOR TESTING

The supplier shall provide and prepare the necessary test pieces, and supply labour and appliance for such testing as may be carried out on his premises in accordance with this standard. Unless otherwise agreed, material for testing shall remain the property of the supplier. Failing facilities at his own works for making the prescribed tests, the supplier shall make the necessary arrangements for making the tests elsewhere.

19. PACKAGING

The method of packaging shall be specified by the purchaser.

When the wire is supplied in coils, the eye diameter and the weight of the coils shall be the subject of agreement between the supplier and the purchaser.

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When the wire is supplied on spools, reels or drums, these shall be of wood, metal or plastics as agreed between the supplier and the purchaser and they should preferably comply with the requirements of BS 1559*.

TABLE 7. MECHANICAL PROPERTIES OF COPPER WIRE

Condition	Diameter		Tensile strength min.		Elongation min.	
	over	up to and including	Plain wire	Tinned wire	Plain wire	Tinned wire
	mm	mm	hbar†	hbar†	%	%
H	—	1·60	45·6	40·9	—	—
	1·60	2·50	44·6	40·2	—	—
	2·50	3·15	43·7	39·4	—	—
	3·15	3·55	42·9	38·6	—	—
	3·55	4·0	42·2	38·0	—	—
	4·0	5·0	41·2	37·1	—	—
	5·0	5·6	40·6	36·6	—	—
O	—	0·14	—	—	10	7
	0·14	0·21	—	—	15	12
	0·21	0·51	—	—	20	17
	0·51	1·36	—	—	25	22
	1·36	—	—	—	30	27

* BS 1559, ' Reels and wooden drums for bare wire, stranded conductors and trolley wire, for use in the United Kingdom '.

† 1 hbar = 10 MN/m² = 10 N/mm². For conversion to kgf/mm² and tonf/in² see Appendix A.

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TABLE 8. PLAIN AND TINNED ANNEALED COPPER WIRE

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/km
0·05	0·052	0·048	—	0·001 963	8 783	8 959	9 530	9 720	0·017 45
0·063	0·065	0·061	—	0·003 117	5 531	5 642	5 900	6 018	0·027 71
0·08	0·082	0·078	—	0·005 027	3 430	3 499	3 608	3 680	0·044 69
0·09	0·092	0·088	—	0·006 362	2 710	2 764	2 835	2 892	0·056 56
0·10	0·102	0·098	—	0·007 854	2 195	2 239	2 286	2 332	0·069 82
0·14	0·144	0·136	—	0·015 39	1 120	1 142	1 187	1 211	0·136 8
0·16	0·164	0·156	—	0·020 11	857·3	874·4	902·2	920·2	0·178 7
0·18	0·184	0·176	—	0·025 45	677·4	690·9	708·6	722·8	0·226 3
0·20	0·204	0·196	—	0·031 42	548·7	559·7	571·5	583·0	0·279 3
0·25	0·254	0·246	—	0·049 09	351·2	358·2	362·7	370·0	0·436 4
0·315	0·319	0·311	0·004	0·077 93	221·2	225·6	227·0	231·5	0·692 8
0·40	0·404	0·396	0·004	0·125 7	137·2	139·9	139·9	142·7	1·117
0·45	0·454	0·446	0·005	0·159 0	108·4	110·6	110·4	112·6	1·414
0·50	0·505	0·495	0·005	0·196 4	87·81	89·55	89·61	91·40	1·746
0·56	0·566	0·554	0·006	0·246 3	70·00	71·40	71·51	72·94	2·190
0·80	0·808	0·792	0·008	0·502 7	34·30	34·99	34·99	35·69	4·469
0·90	0·909	0·891	0·009	0·636 2	27·10	27·64	27·65	28·20	5·656
1·25	1·263	1·237	0·013	1·227	14·05	14·19	14·34	14·49	10·91

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TABLE 8. PLAIN AND TINNED ANNEALED COPPER WIRE—*continued*

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/km
1·40	1·414	1·386	0·014	1·539	11·20	11·31	11·43	11·54	13·68
1·60	1·616	1·584	0·016	2·011	8·573	8·660	8·747	8·834	17·88
1·80	1·818	1·782	0·018	2·545	6·775	6·842	6·914	6·982	22·62
2·00	2·020	1·980	0·020	3·142	5·488	5·542	5·600	5·655	27·93
2·50	2·525	2·475	0·025	4·909	3·512	3·547	3·584	3·620	43·64
2·80	2·828	2·772	0·028	6·158	2·800	2·828	2·857	2·885	54·74
3·15	3·182	3·118	0·032	7·793	2·212	2·234	2·258	2·281	69·28
4·00	4·040	3·960	0·040	12·57	1·372	1·386	1·400	1·414	111·7
4·50	4·550	4·450	0·050	15·90	1·084	1·095	1·109	1·120	141·4
5·00	5·050	4·950	0·050	19·64	0·8780	0·8867	0·8961	0·9051	174·6
5·60	5·650	5·550	0·050	24·63	0·7000	0·7070	0·7127	0·7198	219·0

NOTE. *Preferred sizes.* The above table and Tables 9 and 10 were prepared with the object of embracing on a logical basis a comprehensive selection of sizes for general purposes and at the same time meeting the requirements of the cable industry. Table 10 (Hard-drawn wires) covers the complete range in sizes which comply with ISO Recommendation R388 (R20 sizes). It would have been too cumbersome in dealing with soft wire to meet both requirements in a single table, hence the Tables 8 and 9 both covering annealed wire. Table 8 includes wire to ISO/R388 (R20 sizes) and Table 9 covers additional (non-R20) sizes that are required for cable making purposes. Some of the sizes in Table 9 are so close to R20 sizes as to enable omissions from Table 8. A number of the sizes needed for cable making are R20 sizes and therefore to be found in Table 8.

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TABLE 9. PLAIN AND TINNED ANNEALED COPPER WIRE

(Cable sizes. See note to table 8)

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/km
0·065	0·067	0·063	—	0·003 318	5 196	5 300	5 531	5 642	0·029 50
0·118	0·120	0·116	—	0·010 94	1 576	1 608	1 631	1 664	0·097 26
0·132	0·136	0·128	—	0·013 68	1 260	1 285	1 340	1 367	0·121 6
0·150	0·154	0·146	—	0·017 67	975·7	995·2	1 030	1 051	0·157 1
0·170	0·174	0·166	—	0·022 70	759·6	774·8	796·6	812·5	0·201 8
0·212	0·216	0·208	—	0·035 30	488·4	498·2	507·4	517·5	0·313 8
0·236	0·240	0·232	—	0·043 74	394·2	402·1	407·9	416·1	0·388 8
0·300	0·304	0·296	—	0·070 69	243·9	248·8	250·6	255·6	0·628 4
0·335	0·339	0·331	0·004	0·088 14	195·6	199·5	200·4	204·4	0·783 6
0·600	0·606	0·594	0·006	0·282 7	60·98	62·20	62·22	63·46	2·514
0·670	0·677	0·663	0·007	0·352 6	48·90	49·89	49·94	50·94	3·134
0·750	0·757	0·743	0·008	0·441 8	39·03	39·81	39·76	40·56	3·927
0·850	0·858	0·842	0·009	0·567 5	30·38	30·99	30·96	31·58	5·045
1·04	1·050	1·030	0·010	0·849 5	20·30	20·50	20·69	20·90	7·552
1·13	1·141	1·119	0·011	1·003	17·19	17·36	17·53	17·71	8·917
1·35	1·364	1·336	0·014	1·431	12·05	12·17	12·30	12·42	12·72

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TABLE 9. PLAIN AND TINNED ANNEALED COPPER WIRE—*continued*

(Cable sizes. See note to table 8)

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/km
1·38	1·394	1·366	0·014	1·496	11·53	11·64	11·76	11·88	13·30
1·53	1·545	1·515	0·015	1·839	9·375	9·469	9·562	9·658	16·35
1·70	1·717	1·683	0·017	2·270	7·596	7·672	7·750	7·827	20·18
1·78	1·798	1·762	0·018	2·488	6·930	6·999	7·072	7·143	22·12
1·90	1·919	1·881	0·019	2·835	6·081	6·142	6·204	6·266	25·21
2·03	2·05	2·010	0·020	3·237	5·326	5·379	5·434	5·488	28·78
2·14	2·161	2·118	0·021	3·597	4·793	4·841	4·894	4·943	31·98
2·25	2·272	2·227	0·023	3·976	4·336	4·379	4·426	4·470	35·35
2·36	2·384	2·336	0·024	4·374	3·941	3·981	4·023	4·063	38·88
2·52	2·545	2·495	0·025	4·988	3·457	3·491	3·526	3·562	44·34
2·65	2·677	2·625	0·027	5·515	3·126	3·157	3·186	3·218	49·03
2·76	2·787	2·732	0·028	5·983	2·882	2·911	2·941	2·971	53·19
2·85	2·878	2·822	0·029	6·379	2·703	2·730	2·757	2·784	56·71
3·00	3·030	2·970	0·030	7·069	2·439	2·463	2·489	2·514	62·84
3·20	3·232	3·168	0·032	8·042	2·144	2·165	2·187	2·209	71·50
3·57	3·606	3·535	0·036	10·01	1·722	1·739	1·757	1·775	88·99
6·00	6·050	5·950	0·050	28·27	0·6098	0·6159	0·6201	0·6263	251·4

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TABLE 10. PLAIN AND TINNED HARD DRAWN COPPER WIRE

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/km
0·056	0·058	0·054	—	0·002 463	7 215	7 323	7 760	7 876	0·021 90
0·063	0·065	0·061	—	0·003 117	5 701	5 787	6 081	6 172	0·027 71
0·071	0·073	0·069	—	0·003 959	4 489	4 556	4 753	4 824	0·035 20
0·080	0·082	0·078	—	0·005 027	3 535	3 588	3 719	3 775	0·044 69
0·090	0·092	0·088	—	0·006 362	2 793	2 835	2 922	2 966	0·056 56
0·100	0·102	0·098	—	0·007 854	2 263	2 297	2 356	2 391	0·069 82
0·112	0·114	0·110	—	0·009 852	1 804	1 831	1 870	1 898	0·087 58
0·125	0·127	0·123	—	0·012 27	1 448	1 470	1 496	1 518	0·109 1
0·140	0·144	0·136	—	0·015 39	1 155	1 172	1 223	1 241	0·136 8
0·160	0·164	0·156	—	0·020 11	883·6	896·8	929·8	943·7	0·178 7
0·180	0·184	0·176	—	0·025 45	698·2	708·7	730·4	741·4	0·226 3
0·200	0·204	0·196	—	0·031 42	565·6	574·1	589·0	597·8	0·279 3
0·224	0·228	0·220	—	0·039 41	450·9	457·7	467·5	474·5	0·350 4
0·250	0·254	0·246	—	0·049 09	362·0	367·4	373·9	379·5	0·436 4
0·280	0·284	0·276	—	0·061 58	288·6	292·9	297·0	301·5	0·547 4
0·315	0·319	0·311	0·004	0·077 93	228·0	231·4	233·9	237·4	0·692 8
0·355	0·359	0·351	0·004	0·098 98	179·5	182·2	183·7	186·5	0·879 9
0·400	0·404	0·396	0·004	0·125 7	141·4	143·5	144·2	146·4	1·117
0·450	0·454	0·446	0·005	0·159 0	111·8	113·5	113·8	115·5	1·414
0·500	0·505	0·495	0·005	0·196 4	90·48	91·84	92·36	93·75	1·746
0·560	0·566	0·554	0·006	0·246 3	72·15	73·23	73·72	74·83	2·190

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TABLE 10. PLAIN AND TINNED HARD DRAWN COPPER WIRE—*continued*

1	2	3	4	5	6	7	8	9	10
Diameter			Difference between max. & min. measurements not to exceed	Area	Std. resistance at 20 °C		Max. resistance at 20 °C		Mass
std.	max.	min.			Plain	tinned	plain	tinned	
mm	mm	mm	mm	mm²	Ω/km	Ω/km	Ω/km	Ω/km	kg/kg
0·630	0·636	0·624	0·006	0·3117	57·01	57·87	58·11	58·98	2·771
0·710	0·717	0·703	0·007	0·3959	44·89	45·56	45·78	46·47	3·520
0·800	0·808	0·792	0·008	0·5027	35·35	35·88	36·07	36·61	4·469
0·900	0·909	0·891	0·009	0·6362	27·93	28·35	28·50	28·93	5·656
1·00	1·010	0·990	0·010	0·7854	22·63	22·96	23·09	23·44	6·982
1·12	1·131	1·109	0·011	0·9852	18·04	18·13	18·40	18·49	8·758
1·25	1·263	1·237	0·013	1·227	14·48	14·55	14·79	14·86	10·91
1·40	1·414	1·386	0·014	1·539	11·54	11·60	11·78	11·84	13·68
1·60	1·616	1·584	0·016	2·011	8·836	8·880	9·016	9·061	17·88
1·80	1·818	1·782	0·018	2·545	6·982	7·017	7·125	7·161	22·62
2·00	2·020	1·980	0·020	3·142	5·656	5·684	5·771	5·800	27·93
2·24	2·262	2·218	0·022	3·941	4·509	4·532	4·604	4·627	33·04
2·50	2·525	2·475	0·025	4·909	3·620	3·638	3·694	3·712	43·64
2·80	2·828	2·772	0·028	6·158	2·886	2·900	2·944	2·958	54·74
3·15	3·181	3·118	0·032	7·793	2·280	2·291	2·327	2·339	69·28
3·55	3·585	3·515	0·036	9·898	1·795	1·804	1·831	1·840	87·99
4·00	4·040	3·960	0·040	12·57	1·414	1·421	1·442	1·449	111·7
4·50	4·550	4·450	0·050	15·90	1·118	1·124	1·143	1·149	141·4
5·00	5·050	4·950	0·050	19·64	0·9048	0·9093	0·9236	0·9282	174·6
5·60	5·650	5·550	0·050	24·63	0·7215	0·7251	0·7346	0·7383	219·0

APPENDIX A

CONVERSION OF STRESS VALUES

As amended Aug. 1978

hbar	kgf/mm^2	tonf/in^2
36·6	37·3	23·7
37·1	37·8	24·0
38·0	38·7	24·6
38·6	39·4	25·0
39·4	40·2	25·5
40·2	41·0	26·0
40·6	41·4	26·3
40·9	41·7	26·5
41·2	42·0	26·7
42·2	43·0	27·3
42·9	43·7	27·8
43·7	44·6	28·3
44·6	45·5	28·9
45·6	46·5	29·5

Conversion factors. 1 hbar = 100 bar = 10 MN/m^2 = 10 N/mm^2 = 0·647 49 tonf/in^2 = 1450·38 lbf/in^2 = 1·019 72 kgf/mm^2. For more detailed conversions see BS 350, ' Conversion factors and tables '.

APPENDIX B

FACTORS FOR CORRECTING RESISTANCE AT VARIOUS TEMPERATURES

Factors for correcting the resistance of hard-drawn high conductivity copper and annealed high conductivity copper at various temperatures to those at the standard temperature of 20 °C, and reciprocals of the factors for calculating the resistance at other temperatures are given in Tables 11 and 12.

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TABLE 11. FACTORS FOR CORRECTING RESISTANCE. HARD-DRAWN HIGH CONDUCTIVITY COPPER OF CONDUCTIVITY 97 % I.A.C.S.

1	2	3	1	2	3
Temperature °C	Correction factor	Reciprocal of factor	Temperature °C	Correction factor	Reciprocal of factor
5	1·0606	0·9429	18	1·0077	0·9924
5·5	1·0585	0·9448	18·5	1·0057	0·9943
6	1·0563	0·9467	19	1·0038	0·9962
6·5	1·0542	0·9486	19·5	1·0019	0·9981
7	1·0521	0·9505	20	1·0000	1·0000
7·5	1·0500	0·9524	20·5	0·9981	1·0019
8	1·0479	0·9543	21	0·9962	1·0038
8·5	1·0458	0·9562	21·5	0·9943	1·0057
9	1·0437	0·9581	22	0·9924	1·0076
9·5	1·0417	0·9600	22·5	0·9906	1·0095
10	1·0396	0·9619	23	0·9887	1·0114
10·5	1·0376	0·9638	23·5	0·9868	1·0133
11	1·0355	0·9657	24	0·9850	1·0152
11·5	1·0335	0·9676	24·5	0·9831	1·0171
12	1·0314	0·9695	25	0·9813	1·0191
12·5	1·0294	0·9714	25·5	0·9795	1·0210
13	1·0274	0·9733	26	0·9777	1·0229
13·5	1·0254	0·9752	26·5	0·9758	1·0248
14	1·0234	0·9771	27	0·9740	1·0267
14·5	1·0214	0·9790	27·5	0·9722	1·0286
15	1·0194	0·9810	28	0·9704	1·0305
15·5	1·0174	0·9829	28·5	0·9686	1·0324
16	1·0155	0·9848	29	0·9668	1·0343
16·5	1·0135	0·9867	29·5	0·9651	1·0362
17	1·0116	0·9886	30	0·9633	1·0381
17·5	1·0096	0·9905			

NOTE 1. The primary purpose of this table is to enable a resistance measured at a temperature other than 20 °C to be converted to the resistance at 20 °C in order to determine whether the conductor under test complies with the requirements of the standard. Given the resistance at T °C, the resistance at 20 °C is found by multiplying the resistance at T °C by the constant for T °C given in Column 2. Conversely, given the resistance at 20 °C, the corresponding resistance at T °C is found by multiplying the resistance at 20 °C by the reciprocal for T °C given in Column 3. For this purpose the factors have been given at intervals of ½ degC from 5 °C to 30 °C, and the error in using the table between these limits will not exceed 0·06 % for copper within the range of conductivity 96 % to 98 % I.A.C.S.

NOTE 2. The temperature coefficient of resistance of copper varies slightly from sample to sample according to its exact conductivity. The figures given are based on a value of the temperature coefficient of resistance of 0·003 81 per degC at 20 °C which is an average value for copper of 97 % I.A.C.S. conductivity.

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TABLE 12. FACTORS FOR CORRECTING RESISTANCE. ANNEALED HIGH CONDUCTIVITY COPPER OF CONDUCTIVITY 100 % I.A.C.S.

1	2	3	1	2	3
Temperature °C	Correction factor	Reciprocal of factor	Correction °C	Temperature factor	Reciprocal of factor
5	1·0626	0·9411	18	1·0079	0·9921
5·5	1·0604	0·9430	18·5	1·0059	0·9941
6	1·0582	0·9450	19	1·0039	0·9961
6·5	1·0560	0·9469	19·5	1·0020	0·9980
7	1·0538	0·9489	20	1·0000	1·0000
7·5	1·0517	0·9509	20·5	0·9980	1·0020
8	1·0495	0·9528	21	0·9961	1·0039
8·5	1·0473	0·9548	21·5	0·9941	1·0059
9	1·0452	0·9568	22	0·9922	1·0079
9·5	1·0430	0·9587	22·5	0·9903	1·0098
10	1·0409	0·9607	23	0·9883	1·0118
10·5	1·0388	0·9627	23·5	0·9864	1·0138
11	1·0367	0·9646	24	0·9845	1·0157
11·5	1·0346	0·9666	24·5	0·9826	1·0177
12	1·0325	0·9686	25	0·9807	1·0197
12·5	1·0304	0·9705	25·5	0·9788	1·0216
13	1·0283	0·9725	26	0·9770	1·0236
13·5	1·0262	0·9745	26·5	0·9751	1·0255
14	1·0241	0·9764	27	0·9732	1·0275
14·5	1·0221	0·9784	27·5	0·9714	1·0295
15	1·0200	0·9804	28	0·9695	1·0314
15·5	1·0180	0·9823	28·5	0·9677	1·0334
16	1·0160	0·9843	29	0·9658	1·0354
16·5	1·0139	0·9862	29·5	0·9640	1·0373
17	1·0119	0·9882	30	0·9622	1·0393
17·5	1·0099	0·9902			

NOTE 1. The primary purpose of this table is to enable a resistance measured at a temperature other than 20 °C to be converted to the resistance at 20 °C, in order to determine whether the material under test complies with the requirements of the standard. Given the resistance at T °C, the resistance at 20 °C is found by multiplying the resistance at T °C by the constant for T °C given in Column 2. Conversely, given the resistance for 20 °C, the corresponding resistance at T °C is found by multiplying the resistance at 20 °C by the reciprocal for T °C given in Column 3. For this purpose the factors have been given at intervals of ½ degC from 5 °C to 30 °C, and the error in using the table between these limits will not exceed 0·06 % for copper within the range of conductivity 99 % to 101 % I.A.C.S.

NOTE 2. The temperature coefficient of resistance of copper varies slightly from sample to sample according to its exact conductivity. The figures given are based on a value of the temperature coefficient of resistance of 0·003 93 per degC at 20 °C, the value adopted by the International Electrotechnical Commission for ' standard annealed copper '.

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