BS EN 13602:2013

BSI Standards Publication

Copper and copper alloys — Drawn, round copper wire for the manufacture of electrical conductors

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National foreword

This British Standard is the UK implementation of EN 13602:2013. It supersedes BS EN 13602:2002, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NFE/34/1, Wrought and unwrought copper and copper alloys.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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EN 13602

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English Version

Copper and copper alloys - Drawn, round copper wire for the manufacture of electrical conductors

Cuivre et alliages de cuivre - Fils ronds en cuivre étirés pour la fabrication des conducteurs électriques

Kupfer und Kupferlegierungen - Gezogener Runddraht aus Kupfer zur Herstellung elektrischer Leiter

This European Standard was approved by CEN on 25 April 2013.

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Foreword

This document (EN 13602:2013) has been prepared by Technical Committee CEN/TC 133 “Copper and copper alloys”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2013, and conflicting national standards shall be withdrawn at the latest by December 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13602:2002.

In comparison with EN 13602:2002, the following changes were made:

— Terms have been modified.

— Normative references have been updated.

— Editorial modifications have been made.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 4 "Extruded and drawn products, forgings and scrap" to prepare the following revision of the standard:

EN 13602:2002, *Copper and copper alloys — Drawn, round copper wire for the manufacture of electrical conductors.*

The products specified in this European Standard are those which are especially suitable for electrical purposes, i.e. with specified electrical properties. Drawn round wire for general purposes is specified in EN 12166.

This is one of a series of European Standards for copper products for electrical purposes. Other copper products are specified as follows:

— EN 13599, *Copper and copper alloys — Copper plate, sheet and strip for electrical purposes*

— EN 13600, *Copper and copper alloys — Seamless copper tubes for electrical purposes*

— EN 13601, *Copper and copper alloys — Copper rod, bar and wire for general electrical purposes*

— EN 13604, *Copper and copper alloys — Semiconductor devices, electronic and vacuum products made from high conductivity copper*

— EN 13605, *Copper and copper alloys — Copper profiles and profiled wire for electrical purposes*

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies the composition, property requirements including electrical properties, and dimensional tolerances for drawn round copper wire from 0,04 mm up to and including 5,0 mm for the manufacture of electrical conductors intended for the production of bare and insulated cables and flexible cords.

This standard covers plain or tinned, single or multiline, annealed or hard drawn wire. It does not include wire for enamelling (winding wire, magnet wire), for electronic application and for contact wire for electric traction.

The sampling procedures, the test methods for verification of conformity to the requirements of this standard and the delivery conditions are also specified.

NOTE Due to the thermal and/or mechanical treatment involved in cablemaking processes, the properties of conductors in the final cable or cord differ from those of the original wire supplied. Requirements for conductors taken from cable or cord are given in appropriate cable standards.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 610, *Tin and tin alloys — Ingot tin*

EN 1655, *Copper and copper alloys — Declarations of conformity*

EN 1976, *Copper and copper alloys — Cast unwrought copper products*

EN 10204, *Metallic products — Types of inspection documents*

EN 13603, *Copper and copper alloys — Test methods for assessing protective tin coatings on drawn round copper wire for electrical purposes*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

IEC 60468, *Method of measurement of resistivity of metallic materials*

ISO 1811-2, *Copper and copper alloys — Selection and preparation of samples for chemical analysis — Part 2: Sampling of wrought products and castings*

ISO 4739, *Wrought copper and copper alloy products — Selection and preparation of specimens and test pieces for mechanical testing*

ISO 7801, *Metallic materials — Wire — Reverse bend test*

ISO 7802, *Metallic materials — Wire — Wrapping test*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
wire
wound product of uniform cross-section along its whole length

Note 1 to entry: Rectangles may have round or sharp corners.

[SOURCE: EN 12166:2011, 3.1]

3.2
multiline wire
number of wires of the same nominal diameter and material condition wound at the same time on the same spool with the wires having a maximum of one twist per revolution of the spool

Note 1 to entry: Generally, the wires are drawn simultaneously on the same machine.

3.3
deviation from circular form
difference between the maximum and the minimum diameters measured at any one cross-section of a round product

[SOURCE: EN 12163:2011, 3.2]

4 Designations

4.1 Material

4.1.1 General

The material is designated either by symbol or by number (see Table 1 and Table 2).

4.1.2 Symbol

The material symbol designation is based on the designation system given in ISO 1190-1.

NOTE Although material symbol designations used in this standard might be the same as those in other standards using the designation system given in ISO 1190-1, the detailed composition requirements are not necessarily the same.

4.1.3 Number

The material number designation is in accordance with the system given in EN 1412.

4.2 Material condition

For the purposes of this standard, the following designations, which are in accordance with the system given in EN 1173, apply for the material condition:

R... Material condition designated by the minimum value of tensile strength requirement for the product with mandatory tensile strength requirements;

A... Material condition designated by the minimum value of elongation requirement for the product with mandatory elongation requirements.

Exact conversion between the material conditions designated R... and A... is not possible.

Material condition is designated by only one of the above designations.

4.3 Product

The product designation provides a standardised pattern of designation from which a rapid and unequivocal description of a product can be conveyed in communication. It provides mutual comprehension at the international level with regard to products which meet the requirements of the relevant European Standard.

The product designation is no substitute for the full content of the standard.

The product designation for products to this standard shall consist of:

a) denomination (wire);

b) number of this European Standard (EN 13602);

c) material designation, either symbol or number (see Table 1 and Table 2);

d) material condition designation (see Table 3 and Table 4);

e) surface condition: plain (P) or tinned (grade A, B or C, see Table 7);

f) nominal dimensions:

   1) single wire (S): diameter;

   2) multiline wire (M): number of wires and diameter;

g) form of delivery: coil (Y) or spool (Z).

The derivation of a product designation is shown in Example 1.

EXAMPLE 1 Plain single wire

Drawn round wire for electrical purposes conforming to this standard, in material designated either Cu-ETP1 or CW003A, in material condition A022, produced as a plain single wire, nominal diameter 0,4 mm, in coils, will be designated as follows:

Wire — EN 13602 — Cu-ETP1 — A022 — P— S0,4 — Y

or

Wire — EN 13602 — CW003A — A022 — P— S0,4 — Y

Denomination

Number of this European Standard

Material designation

Material condition designation

Surface condition

Nominal dimension

Form of delivery

EXAMPLE 2 Plain multiline wire

Drawn round wire for electrical purposes conforming to this standard, in material designated either Cu-ETP or CW004A, in material condition A020, produced as plain multiline wire of 7 wires, nominal diameter 0,4 mm, in coils, will be designated as follows:

Wire EN 13602 — Cu-ETP— A020 — P — M7 × 0,4 — Y

or

Wire EN 13602 — CW004A — A020 — P — M7 × 0,4 — Y

EXAMPLE 3 Tinned single wire

Drawn round wire for electrical purposes conforming to this standard, in material designated either Cu-OF1 or CW007A, in material condition A024, produced as tinned grade B single wire, nominal diameter 1,2 mm, in coils, will be designated as follows:

Wire EN 13602 — Cu-OF1— A024 — B — S1,2 — Y

or

Wire EN 13602 — CW007A — A024 — B — S1,2 — Y

EXAMPLE 4 Tinned multiline wire

Drawn round wire for electrical purposes conforming to this standard, in material designated either Cu-FRHC or CW005A, in material condition A018, produced as tinned grade C, multiline wire of 10 wires, nominal diameter 0,5 mm, on spools, will be designated as follows:

Wire EN 13602 — Cu-FRHC — A018 — C — M10 × 0,5 — Z

or

Wire EN 13602 — CW005A— A018 — C — M10 × 0,5 — Z

5 Ordering information

In order to facilitate the enquiry, order and confirmation of order procedures between the purchaser and the supplier, the purchaser shall state on his enquiry and order the following information:

a) quantity of product required (mass or number of coils or spools);

b) denomination (wire);

c) number of this European Standard (EN 13602);

d) material designation (see Table 1 and Table 2);

e) material condition designation (see 4.2 and Table 3 and Table 4);

f) surface condition (see 6.6):

   1) plain; or

   2) tinned (grade A, B or C, see Table 7);

g) nominal dimensions:

1) single wire: nominal diameter;

2) multiline wire: number of wires × nominal diameter of individual wires;

h) form of delivery: coil (Y) or spool (Z);

i) coil size or spool type;

j) whether the multiline wire has to be coiled dynamically or statically.

It is recommended that the product designation, as described in 4.3, is used for items b) to h).

In addition, the purchaser shall also state on the enquiry and order any of the following, if required:

k) whether special surface conditions are required (see 6.6);

l) which form of ductility test is required (see 8.3);

m) which test method is required for assessing tin coating (see 8.5) and if continuity of tin coating, whether wire diameters from 0,04 mm up to and including 0,315 mm are to be tested. If so, the test piece length and pass/fail criteria shall be agreed;

n) whether a special weight or length per coil or per spool is required;

o) whether a declaration of conformity is required (see 9.1);

p) whether an inspection document is required, and if so, which type (see 9.2);

q) whether there are any special requirements for marking, packaging or labelling (see Clause 10).

EXAMPLE Ordering details for 1 500 kg drawn round wire for electrical purposes conforming to EN 13602, in material designated either Cu-ETP1 or CW003A, in material condition A018, produced as tinned grade B, multiline wire of 10 wires, nominal diameter 0,5 mm in coils, dynamically coiled, coil nominal inside diameter 500 mm:

1 500 kg Wire EN 13602 — Cu-ETP1 — A018 — B — M10 × 0,5 — Y

— dynamically coiled

— coil nominal inside diameter 500 mm

or

1 500 kg Wire EN 13602 — CW003A — A018 — B — M10 × 0,5 — Y

— dynamically coiled

— coil nominal inside diameter 500 mm

6 Requirements

6.1 Composition

The composition shall conform to the requirements for the appropriate material given in Table 1 and Table 2.

NOTE For characteristics of coppers for electrical purposes, see Annex A.

6.2 Mechanical properties

6.2.1 Plain wire

The mechanical properties of plain wire shall conform to the appropriate requirements given in Table 3. The tests shall be carried out in accordance with 8.2.

6.2.2 Tinned wire

The mechanical properties of tinned wire shall conform to the appropriate requirements given in Table 4. The tests shall be carried out in accordance with 8.2.

6.3 Electrical properties

The electrical properties of plain and of tinned wire shall conform to the appropriate requirements given in Table 5. The test shall be carried out in accordance with 8.4.

6.4 Dimensions

The geometrical properties of the wires are defined by diameters which shall conform to the tolerances given in Table 6. The material Cu-FRHC (CW005A) shall not be used for wires with diameter less than 0,2 mm.

6.5 Ductility

Wire in the material condition R... with diameter from 0,5 mm up to and including 5,0 mm shall neither break nor show any crack, when tested in accordance with 8.3.1 and examined without optical magnification.

When tested in accordance with 8.3.2 the number of bends before break shall be at least equal to the values given in Table 8 for annealed wire and Table 9 for hard drawn wire.

6.6 Surface condition

6.6.1 General

Wire shall be supplied either plain (P) or tinned. Three grades of thickness of unalloyed tin coating are available, see A, B or C in Table 7.

6.6.2 Plain wire

The wire shall be clean and free from injurious defects which shall be specified by agreement between the purchaser and the supplier at the time of enquiry and order. A superficial film of residual lubricant is normally present on cold drawn products and is permissible unless otherwise specified. Discoloration is permissible as long as it does not impair utilisation.

Special requirements relating to surface quality shall be agreed between the purchaser and the supplier [see Clause 5 list entry f)].

6.6.3 Tinned wire

In addition to 6.6.2, tinned wire shall have a smooth, continuous and adherent layer of tin, free from deleterious impurities; a tin grade according to EN 610 shall be used. The tin coating shall conform to the requirements in Table 7. The test shall be carried out in accordance with one of the test methods in 8.5.

7 Sampling

7.1 General

When required (e.g. if necessary in accordance with specified procedures of a supplier's quality management system, or when the purchaser requests inspection documents with test results, or for use in cases of dispute), an inspection lot shall be sampled in accordance with 7.2 and 7.3.

7.2 Analysis

The sampling rate shall be in accordance with ISO 1811-2. A test sample, depending on the analytical technique to be employed, shall be prepared from each sampling unit and used for the determination of the composition.

When preparing the test sample, care should be taken to avoid contaminating or overheating. Carbide tipped tools are recommended; steel tools, if used, should be made of magnetic material to assist in the subsequent removal of extraneous iron. If the test samples are in finely divided form (e.g. drillings, millings), they should be treated carefully with a strong magnet to remove any particles of iron introduced during preparation.

In cases of dispute concerning the results of analysis, the full procedure given in ISO 1811-2 should be followed.

NOTE Results can be used from analyses carried out at an earlier stage of manufacturing the product, e.g. at the casting stage, if the material identity is maintained and if the quality management system of the manufacturer is certified, e.g. as conforming to EN ISO 9001.

7.3 Mechanical, electrical and tin coating tests

7.3.1 Selection and preparation of test specimens and test pieces for mechanical testing shall be carried out in accordance with ISO 4739.

7.3.2 The number of wires taken from a multiline wire for the determination of mechanical and tin coating properties shall be at the discretion of the supplier.

7.3.3 The rate of sampling for wire shall be one test piece per lot for each of the tests referred to in 8.2, 8.3, 8.4 and 8.5, as appropriate.

8 Test methods

8.1 Analysis

Analysis shall be carried out on the test pieces, or test portions, prepared from the test samples obtained in accordance with 7.2. Except in cases of dispute, the analytical methods used shall be at the discretion of the supplier. In cases of dispute, the methods of analysis to be used shall be agreed between the disputing parties. For expression of results, the rounding rules given in 8.7 shall be used.

8.2 Tensile test

The tensile test shall be carried out in accordance with EN ISO 6892-1 on the test pieces cut from the test samples obtained in accordance with 7.3.

Unless otherwise agreed between purchaser and supplier, wires from multiline wire shall be tested individually and not as a complete multiline wire.

8.3 Ductility test

8.3.1 Wrapping test

Wire in the R... material condition shall be subjected to the wrapping test which shall be carried out in accordance with ISO 7802, on test pieces prepared from the test samples obtained in accordance with 7.3.

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 rewrapped in the same direction as the first wrapping.

8.3.2 Reverse bend test

The test shall be carried out in accordance with ISO 7801 on test pieces prepared from the test samples obtained in accordance with 7.3.

For annealed wire, the test is only applicable to wire with a diameter exceeding 0,50 mm. For hard drawn wire the test is only applicable to wire with a diameter exceeding 1,00 mm.

8.4 Electrical resistivity test

The electrical resistivity or conductivity shall be determined by direct measurement of the single wire or of the complete multiline wire, sampled in accordance with 7.3.

The test shall be carried out in accordance with the routine method specified in IEC 60468.

8.5 Assessment of tin coatings

Unless otherwise agreed between the purchaser and the supplier the assessment of tin coating shall be carried out in accordance with one of the methods in EN 13603 on test pieces prepared from the test samples obtained in accordance with 7.3, either:

— by the determination of the thickness of the unalloyed tin coating; and/or

— by the determination of the continuity of the total tin coating; and/or

— by the determination of the adherence of the total tin coating.

Alternative methods of assessment should be agreed upon between the purchaser and the supplier.

8.6 Retests

If there is a failure of one, or more than one, of the tests in 8.1 to 8.5, two test samples from the same inspection lot shall be permitted to be selected for retesting the failed property(ies). One of these test samples shall be taken from the same sampling unit as that from which the original failed test piece was taken, unless that sampling unit is no longer available, or has been withdrawn by the supplier.

If the test pieces from both test samples pass the appropriate test(s), then the inspection lot represented shall be deemed to conform to the particular requirement(s) of this standard. If a test piece fails a test, the inspection lot represented shall be deemed not to conform to this standard.

8.7 Rounding of results

For the purpose of determining conformity to the limits specified in this standard, an observed or a calculated value obtained from a test shall be rounded in accordance with the following procedure, which is based upon the guidance given in ISO 80000-1:2009, Annex B. It shall be rounded in one step to the same number of

figures used to express the specified limit in this European Standard. Except for tensile strength the rounding interval shall be 10 N/mm^2 [1)] and for elongation the value shall be rounded to the nearest 1 %.

The following rules shall be used for rounding:

a) if the figure immediately after the last figure to be retained is less than five, the last figure to be retained shall be kept unchanged;

b) if the figure immediately after the last figure to be retained is equal to or greater than five, the last figure to be retained shall be increased by one.

9 Declaration of conformity and inspection documentation

9.1 Declaration of conformity

When requested by the purchaser [see Clause 5 list entry o)] and agreed with the supplier, the supplier shall issue for the products the appropriate declaration of conformity in accordance with EN 1655.

9.2 Inspection documentation

When requested by the purchaser [see Clause 5 list entry p)] and agreed with the supplier, the supplier shall issue for the products the appropriate inspection document in accordance with EN 10204.

10 Marking, packaging, labelling

Unless otherwise specified by the purchaser and agreed by the supplier, the marking, packaging and labelling shall be left to the discretion of the supplier [see Clause 5 list entry q)].

1) 1 N/mm^2 is equivalent to 1 MPa.

Table 1 — Composition of Cu-ETP1 (CW003A) and Cu-OF1 (CW007A)

Material designation		Composition % (mass fraction)																					
Symbol	Number	Element	Cu	Ag	As	Bi	Cd	Co	Cr	Fe	Mn	Ni	O	P	Pb	S	Sb	Se	Si	Sn	Te	Zn	Elements listed in this table other than copper	
																							total	excl.
Cu-ETP1	CW003A	min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O
		max.	—	0,002 5	0,000 5[a]	0,000 20[b]	—[a]	—[c]	—[a]	0,001 0[c]	—[a]	—[c]	0,040	—[a]	0,000 5	0,001 5	0,000 4[a]	0,000 20[b]	—[c]	—[c]	0,000 20[b]	—[c]	0,006 5	
Cu-OF1	CW007A	min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O
		max.	—	0,002 5	0,000 5[a]	0,000 20[b]	—[a]	—[c]	—[a]	0,001 0[c]	—[a]	—[c]	—[d]	—[a]	0,000 5	0,001 5	0,000 4[a]	0,000 20[b]	—[c]	—[c]	0,000 20[b]	—[c]	0,006 5	

[a] (As+Cd+Cr+Mn+P+Sb) maximum 0,001 5 %.

[b] (Bi+Se+Te) maximum 0,000 3 %, of which (Se+Te) maximum 0,000 30 %.

[c] (Co+Fe+Ni+Si+Sn+Zn) maximum 0,002 0 %.

[d] The oxygen content shall be such that the material conforms to the hydrogen embrittlement requirements of EN 1976.

Table 2 — Composition of Cu-ETP (CW004A), Cu-FRHC (CW005A) and Cu-OF (CW008A)

Material designation		Composition % (mass fraction)						
		Element	Cu[a]	Bi	O	Pb	other elements (see NOTE)	
Symbol	Number						total	excluding
Cu-ETP	CW004A	min.	99,90	—	—	—	—	Ag, O
		max.	—	0,000 5	0,040[b]	0,005	0,03	
Cu-FRHC	CW005A	min.	99,90	—	—	—	—	Ag, O
		max.	—	—	0,040[b]	—	0,06[d]	
Cu-OF	CW008A	min.	99,95	—	—	—	—	Ag
		max.	—	0,000 5	—[c]	0,005	0,03	

NOTE The total of other elements (than copper) is defined as the sum of Ag, As, Bi, Cd, Co, Cr, Fe, Mn, Ni, O, P, Pb, S, Sb, Se, Si, Sn, Te and Zn, subject to the exclusion of any individual elements indicated.

[a] Including silver, up to a maximum of 0,015 %.

[b] Oxygen content up to 0,060 % is permitted, subject to agreement between the purchaser and the supplier.

[c] The oxygen content shall be such that the material conforms to the hydrogen embrittlement requirements of EN 1976.

[d] Higher total impurities content is permitted, subject to agreement between the purchaser and the supplier.

Table 3 — Mechanical properties of plain wire

Designations				Nominal diameter		Tensile strength R_m	Elongation[b] A_t or $A_{200\ mm}$	
Material		Material condition[a]		mm		N/mm^2	single wire %	multiline wire %
Symbol	Number	single wire	multiline wire	over	up to and including	min.	min.	min.
		A010	A008	0,04[c]	0,08	(200)	10[b]	8[b]
		A015	A013	0,08	0,16	(200)	15[b]	13[b]
		A021	A019	0,16	0,32	(200)	21[b]	19[b]
		A022	A020	0,32	0,50	(200)	22	20
		A024	A022	0,50	1,00	(200)	24	22
		A026	A024	1,00	1,50	(200)	26	24
Cu-ETP1	CW003A	A028	A026	1,50	3,00	(200)	28	26
Cu-ETP	CW004A	A033	—	3,00	5,00	(200)	33	—
Cu-FRHC	CW005A	R460	—	0,16	1,12	460	—	—
Cu-OF1	CW007A	R440	—	1,12	1,50	440	—	—
Cu-OF	CW008A	R430	—	1,50	2,00	430	—	—
		R420	—	2,00	2,40	420	—	—
		R400	—	2,40	3,00	400	—	—
		R390	—	3,00	3,55	390	—	—
		R380	—	3,55	4,00	380	—	—
		R370	—	4,00	4,50	370	—	—
		R360	—	4,50	5,00	360	—	—

NOTE 1 1 N/mm^2 is equivalent to 1 MPa.

NOTE 2 Figures in parentheses are not requirements of this standard, but are given for information only.

[a] Material conditions designated A... correspond to the term “annealed” and those designated R... to the term “hard drawn”.

[b] The elongation values listed are based on original gauge lengths in accordance with EN ISO 6892-1:

— A_t = total elongation (plastic elongation plus elastic elongation) of the gauge length at the moment of fracture, expressed as a percentage of the original gauge length L_o, where $L_o = 11{,}3 \times \sqrt{S_o}$ of a proportional test piece for wire diameters equal to or greater than 1 mm;

— $A_{200\ mm}$ = permanent elongation of the gauge length after fracture, expressed as a percentage of the original gauge length L_o, where L_o = 200 mm of a non-proportional test piece.

[c] Including 0,04 mm.

Table 4 — Mechanical properties of tinned wire

Designations				Nominal diameter		Tensile strength R_m	Elongation[b] A_t or $A_{200\ mm}$	
Material		Material condition[a]		mm		N/mm²	single wire %	multiline wire %
Symbol	Number	single wire	multiline wire	over	up to and including	min.	min.	min.
		A007	A005	0,04[c]	0,08	(200)	7[b]	5[b]
		A013	A011	0,08	0,16	(200)	13[b]	11[b]
		A019	A017	0,16	0,32	(200)	19[b]	17[b]
		A020	A018	0,32	0,50	(200)	20	18
		A022	A020	0,50	1,00	(200)	22	20
		A024	A022	1,00	1,50	(200)	24	22
Cu-ETP1	CW003A	A026	—	1,50	3,00	(200)	26	—
Cu-ETP	CW004A	A031	—	3,00	5,00	(200)	31	—
Cu-FRHC	CW005A	R460	—	0,16	1,12	460	—	—
Cu-OF1	CW007A	R440	—	1,12	1,50	440	—	—
Cu-OF	CW008A	R430	—	1,50	2,00	430	—	—
		R420	—	2,00	2,40	420	—	—
		R400	—	2,40	3,00	400	—	—
		R390	—	3,00	3,55	390	—	—
		R380	—	3,55	4,00	380	—	—
		R370	—	4,00	4,50	370	—	—
		R360	—	4,50	5,00	360	—	—

NOTE 1 1 N/mm² is equivalent to 1 MPa.

NOTE 2 Figures in parentheses are not requirements of this standard, but are given for information only.

[a] Material conditions designated A... correspond to the term “annealed” and those designated R... to the term “hard drawn”.

[b] The elongation values listed are based on original gauge lengths in accordance with EN ISO 6892-1:

—A_t = total elongation (plastic elongation plus elastic elongation) of the gauge length at the moment of fracture, expressed as a percentage of the original gauge length L_o, where $L_o = 11{,}3 \times \sqrt{S_o}$ of a proportional test piece for wire diameters equal to or greater than 1 mm;

—$A_{200\ mm}$ = permanent elongation of the gauge length after fracture, expressed as a percentage of the original gauge length L_o, where L_o = 200 mm of a non-proportional test piece.

[c] Including 0,04 mm.

Table 5 — Electrical properties (at 20 °C)

Material designation		Nominal diameter mm		Material condition	Volume resistivity $\frac{\Omega \times mm^2}{m}$	Mass resistivity[a] $\frac{\Omega \times g}{m^2}$	Conductivity	
Symbol	Number	over	up to and including		max.	max.	MS/m min.	% IACS[b] min.
		Plain wire P						
		0,04[c]	0,08	A... (annealed)	0,017 24	0,153 3	58,0	100,0
				R... (hard drawn)	—	—	—	—
		0,08	0,16	A... (annealed)	0,017 24	0,153 3	58,0	100,0
				R... (hard drawn)	—	—	—	—
		0,16	0,32	A... (annealed)	0,017 24	0,153 3	58,0	100,0
				R... (hard drawn)	0,018 45	0,164 0	54,2	93,4
		0,32	1,50	A... (annealed)	0,017 24	0,153 3	58,0	100,0
				R... (hard drawn)	0,017 93	0,159 4	55,8	96,2
		1,50	5,00	A... (annealed)	0,017 24	0,153 3	58,0	100,0
				R... (hard drawn)	0,017 76	0,157 9	56,3	97,1
		Tinned wire, grades A and C						
		0,04	0,08	A... (annealed)	0,018 62	0,165 5	53,7	92,6
				R... (hard drawn)	—	—	—	—
Cu-ETP1	CW003A	0,08	0,16	A... (annealed)	0,017 93	0,159 4	55,8	96,2
Cu-ETP	CW004A			R... (hard drawn)	—	—	—	—
Cu-FRHC	CW005A	0,16	0,32	A... (annealed)	0,017 59	0,156 4	56,9	98,0
Cu-OF1	CW007A			R... (hard drawn)	0,018 82	0,167 3	53,1	91,6
Cu-OF	CW008A	0,32	1,50	A... (annealed)	0,017 41	0,154 8	57,4	99,0
				R... (hard drawn)	0,018 11	0,161 0	55,2	95,2
		1,50	5,00	A... (annealed)	0,017 41	0,154 8	57,4	99,0
				R... (hard drawn)	0,017 93	0,159 4	55,8	96,2
		Tinned wire, grade B						
		0,04	0,08	A... (annealed)	0,019 31	0,171 7	51,8	89,3
				R... (hard drawn)	—	—	—	—
		0,08	0,16	A... (annealed)	0,018 27	0,162 4	54,7	94,4
				R... (hard drawn)	—	—	—	—
		0,16	0,32	A... (annealed)	0,017 76	0,157 9	56,3	97,1
				R... (hard drawn)	0,019 01	0,169 0	52,6	90,7
		0,32	1,50	A... (annealed)	0,017 59	0,156 4	56,9	98,0
				R... (hard drawn)	0,018 29	0,162 6	54,7	94,3
		1,50	5,00	A... (annealed)	0,017 41	0,154 8	57,4	99,0
				R... (hard drawn)	0,017 93	0,159 4	55,8	96,2

NOTE 1 The % IACS values are calculated as percentages of the standard value for annealed high conductivity copper as laid down by the International Electrotechnical Commission. Copper having a volume resistivity of 0,017 24 μΩ × m at 20 °C, is defined as corresponding to a conductivity of 100 %.

NOTE 2 1 MS/m is equivalent to 1 m/(Ω × mm^2).

[a] Calculated with a density of copper 8,89 g/cm^3.

[b] IACS: International Annealed Copper Standard.

[c] Including 0,04 mm.

Table 6 — Tolerances on diameter

Nominal diameter mm		Tolerance of mean diameter	Deviation from circular form
over	up to and including		max.
—	0,08	± 0,002 mm	0,004 mm
0,08	0,25	± 0,003 mm	0,006 mm
0,25	0,4	± 0,004 mm	0,008 mm
0,4	5,0	± 1%	2 %

Table 7 — Requirements of coatings

Grade	Thickness of unalloyed coating µm min.	Continuity of coating of copper wire surface g/m^2 max.	Adhesion of coating
A	0,3	1,0	no black crack
B	0,6		
C	not specified[a]		

[a] The thickness of the unalloyed coating is subject to agreement between purchaser and supplier.

Table 8 — Number of bends for annealed wire

Nominal diameter d mm		Number of bends	Radius of the mandrel mm
over	up to and including		
0,5[a]	1,0	20	3
1,0	1,5	12	3
1,5	2,5	6	3
2,5	5,0	6	10

[a] Including 0,5.

Table 9 — Number of bends for hard drawn wire

Nominal diameter d mm		Number of bends	Radius of the mandrel mm
over	up to and including		
1,0[a]	1,5	14	6
1,5	2,5	6	6
2,5	5,0	4	10

[a] Including 1,0.

Annex A
(informative)

Characteristics of coppers for electrical purposes

A.1 General grouping of copper types

The characteristic properties of coppers depend to a considerable extent on the presence or absence of certain elements, in particular oxygen, phosphorus and silver.

The various grades of copper fall into four types:

— tough pitch coppers (i.e. oxygen-containing coppers);

— oxygen-free coppers;

— deoxidised coppers;

— silver-bearing coppers.

NOTE The classification of coppers, as "unrefined copper" or "refined copper" as well as specific terms and definitions for the subdivisions of these classes are given in ISO 197-1.

A.2 General characteristics

In general all coppers have excellent formability and solderability. Electrical conductivity and weldability both vary, depending on the purity of the copper grade.

A.3 Particular characteristics

Table A.1 describes the particular characteristics of coppers for electrical purposes. The table also indicates the material designation, i.e. symbols and numbers of the grades of copper corresponding to each type.

NOTE This standard does not necessarily specify all the grades of copper given in Table A.1.

Table A.1 — Particular characteristics of coppers for electrical purposes

Copper type	Characteristics	Material designation	
		Symbol	Number
Tough pitch coppers (oxygen-containing coppers)	Coppers of this type are produced with a controlled amount of oxygen and have high electrical conductivity. Special precautions are necessary when heat-treating, welding or brazing these coppers in atmospheres containing hydrogen to avoid hydrogen embrittlement.	Cu-ETP1 Cu-ETP Cu-FRHC	CW003A CW004A CW005A
Oxygen-free coppers	Coppers of this type are produced in an oxygen-free environment without the use of deoxidisers and have high electrical conductivity. These coppers may be heat-treated, welded or brazed without the need for special precautions to avoid hydrogen embrittlement.	Cu-OF1 Cu-OF Cu-OFE	CW007A CW008A CW009A
Deoxidised coppers	Coppers of this type are produced with the addition of a controlled amount of deoxidiser, preferably phosphorus, and contain a controlled low amount of residual deoxidiser; these coppers have high electrical conductivity. These coppers may be heat-treated, welded or brazed without the need for special precautions to avoid hydrogen embrittlement.	Cu-PHC Cu-HCP Cu-PHCE	CW020A CW021A CW022A
Silver-bearing coppers	Tough pitch, oxygen-free and deoxidised coppers can be produced with additions of silver, up to 0,12 % (mass fraction). The effect of the silver content is to increase the resistance to softening without significantly affecting the electrical conductivity.	CuAg0,04 CuAg0,07 CuAg0,10 CuAg0,04P CuAg0,07P CuAg0,10P CuAg0,04(OF) CuAg0,07(OF) CuAg0,10(OF)	CW011A CW012A CW013A CW014A CW015A CW016A CW017A CW018A CW019A

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[6] EN ISO 9001, *Quality management systems — Requirements (ISO 9001)*

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