BS EN 13601:2013

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 13601:2013. It supersedes BS EN 13601:2002, which is withdrawn.

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

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

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Published by BSI Standards Limited 2013

ISBN 978 0 580 74203 3

ICS 77.150.30

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13601

June 2013

ICS 77.150.30

Supersedes EN 13601:2002

English Version

Copper and copper alloys - Copper rod, bar and wire for general electrical purposes

Cuivre et alliages de cuivre - Barres et fils en cuivre pour usages électriques généraux

Kupfer und Kupferlegierungen - Stangen und Drähte aus Kupfer für die allgemeine Anwendung in der Elektrotechnik

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

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Ref. No. EN 13601:2013: E

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Foreword

This document (EN 13601:2013) 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of an identical text or by endorsement, at the latest by December 2013, and conflicting national standards shall be withdrawn at the latest by December 2013.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 13601:2002.

In comparison with EN 13601:2002, the following significant technical changes have been made:

— Maximum diameters or widths across-flats for round, square and hexagonal rod have been expanded.

— Terms and definitions clause has been modified.

— Cu-OFE (CW009A) and Cu-PHCE (CW022A) have been added.

— Tolerances on width and thickness of bar and rectangular wire have been modified (see Table 6).

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 13601:2002, *Copper and copper alloys – Copper rod, bar and wire for general electrical purposes.*

The products specified in this European Standard are those which are especially suitable for electrical purposes, i.e. with specified electrical properties. Copper rod, bar and wire for general purposes are specified in EN 12163, EN 12166 and EN 12167.

Annex A (informative) gives guidance on the characteristics of coppers for electrical purposes.

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

— 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 tolerances on dimensions and form for copper rod, bar and wire for general electrical purposes. Cross-sections and size ranges are:

— round, square and hexagonal rod with diameters or widths across-flats from 2 mm up to and including 160 mm;

— bar with thicknesses from 2 mm up to and including 40 mm and widths from 3 mm up to and including 200 mm;

— round, square, hexagonal and rectangular wire with diameters or widths across-flats from 2 mm up to and including 25 mm, as well as thicknesses from 0,5 mm up to and including 12 mm with widths from 1 mm up to and including 200 mm.

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

NOTE Drawn, round copper wire — plain or tinned, single or multiline — for the manufacture of electrical conductors is specified in EN 13602.

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 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 ISO 2626, *Copper — Hydrogen embrittlement test (ISO 2626)*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1)*

EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1)*

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

EN ISO 7438, *Metallic materials — Bend test (ISO 7438)*

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

3 Terms and definitions

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

3.1
bar
straight product of uniform rectangular cross-section along its whole length

[SOURCE: EN 12167:2011, 3.2]

3.2
rod
straight product of uniform cross-section along its whole length

[SOURCE: EN 12163:2011, 3.1]

3.3
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]

3.4
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:

D Material condition for the product as cold worked without specified mechanical properties;

H... Material condition designated by the minimum value of hardness requirement for the product with mandatory hardness requirements;

R... Material condition designated by the minimum value of tensile strength requirement for the product with mandatory tensile strength, 0,2 % proof strength and elongation requirements.

Products in the H... condition may be specified to Vickers or Brinell hardness. The material condition designation H... is the same for both hardness test methods.

Exact conversion between the material conditions designated H... and R... 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 (rod, bar or wire);

b) number of this European Standard (EN 13601);

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

d) material condition designation (see Table 3);

e) cross-sectional shape (the following designations shall be used as appropriate: RND for round, SQR for square, HEX for hexagonal);

f) nominal cross-sectional dimensions:

   1) round rod or wire: diameter;

   2) square or hexagonal rod or wire: width across-flats;

   3) bar or rectangular wire: thickness × width;

g) tolerance class for round, square or hexagonal rod or wire (see Table 4);

h) corner type for square or hexagonal rod, bar or rectangular wire (the following designations shall be used as appropriate: SH for sharp, RD for rounded, CE for semi-circular edges) (see 6.6.2).

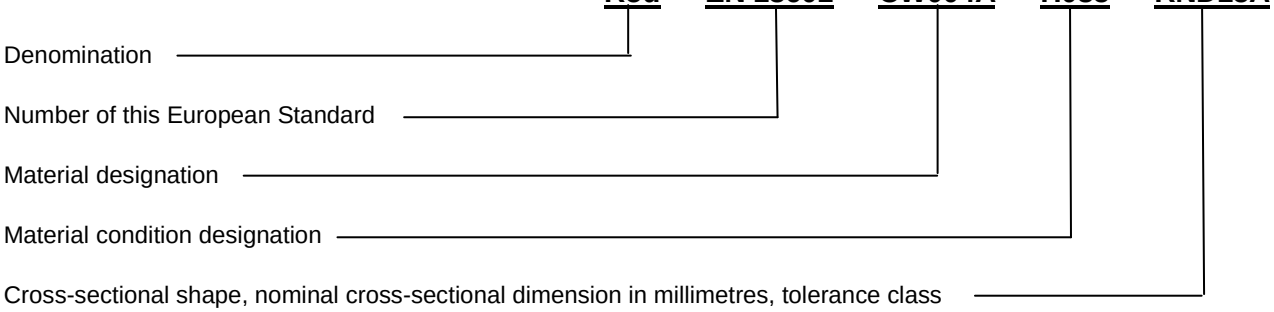
The derivation of a product designation is shown in Example 1 and other typical product designations are shown in Example 2 and Example 3.

EXAMPLE 1 Rod for electrical purposes conforming to this standard, in material designated either Cu-ETP or CW004A, in material condition H085, round, with nominal diameter 15 mm and tolerance Class A, will be designated as follows:

Rod — EN 13601 — Cu-ETP — H085 — RND15A

or

Rod — EN 13601 — CW004A — H085 — RND15A



EXAMPLE 2 Bar for electrical purposes conforming to this standard, in material designated either CuAg0,10 or CW013A, in material condition R280, rectangular, nominal thickness 15 mm, nominal width 100 mm, semi-circular edge, will be designated as follows:

Bar EN 13601 — CuAg0,10 — R280 — 15 × 100 — CE

or

Bar EN 13601 — CW013A— R280 — 15 × 100 — CE

EXAMPLE 3 Wire for electrical purposes conforming to this standard, in material designated either Cu-OF or CW008A, in material condition H035, hexagonal, with nominal width across-flats 8 mm, tolerance Class B and sharp corners, will be designated as follows:

Wire EN 13601 — Cu-OF— H035 — HEX8B — SH

or

Wire EN 13601 — CW008A — H035 — HEX8B — SH

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, number of rods or bars or coils of wire);

b) denomination (rod, bar or wire);

c) number of this European Standard (EN 13601);

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

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

f) cross-sectional shape (round, square, hexagonal or rectangular);

g) nominal dimensions (diameter, width across-flats or thickness × width);

h) tolerance class for round, square or hexagonal rod or wire: either Class A (minus tolerance only) or Class B (plus/minus tolerance) (see Table 4);

i) type of corner (see 6.6.2);

j) for rod or bar, the length required (see 6.6.3);

k) for wire, the coil type: pancake, traverse wound, bunch or on drums (see 6.8);

l) coil size requirements: inside and/or outside diameter and width or mass.

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

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

m) test method to be used for measurement of hardness, i.e. Brinell or Vickers (see 8.3) unless the test method is to be left to the discretion of the supplier;

n) whether sawn or sheared ends are required (see 6.6.3);

o) whether special surface conditions are required (see 6.10);

p) whether a bend test is required (see 6.3);

q) whether form tolerances for wire are required (see 6.7.1);

r) whether length of wire is required (see 6.6.3);

s) whether sampling is required (see Clause 7);

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

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

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

EXAMPLE 1 Ordering details for 250 pieces bar for general electrical purposes conforming to EN 13601, in material designated either CuAg0,10 or CW013A, in material condition R280, rectangular, nominal thickness 15 mm, nominal width 100 mm, semi-circular edge, fixed length 4 500 mm:

250 pieces Bar EN 13601— CuAg0,10 — R280 — 15 × 100 — CE— 4500 FL

or

250 pieces Bar EN 13601— CW013A — R280 — 15 × 100 — CE—4500 FL

EXAMPLE 2 Ordering details for 1 000 kg wire for general electrical purposes conforming to EN 13601, in material designated either Cu-OF or CW008A, in material condition H035, hexagonal, nominal width across flats 8 mm, tolerance Class B, with sharp corners, nominal inside diameter of coil 500 mm:

1 000 kg Wire EN 13601— Cu-OF — H035 — HEX8B — SH— nominal inside diameter of coil 500 mm

or

1 000 kg Wire EN 13601— CW008A — H035 — HEX8B — SH— nominal inside diameter of coil 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

The mechanical properties shall conform to the appropriate requirements given in Table 3. The tests shall be carried out in accordance with either 8.2 (tensile test) or 8.3 (hardness test).

6.3 Bending characteristics

If required, bending characteristics shall be agreed between the purchaser and the supplier at the time of enquiry and order. The test shall be carried out in accordance with 8.4.

6.4 Electrical properties

The electrical properties shall conform to the appropriate requirements given in Table 4. The test shall be carried out in accordance with 8.5.

6.5 Freedom from hydrogen embrittlement

Rod, bar and wire in copper grades Cu-OF (CW008A), CuAg0,04P (CW014A), CuAg0,07P (CW015A), CuAg0,10P (CW016A), CuAg0,04(OF) (CW017A), CuAg0,07(OF) (CW018A), CuAg0,10(OF) (CW019A), Cu-PHC (CW020A) and Cu-HCP (CW021A) shall show no evidence of cracking, when tested and visually examined in accordance with 8.6.

6.6 Dimensions and tolerances

6.6.1 Diameter or width across-flats

The diameter or width across-flats of round, square, hexagonal or rectangular rod, bar or wire shall conform to the appropriate tolerances given in Table 5 and Table 6.

6.6.2 Corner configuration

6.6.2.1 General

Rod, bar and wire may be supplied with sharp corners, rounded corners or semi-circular edges. The type of corner shall be specified at the time of order [see Clause 5 list entry i)].

6.6.2.2 Sharp corners

Sharp corners (SH) of square, hexagonal and rectangular rod, bar and wire (see Figure 1) shall conform to Table 7.

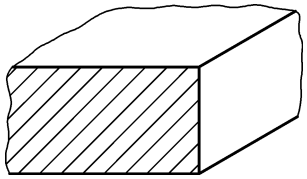


Figure 1 — Sharp corner

6.6.2.3 Rounded corners

Rounded corners (RD) of square, hexagonal and rectangular rod, bar and wire (see Figure 2) shall conform to Table 8.

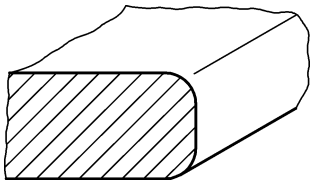


Figure 2 — Rounded corner

6.6.2.4 Semi-circular edge

The radius of semi-circular edges (CE) of rectangular bar and wire (see Figure 3) is half the thickness and shall conform to a tolerance of ± 20 % of the radius; the arc of curvature shall merge smoothly into the adjacent flat side and shall be free from sharp, rough or projecting corners.

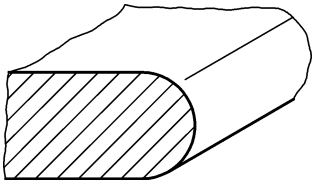


Figure 3 — Semi-circular edge

6.6.3 Length

6.6.3.1 General

Rod and bar shall be supplied either in manufactured length (ML) or fixed length (FL), with ends either sawn or sheared.

If required, the length of wire shall be agreed between the purchaser and the supplier.

6.6.3.2 Manufactured lengths (ML)

Manufactured lengths (ML) shall be supplied in the nominal lengths. The tolerances are by agreement between the purchaser and the supplier.

It is permissible for 10 % of the number of rods and bars in a consignment to be shorter, but not less than 50 % of the nominal length.

6.6.3.3 Fixed lengths (FL)

The lengths supplied as fixed lengths shall conform to the tolerances given in Table 9.

The deviation from squareness of the cut shall be a maximum of 2 % of the diameter or width or major across-flats dimension of the rod and bar and is included in the fixed length tolerance.

6.7 Form tolerances

6.7.1 General

The form tolerances given in 6.7.2 to 6.7.4 shall apply to the following:

a) rod and bar only; if necessary, form tolerances for wire shall be agreed between the supplier and the purchaser;

b) diameters, widths across-flats or widths of bar equal to or greater than 10 mm;

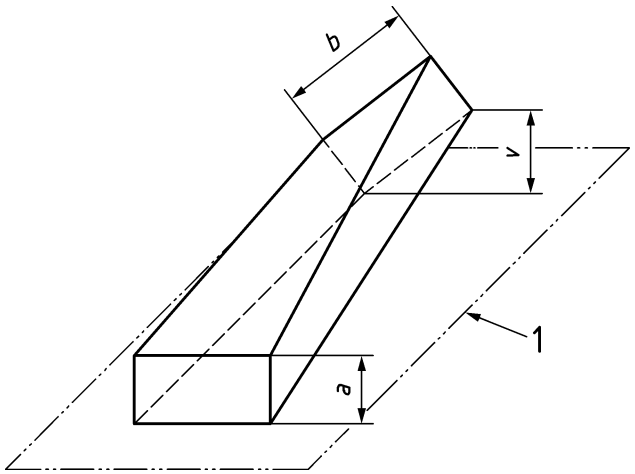
c) all material conditions except D and H035/R200 (annealed).

The deviation shall be measured with the rod or bar supported on a horizontal reference plane, such that the deviation is minimised by the mass of the rod or bar.

6.7.2 Twist

Square or hexagonal rod and bar shall conform to the twist tolerances given in Table 10 (see 6.7.1).

The twist v shall be measured as indicated in Figure 4.



Key

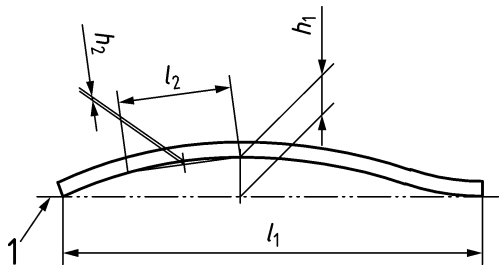
1 reference plane
a thickness
b width
v twist

Figure 4 — Measurement of twist

6.7.3 Straightness

Rod and bar shall conform to the straightness tolerances given in Table 11 (see 6.7.1).

The deviations from straightness h_1 and h_2 shall be measured as indicated in Figure 5.



Key

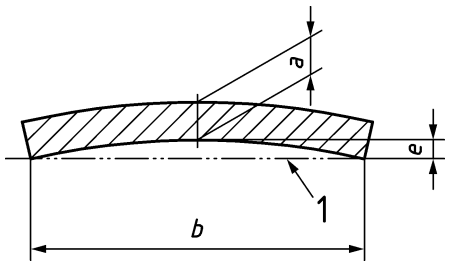
1 reference plane
h_1, h_2 deviations from straightness
l_1, l_2 measuring lengths

Figure 5 — Measurement of straightness

6.7.4 Flatness of bar

Bars shall conform to the flatness tolerances given in Table 12 (see 6.7.1).

The deviation from flatness e of bar (thickness *a*, width b) shall be measured as indicated in Figure 6.



Key

1 reference plane

a thickness

b width

e deviation from flatness

Figure 6 — Measurement of flatness

6.8 Wire in coils

The type of coil, its inside and/or outside diameter, its width or its mass shall be specified by the purchaser at the time of order [see Clause 5 list entry k) and list entry l)].

NOTE Coil types are: pancake, traverse wound, bunch and on drums.

6.9 Mass tolerances

The deviation of the mass of the consignment may amount up to ± 10 %.

6.10 Surface condition

The products 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. Discolouration is permissible as long as it does not impair utilisation.

Special requirements for the application, e.g. contact area, surface coating, shall be agreed between the purchaser and the supplier [see Clause 5 list entry o)].

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 Table 13. 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.

Results may 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 and electrical tests

The sampling rate shall be in accordance with Table 13. Sampling units shall be selected from the finished products. The test samples shall be cut from the sampling units. Test samples, and test pieces prepared from them, shall not be subjected to any further treatment other than any machining operations necessary in the preparation of the test pieces.

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 8.8 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 prepared from the test samples obtained in accordance with 7.3. The test pieces may be full cross-sections of the product or produced by machining, in accordance with EN ISO 6892-1.

8.3 Hardness test

Hardness shall be determined on test pieces prepared from the test samples obtained in accordance with 7.3. The test shall be carried out in accordance with either EN ISO 6506-1 or EN ISO 6507-1 and the impression/indentation made on the outside surface, unless otherwise agreed.

For the Brinell test in accordance with EN ISO 6506-1, a 0,102 F/D^2 ratio of 10 shall be used, i.e. use a 2,5 mm diameter ball and a force of 612,9 N for thicknesses equal to or greater than 2 mm or a 1,00 mm diameter ball and a force of 98,07 N for thicknesses less than 2 mm.

For the Vickers test in accordance with EN ISO 6507-1, a test force of 98,07 N for thicknesses equal to or greater than 2 mm or a test force of 49,03 N for thicknesses less than 2 mm shall be used.

8.4 Bend test

The test shall be carried out in accordance with EN ISO 7438.

8.5 Electrical resistivity test

The test method used shall be left to the discretion of the supplier, e.g. eddy current method or resistance bridge, if not otherwise specified.

The electrical resistivity shall be determined by direct measurement either at 20 °C $\pm$ 1 °C or at another temperature, when the result shall be corrected to the equivalent value at 20 °C, on the product in the as delivered condition.

In cases of dispute, the volume resistivity shall be determined on a drawn wire in accordance with IEC 60468.

8.6 Hydrogen embrittlement test

Rod, bar and wire in the copper grades listed in 6.5 shall be subjected to the hydrogen embrittlement test which shall be carried out in accordance with EN ISO 2626.

Test pieces shall be of convenient dimensions, but machined test pieces shall retain some part of the original surface to be on the outside of the bend. Any edges shall be rounded and smoothed.

After heating the test pieces in hydrogen, as described in EN ISO 2626, they shall be subjected to the close bend test described in EN ISO 7438.

8.7 Retests

If there is a failure of one, or more than one, of the tests in 8.1 to 8.6, 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.

8.8 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 and 0,2 % proof 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 t)] 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 u)] and agreed with the supplier, the supplier shall issue for the products the appropriate inspection document in accordance with EN 10204.

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

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 v)].

Table 1 — Composition of Cu-OFE and Cu-PHCE

Material designation		Composition % (mass fraction)																	
Symbol	Number	Element	Cu	Ag	As	Bi	Cd	Fe	Mn	Ni	O	P	Pb	S	Sb	Se	Sn	Te	Zn
Cu-OFE	CW009A	min.	99,99	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		max.	—	0,002 5	0,000 5	0,000 20	0,000 1	0,001 0	0,000 5	0,001 0	--[a]	0,000 3	0,000 5	0,001 5	0,000 4	0,000 20	0,000 2	0,000 20	0,000 1
Cu-PHCE	CW022A	min.	99,99	—	—	—	—	—	—	—	—	0,001	—	—	—	—	—	—	—
		max.	—	0,002 5	0,000 5	0,000 20	0,000 1	0,001 0	0,000 5	0,001 0	--[a]	0,006	0,000 5	0,001 5	0,000 4	0,000 20	0,000 2	0,000 20	0,000 1

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

Table 2 — Composition of copper grades, other than those made from Cu-OFE (CW009A) and Cu-PHCE (CW022A)

Material designation		Composition % (mass fraction)								
		Element	Cu	Ag	Bi	O	P	Pb	Other elements (see NOTE)	
Symbol	Number								Total	Excluding
Cu-ETP	CW004A	min.	99,90[a]	—	—	—	—	—	—	Ag, O
		max.	—	—	0,000 5	0,040[b]	—	0,005	0,03	
Cu-FRHC	CW005A	min.	99,90[a]	—	—	—	—	—	—	Ag, O
		max.	—	—	—	0,040[b]	—	—	0,06[d]	
Cu-OF	CW008A	min.	99,95[a]	—	—	—	—	—	—	Ag
		max.	—	—	0,000 5	—[c]	—	0,005	0,03	
CuAg0,04	CW011A	min.	Rem.	0,03	—	—	—	—	—	Ag, O
		max.	—	0,05	0,000 5	0,040	—	—	0,03	
CuAg0,07	CW012A	min.	Rem.	0,06	—	—	—	—	—	Ag, O
		max.	—	0,08	0,000 5	0,040	—	—	0,03	
CuAg0,10	CW013A	min.	Rem.	0,08	—	—	—	—	—	Ag, O
		max.	—	0,12	0,000 5	0,040	—	—	0,03	
CuAg0,04P	CW014A	min.	Rem.	0,03	—	—	0,001	—	—	Ag, P
		max.	—	0,05	0,000 5	—[c]	0,007	—	0,03	
CuAg0,07P	CW015A	min.	Rem.	0,06	—	—	0,001	—	—	Ag, P
		max.	—	0,08	0,000 5	—[c]	0,007	—	0,03	
CuAg0,10P	CW016A	min.	Rem.	0,08	—	—	0,001	—	—	Ag, P
		max.	—	0,12	0,000 5	—[c]	0,007	—	0,03	
CuAg0,04(OF)	CW017A	min.	Rem.	0,03	—	—	—	—	—	Ag, O
		max.	—	0,05	0,000 5	—[c]	—	—	0,006 5	
CuAg0,07(OF)	CW018A	min.	Rem.	0,06	—	—	—	—	—	Ag, O
		max.	—	0,08	0,000 5	—[c]	—	—	0,006 5	
CuAg0,10(OF)	CW019A	min.	Rem.	0,08	—	—	—	—	—	Ag, O
		max.	—	0,12	0,000 5	—[c]	—	—	0,006 5	
Cu-PHC	CW020A	min.	99,95[a]	—	—	—	0,001	—	—	Ag, P
		max.	—	—	0,000 5	—[c]	0,006	0,005	0,03	
Cu-HCP	CW021A	min.	99,95[a]	—	—	—	0,002	—	—	Ag, P
		max.	—	—	0,000 5	—[c]	0,007	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

Designations			Dimensions									Hardness				Tensile strength	0,2% proof strength	Elongation	
			Round, square, hexagonal			Rectangular						Brinell		Vickers					
						Thickness			Width							R_m	$R_{p0,2}$	$A_{100\ mm}$	A
Material		Material condition	mm			mm			mm			HBW		HV		N/mm^2	N/mm^2	%	%
Symbol	Number		from	over	up to and including	from	over	up to and including	from	over	up to and including	min.	max.	min.	max.	min.		min.	min.
		D	2	—	160	0,5	—	40	1	—	200	cold worked without specified properties							
		H035[a]	2	—	160	0,5	—	40	1	—	200	35	65	35	65	—	—	—	—
Cu-ETP	CW004A	R200[a]	2	—	160	1	—	40	5	—	200	—	—	—	—	200	max. 120	25	35
Cu-FRHC	CW005A																		
Cu-OF	CW008A	H065	2	—	80	0,5	—	40	1	—	200	65	90	70	95	—	—	—	—
Cu-OFE	CW009A	R250	2	—	10	1	—	10	5	—	200	—	—	—	—	250	min. 200	8	12
CuAg0,04	CW011A	R250	—	10	140	—	10	40	—	10	200	—	—	—	—	250	min. 180	—	15
CuAg0,07	CW012A	R230	—	30	80	—	10	40	—	10	200	—	—	—	—	230	min. 160	—	18
CuAg0,10	CW013A																		
CuAg0,04P	CW014A	H085	2	—	40	0,5	—	20	1	—	120	85	110	90	115	—	—	—	—
CuAg0,07P	CW015A	H075	—	40	80	—	20	40	—	20	160	75	100	80	105	—	—	—	—
CuAg0,10P	CW016A	R300	2	—	20	1	—	10	5	—	120	—	—	—	—	300	min. 260	5	8
CuAg0,04(OF)	CW017A	R280	—	20	60	—	10	20	—	10	160	—	—	—	—	280	min. 240	—	10
CuAg0,07(OF)	CW018A	R260	—	40	60	—	20	40	—	20	160	—	—	—	—	260	min. 220	—	12
CuAg0,10(OF)	CW019A																		
Cu-PHC	CW020A	H100	2	—	10	0,5	—	5	1	—	120	100	—	110	—	—	—	—	—
Cu-HCP	CW021A	R350	2	—	10	1	—	5	5	—	120	—	—	—	—	350	min. 320	3	5
Cu-PHCE	CW022A																		

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

[a] Annealed.

Table 4 — Electrical properties (at 20 °C)

Designations				Volume resistivity $\frac{\Omega \times mm^2}{m}$	Mass resistivity[a] $\frac{\Omega \times g}{m^2}$	Conductivity	
Material		Material condition				MS/m	% IACS[b]
Symbol	Number			max.	max.	min.	min.
Cu-OFE Cu-PHCE	CW009A CW022A	annealed		0,017 07	0,151 7	58,6	101,0
				0,017 24	0,153 3	58,0	100,0
		other than annealed		to be agreed between the purchaser and the supplier			
Cu-ETP Cu-FRHC Cu-OF CuAg0,04 CuAg0,07 CuAg0,10 CuAg0,04(OF) CuAg0,07(OF) CuAg0,10(OF) Cu-PHC	CW004A CW005A CW008A CW011A CW012A CW013A CW017A CW018A CW019A CW020A	D		0,017 86	0,158 8	56,0	96,6
		H035	R200	0,017 24	0,153 3	58,0	100,0
		H065	R250				
		H065	R230				
		H085	R300	0,017 54	0,155 9	57,0	98,3
		H085	R280				
		H075	R260				
		H100	R350	0,017 86	0,158 8	56,0	96,6
CuAg0,04P CuAg0,07P CuAg0,10P Cu-HCP	CW014A CW015A CW016A CW021A	D		0,018 18	0,161 6	55,0	94,8
		H035	R200	0,017 54	0,155 9	57,0	98,3
		H065	R250				
		H065	R230				
		H085	R300	0,017 86	0,158 8	56,0	96,6
		H085	R280				
		H075	R260				
		H100	R350	0,018 18	0,161 6	55,0	94,8

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 0,017 24 $\mu\Omega \times m$ at 20 °C, is defined as corresponding to a conductivity of 100 %.

NOTE 2 1 MS/m is equivalent to 1 $m/(\Omega \times mm^2)$.

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

[b] IACS: International Annealed Copper Standard.

Table 5 — Dimensional tolerances for round, square and hexagonal rod and wire

Values in millimetres

Nominal sizes		Tolerances[a]			
		Round rod and wire[b] (diameter)		Square and hexagonal rod and wire (width across-flats)	
over	up to and including	Class A	Class B	Class A	Class B
2[c]	3	$^{0}_{-0,06}$	± 0,03	—	—
3	6	$^{0}_{-0,08}$	± 0,04	$^{0}_{-0,12}$	± 0,06
6	10	$^{0}_{-0,09}$	± 0,05	$^{0}_{-0,15}$	± 0,08
10	18	$^{0}_{-0,11}$	± 0,06	$^{0}_{-0,18}$	± 0,09
18	30	$^{0}_{-0,13}$	± 0,07	$^{0}_{-0,21}$	± 0,11
30	50	$^{0}_{-0,16}$	± 0,08	$^{0}_{-0,25}$	± 0,13
50	80	$^{0}_{-0,19}$	± 0,10	$^{0}_{-0,30}$	± 0,15
80	120	$^{0}_{-0,35}$	± 0,18	$^{0}_{-0,54}$	± 0,27
120	160	$^{0}_{-0,60}$	± 0,30	$^{0}_{-0,63}$	± 0,32

[a] The tolerances specified are based on ISO h11 or ISO h13 for class A (minus tolerances only) and on ISO js11 or ISO js13 for class B (plus/minus tolerances).

[b] The circularity (see 3.3) is included in the tolerance on diameter and shall not exceed half the tolerance specified above.

[c] Including 2.

Table 6 — Tolerances on width and thickness of bar and rectangular wire

Values in millimetres

Nominal width[a]		Tolerance on width	Tolerance on nominal thickness for range of thickness					
over	up to and including		from 0,5 up to and including 3	over 3 up to and including 6	over 6 up to and including 10	over 10 up to and including 18	over 18 up to and including 30	over 30 up to and including 40
1[b]	10	± 0,08	± 0,05	± 0,06	± 0,08	—	—	—
10	18	± 0,10	± 0,05	± 0,06	± 0,08	± 0,10	—	—
18	30	± 0,15	± 0,05	± 0,07	± 0,09	± 0,10	± 0,15	—
30	50	± 0,20	± 0,06	± 0,09	± 0,10	± 0,12	± 0,15	± 0,20
50	80	± 0,25	± 0,09	± 0,10	± 0,12	± 0,15	± 0,18	± 0,25
80	120	± 0,30	—	± 0,12	± 0,15	± 0,18	± 0,23	± 0,30
120	160	± 0,40	—	—	± 0,18	± 0,20	± 0,25	± 0,35
160	200	± 0,50	—	—	± 0,20	± 0,25	± 0,30	± 0,40

[a] Where the ratio nominal width: nominal thickness is greater than 20 : 1, tolerances shall be agreed between the purchaser and the supplier.

[b] Including 1.

Table 7 — Maximum radii for sharp corners of rod, bar and wire

Dimensions in millimetres

Nominal thickness or width across-flats		Maximum corner radii
over	up to and including	
0,5[a]	2	by agreement
2	6	0,3
6	10	0,4
10	18	0,5
18	30	0,6
30	80	1,0
80	120	1,2
120	160	1,4

[a] Including 0,5.

Table 8 — Radii for rounded corners of rod, bar and wire

Values in millimetres

Nominal thickness or width across-flats		Corner radius	Tolerance on corner radius
over	up to and including		
0,5[a]	1	[b]	—
1	3	0,5	—
3	6	0,8	± 0,2
6	10	1,0	± 0,3
10	30	1,6	± 0,4
30	80	2,5	± 0,5
80	120	4,0	± 1,0
120	160	6,0	± 1,0

[a] Including 0,5.

[b] 0,5 × nominal thickness or width across-flats.

Table 9 — Tolerances on fixed lengths (FL)

Values in millimetres

Ordered length		**Tolerance**
over	up to and including	
—	3 000	$^{+5}_{0}$
3 000	6 000	$^{+10}_{0}$
6 000	10 000	$^{+15}_{0}$

Table 10 — Maximum twist of square or hexagonal rod or rectangular bar

Nominal width mm		**Maximum permitted twist** v mm	
over	up to and including	in any 1 m length	in total length L (in m)[b]
10[a]	18	1,0	$1{,}0 \times L$
18	30	1,5	$1{,}5 \times L$
30	50	2,0	$2{,}0 \times L$
50	80	3,0	$3{,}0 \times L$
80	120	4,5	$4{,}5 \times L$
120	200	6,0	$6{,}0 \times L$

[a] Including 10.

[b] Up to 4 m. Over 4 m, the maximum twist is subjected to agreement.

Table 11 — Straightness of rod and bar

Nominal diameter, width across-flats, thickness or width	**Maximum deviation from straightness** (see 6.7.3)		
	h_2	h_1	
	in any length l_2	for total length l_1	
	of 400 mm	from 1 m up to and including 4 m	over 4 m
≥ 10 mm	0,8 mm	2,0 mm × l_1	by agreement

Table 12 — Flatness of bar

Values in millimetres

Nominal width[a]		**Maximum deviation from flatness** *e* **for nominal thickness**	
over	up to and including	from 1 up to and including 6	over 6 up to and including 40
10[b]	30	0,2	0,15
30	50	0,3	0,2
50	80	0,4	0,25
80	120	0,5	0,3
120	200	—	0,5

[a] Where the ratio nominal width: nominal thickness is greater than 15:1, the deviation from flatness shall be agreed between the purchaser and the supplier.

[b] Including 10.

Table 13 — Sampling rate

Nominal diameter[a] **or width across-flats** mm		**Mass of inspection lot for one test sample** kg
over	up to and including	up to and including
0,1	0,8	100
0,8	3,0	250
3,0	10,0	500
10,0	25,0	1 000
25,0	50,0	1 500
50,0	—	2 000

[a] For wire with polygonal or rectangular cross-section, the diameter of a round wire of equivalent cross-sectional area.

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" and "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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[2] EN 1412, *Copper and copper alloys — European numbering system*

[3] EN 12163:2011, *Copper and copper alloys — Rod for general purposes*

[4] EN 12166:2011, *Copper and copper alloys — Wire for general purposes*

[5] EN 12167:2011, *Copper and copper alloys — Profiles and bars for general purposes*

[6] EN 13602, *Copper and copper alloys — Drawn, round copper wire for the manufacture of electrical conductors*

[7] EN 50149, *Railway applications — Fixed installations — Electric traction — Copper and copper alloy grooved contact wires*

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

[9] ISO 197-1, *Copper and copper alloys — Terms and definitions — Part 1: Materials*

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

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