BS EN 13605:2013

BSI Standards Publication

Copper and copper alloys — Copper profiles and profiled wire for electrical purposes

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National foreword

This British Standard is the UK implementation of EN 13605:2013. It supersedes BS EN 13605:2002 which is withdrawn.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.

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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Date	Text affected

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EN 13605

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English Version

Copper and copper alloys - Copper profiles and profiled wire for electrical purposes

Cuivre et alliages de cuivre - Profilés et fils profilés en cuivre pour usages électriques

Kupfer und Kupferlegierungen - Profile und profilierte Drähte aus Kupfer für die Anwendung in der Elektrotechnik

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

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Foreword

This document (EN 13605:2013) 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of an identical text or by endorsement, at the latest by December 2013 and conflicting national standards shall be withdrawn at the latest by December 2013.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 13605:2002.

In comparison with EN 13605:2002, the following significant technical changes have been made:

— Cu-ETP1 (CW003A), Cu-OF1 (CW007A), Cu-OFE (CW009A) and Cu-PHCE (CW022A) have been added (Table 1).

— The impurity content (other materials) in the chemical composition of Cu-FRHC (CW005A) has been modified in accordance with EN 1976:2012 and EN 1977:2013.

— Mass tolerances have been changed.

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

EN 13605:2002, *Copper and copper alloys — Copper profiles and profiled wire for electrical purposes.*

The products specified in this European Standard are those which are especially suitable for electrical purposes, i.e. with specified electrical properties. Profiles for general purposes are specified in 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 13601, *Copper and copper alloys — Copper rod, bar and wire for general 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*

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 profiles and profiled wire for electrical purposes, which would fit within a circumscribing circle of maximum 180 mm diameter.

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

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)*

3 Terms and definitions

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

3.1
profile
wrought product of uniform cross-section along its whole length, supplied in straight lengths

Note 1 to entry: It may be solid or hollow:

— if solid, the contour of its cross-section is complex;

— if hollow, the external contour and/or the internal contour of its cross-section is (are) complex.

3.2
profiled wire
particular type of wire, i.e. a wrought product of uniform cross-section along its whole length, supplied in coiled form

Note 1 to entry: It may be solid or hollow:

— if solid, the contour of its cross-section is complex;

— if hollow the external contour and/or the internal contour of its cross-section is (are) complex.

3.3
circumscribing circle
smallest circle which completely encloses the contour of the cross-sections of the profile or profiled wire

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 drawn 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 (profile or profiled wire);

b) number of this European Standard (EN 13605);

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

d) material condition designation (see Table 3);

e) for profiles or profiled wire, a number, or the number of a fully dimensioned and toleranced drawing;

f) for profiles, length, either as manufactured length (ML) or fixed length (FL);

g) for profiled wire, form of delivery: coil (Y) or spool (Z).

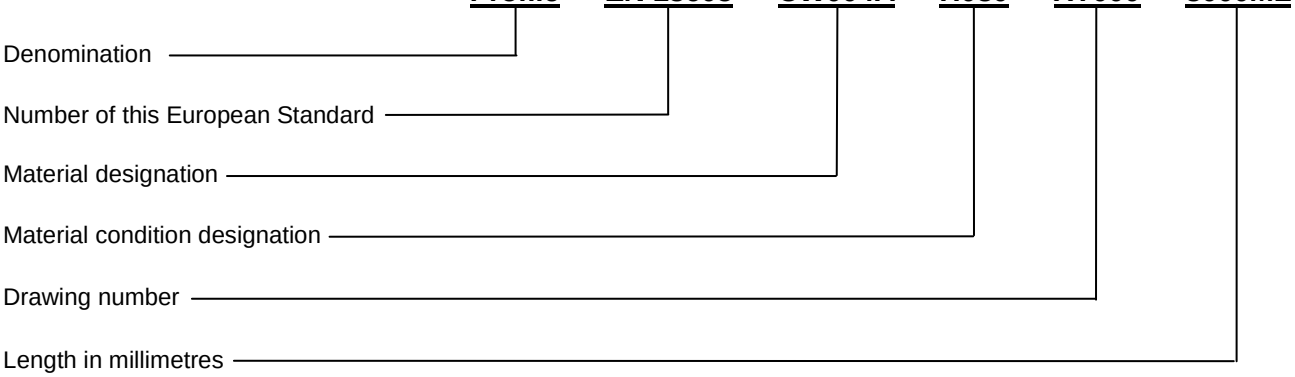
The derivation of a product designation is shown in Example 1 and another typical product designation is shown in Example 2.

EXAMPLE 1 Profile for electrical purposes conforming to this standard, in material designated either Cu-ETP or CW004A, in material condition H080, drawing number XY000, manufactured length 3 000 mm, will be designated as follows:

Profile — EN 13605 — Cu-ETP — H080 — XY000 — 3000ML

or

Profile — EN 13605 — CW004A — H080 — XY000 — 3000ML



EXAMPLE 2 Profiled wire for electrical purposes conforming to this standard, in material designated either CuAg0,10 or CW013A in material condition H035, drawing number BC000, in coils, will be designated as follows:

Profiled wire EN 13605 — CuAg0,10 — H035 — BC000 — Y

or

Profiled wire EN 13605 — CW013A — H035 — BC000 — Y

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 profiles or number of coils or spools);

b) denomination (profile or profiled wire);

c) number of this European Standard (EN 13605);

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

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

f) number of the profile or fully dimensioned and toleranced drawing;

g) for profiles, nominal length, either as manufactured length (ML) or fixed length (FL), see 6.6.4;

h) for profiled wire, form of delivery: pancake, traverse wound, bunched coils or on spools (see 6.7);

i) coil dimensions, mass or spool type;

j) for profiled wire, the direction of coiling to be indicated on the drawing (see 6.5);

k) whether Brinell or Vickers hardness test is mandatory;

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

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

l) whether first articles are required (see 6.5);

m) for profiles, whether sawn or sheared ends are required (see 6.6.4);

n) whether special surface conditions are required (see 6.9);

o) for profiled wire, whether form tolerances are required;

p) for profiled wire, whether specific length is required;

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

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

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

EXAMPLE 1 Ordering details for 1 000 pieces of profiles for electrical purposes conforming to EN 13605, in material designated either Cu-ETP or CW004A, in material condition H080, drawing number XY123, manufactured length 3 000 mm:

1 000 pieces Profile EN 13605 — Cu-ETP — H080 — XY123 — 3 000ML

or

1 000 pieces Profile EN 13605 — CW004A — H080 — XY123 — 3 000ML

EXAMPLE 2 Ordering details for 2 000 kg of profiled wire for electrical purposes conforming to EN 13605, in material designated either CuAg0,10 or CW013A, in material condition H035, drawing number BC123, in 250 kg coils:

2 000 kg Profiled wire EN 13605 — CuAg0,10 — H035 — BC123 — Y—250

or

2 000 kg Profiled wire EN 13605 — CW013A — H035 — BC123 — Y—250

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 Electrical properties

The electrical properties shall conform to the appropriate requirements given in Table 4. The tests shall be carried out in accordance with 8.4.

6.4 Freedom from hydrogen embrittlement

Profiles and profiled wire in copper grades Cu-OF1 (CW007A), 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), Cu-HCP (CW021A), shall show no evidence of cracking, when tested and visually examined in accordance with 8.5.

6.5 Drawings

Unless the profile or profiled wire can be described by nominal dimensions, the purchaser shall supply a drawing of the profile or profiled wire showing the dimensions and tolerances and in the case of profiled wire, the direction of coiling and position of the cross-section within the coil.

Special surface requirements, e.g. contact areas, shall be indicated on the drawing.

From the data submitted, the manufacturer of the profile or profiled wire shall prepare a drawing which includes the dimensions and tolerances. This drawing shall be checked and approved by the customer and returned to the manufacturer before die-sinking is started.

By agreement between the purchaser and the manufacturer, first articles shall be sent to the purchaser for approval before commencing bulk production.

6.6 Dimensions and tolerances

6.6.1 General

The tolerances on dimensions and form apply to profiles and tolerances on dimensions apply to profiled wires, within a circumscribing circle with a maximum diameter of 180 mm (see Figure 1).

Dimensions in millimetres

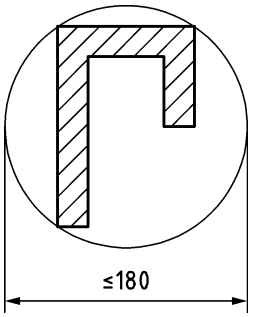


Figure 1 — Profile within a circumscribing circle

The tolerances specified on drawings shall conform to the requirements of this standard. If no tolerances are specified on the drawings of profiles, the specifications in this standard apply. It is advisable to make a suitable reference to this standard on the drawings.

If required, tighter tolerances than those specified shall be agreed between the purchaser and the supplier.

NOTE Dimensional tolerances are influenced by the fabrication accuracy of the tools, tool wear, and unavoidable deviations caused by fabrication.

6.6.2 Tolerances on cross-sectional dimensions

6.6.2.1 Profiles and profiled wires with a ratio $b_{max.}$ or $h_{max.}$ to $s_{min.}$ less than 20 : 1 shall conform to the requirements given in Table 5 (see Figure 2).

6.6.2.2 Profiles and profiled wires with a ratio $b_{max.}$ or $h_{max.}$ to $s_{min.}$ equal to or greater than 20 : 1 shall conform to the requirements given in Table 6 (see Figure 2).

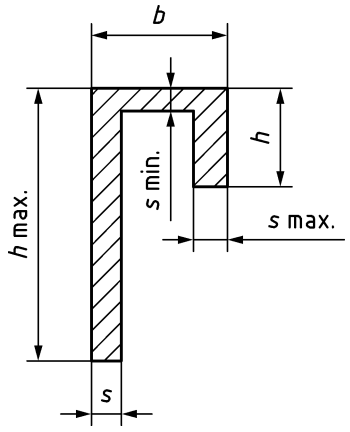


Figure 2 — Cross-sectional dimensions

6.6.2.3 The thicknesses of profiles and profiled wires shall conform to the tolerances given in Table 7.

For hollow profiles and hollow profiled wires the wall thickness shall conform to a tolerance of ± 10 % of its nominal dimension.

6.6.2.4 Radii, dimensioned in the drawing, shall conform to the tolerances given in Table 8.

6.6.2.5 The radii of sharp corners shall conform to the maximum values given in Table 9.

6.6.3 Tolerances on form

6.6.3.1 General

The form tolerances given in 6.6.3.2 to 6.6.3.7 apply to:

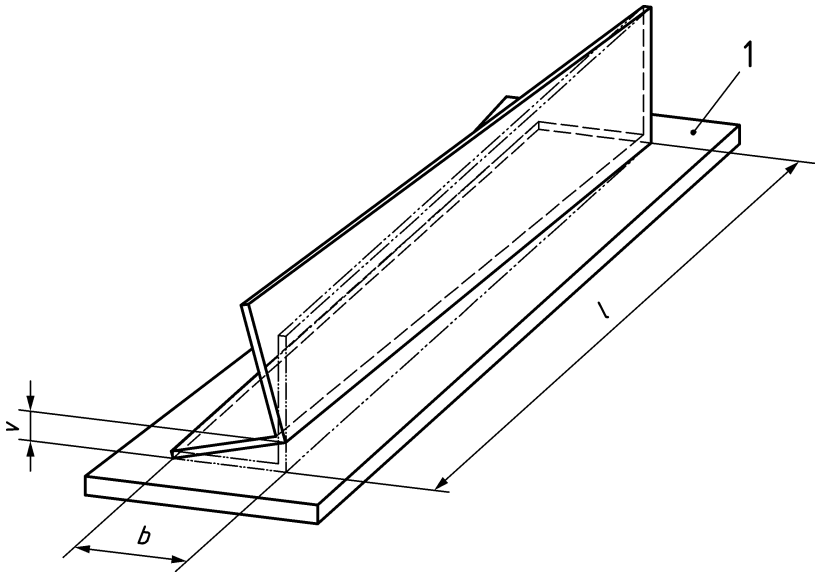
a) profiles, but not profiled wires, whose cross-sections would fit within a circumscribing circle from 15 mm up to and including 180 mm; if necessary form tolerances for profiled wire shall be agreed between the supplier and the purchaser;

b) all material conditions except those designated H035/R200 (annealed).

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

6.6.3.2 Twist

Profiles shall be straightened to conform to the twist tolerance v which is determined by multiplying the width b of the profile with the coefficient f given in Table 10 as a function of the diameter of the circumscribing circle (see Figure 3).



Key
1 reference plane
twist tolerances $v = b \times f$
where
b is the width
f is a coefficient
l is the length

Figure 3 — Twist of a profile

6.6.3.3 Flatness

The flatness of profiles shall conform to the appropriate tolerance illustrated in Figure 4 and Figure 5.

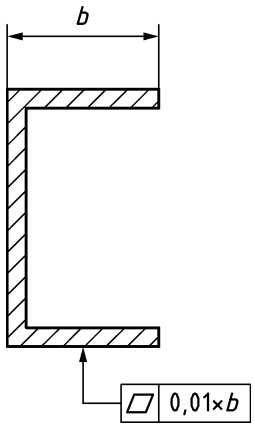


Figure 4 — Indication of flatness on a U-Profile

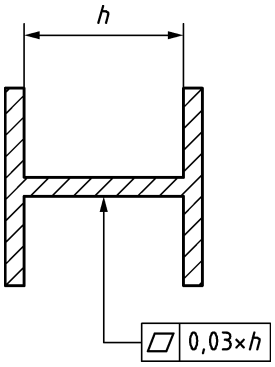


Figure 5 — Indication of flatness on a H-Profile

6.6.3.4 Perpendicularity and angularity

The perpendicularity and angularity of profiles shall conform to the appropriate tolerance illustrated in Figure 6 and Figure 7.

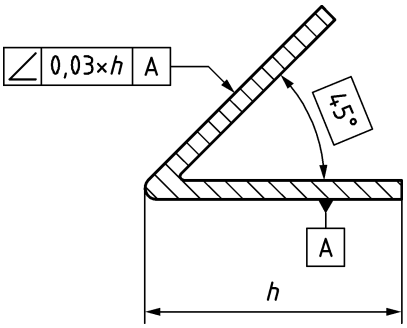


Figure 6 — Indication of angularity

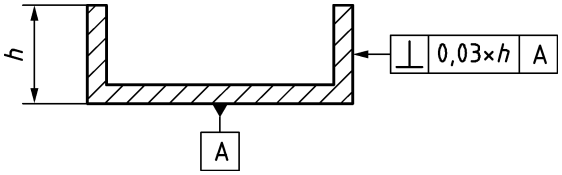


Figure 7 — Indication of perpendicularity

6.6.3.5 Deviation from circular form

In the case of round hollow profiles, the tolerance of the outside diameter includes the deviation from circular form.

6.6.3.6 Concentricity

The concentricity tolerance of symmetrical hollow profiles is included in the wall thickness tolerance (see 6.6.2.3).

6.6.3.7 Straightness

Profiles shall be straightened to conform to the straightness tolerances h_1 and h_2 given in Table 11 (see Figure 8).

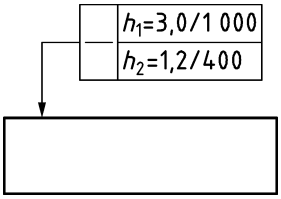


Figure 8 — Indication of straightness tolerances

6.6.4 Length of profiles

Profiles in accordance with this standard shall be supplied either in manufactured lengths or in fixed lengths, with ends either sawn or sheared.

6.6.4.1 Tolerances on manufactured lengths

Manufactured lengths (ML) shall be supplied in the size ranges and with the tolerances and shorter lengths as given in Table 12.

6.6.4.2 Tolerances on fixed lengths

The lengths supplied as fixed lengths (FL) shall conform to the tolerances given in Table 13.

The deviation from squareness of the cut shall be a maximum of 2 % of the width or diameter and is included in the fixed length tolerance.

6.7 Form of delivery of profiled wire

Profiled wire shall be delivered in coiled form of the following types:

— pancake;

— traverse wound;

— bunched;

— on spools.

The direction of coiling and the position of the cross-section within the coil shall be indicated on the drawing.

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 enquiry and order [see Clause 5 list entry h) and Clause 5 list entry i)].

6.8 Mass tolerances

The mass of a consignment shall not exceed ± 10 % referred to the ordered quantity.

6.9 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 worked products and is permissible unless otherwise specified. Discolouration is permissible as long as it does not impair utilisation.

Special requirements shall be agreed between the purchaser and the supplier [see Clause 5 list entry m)] and shall then be indicated on the drawing as appropriate.

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 14. 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, electrical and hydrogen embrittlement tests

Unless otherwise specified, the sampling rate for each of the tests in 8.2 to 8.5 shall be in accordance with Table 14. 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 8.7 shall be used.

8.2 Tensile test

The tensile properties shall be determined 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 a full cross-section 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. The following test conditions apply:

a) for the Brinell hardness test in accordance with EN ISO 6506-1, a 0,102 F/D^2 ratio of 10:

   1) a 2,5 mm diameter ball and a force of 612,9 N for thicknesses equal to or greater than 2 mm;

   2) a 1,0 mm diameter ball and a force of 98,07 N for thicknesses less than 2 mm;

b) for the Vickers hardness test in accordance with EN ISO 6507-1:

   1) a test force of 98,07 N for thicknesses equal to or greater than 2 mm;

   2) a test force of 49,03 N for thicknesses less than 2 mm.

8.4 Electrical 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 or conductivity shall be determined by direct measurement either at 20 °C ± 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, sampled in accordance with 7.3.

8.5 Hydrogen embrittlement test

Profiles and profiled wire in copper grades listed in 6.4 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 length and either of the full cross-section or of convenient thickness or diameter not greater than 12 mm. Any edges shall be rounded and smoothed. Machined test pieces shall retain some part of the original surface to be on the outside of the bend.

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.

8.6 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 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:

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

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 q)] 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 r)] 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 s)].

Table 1 — Composition of unalloyed copper grades

Material designation		Composition % (mass fraction)												
Symbol	Number	Element	Cu	Ag	As	Bi	Cd	Co	Cr	Fe	Mn	Ni	O	P
Cu-ETP1	**CW003A**	min.	—	—	—	—	—	—	—	—	—	—	—	—
		max.	—	0,002 5	0,000 5[a]	0,000 20[b]	—[a]	—[c]	—[a]	0,001 0[c]	—[a]	—[c]	0,040	—[a]
Cu-OF1	**CW007A**	min.	—	—	—	—	—	—	—	—	—	—	—	—
		max.	—	0,002 5	0,000 5[a]	0,000 20[b]	—[a]	—[c]	—[a]	0,001 0[c]	—[a]	—[c]	—[d]	—[a]
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	—[d]	0,000 3
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	—[d]	0,006

Material designation		Composition % (mass fraction)										
Symbol	Number	Element	Pb	S	Sb	Se	Si	Sn	Te	Zn	Elements listed in this table other than copper	
											total	excluding
Cu-ETP1	**CW003A**	min.	—	—	—	—	—	—	—	—	—	O
		max.	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.	0,000 5	0,001 5	0,000 4[a]	0,000 20[b]	—[c]	—[c]	0,000 20[b]	—[c]	0,006 5	
Cu-OFE	**CW009A**	min.	—	—	—	—	—	—	—	—	—	—
		max.	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.	—	—	—	—	—	—	—	—	—	—
		max.	0,000 5	0,001 5	0,000 4	0,000 20	—	0,000 2	0,000 20	0,000 1	—	

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

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

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

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

Table 2 — Composition of copper grades

Material designations		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	—	0,007	—	0,03	
CuAg0,07P	CW015A	min.	Rem.	0,06	—	—	0,001	—	—	Ag, P
		max.	—	0,08	0,000 5	—	0,007	—	0,03	
CuAg0,10P	CW016A	min.	Rem.	0,08	—	—	0,001	—	—	Ag, P
		max.	—	0,12	0,000 5	—	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	—	0,006	0,005	0,03	
Cu-HCP	CW021A	min.	99,95[a]	—	—	—	0,002	—	—	Ag, P
		max.	—	—	0,000 5	—	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		Mechanical properties							
					hardness				Tensile strength	0,2% proof strength	elongation[a]	
					HBW		HV		R_m	$R_{p0,2}$	$A_{100\ mm}$	A
Material		Material condition	thickness mm max.	width/height mm max.	min.	max.	min.	max.	N/mm² min.	N/mm²	% min.	% min.
Cu-ETP1	CW003A	D	50	180	as drawn							
Cu-ETP	CW004A											
Cu-FRHC	CW005A											
Cu-OF1	CW007A	H035[b]	50	180	35	65	35	70	—	—	—	—
Cu-OF	CW008A											
Cu-OFE	CW009A	R200[b]	50	180	—		—		200	max. 120	25	35
CuAg0,04	CW011A											
CuAg0,07	CW012A											
CuAg0,10	CW013A	H065[c]	10	150	65	95	70	100	—	—	—	—
CuAg0,04P	CW014A											
CuAg0,07P	CW015A	R240[c]	10	150	—		—		240	min. 160	—	15
CuAg0,10P	CW016A											
CuAg0,04(OF)	CW017A											
CuAg0,07(OF)	CW018A											
CuAg0,10(OF)	CW019A	H080[c]	5	100	80	115	85	120	—	—	—	—
Cu-PHC	CW020A											
Cu-HCP	CW021A	R280[c]	5	100	—		—		280	min. 240	—	8
Cu-PHCE	CW022A											

NOTE 1 N/mm² is equivalent to 1 MPa.

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

– on a gauge length L_o, where $L_o = 5{,}65\ \sqrt{S_o}$ mm for thicknesses equal to or greater than 3 mm; and

– on a fixed gauge length L_o, where L_o = 100 mm for thicknesses less than 3 mm.

[b] Annealed.

[c] The values of these tempers are valid only for a certain location of the test piece when agreed between the customer and the manufacturer at the time of the enquiry and order.

Table 4 — Electrical properties (at 20 °C)

Designations				Volume resistivity	Mass resistivity[a]	Conductivity	
Material		Material condition		$\frac{\Omega \times mm^2}{m}$	$\frac{\Omega \times g}{m^2}$		
Symbol	Number			max.	max.	MS/m min.	% IACS[b] min.
Cu-ETP1	CW003A	D		0,017 86	0,158 8	56,0	96,6
Cu-ETP	CW004A						
Cu-FRHC	CW005A	H035	R200	0,017 24	0,153 3	58,0	100,0
Cu-OF1	CW007A						
Cu-OF	CW008A	H065	R240	0,017 54	0,155 9	57,0	98,3
Cu-OFE	CW009A						
CuAg0,04	CW011A						
CuAg0,07	CW012A						
CuAg0,10	CW013A	H080	R280	0,017 86	0,158 8	56,0	96,6
CuAg0,04(OF)	CW017A						
CuAg0,07(OF)	CW018A						
CuAg0,10(OF)	CW019A						
Cu-PHC	CW020A						
CuAg0,04P	CW014A	D		0,018 18	0,161 6	55,0	94,8
CuAg0,07P	CW015A	H035	R200	0,017 54	0,155 9	57,0	98,3
CuAg0,10P	CW016A						
Cu-HCP	CW021A	H065	R240	0,017 86	0,158 8	56,0	96,6
Cu-PHCE	CW022A	H080	R280	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 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.

Table 5 — Tolerances for dimensions b and h, ratio $b_{max.}$ or $h_{max.}$ to $s_{min.}$ < 20 : 1

Values in millimetres

Nominal dimensions b and h		Tolerances for dimensions b and h within a circumscribing circle		
over	up to and including	up to and including 50	over 50 up to and including 120	over 120 up to and including 180
—	10	± 0,11	± 0,18	± 0,29
10	18	± 0,14	± 0,22	± 0,35
18	30	± 0,17	± 0,26	± 0,42
30	50	± 0,20	± 0,31	± 0,50
50	80	—	± 0,37	± 0,60
80	120	—	± 0,44	± 0,70
120	180	—	—	± 0,80

Table 6 — Tolerances for dimensions b and h, ratio $b_{max.}$ or $h_{max.}$ to $s_{min.}$ ≥ 20 : 1

Values in millimetres

Nominal dimensions b and h		**Tolerances for dimensions b and h within a circumscribing circle**		
over	up to and including	up to and including 50	over 50 up to and including 120	over 120 up to and including 180
—	10	± 0,18	± 0,29	± 0,45
10	18	± 0,22	± 0,35	± 0,55
18	30	± 0,26	± 0,42	± 0,65
30	50	± 0,31	± 0,50	± 0,80
50	80	—	± 0,60	± 0,95
80	120	—	± 0,70	± 1,10
120	180	—	—	± 1,25

Table 7 — Thickness tolerances

Values in millimetres

Nominal thickness		**Thickness tolerances within a circumscribing circle**	
over	up to and including	up to and including 50	over 50 up to and including 180
—	3	± 0,13	± 0,20
3	6	± 0,15	± 0,24
6	10	± 0,18	± 0,29
10	18	± 0,22	± 0,35
18	30	± 0,26	± 0,42
30	50	—	± 0,50

Table 8 — Radius tolerances

Nominal radius mm	**Normal tolerances**	**Close tolerances**
up to and including 5	± 15 % (± 0,4 mm min.)	± 10 % (± 0,3 mm min.)
over 5	± 10 % (± 0,75 mm min.)	± 8 % (± 0,5 mm min.)

Table 9 — Maximum radii of sharp corners

Sharp corners	**Maximum radii**	
	normal	reduced
external/internal	0,8 mm	0,5 mm
NOTE If sharp corners are not essential, for ease of production and for tool life it is desirable to produce the largest radius possible, particularly on internal corners (values of 1,5 mm or more facilitate the production process).		

Table 10 — Twist tolerances — coefficient f

Diameter of the circumscribing circle mm		**Coefficient f for twist tolerance v**	
over	up to and including	per 1 m length	on total length l greater than 2 m
15[a]	50	0,08	0,15
50	120	0,05	0,10
120	180	0,04	0,08

[a] Including 15.

Table 11 — Straightness tolerances for profiles

Diameter of the circumscribing circle mm	**Maximum deviation from straightness**		
	h_2 in any length l_2 of 400 mm	h_1 for total length l_1	
		from 1 m up to and including 4 m	over 4 m
from 15 up to and including 180	1,2 mm	3,0 mm × l_1	to be agreed

Table 12 — Tolerances on "manufactured" lengths

Values in millimetres

Nominal length	**Diameter of the circumscribing circle**		**Tolerance on length** [a]
	over	up to and including	
3 000, 3 500	—	50	± 200
4 000, 4 500 5 000, 5 500 6 000	50	120	± 300
by agreement	120	180	± 500

[a] 10 % of the number of profiles of a consignment may be shorter than the tolerance given, but not less than 50 % of the nominal length.

Table 13 — Tolerances on "fixed" lengths

Values in millimetres

Diameter of the circumscribing circle		Tolerance on length for fixed lengths		
over	up to and including	up to and including 1 000	over 1 000 up to and including 2 000	over 2 000 up to and including 6 000
—	50	$^{+4}_{0}$	$^{+5}_{0}$	$^{+8}_{0}$
50	120	$^{+5}_{0}$	$^{+6}_{0}$	$^{+9}_{0}$
120	180	$^{+6}_{0}$	$^{+7}_{0}$	$^{+10}_{0}$

Table 14 — Sampling rate

Mass per unit length kg/m		Mass of inspection lot for one test sample kg
over	up to including	up to and including
—	1	500
1	5	1 000
5	20	1 500
20	50	2 000
NOTE Larger masses require sampling in proportion, up to a maximum of five test samples.		

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

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

[5] EN ISO 9001, *Quality management systems — Requirements*

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

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[8] 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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