BS EN 13599:2014

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 13599:2014. It supersedes BS EN 13599:2002 which is withdrawn.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.

ISBN 978 0 580 82036 6

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 28 February 2014.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13599

January 2014

ICS 77.150.30

Supersedes EN 13599:2002

English Version

Copper and copper alloys - Copper plate, sheet and strip for electrical purposes

Cuivre et alliages de cuivre - Plaques, tôles et bandes en cuivre pour usages électriques

Kupfer und Kupferlegierungen - Platten, Bleche und Bänder aus Kupfer für die Anwendung in der Elektrotechnik

This European Standard was approved by CEN on 3 November 2013.

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Foreword

This document (EN 13599:2014) 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of an identical text or by endorsement, at the latest by July 2014, and conflicting national standards shall be withdrawn at the latest by July 2014.

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 13599:2002.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 2 “Rolled flat products” to revise the following standard:

EN 13599:2002, *Copper and copper alloys — Copper plate, sheet and strip 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. Copper plate, sheet and strip for general purposes are specified in EN 1652.

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

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 — Products of high conductivity copper for electronic tubes, semiconductor devices and vacuum applications*

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

In comparison with EN 13599:2002, the following significant changes were made:

a) Table 2, Cu-FRHC, other elements – content has been modified and a new footnote “d” has been added;

b) the normative references have been updated.

According to the CEN-CENELEC Internal Regulations, the national standards organizations 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 plate, sheet and strip for electrical purposes with thicknesses from 0,05 mm up to and including 25 mm and widths from 10 mm up to and including 1 250 mm.

The sampling procedures and the methods of test for verification of conformity to the requirements of this European Standard 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 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)*

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

3 Terms and definitions

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

3.1
plate
flat rolled product of rectangular cross-section with uniform thickness greater than 10 mm

3.2
sheet
flat rolled product of rectangular cross-section with uniform thickness from 0,2 mm up to and including 10 mm, supplied in straight lengths, usually with sheared or sawn edges

Note 1 to entry: The thickness does not exceed one tenth of the width.

3.3
strip
flat rolled product of rectangular cross-section with uniform thickness from 0,05 mm up to and including 5,0 mm manufactured in coil and supplied in as sheared coils, traverse wound coils or cut to length, usually with slit edges

Note 1 to entry: The thickness does not exceed one tenth of the width.

4 Designations

4.1 Material

4.1.1 General

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

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 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:

M Material condition for the product as manufactured 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 and elongation requirements.

NOTE Some R... material conditions in this European Standard apply to products which also have mandatory 0,2 % proof strength requirements.

Exact conversion between 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 European Standard shall consist of:

— denomination (Plate, Sheet or Strip);

— number of this European Standard (EN 13599);

— material designation, either symbol or number (see Table 1);

— material condition designation (see Table 2);

— nominal dimensions;

— plate: thickness × width × length [either “as manufactured” (ML) or “fixed” (FL) length];

— sheet: thickness × width × length [either “as manufactured” (ML) or “fixed” (FL) length] (see Example 1);

— strip (as sheared coils or as transverse wound coils on spools): thickness × width (see Example 2);

— strip (cut to length): thickness × width × length [either “as manufactured” (ML) or “fixed” (FL) length].

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

EXAMPLE 1 Sheet for electrical purposes conforming to this European Standard, in material designated either Cu-ETP or CW004A, in material condition H040, nominal thickness 6,0 mm, nominal width 600 mm, as manufactured length 2 000 mm, will be designated as follows:

Sheet EN 13599 — Cu-ETP — H040 — 6,0 × 600 × 2 000ML

or

Sheet EN 13599 — CW004A — H040 — 6,0 × 600 × 2 000ML

Denomination

Number of this European Standard

Material designation

Material condition designation

Nominal dimension in millimetres

EXAMPLE 2 Strip for electrical purposes conforming to this European Standard, in material designated either CuAg0,10 or CW013A, in material condition R290, nominal thickness 2,0 mm, nominal width 1 000 mm, will be designated as follows:

Strip EN 13599 — CuAg0,10 — R290 — 2,0 × 1 000

or

Strip EN 13599 — CW013A — R290 — 2,0 × 1 000

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:

   1) plate: number of pieces or mass;

   2) sheet: number of pieces or mass;

   3) strip (as sheared coils or as transverse wound coils on spools): mass;

   4) strip (cut to length): mass or number of pieces;

b) denomination (Plate, Sheet or Strip);

c) number of this European Standard (EN 13599);

d) material designation (see 4.1 and Table 1);

e) material condition designation (see 4.2 and Table 2);

f) nominal dimensions:

1) plate, sheet, strip (cut to length): thickness [for thicknesses from 0,05 mm up to and including 3,2 mm and with widths from 10 mm up to and including 200 mm, thickness tolerance either “normal” (N) or “special” (S)] × width × length (either “as manufactured” or “fixed” length);

2) strip (as sheared coils or as transverse wound coils on spools): thickness [for thicknesses from 0,05 mm up to and including 3,2 mm and with widths from 10 mm up to and including 200 mm, thickness tolerance either “normal” (N) or “special” (S)] × width;

g) size of sheared coils (strip) requirements: nominal inside diameter in millimetres and maximum outside diameter in millimetres and either maximum mass in kilograms or approximate specific coil mass (mass per width) in kilograms per millimetre;

h) size of traverse wound coils (strip): type or dimensions.

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

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

i) maximum edgewise curvature values for strip over 3,2 mm up to and including 5,0 mm thickness and width over 30 mm (see Table 9);

j) whether special surface conditions are required (see 6.8);

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

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

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

EXAMPLE 1 Ordering details for 100 sheets for electrical purposes conforming to EN 13599, in material designated either Cu-ETP or CW004A, in material condition H040, nominal thickness 6,0 mm, nominal width 600 mm, as manufactured length 2 000 mm:

100 pieces Sheet EN 13599 — Cu-ETP — H040 — 6,0 × 600 × 2 000ML

or

100 pieces Sheet EN 13599 — CW004A — H040 — 6,0 × 600 × 2 000ML

EXAMPLE 2 Ordering details for 5 000 kg strip for electrical purposes conforming to EN 13599, in material designated either CuAg0,10 or CW013A, in material condition R290, nominal thickness 0,4 mm, normal thickness tolerance, nominal width 60 mm, nominal inside diameter of coil 400 mm, maximum outside diameter of coil 960 mm and approximate specific coil mass (mass per width) 4,5 kg/mm:

5 000 kg Strip EN 13599 — CuAg0,10 — R290 — 0,4N × 60
— nominal inside diameter of coil 400 mm
— maximum outside diameter of coil 960 mm
— approximate specific coil mass 4,5 kg/mm

or

5 000 kg Strip EN 13599 — CW013A — R290 — 0,4N × 60
— nominal inside diameter of coil 400 mm
— maximum outside diameter of coil 960 mm
— approximate specific coil mass 4,5 kg/mm

6 Requirements

6.1 Composition

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

Percentage content of the element shown as “remainder” (Rem.) is usually calculated by difference from 100 %.

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 2. The tests shall be carried out in accordance with either 8.2 (tensile test) or 8.3 (hardness test).

6.3 Bending characteristics

The bending edge shall show no evidence of cracks on the tension side, when tested and examined with the unaided eye, corrected to normal vision if necessary, in accordance with 8.4.

6.4 Electrical properties

The electrical properties shall conform to the appropriate requirements given in Table 3. The test shall be carried out in accordance with 8.5.

6.5 Freedom from hydrogen embrittlement

Sheet and strip in copper grades Cu-OF (CW008A), CuAg0,10P (CW016A), 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.

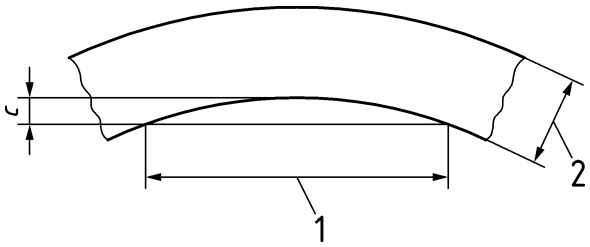
6.6 Dimensions and tolerances

Plate, sheet and strip shall conform to the appropriate tolerances on dimensions and form given in Tables 4 to 8. Plate, sheet and strip up to 5 000 mm in length may be supplied in “as manufactured” or “fixed lengths” (see Table 7).

6.7 Edgewise curvature *c*

For the straightness of the longitudinal edge of strip, which unless otherwise agreed between the purchaser and the supplier shall be based on a measuring length of 1 000 mm, the edgewise curvature *c* (see Figure 1) shall not exceed the values given in Table 9.

If the purchaser and the supplier agree on a measuring length of 2 000 mm, the edgewise curvature *c* shall not exceed the values given in Table 9 multiplied by 4.



Key

1 measuring length

2 strip width

c edgewise curvature

Figure 1 — Edgewise curvature *c*

6.8 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 rolled products and is permissible unless otherwise specified. Discoloration 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 j)]. The dimensions, mechanical and electrical properties of plate, sheet and strip with surface coatings shall be agreed between the purchaser and the supplier.

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 the test sample. 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 or master coil 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 one test sample per master coil. 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 in accordance with the appropriate ISO standards 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 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, except that the gauge length for determining elongation shall be:

a) for thickness over 2,5 mm, gauge length $l_0 = 5{,}65\sqrt{S_0}$ (elongation A);

b) for thickness from 0,10 mm up to and including 2,5 mm, a fixed gauge length of 50 mm (elongation $A_{50\ mm}$).

8.3 Hardness test

The Vickers hardness shall be determined in accordance with EN ISO 6507-1 using a suitable test force selected from those given, on the test pieces prepared from the test samples obtained in accordance with 7.3.

8.4 Bend test

A bend test shall be carried out in accordance with EN ISO 7438 with the bending edge parallel to the direction of rolling, see Figure 2. The test piece shall be at least 10 mm wide and 20 mm long.

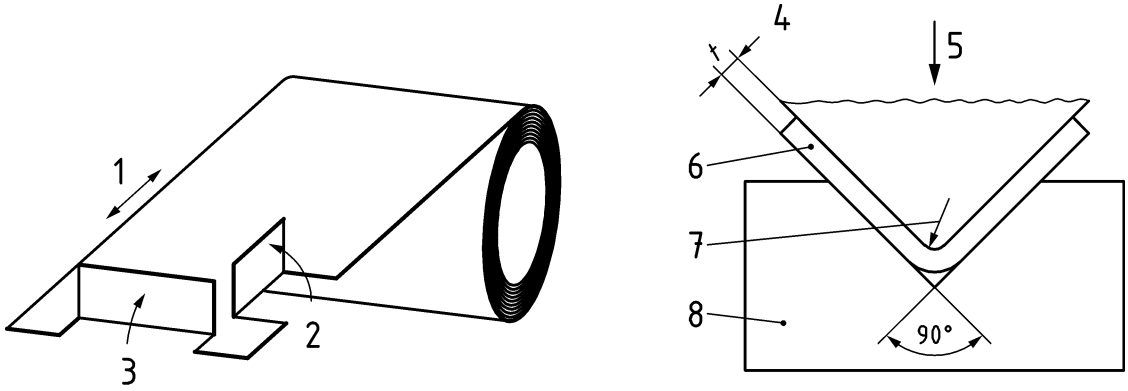
For strips with widths 20 mm or wider, the bending edge shall be parallel to the direction of rolling. For strips with widths less than 20 mm, the bending edge shall be transverse to the direction of rolling. The properly deburred test pieces from strips in the H110 material condition only shall be bent through 90° using the following bending radii:

— 1 × *t* for Cu-OF (CW008A), CuAg0,10P (CW016A), CuAg0,10(OF) (CW019A), Cu-PHC (CW020A) and Cu-HCP (CW021A);

— 2 × *t* for Cu-ETP (CW004A), Cu-FRHC (CW005A) and CuAg0,10 (CW013A).

where

t is the thickness of the strip.



Key

1 direction of rolling
2 bending edge parallel to direction of rolling
3 bending edge transverse to direction of rolling
thickness of strip *t*
5 punching direction
6 test piece
7 bending radius
8 V-shaped die

Figure 2 — Orientation of test pieces and arrangement of punch and die for 90° bend test

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 ± 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.

8.6 Hydrogen embrittlement test

Plate, sheet and strip 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, the test pieces 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 (properties). 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 European Standard.

8.8 Rounding of results

For the purpose of determining conformity to the limits specified in this European 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 5, 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 5, 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 k)] 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 l)] 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 m)].

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

Table 1 — Composition of copper

Material designation		Composition in % (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	
CuAg0,10	CW013A	min.	Rem.	0,08	—	—	—	—	—	Ag, O
		max.	—	0,12	0,000 5	0,040	—	—	0,03	
CuAg0,10P	CW016A	min.	Rem.	0,08	—	—	0,001	—	—	Ag, P
		max.	—	0,12	0,000 5	— [c]	0,007	—	0,03	
CuAg0,10(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 2 — Mechanical properties

Designations			Nominal thickness		Hardness		Tensile strength		0,2 % proof strength		Elongation	
			t[a]		HV		R_m		$R_{p0,2}$		$A_{50\ mm}$ for thicknesses from 0,1 mm up to and including 2,5 mm	A for thicknesses over 2,5 mm
Material		Material condition	mm				N/mm²		N/mm²		%	%
Symbol	Number		from	up to and including	min.	max.	min.	max.	min.	max.	min.	min.
Cu-ETP[b] Cu-FRHC[b] Cu-OF CuAg0,10[b] CuAg0,10P CuAg0,10(OF) Cu-PHC Cu-HCP	CW004A[b] CW005A[b] CW008A CW013A[b] CW016A CW019A CW020A CW021A	M	10	25	as manufactured							
		H040	0,10	5	40	65	—	—	—	—	—	—
		R220[b]			—	—	220	260	—	(140)	33	42
		H040	0,20	10	40	65	—	—	—	—	—	—
		R200			—	—	200	250	—	(100)	—	42
		H065	0,10	10	65	95	—	—	—	—	—	—
		R240			—	—	240	300	180	—	8	15
		H090	0,10	10	90	110	—	—	—	—	—	—
		R290			—	—	290	360	250	—	4	6
		H110	0,10	2	110	—	—	—	—	—	—	—
		R360			—	—	360	—	320	—	2	—

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

NOTE 2 Figures in parenthesis are not requirements of this European Standard, but are given for information only.

[a] For thicknesses less than 0,10 mm the mechanical properties shall be agreed between the purchaser and the supplier.

[b] For Cu-ETP (CW004A) and Cu-FRHC (CW005A) and CuAg0,10 (CW013A) with thicknesses from 0,10 mm up to and including 0,20 mm, the following values shall apply:
R_m min. 200 N/mm² and $A_{50\ mm}$ min. 28 %.

Table 3 — Electrical properties (at 20 °C)

Designations				Volume resistivity	Mass resistivity [a]	Conductivity	
Material		Material condition		$\frac{\Omega \times mm^2}{m}$	$\frac{\Omega \times g}{m^2}$	MS/m	% IACS [b]
Symbol	Number			max.	max.	min.	min.
Cu-ETP Cu-FRHC Cu-OF CuAg0,10 CuAg0,10(OF) Cu-PHC	CW004A CW005A CW008A CW013A CW019A CW020A	M		0,017 54	0,155 9	57,0	98,3
		H040	R200	0,017 24	0,153 3	58,0	100,0
		H040	R220				
		H065	R240	0,017 54	0,155 9	57,0	98,3
		H090	R290				
		H110	R360	0,017 86	0,158 8	56,0	96,6
CuAg0,10P Cu-HCP	CW016A CW021A	M		0,017 86	0,158 8	56,0	96,6
		H040	R200	0,017 54	0,155 9	57,0	98,3
		H040	R220				
		H065	R240	0,017 86	0,158 8	56,0	96,6
		H090	R290				
		H110	R360	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 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.

Table 4 — Tolerances on thickness of plate, sheet and strip

Values in millimetres

Nominal thickness		Tolerance on thickness for nominal widths					
		from 10 up to and including 200		over 200 up to and including 350	over 350 up to and including 700	over 700 up to and including 1 000	over 1 000 up to and including 1 250
over	up to and including	normal	special				
0,05 [a]	0,1	±10 % [b]	–	–	–	–	–
0,1	0,2	±0,010	±0,007	±0,015	–	–	–
0,2	0,3	±0,015	±0,010	±0,020	±0,03	±0,04	–
0,3	0,4	±0,018	±0,012	±0,022	±0,04	±0,05	±0,07
0,4	0,5	±0,020	±0,015	±0,025	±0,05	±0,06	±0,08
0,5	0,8	±0,025	±0,018	±0,030	±0,06	±0,07	±0,09
0,8	1,2	±0,030	±0,022	±0,040	±0,07	±0,09	±0,10
1,2	1,8	±0,035	±0,028	±0,06	±0,08	±0,10	±0,11
1,8	2,5	±0,045	±0,035	±0,07	±0,09	±0,11	±0,13
2,5	3,2	±0,055	±0,040	±0,08	±0,10	±0,13	±0,17
3,2	4,0	–	–	±0,10	±0,12	±0,15	±0,20
4,0	5,0	–	–	±0,12	±0,14	±0,17	±0,23
5,0	6,0	–	–	±0,14	±0,16	±0,20	±0,26
6,0	7,0	–	–	±0,16	±0,19	±0,23	±0,29
7,0	8,0	–	–	±0,18	±0,22	±0,26	±0,32
8,0	9,0	–	–	±0,20	±0,25	±0,29	±0,35
9,0	10,0	–	–	±0,22	±0,28	±0,32	±0,38
10,0	25,0	–	–	±0,25	±0,30	±0,35	±0,45

[a] Including 0,05.

[b] ± 10 % of nominal thickness.

Table 5 — Tolerances on width of strip

Values in millimetres

Nominal thickness		Tolerances on width for nominal widths						
over	up to and including	up to and including 50	over 50 up to and including 100	over 100 up to and including 200	over 200 up to and including 350	over 350 up to and including 500	over 500 up to and including 700	over 700 up to and including 1 250
0,05 [a]	0,1	$^{+0,2}_{0}$	–	–	–	–	–	–
0,1	1,0	$^{+0,2}_{0}$	$^{+0,3}_{0}$	$^{+0,4}_{0}$	$^{+0,6}_{0}$	$^{+1,0}_{0}$	$^{+1,5}_{0}$	$^{+2,0}_{0}$
1,0	2,0	$^{+0,3}_{0}$	$^{+0,4}_{0}$	$^{+0,5}_{0}$	$^{+1,0}_{0}$	$^{+1,2}_{0}$	$^{+1,5}_{0}$	$^{+2,0}_{0}$
2,0	2,5	$^{+0,5}_{0}$	$^{+0,6}_{0}$	$^{+0,7}_{0}$	$^{+1,2}_{0}$	$^{+1,5}_{0}$	$^{+2,0}_{0}$	$^{+2,5}_{0}$
2,5	3,0	$^{+1,0}_{0}$	$^{+1,1}_{0}$	$^{+1,2}_{0}$	$^{+1,5}_{0}$	$^{+2,0}_{0}$	$^{+2,5}_{0}$	$^{+3,0}_{0}$
3,0	5,0	$^{+2,0}_{0}$	$^{+2,3}_{0}$	$^{+2,5}_{0}$	$^{+3,0}_{0}$	$^{+4,0}_{0}$	$^{+5,0}_{0}$	$^{+6,0}_{0}$

[a] Including 0,05.

Table 6 — Tolerances on width of plate and sheet

Values in millimetres

Nominal thickness		Tolerances on width for nominal widths	
over	up to and including	up to and including 350	over 350 up to and including 1 250
0,05 [a]	2	$^{+2,0}_{0}$	$^{+6,0}_{0}$
2	5	$^{+4,0}_{0}$	$^{+8,0}_{0}$
5	10	$^{+8,0}_{0}$	$^{+10,0}_{0}$
10	25	$^{+10,0}_{0}$	$^{+12,0}_{0}$

[a] Including 0,05.

Table 7 — Tolerances on length of plate, sheet and strip cut to length for lengths up to 5 000 mm

Values in millimetres

Length	Nominal thickness	Tolerance on length
as manufactured (ML)	up to and including 25	± 50
fixed length (FL)	up to and including 5	$^{+10}_{0}$
	over 5 up to and including 10	$^{+15}_{0}$
	over 10 up to and including 25	$^{+20}_{0}$

Table 8 — Squareness of cut plate and sheet

Dimensions in millimetres

Nominal width		Maximum allowable differences between diagonals, for lengths		
over	up to and including	over 1 000 up to and including 2 000	over 2 000 up to and including 3 000	over 3 000
350	700	6	7	8
700	1 250	8	9	10

Table 9 — Edgewise curvature *c*

Dimensions in millimetres

Nominal width		Maximum edgewise curvature *c* for thicknesses				
over	up to and including	up to and including 0,5	over 0,5 up to and including 1,2	over 1,2 up to and including 2,5	over 2,5 up to and including 3,2	over 3,2 up to and including 5,0
10 [a]	15	7	10	—	—	—
15	30	4	6	8	—	—
30	50	3	4	6	7	by agreement
50	1 250	2	3	4	5	

[a] Including 10.

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 European 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 1652, *Copper and copper alloys - Plate, sheet, strip and circles for general purposes*

[4] EN ISO 9001, *Quality management systems - Requirements (ISO 9001)*

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

[6] ISO 197-3, *Copper and copper alloys — Terms and definitions — Part 3: Wrought products*

[7] ISO 1190-1, *Copper and copper alloys — Code of designation — Part 1: Designation of materials*

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