BRITISH STANDARD

BS EN
1978:1998

Copper and copper alloys — Copper cathodes

The European Standard EN 1978:1998 has the status of a British Standard

ICS 77.150.30

National foreword

This British Standard is the English language version of EN 1978:1998. Together with BS EN 1976:1998 it supersedes BS 6017:1981 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee NFE/34, Copper and copper alloys, to Subcommittee NFE/34/1, Wrought and unwrought copper and copper alloys, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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Summary of pages

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ICS

Descriptors: Copper, copper alloys, cathodes, designation, chemical composition, dimensions, electrical properties, sampling, tests, marking

English version

Copper and copper alloys — Copper cathodes

Cuivre et alliages de cuivre — Cathodes en cuivre

Kupfer und Kupferlegierungen — Kupfer-Kathoden

This European Standard was approved by CEN on 28 February 1998.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 1978:1998 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 133, Copper and copper alloys, the secretariat of which is held by DIN.

Within its programme of work, Technical Committee CEN/TC 133 requested CEN/TC 133/WG 1, Unwrought copper products to prepare the following standard:

EN 1978, *Copper and copper alloys — copper cathodes*.

This is one of a series of European Standards for products manufactured from refined copper grades. Other products are specified as follows:

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

EN 1977, *Copper and copper alloys — Copper drawing stock (wire rod)*.

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 September 1998, and conflicting national standards shall be withdrawn at the latest by September 1998.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

Introduction

This standard was prepared to combine the various requirements and methods of test for copper cathodes, previously dealt with in a range of separate national standards.

Copper cathodes are intended for melting. Cu-CATH-1 (CR001A) is primarily intended for the production of high conductivity copper, such as for drawing stock. Cu-CATH-2 (CR002A) is intended for the production of other wrought products for electrical and general purposes.

1 Scope

This European Standard specifies the composition and property requirements for cathodes of two copper grades, designated Cu-CATH-1 (CR001A) and Cu-CATH-2 (CR002A).

Annex A (normative) describes methods for sampling cathodes for use in cases of dispute between the purchaser and the supplier. Annex B (informative) gives information on the relationships between electrical resistivity and conductivity of copper.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

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

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

IEC 468, *Method of measurement of resistivity of metallic materials.*

ISO 1553, *Unalloyed copper containing not less than 99,90 % of copper — Determination of copper content — Electrolytic method.*

NOTE Informative references to documents used in the preparation of this standard, and cited at the appropriate places in the text, are listed in a bibliography, see annex C.

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1

cathode

flat, unwrought product made by electrolytic deposition

3.2

lot (copper cathodes)

quantity of copper cathodes weighing over 25 t and up to and including 200 t, consisting of one consignment, or part of one consignment, produced by one refinery

3.3

bundle

total amount of a certain number of cathodes, typically 20 to 60, stacked together and secured, generally by steel bands

3.4

sample cathodes

number of cathodes randomly selected from the lot, and considered in total to be representative of the lot

3.5

cathode sample

portion of one of the sample cathodes (see **3.4**) obtained by systematic cutting of vertical strips

3.6

bulk sample

sample produced by melting and casting into a suitable mould (or moulds) the cathode samples (see **3.5**) obtained from all the sample cathodes and considered to be representative of the lot

3.7

analysis sample

representative fractions of swarf taken from the swarf arising from drilling, milling or sawing the bulk sample castings (see **3.6**)

4 Designations

4.1 Material

4.1.1 *General*

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

4.1.2 *Symbol*

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

4.1.3 *Number*

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

4.2 Product

The product designation provides a standardized pattern of designation from which a rapid and unequivocal description of a product is 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:

— denomination (Cathode);

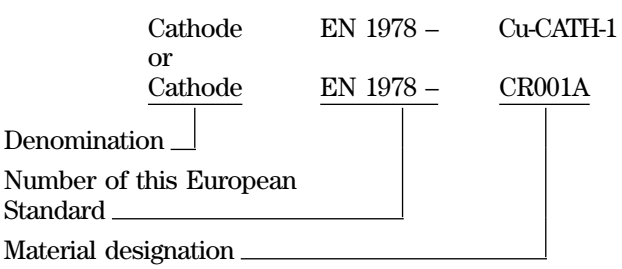
— number of this European Standard (EN 1978);

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

The derivation of a product designation is shown in the following example.

EXAMPLE

Cathode conforming to this standard, in material designated either Cu-CATH-1 or CR001A, shall be designated as follows:



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);

b) denomination (Cathode);

c) number of this European Standard (EN 1978);

d) material designation (see Table 1).

NOTE It is recommended that the product designation, as described in **4.2**, is used for items b) to d).

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

e) the dimensions and tolerances required, if the cathodes are to be supplied cut to size (see **6.3**);

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

g) whether an inspection document is required, and if so, which type (see **9.2**).

EXAMPLE

Ordering details for 100 t of cathode conforming to EN 1978, in material designated either Cu-CATH-1 or CR001A:

100 t Cathode EN 1978 – Cu-CATH-1

or

100 t Cathode EN 1978 – CR001A

6 Requirements

6.1 Composition

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

6.2 Electrical properties

The electrical properties shall conform to the requirements for the appropriate grade given in Table 2. The tests shall be carried out in accordance with **8.2**.

NOTE Mass resistivity is the mandatory electrical property requirement in this standard. The relationship between mass resistivity and the corresponding volume resistivity and conductivity is given in annex B.

6.3 Dimensions and tolerances

The cathodes shall be either whole, or cut to sizes as agreed between the purchaser and the supplier and stated in the purchaser's order [see **5**e)].

6.4 Surface condition

Cathodes shall withstand ordinary handling without breakage. They shall be reasonably free from nodules, outgrowth edges and from all extraneous materials such as electrolyte residues, dirt, grease and oil.

Table 1 — Composition of Cu-CATH-1 (CR001A) and Cu-CATH-2 (CR002A)

Material designation		Composition % (*m/m*)																			
Symbol	**Number**	**Element**	**Cu**	**Ag**	**As**	**Bi**	**Cd**	**Co**	**Cr**	**Fe**	**Mn**	**Ni**	**P**	**Pb**	**S**	**Sb**	**Se**	**Si**	**Sn**	**Te**	**Zn**	**Sum of elements listed in this table other than copper**
Cu-CATH-1	CR001A	min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		max.	—	0,0025	0,0005[1)]	0,00020[2)]	—[1)]	—[3)]	—[1)]	0,0010[3)]	—[1)]	—[3)]	—[1)]	0,0005	0,0015[4)]	0,0004[1)]	0,00020[2)]	—[3)]	—[3)]	0,00020[2)]	—[3)]	0,0065
Cu-CATH-2	CR002A	min.	99,90[5)]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		max.	—	—	—	0,0005	—	—	—	—	—	—	—	0.005	—	—	—	—	—	—	—	0,03 excluding Ag

[1)] (As + Cd + Cr + Mn + P + Sb) maximum 0,0015 %.

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

3) (Co + Fe + Ni + Si + Sn + Zn) maximum 0,0020 %.

4) The sulfur content shall be determined on a cast sample.

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

Table 2 — Electrical properties of Cu-CATH-1 (CR001A) and Cu-CATH-2 (CR002A) at 20 °C

Material designation		Electrical properties (see NOTE 1)			
Symbol	Number	Mass resistivity	Nominal volume resistivity	Nominal conductivity	
		$\Omega \cdot g/m^2$	$\mu\Omega \cdot m$	MS/m	% IACS
		max.	max.	min.	min.
Cu-CATH-1	CR001A	0,151 76	(0,017 07)	(58,58)	(101,0)
Cu-CATH-2	CR002A	0,153 28	(0,017 24)	(58,00)	(100,0)

NOTE 1 Nominal values for volume resistivity and conductivity have been calculated from mass resistivity by methods described in annex B.

NOTE 2 Because of the inaccuracies involved in the calculations, these nominal values, which are given for guidance purposes, are enclosed in parentheses.

NOTE 3 For explanation of "% IACS", see **B.2**.

7 Sampling

For the routine sampling of cathodes for analysis, or for the routine determination of electrical properties, the method of sampling shall be at the discretion of the sampler.

In cases of dispute concerning the composition, the cathodes shall be sampled and the analysis samples prepared in accordance with the procedure described in annex A.

In cases of dispute concerning the electrical properties, unless otherwise agreed between the disputing parties (see NOTE), the cathodes shall be sampled in accordance with the procedure described in annex A. The electrical resistivity of each lot in dispute shall be determined on one of the three test ingots cast from the bulk sample(s) (see **A.6**).

NOTE Other sampling methods may be used for obtaining the representative sample(s) for the determination of the electrical resistivity in cases of dispute, subject to agreement between the disputing parties.

8 Test methods

8.1 Analysis

8.1.1 *Routine analysis*

For the routine analysis of cathodes, the methods of analysis used shall be at the discretion of the analyst.

8.1.2 *Analysis in cases of dispute*

In cases of dispute concerning the composition, the analysis shall be determined on the samples selected in accordance with clause **7**, as follows:

for copper grade Cu-CATH-1 (CR001A), the methods of analysis used for the elements listed in Table 1 shall be agreed between the disputing parties;

for copper grade Cu-CATH-2 (CR002A), the copper shall be determined in accordance with the method in ISO 1553.

8.2 Electrical resistivity

8.2.1 *Routine determination of electrical resistivity*

For the routine determination of electrical resistivity, the methods used shall be at the discretion of the tester.

8.2.2 *Determination of electrical resistivity in cases of dispute*

In cases of dispute the electrical resistivity shall be determined on a representative sample from each lot, selected in accordance with clause **7**.

External oxide shall be removed from the test ingot (see clause **7**), which shall then be rolled and/or drawn to 2 mm diameter wire.

NOTE The sample may be hot worked initially provided care is taken to avoid contamination or excessive oxidation.

The 2 mm diameter wire shall be degreased and annealed at (500 ± 10) °C for 30 min in an inert atmosphere, and the resistivity test carried out in accordance with IEC 468.

8.3 Retests

If there is a failure of one, or more than one, of the tests in **8.1** or **8.2**, 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 standard.

8.4 Rounding of results

For the purpose of determining conformity to the limits specified in this standard for composition or for electrical resistivity, 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 31-0:1992, annex B. It shall be rounded in one step to the same number of figures used to express the specified limit in this standard.

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 **5**f)] and agreed with the supplier, the supplier shall issue for the product the appropriate declaration of conformity in accordance with EN 1655.

9.2 Inspection documentation

When requested by the purchaser [see **5**g)] and agreed with the supplier, the supplier shall issue for the product the appropriate inspection document in accordance with EN 10204.

10 Marking

Cathodes, whether full-size or cut, shall be assembled into bundles of suitable weight for handling. Each bundle shall be marked to identify it with its refinery source and grade (i.e. the brand).

No metallic identifying markers shall be directly fixed to the cathodes.

Annex A (normative)

Methods for use in cases of dispute, for the sampling of cathodes and for the preparation of analysis samples

A.1 Introduction

A technique is described, which is intended for use in cases of dispute, for the selection of samples from a consignment of cathodes. The procedures are also described for obtaining from these selected cathode samples, replicate laboratory samples representative of the consignment in a form suitable for analysis and for determination of the electrical properties.

A.2 Definitions

For the purpose of this method, the definitions in **3.4** to **3.7** apply.

A.3 Apparatus and reagents

A.3.1 *Crucible*, with a close fitting lid.

A.3.2 *Hydrochloric acid*, 10 % (by volume), commercial grade.

A.3.3 *Deionized water*.

A.3.4 *Electric induction, or resistance, melting furnace*, with provision for an inert internal atmosphere at high temperatures.

A.3.5 *Rod*.

A.3.6 *Test ingot moulds*, to provide ingots 20 mm × 20 mm in cross-section and 100 mm to 200 mm long.

NOTE Other designs of test ingot moulds may be used, subject to agreement between the purchaser and the supplier.

A.3.7 *Drilling, milling or sawing machine*, equipped with carbide-tipped cutting tools.

A.3.8 *Magnet*.

A.4 Selection of sample cathodes

A.4.1 *Division of a consignment into lots*

A.4.1.1 If the consignment of cathodes originates from one refinery, consider it as one lot if it consists of more than 25 t and up to and including 200 t of cathodes. Subdivide any consignment greater than 200 t into a number of approximately equal lots, each not exceeding 200 t.

A.4.1.2 If the consignment consists of cathodes originating from more than one refinery, separate it into part consignments, each from one refinery, and divide each part-consignment into lots, as described in **A.4.1.1**.

A.4.2 *Random sampling of a lot*

Randomly select 24 sample cathodes from each lot using either method a) or b), as follows:

a) number consecutively every cathode in the lot. Randomly select 24 sample cathodes by the use of random number tables (see NOTE);

b) number consecutively every bundle in the lot. Randomly select 24 individual bundles by the use of random number tables (see NOTE). Number sequentially each cathode position within a typical bundle. By the use of the random number tables, randomly select one cathode from each randomly selected bundle to produce 24 sample cathodes.

NOTE Published tables of random numbers are available; for instance in ISO 2859-0. There is also a variety of computer programs capable of generating random numbers.

If the lot consists of less than 24 bundles, use method a). If the lot consists of 24 bundles or more, the choice of method is a matter for agreement between the purchaser and the supplier. If no specific choice is made, use method a).

A.5 Preparation of cathode samples

Individually sample each of the 24 sample cathodes, selected in accordance with **A.4**, by cutting a vertical strip from each cathode. The strip shall be from such a position that the collection of the 24 strips so cut represents all points of one, two or three full cathodes, including the cathode edges and the hangers. Ensure that all the vertical strips are of the same width and are cut sequentially from left to right in the same order as the sample cathodes were selected.

A.6 Preparation of bulk sample

Prepare a clean crucible (see **A.3.1**) by melting in it a quantity of copper from the lot to be analysed and discard this melt.

Clean the 24 strips selected in accordance with **A.5**, by immersing them in hydrochloric acid (see **A.3.2**) at ambient temperature for 15 min. Then thoroughly wash the cathode strips in deionized water (see **A.3.3**) and allow them to dry.

Depending upon the size of the melting equipment available, proceed according to a) or b) as follows, taking care to avoid ingress of oxygen into the melt so as to avoid oxidation of iron and chromium, which could affect the subsequent analysis:

a) place all the cleaned strips into the cleaned crucible in the furnace (see **A.3.4**) and heat under an inert atmosphere until the sample is melted. Thoroughly stir the melt, which constitutes the bulk sample, with a rod (see **A.3.5**) and cast it into conventional ingot moulds, pouring three test ingots, one each at the beginning, middle and end of the casting operation, using the test ingot moulds (see **A.3.6**);

b) if the available furnace/crucible is not large enough to melt the composite sample then group the 24 strips into two or more batches for melting and casting, as in **A.6**a), casting three test ingots from each batch, as before, into the moulds (see **A.3.6**).

Use one of the three test ingots obtained from a) or b) for the determination of the electrical properties in cases of dispute (see clause **7**).

A.7 Preparation of aggregate analysis sample

Sample all the test ingots prepared in accordance with **A.6** by drilling, milling or sawing. Use carbide tipped tools, taking care to avoid overheating and consequent oxidation of the chips, to produce an aggregate analysis sample exceeding 600 g of small chips, representative of the bulk sample and hence of the lot.

Use a magnet to remove carefully any ferrous particles present in the aggregate sample.

A.8 Preparation and distribution of analysis samples

Divide the aggregate analysis sample obtained in accordance with **A.7** into four portions, each to be a minimum of 150 g.

Place each portion into a clean, dry container and identify the container clearly with the following:

a) date and place of sampling;

b) detail of the consignment/lot(s) represented by the sample;

c) the name of the sampler;

d) the sample number;

e) any other relevant information.

Use one of these portions for analysis by the supplier, one for analysis by the purchaser, reserve one for referee analysis (in case this should become necessary) and reserve the fourth for contingencies.

Annex B (informative)

Information on electrical resistivity and conductivity relationships

B.1 Mass resistivity

Determination of cross-sectional areas to the requisite degree of accuracy is difficult. Hence, in practice nearly all assessments of resistivity are made by measuring the resistance, mass, and length of a representative sample. Mass resistivity can be calculated directly from these values and this gives a true measure of the quality of the copper for carrying electric current.

B.2 Standard annealed copper (IACS)

IEC 28 uses evidence from earlier years (see USA National Bureau of Standards Circular 31, 1956, superseded by USA National Bureau of Standards Handbook 100, 1966) to establish a fixed value for the resistance to flow of an electric current within an imaginary "standard" annealed copper. This is based on a volume resistivity of 1/58 $\mu\Omega$·m or 0,017 241 $\mu\Omega$·m at 20 °C, which is defined as corresponding to a conductivity of 100 % IACS at 20 °C. The introduction of the International ohm in 1948 altered the volume resistivity of standard annealed copper by only 0,049 %.

Also on this earlier evidence the standard annealed copper is allotted a density of 8,89 g/cm^3.

B.3 Commercial annealed copper

IEC 28 states that "the (electrical) conductivity of commercial annealed copper shall be expressed as a percentage, at 20 °C, of that of standard annealed copper given to approximately 0,1 %", on the assumption that "the density of commercial annealed copper at 20 °C is 8,89 g/cm^3".

B.4 Nominal volume resistivity

The density of commercial copper varies with small changes in composition, particularly oxygen content. Thus, a true volume resistivity can only be calculated from a measured mass resistivity if the true density of the particular sample is known or is measured to the requisite degree of accuracy, i.e. better than 0,1 %.

For general purposes, however, a nominal volume resistivity may be calculated using the density of 8,89 g/cm^3, as referred to in clause **B.2**, and used in Table 2.

B.5 Differences between measured and nominal values

If true volume resistivity or true conductivity is required from measured mass resistivity and therefore actual density is used in calculation, differences of up to 0,5 % may result between these values and the corresponding nominal values.

Conductivity calculated from the ratio of the mass resistivity of standard annealed copper (0,153 28 Ω·g/m^2) to the derived mass resistivity may also exhibit a similar disparity.

Annex C (informative)

Bibliography

In the preparation of this European Standard, use was made of a number of documents for reference purposes. These informative references are cited at the appropriate places in the text and the publications are listed hereafter.

EN 1412, *Copper and copper alloys — European numbering system.*

IEC 28, *International standard of resistance for copper.*

IEC 31-0:1992, *Quantities and units — Part 0: General principles.*

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

ISO 2859-0, *Sampling procedures for inspection by attributes — Part 0: Introduction to the ISO 2859 attribute sampling system.*

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