BS EN 1977:2013

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Copper and copper alloys — Copper drawing stock (wire rod)

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National foreword

This British Standard is the UK implementation of EN 1977:2013. It supersedes BS EN 1977:1998 which is withdrawn.

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

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

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Published by BSI Standards Limited 2013

ISBN 978 0 580 76406 6

ICS 77.150.30

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 28 February 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1977

January 2013

ICS 77.150.30

Supersedes EN 1977:1998

English Version

Copper and copper alloys - Copper drawing stock (wire rod)

Cuivre et alliages de cuivre - Fil machine en cuivre

Kupfer und Kupferlegierungen - Vordraht aus Kupfer

This European Standard was approved by CEN on 24 November 2012.

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Foreword

This document (EN 1977:2013) 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of an identical text or by endorsement, at the latest by July 2013, and conflicting national standards shall be withdrawn at the latest by July 2013.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 1977:1998.

This document 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 1978, *Copper and copper alloys — Copper cathodes*

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

In comparison with EN 1977:1998, the following significant technical changes were made:

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

b) 6.4 and 8.4 “Annealability” have been modified;

c) A.2 “Standard annealed copper (IACS)” has been modified;

d) Annex B (normative) “Rapid Elongation Test method (AR-Test) for diameter 8 mm Cu-ETP1 wire rod” has been added.

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.

Introduction

Copper drawing stock (wire rod) is normally manufactured by one of the following process routes:

— continuous casting and hot rolling in tandem;

— continuous or semi-continuous casting and cold rolling;

— rolling of wire bar or billets; or

— extrusion.

Annex A (informative) gives information on the relationships between electrical resistivity and conductivity (of copper).

Annex B (normative) describes the rapid elongation test method (AR-Test) for diameter 8 mm Cu-ETP1 wire rod.

1 Scope

This European Standard specifies the composition, mechanical, electrical and physical properties for high conductivity copper drawing stock (wire rod) suitable for fabrication into wire by cold drawing, principally for the manufacture of electrical conductors. This European Standard covers drawing stock (wire rod), in nine grades of copper and nine silver-bearing copper grades. Normally, the cross-section is approximately circular, in a range of diameters from 6 mm.

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 10204, *Metallic products — Types of inspection documents*

EN 12893, *Copper and copper alloys — Determination of spiral elongation number*

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

EN ISO 6892-1:2009, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

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

ISO 4746, *Oxygen-free copper — Scale adhesion test*

3 Terms and definitions

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

3.1
drawing stock
wire rod
intermediate solid wrought product, of uniform cross-section along its whole length, supplied in coils

4 Designations

4.1 Material

4.1.1 General

The material is designated either by symbol or number (see Tables 1 to 4).

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 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 European Standard shall consist of:

— denomination (copper drawing stock);

— number of this European Standard (EN 1977);

— material designation, either symbol or number (see Tables 1 to 4);

— nominal diameter;

— nominal coil mass;

— surface condition (the following designations shall be used, as appropriate: M for as manufactured, CL for cleaned).

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

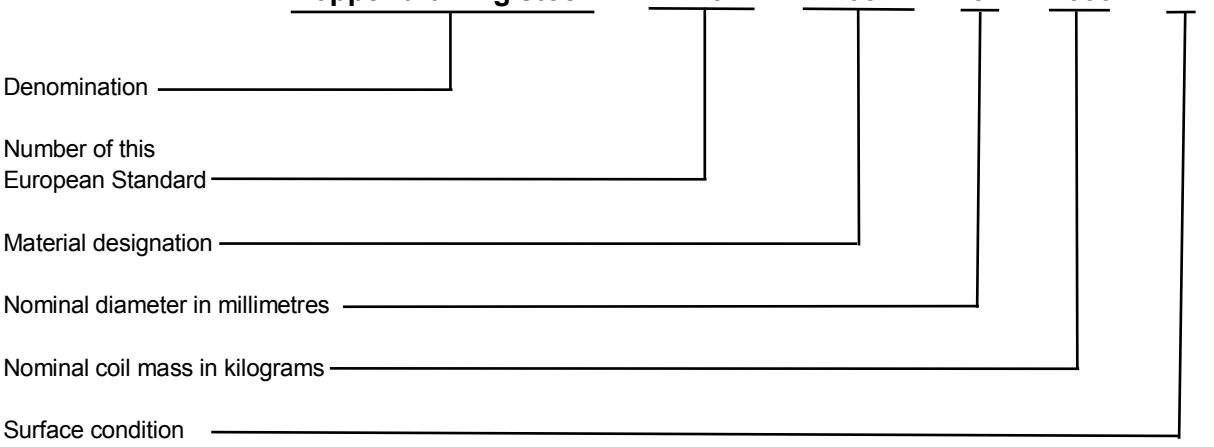
EXAMPLE

Drawing stock (wire rod) conforming to this standard, in material designated either Cu-ETP or CW004A, nominal diameter 8 mm, in 1 000 kg coils, cleaned surface condition, shall be designated as follows:

Copper drawing stock EN 1977 – Cu-ETP – 8 – 1 000 – CL

or

Copper drawing stock EN 1977 – CW004A – 8 – 1 000 – CL



5 Ordering information

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

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

b) denomination (copper drawing stock);

c) number of this European Standard (EN 1977);

d) material designation (see Tables 1 to 4);

e) nominal diameter;

f) nominal coil mass;

g) surface condition (see 6.8).

It is recommended that the product designation as described in 4.2 is used for items b) to g).

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

h) whether joins are permitted in the coils (see 6.9);

i) additional tests, if any, which the purchaser requires to be carried out by the manufacturer on the material, selected from the tests appropriate to each copper grade given in Table 5;

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

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

EXAMPLE

Ordering details for 5 000 kg of drawing stock conforming to EN 1977, in material designated either Cu-ETP or CW004A, nominal diameter 8 mm, in 1 000 kg coils, cleaned surface condition:

5 000 kg Copper drawing stock EN 1977 – Cu-ETP – 8 – 1 000 – CL

or

5 000 kg Copper drawing stock EN 1977 – CW004A – 8 – 1 000 – CL

6 Requirements

6.1 Composition

The composition shall conform to the requirements for the appropriate grade given in Tables 1 to 4.

6.2 Elongation

Hot-finished drawing stock shall have a minimum elongation of 30 %. The test shall be carried out in accordance with 8.2.

No elongation requirements are specified for cold-finished drawing stock. If such requirements are necessary, they should be agreed between the purchaser and the supplier.

6.3 Electrical properties

The maximum volume resistivity at 20 °C of hot-finished drawing stock shall conform to the appropriate requirements given in Table 6. The test shall be carried out in accordance with 8.3.

Table 1 — Composition of copper grades made from Cu-CATH-1 (CR001A)

Material designation		Composition % (mass fraction)																					
Symbol	Number	Element	Cu	Ag	As	Bi	Cd	Co	Cr	Fe	Mn	Ni	O	P	Pb	S	Sb	Se	Si	Sn	Te	Zn	Elements listed in this table other than copper: total	Elements listed in this table other than copper: excluding
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]	0,000 5	0,001 5	0,000 4[a]	0,000 20[b]	_[c]	_[c]	0,000 20[b]	_[c]	0,006 5	O
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]	0,000 5	0,001 5	0,000 4[a]	0,000 20[b]	_[c]	_[c]	0,000 20[b]	_[c]	0,006 5	O
Cu-OFE	CW009A	min.	99,99	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
		max.	–	0,002 5	0,000 5	0,000 20	0,000 1	–	–	0,001 0	0,0005	0,0010	_[d]	0,000 3	0,000 5	0,001 5	0,000 4	0,000 20	–	0,000 2	0,000 20	0,000 1	–	–
Cu-PHCE	CW022A	min.	99,99	–	–	–	–	–	–	–	–	–	–	0,001	–	–	–	–	–	–	–	–	–	
		max.	–	0,002 5	0,000 5	0,000 20	0,000 1	–	–	0,001 0	0,0005	0,0010	_[d]	0,006	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.

Table 2 — Composition of copper grades, other than those made from Cu-CATH-1 (CR001A)

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

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

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

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

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

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

Table 3 — Composition of phosphorus-containing copper grades

Material designation		**Composition** % (mass fraction)						
		Element	Cu [a]	Bi	P	Pb	other elements (see Note)	
Symbol	Number						total	excluding
Cu-PHC	CW020A	min.	99,95	–	0,001	–	–	Ag, P
		max.	–	0,000 5	0,006	0,005	0,03 [b]	
Cu-HCP	CW021A	min.	99,95	–	0,002	–	–	Ag, P
		max	–	0,000 5	0,007	0,005	0,03 [b]	

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] The oxygen content shall be controlled by the manufacturer so that the material conforms to the hydrogen embrittlement requirements.

Table 4 — Composition of silver-containing copper grades (silver-bearing coppers)

Material designation		**Composition** % (mass fraction)							
		Element	Cu	Ag	Bi	O	P	other elements (see Note)	
Symbol	Number							total	excluding
CuAg0,04	CW011A	min. max.	Rem. —	0,03 0,05	— 0,000 5	— 0,040	— —	— 0,03	Ag, O
CuAg0,07	CW012A	min. max.	Rem. —	0,06 0,08	— 0,000 5	— 0,040	— —	— 0,03	Ag, O
CuAg0,10	CW013A	min. max.	Rem. —	0,08 0,12	— 0,000 5	– 0,040	— —	— 0,03	Ag, O
CuAg0,04P	CW014A	min. max.	Rem. —	0,03 0,05	— 0,000 5	— — [a]	0,001 0,007	— 0,03	Ag, P
CuAg0,07P	CW015A	min. max.	Rem. —	0,06 0,08	— 0,000 5	— — [a]	0,001 0,007	— 0,03	Ag, P
CuAg0,10P	CW016A	min. max.	Rem. —	0,08 0,12	— 0,000 5	— — [a]	0,001 0,007	— 0,03	Ag, P
CuAg0,04(OF)	CW017A	min. max.	Rem. —	0,03 0,05	— 0,000 5	— — [a]	— —	— 0,006 5	Ag, O
CuAg0,07(OF)	CW018A	min. max.	Rem. —	0,06 0,08	— 0,000 5	— — [a]	— —	— 0,006 5	Ag, O
CuAg0,10(OF)	CW019A	min. max.	Rem. —	0,08 0,12	— 0,000 5	— — [a]	— —	— 0,006 5	Ag, O

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] The oxygen content shall be controlled by the manufacturer so that the material conforms to the hydrogen embrittlement requirements.

Table 5 — Tests applicable

Material designation		Test appropriate to copper grade						
Symbol	Number	Analysis (including oxygen)	Elongation [a]	Volume resistivity	Hydrogen embrittlement	Scale adhesion	Annealability	Diameter
Cu-ETP1	CW003A	X	X	X	–	–	X	X
Cu-ETP	CW004A	X	X	X	–	–	–	X
Cu-FRHC	CW005A	X	X	X	–	–	–	X
Cu-OF1	CW007A	X	X	X	X [b]	–	–	X
Cu-OF	CW008A	X	X	X	X [b]	–	–	X
Cu-OFE	CW009A	X	X	X	X [c]	X	–	X
Cu-PHC	CW020A	X	X	X	X [b]	–	–	X
Cu-HCP	CW021A	X	X	X	X [b]	–	–	X
Cu-PHCE	CW022A	X	X	X	X [c]	–	–	X
CuAg0,04	CW011A	X	X	X	–	–	–	X
CuAg0,07	CW012A	X	X	X	–	–	–	X
CuAg0,10	CW013A	X	X	X	–	–	–	X
CuAg0,04P	CW014A	X	X	X	X [b]	–	–	X
CuAg0,07P	CW015A	X	X	X	X [b]	–	–	X
CuAg0,10P	CW016A	X	X	X	X [b]	–	–	X
CuAg0,04(OF)	CW017A	X	X	X	X [b]	–	–	X
CuAg0,07(OF)	CW018A	X	X	X	X [b]	–	–	X
CuAg0,10(OF)	CW019A	X	X	X	X [b]	–	–	X

[a] Normally this test is only applicable to hot-finished drawing stock. If requested for cold-finished material, then the minimum elongation required should be agreed between the purchaser and the supplier.

[b] The assessment criterion for hydrogen embrittlement shall be the close-bend test in EN ISO 2626.

[c] The assessment criterion for hydrogen embrittlement shall be the reverse bend test (10 reversals) in EN ISO 2626.

Table 6 — Electrical properties of grades of copper at 20 °C

Material designation		Electrical properties			
		Volume resistivity	Nominal mass resistivity	Nominal conductivity	
Symbol	Number	$\mu\Omega \cdot m$ max.	$\Omega \cdot g/m^2$ max.	MS/m min.	% IACS min.
Cu-ETP1	CW003A	0,017 07	(0,151 76)	(58,58)	(101,0)
Cu-ETP	CW004A	0,017 24	(0,153 28)	(58,00)	(100,0)
Cu-FRHC	CW005A	0,017 24	(0,153 28)	(58,00)	(100,0)
Cu-OF1	CW007A	0,017 07	(0,151 76)	(58,58)	(101,0)
Cu-OF	CW008A	0,017 24	(0,153 28)	(58,00)	(100,0)
Cu-OFE	CW009A	0,017 07	(0,151 76)	(58,58)	(101,0)
Cu-PHC	CW020A	0,017 24	(0,153 28)	(58,00)	(100,0)
Cu-HCP	CW021A	0,017 54	(0,155 97)	(57,00)	(98,3)
Cu-PHCE	CW022A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,04	CW011A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,07	CW012A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,10	CW013A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,04P	CW014A	0,017 54	(0,155 97)	(57,00)	(98,3)
CuAg0,07P	CW015A	0,017 54	(0,155 97)	(57,00)	(98,3)
CuAg0,10P	CW016A	0,017 54	(0,155 97)	(57,00)	(98,3)
CuAg0,04(OF)	CW017A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,07(OF)	CW018A	0,017 24	(0,153 28)	(58,00)	(100,0)
CuAg0,10(OF)	CW019A	0,017 24	(0,153 28)	(58,00)	(100,0)

NOTE 1 Figures in parentheses are not requirements of this European Standard but are given for guidance purposes only.

NOTE 2 For an explanation of "% IACS", see A.2.

6.4 Annealability

Drawing stock in copper grade Cu-ETP1 (CW003A) shall have a minimum spiral elongation number (S.E.N.) of 350, when tested in accordance with EN 12893.

When tested according to the Annex B (AR-Test), the A_{200} value shall be at least 20 %. Otherwise the spiral elongation test method given in EN 12893 shall be used as the reference method.

6.5 Hydrogen embrittlement

Drawing stock in copper grades Cu-OF1 (CW007A), Cu-OF (CW008A), Cu-OFE (CW009A), 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) and Cu-PHCE (CW022A), shall show no evidence of cracking, when tested in accordance with 8.5.

6.6 Scale adhesion

Drawing stock in copper grade Cu-OFE (CW009A) shall conform to the requirements of the scale adhesion test, when tested in accordance with 8.6.

6.7 Dimensions and tolerances

The diameter of drawing stock, measured at any point, shall conform to the tolerances given in Table 7.

Tolerances on drawing stock having a nominal diameter greater than 35 mm should be subject to agreement between the supplier and the purchaser.

Table 7 — Tolerances

Dimensions in millimetres

Nominal diameter		Tolerances
over	up to and including	
6,0[a]	6,35	+ 0,5 − 0,25
6,35	19	± 0,4
19	25	± 0,6
25	35	± 0,8

[a] Including 6,0.

6.8 Surface condition

The drawing stock shall be supplied in one of the following surface conditions, as specified by the purchaser in the enquiry and order [see 5 g)]:

a) as manufactured; or

b) cleaned (with, or without, a protective coating).

Cleaned drawing stock shall be treated prior to delivery to remove the surface oxides resulting from the production process and shall have a surface suitable for cold drawing without the need for preliminary cleaning.

6.9 Joins

Each coil of drawing stock shall be supplied in one continuous length without joins, unless they are specifically permitted in the order [see 5 h)].

7 Sampling

7.1 General

When required (e.g. if necessary in accordance with specified procedures of a supplier's quality system, or when the purchaser requests inspection documents with test results, or for use in cases of dispute), an inspection lot shall be sampled as follows (see also Table 8):

a) in accordance with 7.2 to 7.4 for drawing stock in grade Cu-ETP1 (CW003A); or

b) in accordance with 7.5 for drawing stock in grades other than Cu-ETP1 (CW003A).

Table 8 — Sampling rate

Test	Mass of drawing stock for each sampling unit t	
	Cu-ETP1 (CW003A)	other grades
Analysis (Oxygen)	60	At the discretion of the manufacturer unless otherwise specified by the purchaser at the time of enquiry and order.
Analysis (other than oxygen)	500	
Diameter	60	
Annealability	200	
Elongation	500	
Electrical resistivity	200	

7.2 Analysis (oxygen only) and measurement of diameter of Cu-ETP1 (CW003A) drawing stock

The minimum rate of sampling shall be one sampling unit from every 60 t of drawing stock.

The sampling units shall be cut off the finished material and the test samples or 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.

7.3 Annealability testing of Cu-ETP1 (CW003A) drawing stock

For the determination of the annealability, the minimum rate of sampling shall be one sampling unit from every 200 t of finished drawing stock.

7.4 Analysis (other than oxygen) and measurement of elongation and electrical properties of Cu-ETP1 (CW003A) drawing stock

For the determination of the composition, other than oxygen, and for elongation measurement, the minimum rate of sampling shall be one sampling unit from every 500 t of drawing stock.

For the determination of the electrical resistivity, the minimum rate of sampling shall be one sampling unit from every 200 t of drawing stock.

In all cases, the sampling units shall be cut off the finished material and the test samples or 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.

7.5 Tests on drawing stock in grades other than Cu-ETP1 (CW003A)

Unless otherwise specified by the purchaser, the sampling rates for testing drawing stock in grades other than Cu-ETP1 (CW003A), shall be at the discretion of the manufacturer.

The sampling units shall be cut off the finished material and the test samples or 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 sample(s) obtained in accordance with 7.2, 7.4 or 7.5, as appropriate.

The copper content of Cu-OFE (CW009A) and Cu-PHCE (CW022A) shall be determined by subtracting the total percentage of the concentrations of the specified impurities present from 100 % (see Table 1).

For routine quality control purposes, the composition shall be determined using generally recognised analytical techniques.

In cases of dispute concerning the results of analysis of Cu-ETP1 (CW003A) drawing stock, the methods used shall be agreed between the disputing parties.

In cases of dispute concerning the results of analysis of drawing stock in grades other than Cu-ETP1 (CW003A), the method(s) of analysis to be used shall be agreed between the supplier, the purchaser and if necessary, any mutually accepted arbitrator, and shall be for all impurities for which limits are specified in Tables 1 to 4.

For expression of results, the rounding rules given in 8.7 shall be used.

8.2 Elongation

The elongation shall be determined on a test piece cut from the sampling unit of drawing stock obtained in accordance with 7.4 or 7.5 as appropriate. The test shall be on the full cross-section of the drawing stock using the tensile testing method given in EN ISO 6892-1.

The load shall be applied gradually and uniformly to a straightened length of the sampling unit. An original gauge length of 200 mm shall be used. The rate of separation of the crossheads of the machine shall not be in excess of 240 mm/min.

At the completion of the test, the measured elongation value shall be valid, whatever the position of the fracture, if the minimum specified value is achieved. If the minimum value is not reached, the determination shall only be considered valid if the fracture occurs between the gauge marks and is not closer than 25 mm to either mark.

For expression of results, the rounding rules given in 8.7 shall be used.

8.3 Electrical resistivity

The volume resistivity, corrected to 20 °C, shall be determined on the sampling unit of drawing stock obtained in accordance with 7.4 or 7.5, as appropriate, either;

a) by direct measurement on a cleaned sampling unit of the drawing stock; or

b) by measurement on a length of wire which has been drawn from the sampling unit to 2,00 mm ± 0,01 mm diameter, coiled to a diameter of not less than 200 mm and annealed in an inert atmosphere at 500 °C ± 10 °C for not less than 30 min.

The volume resistivity shall be determined by one of the methods given in IEC 60468. The routine method shall normally be used. In cases of dispute, however, the reference method shall be used.

For expression of results, the rounding rules given in 8.7 shall be used.

NOTE Information on the relationships between volume resistivity and conductivity are given in Annex A.

8.4 Annealability

Unless otherwise specified by the purchaser, the producer can choose between the AR-Test method described in Annex B and the standard method given in EN 12893, in order to secure the annealability of the finished drawing stock.

If the AR-Test result is less than 20 %, or in case of controversy, the spiral elongation test method given in EN 12893 shall be used as the reference method on the sampling unit obtained in accordance with 7.3.

NOTE Annealability testing is applicable to grade Cu-ETP1 (CW003A) only.

8.5 Hydrogen embrittlement

The sampling unit of the drawing stock obtained in accordance with 7.5 shall be heated in a hydrogen atmosphere, quenched in water, and assessed for hydrogen embrittlement, all in accordance with the method given in EN ISO 2626.

NOTE The hydrogen embrittlement test is not applicable to grades Cu-ETP1 (CW003A), Cu-ETP (CW004A), Cu-FRHC (CW005A), CuAg0,04 (CW011A), CuAg0,07 (CW012A) and CuAg0,10 (CW013A) (see Table 5).

For drawing stock in grades Cu-OFE (CW009A) and Cu-PHCE (CW022A), the reverse bend test piece shall be used and the assessment of embrittlement shall be by the reverse bend test (10 reversals), followed by visual examination for cracks, all in accordance with EN ISO 2626.

For drawing stock in all other grades for which the test is applicable, the close-bend test piece shall be used, and the assessment of embrittlement shall be by the close-bend test, followed by visual examination for cracks, all in accordance with EN ISO 2626.

8.6 Scale adhesion

The scale adhesion test method given in ISO 4746 shall be used on the sampling unit obtained in accordance with 7.5.

NOTE Scale adhesion testing is applicable to grade Cu-OFE (CW009A) only.

8.7 Rounding of results

For the purpose of determining conformity to the limits specified in this standard for composition, elongation or 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 Annex B of ISO 80000-1:2009. It shall be rounded in one step to the same number of figures used to express the specified limit in this standard, except that for elongation the rounding interval shall be 0,5 %.

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 j)] 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 k)] and agreed with the supplier, the supplier shall issue for the product the appropriate inspection document in accordance with EN 10204.

10 Marking

Coils shall be marked individually, or otherwise identified with the following information:

a) the manufacturer's name, brand or trademark;

b) the number of this standard (EN 1977) and the grade designation for the material;

c) coils made by continuous casting and rolling shall also be identified with the coil production number and the date of manufacture;

d) the net mass of the coil.

Any requirement for additional marking of coils shall be agreed between the purchaser and the supplier.

Annex A
(informative)

Information on electrical resistivity and conductivity relationships

A.1 Volume resistivity

The greatest use of copper drawing stock is for manufacturing electrical conductor wire that is drawn to close dimensional tolerances (usually round). Therefore volume resistivity (resistance of a cross-section per unit length) is the property most usually determined. Volume resistivity is therefore the mandatory property in this European Standard.

For irregular sections, or in cases where the actual cross-sectional area is difficult to determine, mass resistivity can be calculated from the resistance, mass and length of a sampling unit. If the density of the sampling unit is known to be close to the density of standard copper, this method is an acceptable alternative to volume resistivity.

In cases where the density is unknown or known to vary greatly, it is essential that the actual density of the sample be determined in order to obtain the required accuracy of the value of resistivity.

A.2 Standard annealed copper (IACS)

IEC 60028 establishes 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 μΩ·m or 0,017 241 μΩ·m at 20 °C. The introduction of the International ohm in 1948 altered the volume resistivity of standard annealed copper by only 0,049 %.

The standard annealed copper is also allotted a density of 8 890 kg/m^3 (8,89 g/cm^3).

Hence, as the mass resistivity is the product of the volume resistivity and the density, the mass resistivity of standard annealed copper is 0,153 28 Ω·g/m^2.

A.3 Commercial annealed copper

IEC 60028 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”.

A.4 Nominal mass resistivity

The density of commercial copper varies with small changes in composition, particularly oxygen content. Thus, true mass resistivity can only be calculated from a measured volume 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 mass resistivity may be calculated using the density of 8 890 kg/m^3, as referred to in A.2 (this practice has been adopted in Table 6 of this European Standard in presenting values for nominal mass resistivity and for nominal conductivity corresponding to the mandatory volume resistivity).

A.5 Differences between measured and nominal values

If true mass resistivity or true conductivity is required from measured volume resistivity and therefore actual density is used in calculation, differences of up to 0,6 % (for example for oxygen-free coppers) 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 $\Omega \cdot g/m^2$) to the derived mass resistivity may also exhibit a similar disparity.

Annex B
(normative)

Rapid Elongation Test method (AR-Test) for diameter 8 mm Cu-ETP1 wire rod

B.1 General

The test described in this annex is a short and fast method to obtain a good approximation for the annealability. It is applicable for diameter 8 mm copper wire rod grade Cu-ETP1 only. It is based on the essays that producers apply to perform a routine test according to their experience.

B.2 Procedure

B.2.1 Sampling and preparation of the test sample

The frequency of sampling shall be in accordance with Table 8 of this European Standard.

The sample shall be drawn down to diameter 6,30 mm ± 0,02 mm in one drawing step. In case of using a drawing drum, the drum should have a minimum diameter of 400 mm.

The pointing zones at the ends of the wire shall be discarded. The length of the test sample excluding the pointing zone shall be 270 mm.

The sampling and preparation parameters, tolerances and remarks are described in Table B.1, Steps 1, 2 and 3.

B.2.2 Annealing procedure

The exact handling of the annealing procedure is the key factor to obtain exact and repeatable results.

The main parameters are: 260 °C ± 1 °C annealing temperature and 480 s ± 2 s annealing time.

After this period in the silicon oil or salt bath, the annealing agent shall be removed within 5 s and then the sample shall be quenched in water at room temperature.

It is allowed to anneal up to three samples at the same time in a minimum of 20 l of annealing agent.

The annealing and quenching parameters, tolerances and remarks are described in Table B.1, Steps 4 and 5.

B.2.3 Tension test

Tension test shall be done in accordance to the requirements of EN ISO 6892-1.

The measuring length is 200 mm and the distance between the clamps 220 mm.

The elongation A_{200} in percent is equal to the AR-value.

The elongation parameters, tolerances and remarks are described in Table B.1, Step 6.

Table B.1 —Parameters for the AR-Test procedure

Step	Description	Parameter	Value	Tolerance	Remarks
1	Take sample of diameter 8 mm wire rod	Nominal diameter	8,00 mm	± 0,4 mm	
2	One single drawing step to obtain diameter 6,30 mm wire	Drawing speed			According to the producer machine test.
		Drawing drum	Diameter min. 400 mm		Horizontal drawing can be used.
		Lubrication			Grease
		Nominal diameter of final wire	6,30 mm	± 0,02 mm	
3	Sample preparation at diameter 6,30 mm	Discard length	Pointing zone		
		Sample length	270 mm		
4	Hot annealing	Oven annealing agent capacity	20 l		Minimum capacity
		Bath type	Silicon oil or salt bath		According to the producer.
		Annealing temperature	260 ºC	± 1 ºC	Controlled by a calibrated thermometer (very critical).
		Bath stirrer			According to the producer.
		Annealing time	480 s	± 2 s	Starting when the sample is covered with the liquid and ending when leaving the bath.
		Drying	5 s		At the air, to remove liquid from the sample.
5	Sample quenching	Quenching temperature	15 ºC to 25 ºC		Room temperature
		Quenching media	Water or cleaning agent		
6	Elongation test	Sample preparation and test procedure	According to EN ISO 6892-1: 2009, Annex D		
		Elongation type	A_{200}		
		Test temperature	15 ºC to 25 ºC		Room temperature
		Test speed	According to EN ISO 6892-1: 2009		
		Distance between clamps	220 mm		
		Measuring length	200 mm		
		Measurement	Manual		

B.3 Test results

The AR-value (elongation A_{200}) of the annealed 6,3 mm wire shall be at least 20 %. In the case the result of the AR is below 20 %, the spiral elongation number (S.E.N.) of the original wire rod shall be determined according to EN 12893.

Bibliography

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

[2] IEC 60028, *International standard of resistance for copper*

[3] ISO 80000-1:2009, *Quantities and units — Part 1: General*

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

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