SLOVENSKI STANDARD
SIST EN 12893:2002

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Baker in bakrove zlitine - Ugotavljanje spiralnega razteznostnega števila

Copper and copper alloys - Determination of spiral elongation number

Kupfer und Kupferlegierungen - Bestimmung der Spiralverlängerungszahl

Cuivre et alliages de cuivre - Détermination de l'indice d'allongement par spirale

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77.120.30 Baker in bakrove zlitine Copper and copper alloys

SIST EN 12893:2002 **en**

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English version

Copper and copper alloys - Determination of spiral elongation number

Cuivre et alliages de cuivre - Détermination de l'indice d'allongement par spirale

Kupfer und Kupferlegierungen - Bestimmung der Spiralverlängerungszahl

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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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 12893 Copper and copper alloys - Determination of spiral elongation number

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of an identical text or by endorsement, at the latest by September 2000, and conflicting national standards shall be withdrawn at the latest by September 2000.

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.

Introduction

The spiral elongation test is a means for measuring the response of high purity copper, intended for drawing into wire, to low temperature annealing. It is possible to discriminate between different purities of copper which vary only slightly within the composition limits of the grade and hence to assess their suitability for use in critical production processes.

The test method described is based essentially on that reviewed in ISO/TR 4745 High Conductivity Copper - Spiral Elongation Test, published in 1978 by the International Organization for Standardization (ISO). The Technical Report drew attention to the uncertainties of the test and also suggested further work by which these uncertainties might be dispelled.

A Task Group was established by CEN/TC 133/WG 1 "Unwrought copper products" to investigate the precision, in terms of repeatability and reproducibility, of a test method which had been drafted by CEN/TC 133/WG 1 following work undertaken, mainly in the UK, to improve the precision of the ISO/TR 4745 test method. The Task Group comprised eight laboratories representing five countries: Belgium, France, Germany, Spain and UK. After testing an initial round of samples, the draft test method was further moderately revised and used for a further round of tests, the results of which were subjected to statistical assessment and used for the precision details in the present test method.

The Spiral Elongation Number (SEN) obtained from the test is indicative of the annealability of the sample.

NOTE: The word spiral used in this context implies helical in strictly scientific terms.

1 Scope

This European Standard specifies a method for performing the spiral elongation test on high purity copper drawing stock conforming to EN 1977, grade Cu-ETP1 (CW003A).

The method has been designed for testing high purity copper sampled at the drawing stock stage. It is not relevant for assessing the quality of copper wire selected at a later stage of processing.

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 1977
Copper and copper alloys - Copper drawing stock (wire rod)

3 Principle

Copper wire is drawn using specified conditions, and annealed at low temperature under carefully controlled conditions. It is then wound into a spiral while supporting a specified mass. The spiral is then axially extended by the same mass. The change in length, after removal of the mass, is measured.

A spiral wound from wire that retains, after the annealing treatment, some effects of the previous cold working does not extend as much as one made from wire which the annealing treatment has made softer.

Correct preparation of the test piece is very important to achieve an accurate test result.

4 Apparatus

4.1 Wire drawing facility, such as a stringing-up machine, pulling-in block or drawing bench, capable of drawing (8,0 ± 0,4) mm diameter annealed copper drawing stock in a series of single passes in one direction to (2,00 ± 0,01) mm diameter. The facility shall include a set of dies for drawing copper. The dimensions and tolerances of the dies shall conform to Table 1. The facility shall also include suitable lubrication to reduce friction and overheating of the test sample during drawing.

4.2 Annealing bath, of sufficient size to contain a test sample in the form of a (200 ± 50) mm diameter coil of wire, equipped with suitable controls to maintain a temperature of (200 ± 0,5) °C for a period of (2,0 ± 0,02) h. The annealing bath shall contain either silicone oil of low viscosity, or a suitable salt (melting point approximately 150 °C) and be equipped with a stirrer to ensure a uniform temperature throughout the bath.

> NOTE: The performance of the annealing bath should be such that if a simulated test sample is inserted, it should reach a temperature of (200 ± 0,5) °C within 5 min. The simulated sample consists of 8 mm diameter copper drawing stock formed into a coil, 200 mm in diameter, into which a thermocouple is embedded to a depth of 4 mm. The coil is placed in the annealing bath in the position normally occupied by the test samples.

4.3 Thermometer, capable of indicating or recording the temperature to an accuracy of ± 0,1 °C at 200 °C.

4.4 Timer, capable of measuring intervals of 2,0 h in increments of 1,0 min.

4.5 Circular gauge, as shown in Figure 1a), for marking a 1 000 mm gauge length without straining the annealed wire sample. The gauge dimensions shown in Figure 1 are approximate. The positions A and B are inscribed on the gauge, using a straightened length of annealed (2,00 ± 0,01) mm diameter copper wire on which a 1 000 mm gauge length has been marked to an accuracy of ± 0,5 mm.

4.6 Polished steel mandrel, (20,0 ± 0,1) mm diameter by 50 mm minimum length, mounted with its axis horizontal ± 3° and provided with a drive mechanism to rotate it at (50 ± 5) min^{-1}.

4.7 Metal block, fitted with a hook at its upper end, of total mass (2 240 ± 2,0) g.

4.8 Steel rule, capable of measuring 1,0 m in increments of (1,0 ± 0,2) mm.

4.9 Loading device, capable of applying the load (see 4.7) to the test piece, positioned with its axis vertical, such that the rate of extension of the spiral does not exceed 20 mm · s^{-1}. The load shall be applied either by:

- lowering the mass; or
- raising the upper end of the spiral.

5 Selection of test sample

5.1 For drawing stock nominally 8 mm diameter

Select a test sample of minimum length 500 mm, in order to provide sufficient material for the test.

5.2 For drawing stock less than 8 mm diameter

Select a test sample of length corresponding to a minimum mass of 200 g.

5.3 For drawing stock greater than 8 mm diameter

Select a test sample of length corresponding to a minimum mass of 300 g.

6 Preparation of the test sample

6.1 General

Carry out the appropriate cold drawing operations described in 6.2 to 6.4, using the wire drawing facility (see 4.1) at a maximum drawing speed of 65 m · min^{-1}. During drawing, lubricate the dies freely and allow the wire to cool for 5 min between passes or quench in water after each pass, so as to minimize the temperature rise of the sample. All passes shall be in the same direction.

6.2 For drawing stock nominally 8 mm diameter

Cold draw the test sample obtained in accordance with 5.1, under the conditions given in 6.1, using the die sizes given in Table 1 to produce (2,00 ± 0,01) mm diameter wire.

The final diameter of the wire shall be (2,00 ± 0,01) mm, which shall be verified by measuring with a micrometer two diameters at right angles at each of three positions and using the mean of the results.

Table 1: Dimensions and tolerances of the dies for reducing 8 mm diameter copper drawing stock to (2,00 ± 0,01) mm diameter wire

Die diameter Mm	Maximum tolerance on mean diameter mm	Maximum ovality mm	Reduction in area per pass (for information) %
7,13	± 0,02	0,01	20,6
6,28	± 0,02	0,01	22,4
5,53	± 0,02	0,01	22,5
4,87	± 0,02	0,01	22,4
4,29	± 0,02	0,01	22,4
3,78	± 0,02	0,01	22,4
3,33	± 0,02	0,01	22,4
2,93	± 0,02	0,01	22,6
2,58	± 0,02	0,01	22,5
2,27	± 0,02	0,01	22,6
2,00	± 0,01	0,005	22,4

NOTE: Check the die dimensions by measuring the wire dimensions produced by the die.

Then:

- mean diameter is the mean of one or more pairs of measurements, taken at right angles, at the same cross-section of the wire; and
- ovality is the difference between the maximum and the minimum diameters at one cross-section of the wire.

6.3 For drawing stock less than 8 mm diameter

Cold draw the test sample obtained in accordance with 5.2, under the conditions given in 6.1, but using a set of dies tailored to the drawing stock diameter, and chosen to achieve similar reductions per pass as those given in Table 1, to produce (2,00 ± 0,01) mm diameter wire.

Verify that the final diameter of the wire is (2,00 ± 0,01) mm by measuring, as in 6.2.

6.4 For drawing stock greater than 8 mm diameter

Reduce the test sample obtained in accordance with 5.3 to 8,0 mm diameter by rolling, swaging or drawing. At the 8 mm stage cut the test sample to 500 mm and discard the surplus.

Anneal the test sample at (700 ± 20) °C for (1,0 ± 0,02) h, then quench it in water. Clean in dilute sulphuric acid (solution with a volume fraction of 10 %) and wash thoroughly in water to remove scale and loose copper dust.

Cold draw the test sample under the conditions given in 6.1, using the die sizes given in Table 1, to produce (2,00 ± 0,01) mm diameter wire.

Verify that the final diameter of the wire is (2,00 ± 0,01) mm by measuring, as in 6.2.

7 Annealing the test sample

Discard a 1 m length from each end of the (2,00 ± 0,01) mm diameter wire obtained in accordance with clause 6, to produce the test sample length. Wind this into a coil (200 ± 50) mm diameter by wrapping it around a suitable former and bind the coil with copper wire ties to retain its shape.

Using the annealing bath (see 4.2) and the timer (see 4.4), anneal the coiled test sample at (200 ± 0,5) °C for (2,0 ± 0,02) h and quench in water. In subsequent handling of the annealed wire, exercise care to prevent introducing unnecessary strain.

NOTE: The annealing temperature is critical. Avoid the introduction of large masses of copper wire into the annealing bath, so as not to depress the temperature too much, otherwise recovery to the annealing temperature is prolonged. It is necessary to ensure that the temperature of the annealing bath (see 4.2) is accurate and uniform throughout the process.

8 Preparation of the test piece

Carefully remove the wire ties from the annealed test sample obtained in accordance with clause 7.

Form 10 mm at one end of the test sample into a right angle. Insert and clamp the 10 mm length into the (3 ± 0,5) mm hole [see Figure 1b)] in the circular gauge (see 4.5).

Carefully wind the test sample around the gauge in a clockwise direction. To minimise strain while unwinding the annealed, coiled test sample, maintain its curvature.

When sufficient test sample has been wound around the gauge beyond point B/D, apply light tension to the free end of the sample to ensure close contact with the circumference of the circular gauge.

Mark the test sample at points A/C and B/D [see Figure 1b)] using an indelible marker.

NOTE 1: Local degreasing may be necessary.

Cut the free end of the test sample beyond point D. Remove the test piece length from the circular gauge. Cut at A and D. The length A to D leaves sufficient wire length either side of the gauge marks C and B for subsequent handling and forming of the test piece [see Figure 1c)]. Retain the remainder of the sample to prepare at least two further test piece lengths.

Secure one end of the test piece length by means of a notch, hole or pin to the polished steel mandrel (see 4.6) and form a hook or loop at the other end of the test piece length outside the gauge length (B to C).

Attach the mass (see 4.7) to the hook or loop and wind the test piece length into a close spiral by rotating the mandrel (see 4.6) at (50 ± 5) min^{-1}, ensuring that each turn of the spiral touches the preceding one. During winding, do not straighten the wire or handle it other than to guide it gently onto the mandrel to form a close spiral.