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High conductivity copper — Spiral elongation test

Cuivre de haute conductivité — Essai d'allongement spirale

Technical Report 4745 was drawn up by Technical Committee ISO/TC 26, *Copper and copper alloys*, and approved by the majority of its members. The reasons which led to the decision to publish the document in the form of a Technical Report rather than an International Standard are given in annex A.

In may 1978, this document was submitted to the ISO Council, which approved its publication as a Technical Report.

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0 INTRODUCTION

The spiral elongation test is essentially a proposed means for measuring the ease with which high conductivity copper may be softened by a low temperature annealing treatment. For example, the suitability of high conductivity copper rod for producing enamelled fine wires can be tested in this way.

This method of carrying out the test is proposed so that results obtained in different laboratories may be compared and discussed.

This Technical Report draws attention to the uncertainties of the test, for example the reproducibility of test results, and suggests further work by which these uncertainties might be dispelled. For problems in the standardization of the spiral elongation test see annex A; for literature references, see annex B.

Users of this Technical Report are requested to send in their test results obtained by the proposed method to the ISO/TC 26 Secretariat (DIN Deutsches Institut für Normung e.V., Kamekestr. 8, D-5000 Köln 1 Germany F. R.) within two years after publication of this Technical Report, as the same time indicating their comments on the problems pointed out in annex A.

1 SCOPE AND FIELD OF APPLICATION

1.1 This Technical Report gives a method to be used in carrying out the spiral elongation test on copper that has been worked into the form described in clauses 3 and 4.

NOTE — The word "spiral" as used in this context implies "helical" in strictly scientific terms.

1.2 The response of a given copper to the test is influenced by the treatment it has received in the preparation of the wire sample, and for this reason the details of processing are specified.

1.3 The test applies only to high conductivity copper, sampled at the wire bar or rod stage, and is not concerned with assessing the quality of copper wire selected at later stages in commercial processing.

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2 PRINCIPLE

Basically the test consists in winding a spiral copper wire spring that has received a specified low temperature anneal under carefully controlled conditions, stretching the spiral spring with a weight having a specified mass and then measuring the change in length after removing the weight. A spiral wound from wire that retains, after the annealing treatment, some effects of previous cold drawing does not extend as much as one made from wire which the annealing treatment has rendered quite limp.

3 SELECTION OF TEST SAMPLES

A sample of 6,3 ± 0,5 mm rod of a length suitable for cold drawing shall be prepared in one of the following ways :

3.1 Sample from a wire bar

Cut a slice 20 mm thick from the mid-length of the wire bar perpendicularly to the axis. From this slice, cut a sample 20 mm square orientated either as in figure 1 or as in figure 2.

From the sample if orientated as in figure 1, cut off and discard the oxygen-rich portion at the set surface. In the case of vertically cast bars, cut the sample in the same way; however, no discard is necessary.

Reduce the sample to a round rod of 6,3 mm diameter by rolling, swaging, hammering or any convenient method.

NOTE — See sub-clause A.2.1 of annex A.

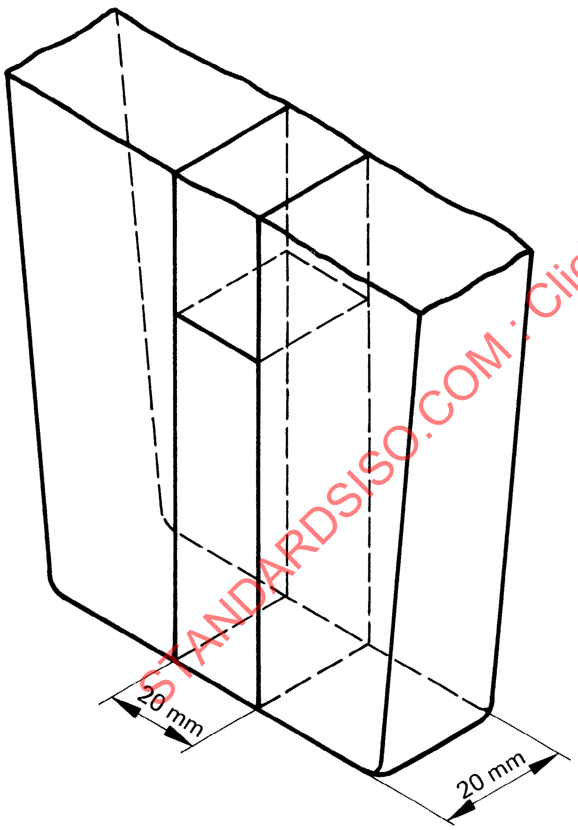

FIGURE 1 — **Vertical sample cut from a horizontally cast wire bar**

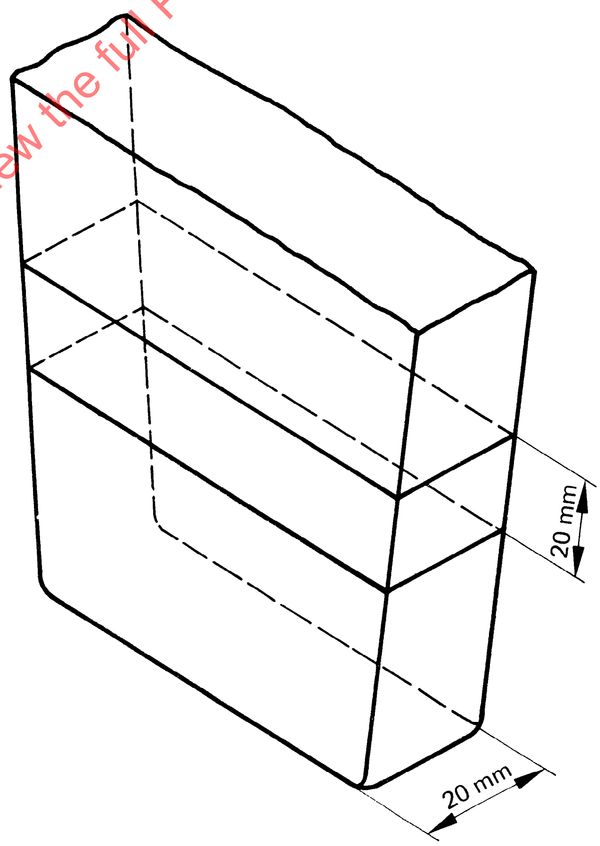

FIGURE 2 — **Horizontal sample cut from a horizontally cast wire bar**

3.2 Sample from hot-rolled wire bar

Take a sample rod of length suitable for cold drawing from approximately the centre of the length of rod representing a full wire bar. In the case of hot-rolled rod of diameter greater than 6,3 mm, process the sample to 6,3 mm diameter by cold drawing.

3.3 Sample from continuously cast rod

Take a sample of rod of length suitable for drawing. In the case of rod greater than 6,3 mm diameter, process the sample to 6,3 mm diameter by cold drawing.

NOTE — See clause 3 of annex A.

4 PREPARATION OF TEST SAMPLES

Place the rod, selected as in clause 3, in an electric furnace and hold at 700 ± 5 °C for 1 h in a normal atmosphere.

Then quench the rod rapidly, in water at ambient temperature, or in very dilute sulphuric acid, approximately 10 % (*V/V*), pickle it in sulphuric acid and thoroughly wash it until it is free from scale and loose copper dust.

Cold draw the rod in a sequence of passes each of which should cause a reduction in cross-sectional area of between 20 and 25 %. The final draw should produce a diameter of 2 ± 0,01 mm. In no draw should the speed exceed 1 m/s. Perform each draw in the same direction.

Finally, wind the wire into a coil of outside diameter 200 ± 10 mm.

5 ANNEALING TREATMENT

Anneal the coil of wire obtained in accordance with clause 4, at 200 ± 0,5 °C for 2 h. The heating equipment should be such that its response time is of the order of seconds; for example, a salt bath, oil bath or fluidized bed heater. After annealing the coil of wire, quench it in water at ambient temperature. Care should be taken to avoid any stress other than that required to carry out the test in clause 6.

6 TESTING PROCEDURE

Cut a length of 1 200 mm from the annealed wire and mark a gauge length of 1 000 mm in the centre of this with indelible dye or ink. Secure one end of the wire with the aid of a notch or hole around a horizontaly disposed polished steel mandrel of diameter 20 ± 0,01 mm. From the other end suspend a weight which applies to the wire a specific stress of 7 N/mm^2; the mass of the weight is determined to the nearest 10 g from the measured area of cross-section of the wire. Wind the wire in a spiral by slowly rotating the mandrel (at approximately 50 min^{-1}), ensuring that each turn of the spiral touches the preceding one.

Measure the length of the spiral thus formed between gauge marks (about 28 mm), carefully remove the spiral from the mandrel and shape the ends into hooks. The ends should be formed in such a manner as to ensure that the spiral within the gauge length is not deformed or damaged in any way and that the subsequent loading is applied as axially as possible.

Then suspend the spiral vertically and load at the lower end with the same weight as that used in winding. The weight should initially be supported by a platform. Either lower the platform, or raise the upper hook of the spiral, without shock and at a speed not exceeding 0,02 m/s, until the weight is freely suspended from the spiral. After 1 min of free suspension, remove the weight, place the spiral on a table and allow it to relax for a further 1 min.

Measure the distance between the two points marked with indelible dye or ink and subtract the measured length of the original tightly coiled spring (28 mm).

In the case of query, the test should be carried out three times on the same coil of wire and the average of the three results quoted is called the spiral elongation number, designated ΔL. The elongation number should be quoted to the nearest 10 mm.

ANNEX A

PROBLEMS IN THE STANDARDIZATION OF THE SPIRAL ELONGATION TEST

A.1 REPRODUCIBILITY AND INTER-LABORATORY AGREEMENT

Comparisons of results reported by users of the test have proved disappointing and there is evidence that discrepancies are not due merely to failure to reproduce test conditions exactly; they may be due to factors which are not specified, or specified inadequately or incorrectly, in the present test description.

A.2 SUGGESTED FURTHER WORK

If the discrepancies referred to in clause A.1 are to be resolved, and this will be necessary before comparable results can be obtained, further study of the discrepancies is called for.

Comments and results of investigations shall be submitted to the Secretariat of ISO/TC 26.

The following fields of investigation are suggested :

A.2.1 Assessment of methods of sampling cast copper and of converting a cut wire bar sample to the round rod for heat treatment. This assessment shall include reference to the temperature at which the conversion is made.

A.2.2 Establishment of the case for and against the use of a heat treatment on commercially produced rod.

A.2.3 Establishment of the case for and against 700 °C as the heat treatment temperature.

A.2.4 Verification that variable cold drawing adjustment of over-size rod does not affect the test value.

A.2.5 Re-examination of the influence of wire diameter on reproducibility and investigation of the question whether a smaller size than 2 mm would be preferable.

A.2.6 Assessment as between 1 and 2 h annealing time in relation to percentage cold reduction of wire sample.

A.2.7 Assessment of the effect, if any, of the geometric location in the spirally wound sample of the original set surface.

A.2.8 Assessment of reproducibility obtainable between laboratories, within laboratories and within samples.

A.3 CONTINUOUSLY CAST ROD AND HOT-ROLLED ROD

The metallurgical history of continuously cast rod is quite different from that of rod rolled from wire bar, but there is a similar need to assess its annealing and springiness performance, after drawing to wire.

It is suggested that studies be made as to how the test method needs to be modified to accommodate this rod. Clearly the need for a heat treatment is highly debatable. Other variations might appear necessary on detailed examination.

ANNEX B

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