INTERNATIONAL STANDARD

ISO 2624

Second edition
1990-02-01

Copper and copper alloys — Estimation of average grain size

Cuivre et alliages de cuivre — Évaluation de la dimension moyenne du grain

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Reference number
ISO 2624 : 1990 (E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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International Standard ISO 2624 was prepared by Technical Committee ISO/TC 26, *Copper and copper alloys.*

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This second edition cancels and replaces the first edition (ISO 2624 : 1973), of which it constitutes a minor revision.

Annex A forms an integral part of this International Standard.

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Introduction

On a section of metal, a grain is that area within the boundary of a crystal. For the purpose of applying the methods described in this International Standard, a crystal and its twin bands are considered as one grain. Sub-grains, minor constituent phases, inclusions and additives are not considered in the estimation of the grain size.

It is important, in using these methods, to recognize that the estimation of grain size is not a precise measurement. A metal structure is an aggregate of three-dimensional crystals of varying sizes and shapes. Even if all these crystals were identical in size and shape, the grain cross-sections produced by a random plane (surface of observation) through such a structure would have a distribution of areas varying from a maximum value to zero, depending upon where the plane cuts each individual crystal. Clearly, no two fields of observation can be exactly the same.

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Practical reasons limit the number of grains that can reasonably be counted to less than the number statistically desirable.

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Copper and copper alloys — Estimation of average grain size

1 Scope

This International Standard specifies three procedures for estimating, and rules for expressing, the average grain size of copper and copper alloys consisting principally of a single phase. The respective procedures are termed the comparison procedure, the intercept procedure and the planimetric procedure.

The comparison procedure (comparing the specimen with a standard chart) is most convenient and is sufficiently accurate for most commercial purposes.

Higher degreees of accuracy in estimating grain size are obtainable by using the intercept (Heyn) or planimetric (Jeffries) procedures. In cases of dispute, it is recommended that the use of one of these procedures be agreed between the parties.

For material with non-equiaxial structures it is recommended that the intercept procedure be used.

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2 Symbols and designations

Symbol	Designation
f	Jeffries' multiplier used to obtain number of grains per square millimetre by planimetric method
m	Number of grains per square millimetre
d	Average grain "diameter" in millimetres; an arbitrary measure defined as $1/\sqrt{m}$
l	Average intercept length
γ	Magnification

3 Test samples

3.1 Grain size estimations shall be made on three or more representative fields of each sample section. In known equiaxial structures only a representative section need be taken on the sample. For non-equiaxial or unknown structures three sections must be prepared, each at right angles to the other.

3.2 The specimen shall be carefully prepared to reveal the grain boundaries using a contrast etch to match the standard charts.

4 Procedures

4.1 Comparison procedure

The estimation of grain size is made by direct comparison of a projected image of a photomicrograph of a representative field of the test specimen, either with the photomicrographs of the standard grain size series or with suitable reproductions of them (for standard grain size charts, see annex A); when a projection microscope is not available a bench microscope may be used. It is recommended that, to facilitate comparison, mechanical arrangements be made to permit bringing the standard photomicrographs successively into juxtaposition with the projected image.

4.2 Intercept procedure

4.2.1 The grain size is estimated by counting, on the ground glass screen of a projection microscope, on the image in a bench microscope fitted with a graticule, on a photomicrograph of a representative field of the specimen, or on the specimen itself, the number of grains intercepted by one or more straight lines sufficiently long to yield at least 10 intercepts per line and at least 50 intercepts for all lines for normal purposes and at least 200 intercepts for referee purposes. Grains touched by the end of the line count only as half grains. The length of the line or lines in millimetres at the surface of the section, divided by the number of grains intersected by it, gives the average intercept length l. For practical purposes, the average intercept length, l, may be regarded as equal to the average grain diameter d[1)].

4.2.2 For non-equiaxial structures, measurements should be made on longitudinal and transverse sections along lines that lie in all three principal directions of the specimen. For each direction, the average grain "diameters" should be calculated as in 4.2.1.

1) To achieve compatibility with estimations of grain "diameter" made by the planimetric or comparison procedure, the intercept length, l, should be multiplied by the factor 1,13.

4.3 Planimetric procedure

4.3.1 In the planimetric procedure, a circle or rectangle of known area (usually 5 000 mm^2 to simplify the calculation) is inscribed on a photomicrograph or on the ground glass screen of the projection microscope.

A magnification should be selected which will give at least 50 grains for normal purposes and 200 grains for referee purposes in the field to be counted. When the image is focused properly, the number of grains within this area should be counted. The sum of all the grains included completely within the known area plus one half the number of grains intersected by the circumference of the area should be taken as giving the number of equivalent whole grains, measured at the magnification used, within the area. If this number is multiplied by Jeffries' multiplier, f, in the second column of table 1 opposite the appropriate magnification, the product will be the number of grains per square millimetre, m.

4.3.2 The average grain "diameter" in millimetres, d, for each field may then be calculated from the formula $d = 1/\sqrt{m}$.

Table 1 — Jeffries' multipliers for area of 5 000 mm^2

Magnification used, γ	Jeffries' multiplier, f, to obtain grains per mm^2
1	0,000 2
10	0,02
25	0,125
50	0,5
75*)	1,125
100	2,0
150	4,5
200	8,0
250	12,5
300	18,0
500	50,0
750	112,5
1 000	200,0

*) At 75 diameters magnification, Jeffries' multiplier, f, becomes unity if the area used is 5 625 mm^2 (a circle of 84,5 mm diameter).

5 Test report

5.1 Comparison procedure

The estimated grain size for each field shall be reported as that of the nearest standard grain size chart (see annex A). Alternatively, where a single figure is required the median of these results shall be reported.

The charts are reproduced at a magnification of × 75, which is normally suitable for copper and copper alloys. If it is necessary to use other magnifications, the appropriate grain size from table 2 shall be reported. The values shown in this table have been rounded off to approximate commercial usage.

Table 2 may be used for comparisons at other magnifications by using the appropriate factor; for example, at × 250 divide by 10 the grain size indicated at × 25, or at × 400 divide by 2 the grain size indicated at × 200. Thus at × 250, a grain size which will match the same standard photograph of 0,050 mm at × 75 will be a 0,015 mm grain size (0,150 at × 25 divided by 10).

It should be appreciated that it is not uncommon for operators to differ by one step in the charts when estimating the grain size of a given field.

5.2 Intercept or planimetric procedures

In equiaxial material, the results for each of the three or more representative fields on which estimations have been made shall be reported. Alternatively, where a single figure is required the median of these results shall be reported.

In non-equiaxial material, when the intercept procedure should be used, the results for each of the three directions shall be reported either for individual fields or as the corresponding median for each direction.

5.3 Mixed grain sizes

These are sometimes encountered, for example in hotworked metal. These shall be expressed by giving the estimated area percentages occupied by the two sizes or the two ranges of sizes, by using the comparison method.

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Table 2 — Relationships between the actual grain size of specimens viewed at various magnifications and the standard series of photomicrographs

Image magnification	Grain size when image matches standard chart mm												
× 75 (standard)	0,010	0,015	0,020	0,025	0,035	0,045	0,050	0,060	0,070	0,090	0,120	0,150	0,200
× 25	0,030	0,045	0,060	0,080	0,110	0,140	0,150	0,180	0,210	0,270	0,360	0,450	0,600
× 50	0,015	0,020	0,030	0,040	0,050	0,070	0,080	0,090	0,100	0,140	0,180	0,220	0,300
× 100	0,008	0,010	0,015	0,020	0,025	0,035	0,040	0,045	0,050	0,070	0,090	0,110	0,150
× 200	—	0,005	0,007	0,010	0,012	0,017	0,020	0,022	0,025	0,035	0,045	0,055	0,075
× 500	—	—	—	—	0,005	0,007	0,008	0,009	0,010	0,014	0,018	0,022	0,030

Annex A
(normative)

Standard grain size charts (× 75)

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0,200 mm average grain diameter

NOTE — The reference photomicrograph plates given in this annex are taken from the ASTM standard E112-85, *Standard methods for determining the average grain size*, Plate III.

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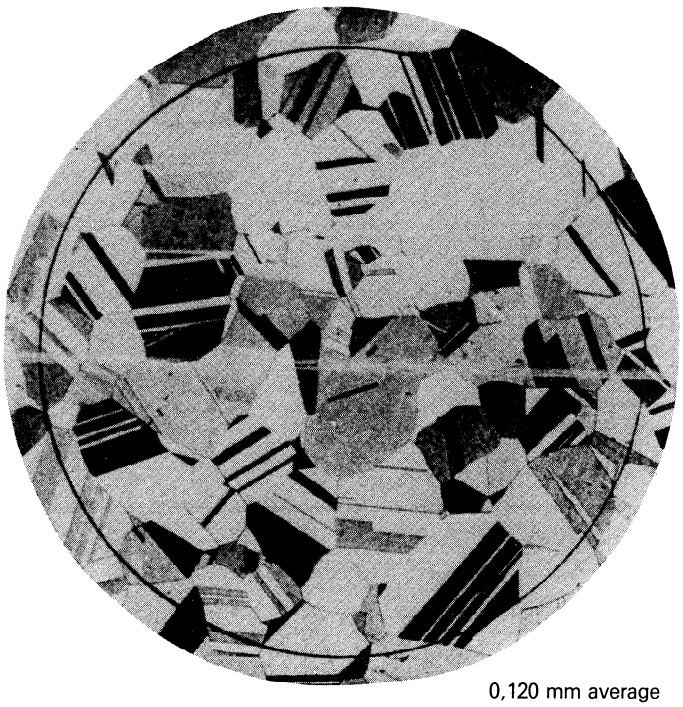
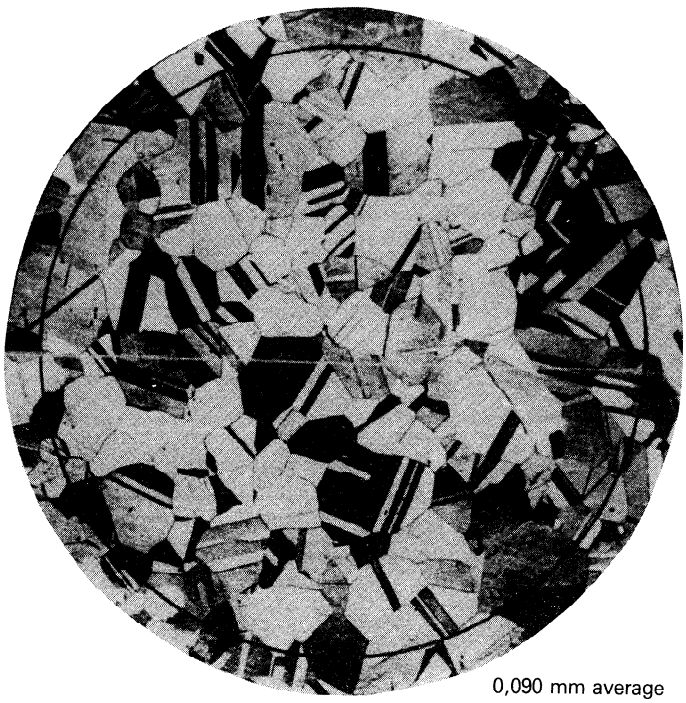
0,150 mm average grain diameter



0,120 mm average grain diameter



0,090 mm average grain diameter

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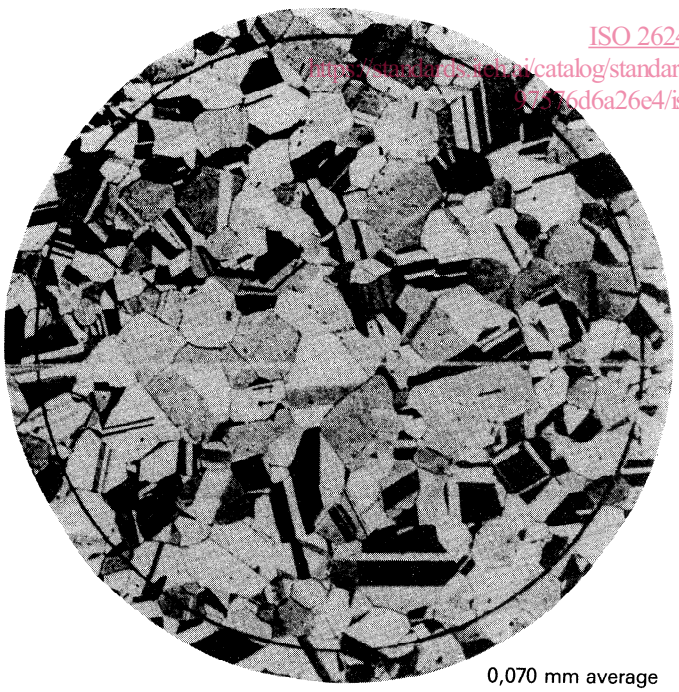
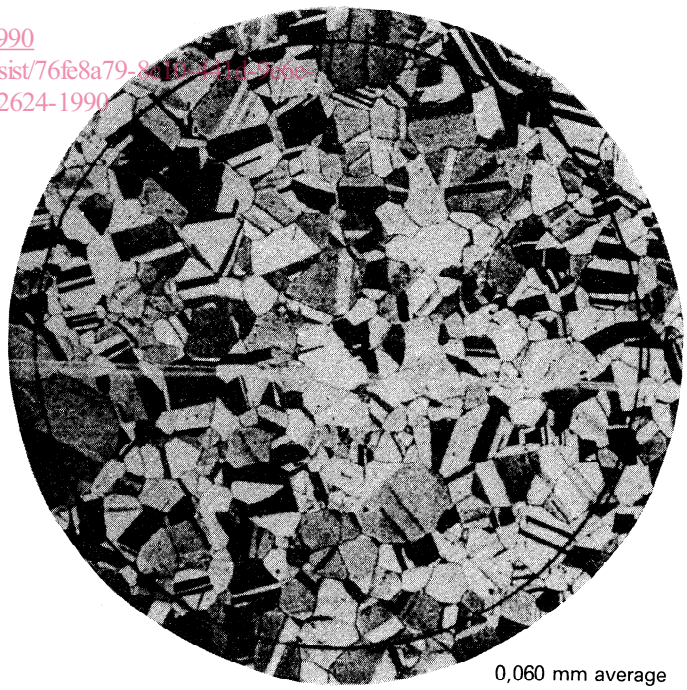


0,070 mm average grain diameter



0,060 mm average grain diameter