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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 4967

Steel — Determination of the non-metallic inclusion content — Micrographic method

*Acier — Détermination de la teneur en inclusions non métalliques
— Méthode micrographique*

ICS: 77.040.99

ISO/TC 17/SC 7

Secretariat: **AFNOR**

Voting begins on:
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2025-04-30

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 7, *Methods of testing (other than mechanical tests and chemical analysis)*.

This fifth edition cancels and replaces the fourth edition (ISO 4967:2013), which has been technically revised.

The main changes are as follows:

- Adding terms and definitions;
- Modifying the proximity conditions for stringers (allowing for legacy conditions): the new transverse conditions mirror the conditions used longitudinally and remove ambiguity;
- Changing the width definition (allowing for legacy definitions): the new definition avoids the sensitivity to misalignment of the bounding box and the underestimation of the “largest particle” approach;
- Clarifying the treatment of inclusions intersecting the field of view, particularly for long inclusions (allowing for legacy treatment);
- Modifying [Table 2](#) and [3](#);
- Adding the sampling specifications for the case that the cross-section thickness is not great enough;
- Including the DS subgroup into D thick rating;
- Clarifying the treatment of DS inclusions in Method B;
- Modifying most of the chart diagrams;
- Replacing the global metrics for Method B (allowing for legacy metrics);
- Adding more analysis examples.

ISO/DIS 4967:2025(en)

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Steel — Determination of the non-metallic inclusion content — Micrographic method

1 Scope

This document specifies a micrographic method of determining the non-metallic inclusions in rolled or forged steel products having a reduction ratio of at least 3 using standard reference chart or direct measurement by image analysis technologies.

This method is widely used to assess the suitability of a steel product for a given use. However, since it is difficult to achieve reproducible results owing to the distributional randomness of non-metallic inclusion, even with a large number of specimens, precautions should be taken when using the method.

NOTE For certain types of steel (e.g. free cutting steels), the standard comparison chart described in this document is not entirely applicable.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at www.iso.org/obp
- IEC Electropedia: available at www.electropedia.org

3.1 particle

single precipitate, in general non-metallic

[SOURCE: BS EN 10247:2017, 3.1].

3.2 stringer

arrangement of at least 2 particles for type A and C inclusions and 3 particles for type B, aligned in a plane parallel to the hot working axis and offset by no more than 10 µm, with a separation of less than 40 µm between any two nearest neighbour particles

3.3 inclusion

general designation of a rateable feature composed of at least one particle, defined by the size and proximity of its constituents

Note 1 to entry: The inclusion can describe a single particle or a single stringer.

3.4 length

l

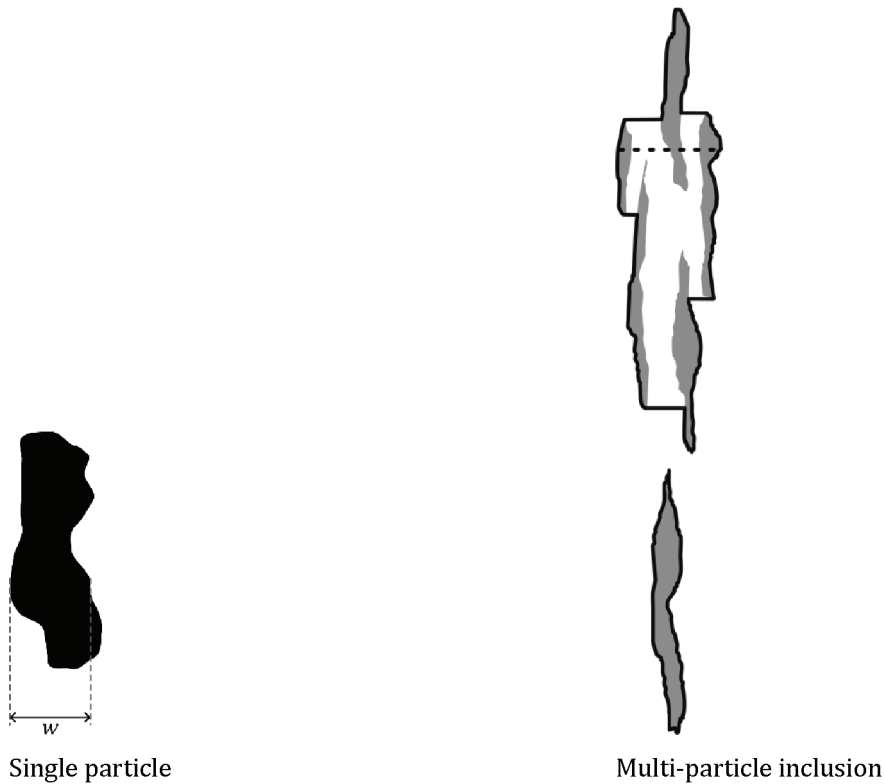
dimension of a particle or an inclusion in the main deformation direction, usually larger than the width

3.5

width

w

largest local dimension of a particle or an inclusion perpendicular to the main deformation direction (“calliper width”)



Note 1 to entry: The calliper width clarifies an ambiguity in previous editions. The “bounding box” and the “largest particle” approach were among the most frequent alternatives. Further illustrations are shown in Figures 10-13 .

3.6

aspect ratio

ratio of length to width

3.7

diameter

D

dimension of a globular particle or inclusion in the main deformation direction

3.8

worst-field rating

rating in which the specimen is rated for each group and subgroup of inclusion by assigning the value for the highest severity rating observed of that inclusion group and subgroup anywhere on the evaluated area of the specimen

3.9

type

categorization of inclusions according to morphology, colour, and proximity

3.10

class

categorization by width or diameter within types (fine and thick)

3.11**group**

categorization by type and class

3.12**globular particles**

particles with an aspect ratio less than 3

3.13**elongated particles**

particles with an aspect ratio more than or equal to 3

3.14**reduction ratio**

ratio between original and final cross-sectional area after rolling or forging

3.15**legacy**

designating a procedure, process, or definition explicitly described or implicitly permitted in the previous 2013 edition of ISO 4967 and allowed by mutual agreement but not recommended in this document

4 SymbolsThe symbols used are given in [Table 1](#).**Table 1 — Symbols**

Symbols	Definitions	Values
b	Length of sample in rolling direction of tube as shown in Figure 7	
l	Dimension of a particle or an inclusion in the main deformation direction, usually larger than the width	
w	Dimension of a particle or an inclusion perpendicular to the main deformation direction	
d	Longitudinal distance between particles as shown in Figures 10-13	
D	Dimension of a globular particle or inclusion in the main deformation direction	
s	Transverse distance between particles as shown in Figures 10-13	
r	Width of plate as shown in Figures 4-6	
N	Number of rated fields	
n	Number of type D globular oxides per field	
i	Index	
n_i	Total number of fields (A, B, C, and D) and inclusions (DS) rated as index i	
f_i	Weighting factor of index i , always rounded to one significant digit	$f_i = 10^{\frac{i-2,5}{1,5}}$
i_{tot}	Total index for the entire assessed surface	$\sum_i n_i \times i$
i_{moy}	Mean index for the entire assessed surface	$i_{moy} = i_{tot} / N$
C_t	The cleanness index	$\sum_{group} \sum_i n_i \times f_i$
S	Specimen area	

5 Principle

5.1 The method consists of comparing the observed field to the chart images defined in this document and taking in consideration separately each group and subgroup of inclusion. In the case of image analysis, fields will be rated according to [Table 2](#), [Table 3](#), and the relationships given in [Annex E](#). Automatic image analysis can be used provided that the accuracy of the method has previously been validated. Digitized images should have a calibration factor of 1 μm / pixel or preferably finer.

5.2 The chart images correspond to square fields of view, each with an area of 0,50 mm², as obtained with a longitudinal plane-of-polish and as observed at 100 $\times$.

5.3 According to the shape, grey level and distribution of the inclusions, the chart images are divided into four main types, bearing the reference A, B, C, and D. These four types represent the most commonly observed inclusion types and morphologies:

- **Type A (“sulfide” type):** highly malleable, individual grey particles with a wide range of aspect ratios and generally rounded ends;
- **Type B (“aluminate” type):** numerous non deformable, angular, low aspect ratio (< 3), black or bluish particles (at least three) aligned in the deformation direction;
- **Type C (“silicate” type):** highly malleable, individual black or dark grey particles with a wide range of aspect ratios (≥ 3) and generally sharp ends;
- **Type D (globular “oxide” type):** non deformable, angular or circular, low aspect ratio (< 3), black or bluish, randomly distributed particles.

NOTE The chemical composition of the inclusions present in a steel sample cannot be determined with the methods described in this document. The apparent chemical names attributed to the types A, B, C, and D derive from the typical composition historically found when analysing inclusions of such morphology and colour. The same is true for the non-traditional inclusion types in the paragraphs that follow.

5.4 Non-traditional inclusion types may also be rated based on their morphology compared to the above four types and a statement about their apparent chemical nature. As an example, globular sulfides would be rated as a D type and denoted with a descriptive subscript (e.g. D_{sulf}) defined in the test report. Examples of subscripts include D_{cas} (globular calcium sulfides); D_{RES} (globular rare earth sulfides); and D_{Dup} (globular duplex inclusions, such as calcium sulfide surrounding an aluminate). The treatment of complex inclusions should be separately agreed between the parties. Examples are given in [Annex C](#).

5.5 Types of precipitate such as borides, carbides, carbonitrides or nitrides may also be rated based on their morphology compared to the above four types and a statement about their apparent chemical nature as described in [5.4](#). Examination at a magnification greater than 100 $\times$ may be used to identify the nature of the non-traditional inclusions before performing the test.

5.6 The categorization of type A, B, C and D of inclusions is based on their morphologies and grey level. Each of the four types is further categorized into two classes based on their width or diameter, for which six images representing increasing inclusion content are provided in [Annex A](#). The images for indices 3,5 and higher and the limit values for indices 5,5 and higher are not given in this document. For simplifying the frequent oversized reporting for Type D inclusions with a diameter $> 13 \mu\text{m}$ an additional **Subgroup DS** is defined. Oversized Type D inclusions are rated as D_{thick} and also as DS.

5.7 The chart images in [Annex A](#) carry an index number, i , from 0,5 to 3, the numbers increasing with the inclusion lengths (Types A, B, C) or by the number (Type D) or by the diameter (Subgroup DS), as defined in [Table 2](#), and categorized by thickness, as defined in [Table 3](#). The total length of inclusions, or number of inclusions, or diameter of the inclusion in each chart image is the lower boundary value of [Table 2](#). For

example, the images for A 2 depict inclusions with a morphology in accordance with type A and with the total length corresponding to the lower boundary value of $i = 2$.

Table 2 — Inclusion rating limits

Index i	Type				Subgroup
	A total length μm	B total length μm	C total length μm	D count number	DS diameter μm
0,5	≥ 37	≥ 17	≥ 18	≥ 1	> 13
1,0	≥ 127	≥ 77	≥ 76	≥ 4	≥ 19
1,5	≥ 261	≥ 184	≥ 176	≥ 9	≥ 27
2,0	≥ 436	≥ 343	≥ 320	≥ 16	≥ 38
2,5	≥ 649	≥ 555	≥ 510	≥ 25	≥ 53
3,0	≥ 898	≥ 822	≥ 746	≥ 36	≥ 76
3,5	$\geq 1\,181$	$\geq 1\,147$	$\geq 1\,029$	≥ 49	≥ 107
4,0	$\geq 1\,498$	$\geq 1\,530$	$\geq 1\,359$	≥ 64	≥ 151
4,5	$\geq 1\,848$	$\geq 1\,973$	$\geq 1\,737$	≥ 81	≥ 214
5,0	$\geq 2\,230$ ($< 2\,461$)	$\geq 2\,476$ ($< 3\,042$)	$\geq 2\,163$ ($< 2\,639$)	≥ 100 (< 121)	≥ 303 (< 429)
⋮	⋮	⋮	⋮	⋮	⋮

Table 3 — Inclusion width and diameter parameters

Type	Fine class		Thick class	
	μm	μm	μm	μm
A (width)	≥ 2	≤ 4	> 4	≤ 12
B (width)	≥ 2	≤ 9	> 9	≤ 15
C (width)	≥ 2	≤ 5	> 5	≤ 12
D (diameter)	≥ 2	≤ 8	> 8	≤ 13
NOTE Type D inclusions with a width less than $2\,\mu\text{m}$ are also not included in the inclusion rating.				

6 Sampling

6.1 The shape of the inclusion depends to a large extent on the reduction ratio of the steel; therefore, comparative measurements may only be carried out on prepared specimens taken from samples with a similar reduction ratio.

6.2 Unless something else is defined in the product standard or agreed by the parties involved, the polished surface of the specimen used to determine the content of inclusions should be about $200\,\text{mm}^2$.

6.3 When the cross-section thickness is not great enough, more than one specimen shall be taken from the same sampling location to conform to 6.2. Where reaching $200\,\text{mm}^2$ or more is onerous, the total length of the longitudinal pieces taken from each sampling location shall not be less than 100 mm. These specimens shall be analysed as one whole specimen.

6.4 Sections less than 0,71 mm in thickness shall not be analysed using this test method. Thinner sections stacked together without a gap may be considered as a single specimen $> 0,71\,\text{mm}$.

NOTE The narrowest cross section, or stack of cross sections, is limited by the field side length to 0,71 mm.

6.5 The method of sampling, including the sampling location and the number of sampling location, shall be defined in the product standard or subject to agreement between the parties. The test surface, in the case of plates, shall be approximately at a quarter of the width.

6.6 In the absence of such specifications, the sampling procedure should be as follows:

- bar with a diameter less than or equal to 25 mm: the surface to be examined consists of the full diametral section of length sufficient to obtain a surface conform to 5.2 (see [Figure 1](#));
- bar or billet with a diameter greater than 25 mm and less than or equal to 40 mm: the surface to be examined consists of at least half the diametral section (from the centre to the edge of the sample) (see [Figure 2](#));
- bar or billet with diameters greater than 40 mm: the surface to be examined consists of a part of diametral section located halfway between the outer surface and the centre (see [Figure 3](#));
- plate with a thickness less than or equal to 25 mm: the surface to be examined consists of the whole thickness, and located at the quarter of the width (see [Figure 4](#));
- plate with a thickness greater than 25 mm and less than or equal to 40 mm: the surface to be examined consists of at least half the thickness from the surface to the centre and is located at the quarter of the width (see [Figure 5](#));
- plate with a thickness greater than 40 mm: the surface to be examined consists of quarter the thickness and is located halfway between the outer surface and the middle of the thickness and at the quarter of the width (see [Figure 6](#));
- tube or pipe with a wall thickness less than or equal to 25 mm: the surface to be examined consists of the full diametral section of a length sufficient to obtain a sufficient surface, and, for welded products, located far away from the welding bead (see [Figure 7](#));
- tube or pipe greater than 25 mm: the surface to be examined consists of a part of the diametral section located halfway between the outer diameter and the inner diameter, and, for welded products, far away from the welding bead (see [Figure 8](#)).

6.7 The number of samples to be taken is defined in the product standard or by special agreement.

For any other product, the sampling procedures shall be subject to agreement between the parties.

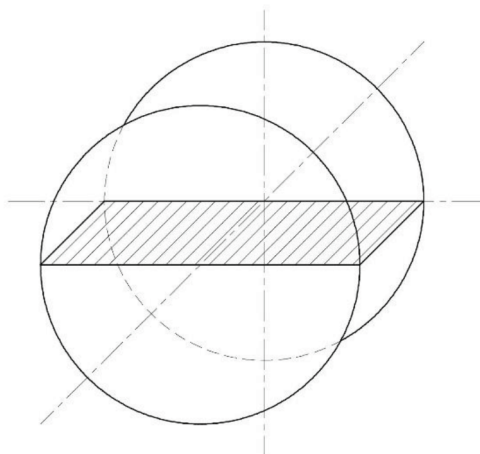


Figure 1 — Sample from bar with a diameter ≤ 25 mm

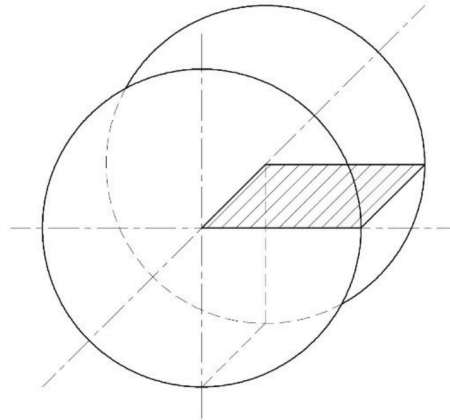


Figure 2 — Sample from bar or billet with a diameter or length of side > 25 mm and ≤ 40 mm

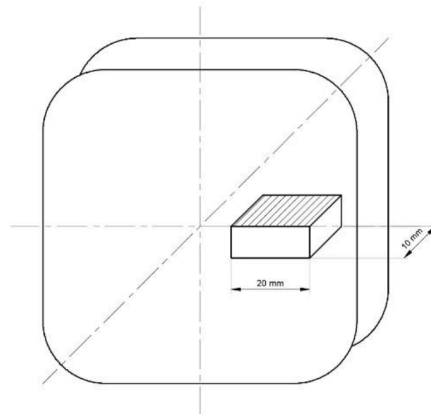
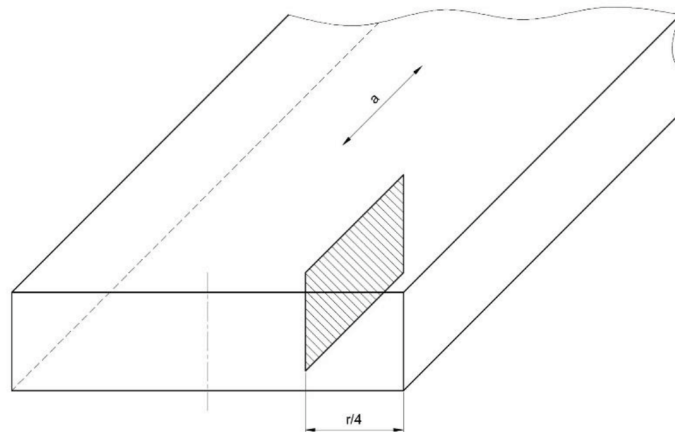


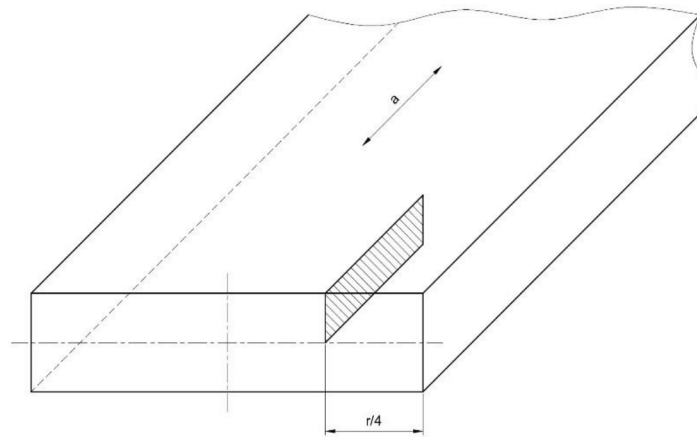
Figure 3 — Sample from bar or billet with a diameter or length of side > 40 mm



Key

- r width
- a rolling direction

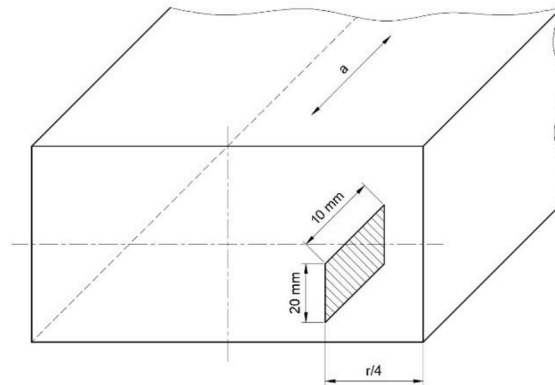
Figure 4 — Sample from plate with thickness ≤ 25 mm



Key

r width
 a rolling direction

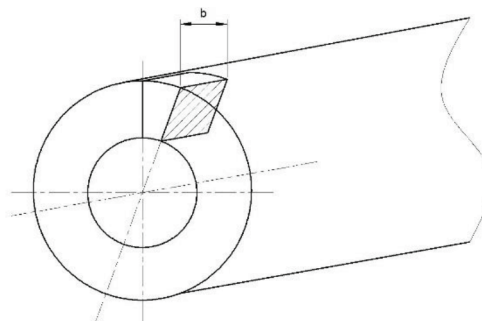
Figure 5 — Sample from plate with thickness > 25 mm and ≤ 40 mm



Key

r width
 a rolling direction

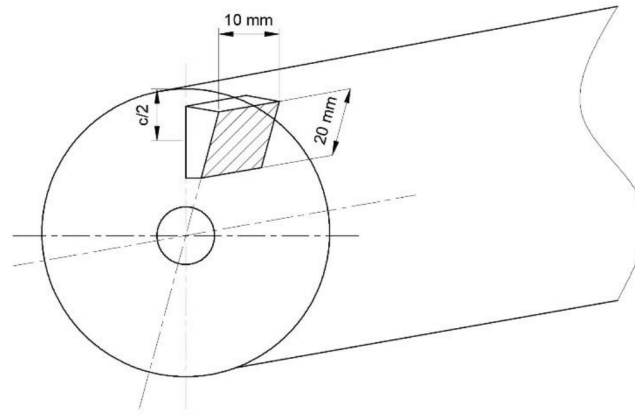
Figure 6 — Sample from plate with thickness > 40 mm



Key

b 10 mm

Figure 7 — Sample from tube or pipe with a wall thickness ≤ 25 mm

**Key**

c wall thickness

Figure 8 — Sample from tube or pipe with a wall thickness > 25 mm

7 Preparation of specimens

7.1 The specimen shall be cut so as to obtain a surface for examination. In order to achieve a flat surface and to avoid rounding the edges of the specimen when polishing, the specimen may be held mechanically or may be mounted.

7.2 When polishing specimens, it is important to avoid any tearing out or deformation of the inclusions, or contamination of the polished surface, so that the surface is as clean as possible, and the shape of the inclusions is not affected. These precautions are of particular importance when the inclusions are small. It is advisable to use diamond paste for polishing. In certain cases, it may be necessary for the specimen to be heat treated before polishing in order to give it the maximum possible hardness.

8 Determination of the content of inclusions

8.1 Method of observation

8.1.1 Examination with the microscope may be by one of two methods:

- by images on the computer screen, ground glass, or other similar device;
- by observation by means of an eyepiece.

8.1.2 The method of observation chosen shall be maintained throughout the test.

8.1.3 If the image is displayed on a computer screen, ground glass, or other similar device, the magnification shall be $100 \times \pm 2 \times$ on the screen. Place an overlay ([Figure 9](#)) of a 71 mm square ($0,50 \text{ mm}^2$ true area) over or behind the computer screen, ground glass, or other projection screen. The image within the test square is compared to the standard images on the chart ([Annex A](#)).

8.1.4 If the inclusions are examined through the microscope eyepieces, insert a reticle with the test pattern shown in [Figure 7](#) in the microscope at the appropriate location so that the test grid area is $0,50 \text{ mm}^2$ at the

image plane. In some cases, a magnification greater than $100\times$ may be used, provided that the same reference field size ($0,5\text{ mm}^2$) is applied for the standard images. This approach shall be recorded in the test report.

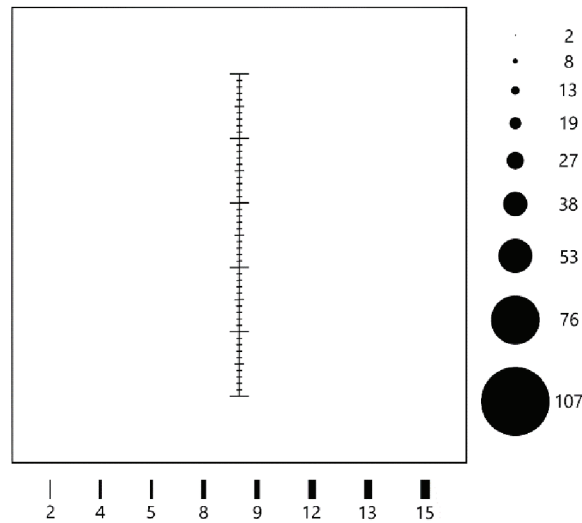


Figure 9 — Test pattern for grid overlays or reticles

8.2 Actual examination

8.2.1 General

Two methods are defined as described in [8.2.2](#) and [8.2.3](#).

8.2.2 Method A

Method A is a worst-field rating method. The entire polished surface is examined and, for each type and class of inclusions, a note is made of the index number i of the chart image which corresponds to the worst field examined.

8.2.3 Method B

8.2.3.1 The entire polished surface is examined, and each field of the specimen is compared with the chart images. The index number i of the field which best corresponds to the field examined for each type and class of inclusions is noted. An assessment example of inclusions of a field can be seen in [B.1](#) of [Annex B](#).

8.2.3.2 In order to minimize the cost of examination, it may be agreed upon to make a partial examination of the specimen by studying a reduced number of fields, distributed in accordance with a fixed scheme. Both the number of fields examined and their distribution shall be arranged by prior agreement. In general, at least 100 fields are examined.

8.2.4 General rules for methods A and B

8.2.4.1 Each field observed is compared with the chart images. If a field of inclusions falls between two chart images, it is rated following the lower image.

NOTE The presence of numerous elongated inclusions oriented in a consistently different direction from the presumed main deformation direction indicates a need to rotate the sample. The presence of numerous elongated inclusions oriented in various different directions indicates that the sample is not suitable for the standard.