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Mikrografsko ugotavljanje deleġa nekovinskih vkljuḷ kov v jeklih z uporabo standardnih slik

Micrographic examination of the nonmetallic inclusion content of steels using standard pictures

Metallographische Prüfung des Gehaltes nichtmetallischer Einschlüsse in Stählen mit Bildreihen

Détermination micrographique de la teneur en inclusions non métalliques des aciers a l'aide d'images-types

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English version

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This European Prestandard (ENV) was approved by CEN on 11 July 1997 as a prospective standard for provisional application.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Content

Foreword

This European Prestandard has been prepared by Technical Committee ECISS/TC 1 "Steel testing", the secretariat of which is held by AFNOR.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European prestandard establishes procedures for the assessment of inclusions in steels based on their morphology using standard pictures.

These procedures include principles that are coherent with physical results obtained from inclusion measurements.

The results are in physical units: number/mm², length in µm/mm², areas in µm² per mm². These results can be transposed into other standard's ratings for comparison purposes.

The conditions of assessements for instance the rules to scan fields on the specimen are defined such that there is an optimization between magnification and number of fields to be assessed. The precision level is achieved by using the same method in manual evaluation and measurements.

The chart of standard pictures is derived from mathematical principles.

The results and their precision may be directly computed from the fields assessments.

1 Scope

This Draft European prestandard defines a method of microscopic nonmetallic inclusion assessment using picture charts.

The method does not apply to inclusions of length less than 3 µm or smaller than 2 µm width. Defined by a product standard or an agreement between the involved parties for certain special products inclusions with a width below 2 µm can only be evaluated according to their length. Elongated inclusions above 1 410 µm long are counted separately and are beyond the upper limit of application of the prestandard. Globular inclusions of diameter 3,00 µm and above, are included in the assessment.

It is assumed, if particles are elongated or if there are stringers of particles, they are parallel to each other. Other arrangements are not covered by the prestandard. This prestandard applies to samples with a microscopic segregation approaching random distribution

From the data of measurements obtained by this method, evaluation according to other standards can be established.

The prestandard is not suitable for free cutting steels.

NOTE: The basic principle of the prestandard allows the determination of nonmetallic inclusion content by image analysis techniques.

2 Normative references

This Draft European prestandard 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 prestandard only when incorporated in it by amendment or revision. For undated references the lastest edition of the publication referred to applies.

ISO 9042
Steels – Manual point counting method for statistically estimations the volume fraction of a constituent with a point grid.

3 Principles

The method consists of a comparison between the inclusions observed in a field of view with a picture of the chart and taking into consideration separately each shape of inclusion. The pictures of the chart defined by this European prestandard are based on the shape of inclusions and for each shape on length, width and area, for columns 1 to 10 and number for column 11.

The prestandard employs only an ellipse as a basic shape with the circle as a special case of an ellipse (see figure 1a). Inclusions having a shape like a rectangle or a square are treated as ellipses or circles respectively since their areas are not significantly different for the purpose of this method.

The pictures are arranged in rows and columns. The length changes from row to row, the shape factor changes from column to column. The prestandard is principally concerned with the morphology and arrangement of inclusions. It does not provide information relevant to crystal structure or chemical constitution of measured inclusions.

The general practice usually requires differentiation between inclusions of different chemical composition. The definition of the types should be defined by the product standards. Should no standard be available, than the definition of characteristic morphologies shall be by agreement between the involved parties.

To make description easier, a tree of specific terms is given in Annex A, Figure A.1.

The pictures of the chart are the upper limits of classes. The length L_x is classified in row q if

$$L_{q-1} < L_x \leq L_q \ \mu\text{m}. \tag{1}$$

The width w_x is classified in column k if

$$w_{k-1} < w_x \leq w_k \ \mu\text{m} \tag{2}$$

In figure 5 the first row on the top without number and the first column on the left without number and a thicker surrounding contain the lower limiting pictures. Inclusions with a length shorter than that given in that row or a width smaller than that given in that column are not taken into account for classification.

Inclusions classified as column 6 are called globular.

The parameters measured are number, length, width and area. The results of the evaluations can give expressions of worst inclusion, worst field or an average field value all of which have physical dimensions. In addition to these values, the method gives an estimation of distribution of the inclusions within the test specimens.

The whole chart is mathematically based. It has a limited number of pictures which limits choice and hence improves reproducibility, when used in manual method. The mathematical basis permits use by manual and image analysis methods giving a potential for higher statistical precision. The data produced gives a wide range of features for cleanness definition. The chart employs different shapes and magnifications allowing an application to cleaner steels and where shape control is of interest.

The prestandard contains several different methods of evaluation. The choice of method shall be defined by the product standard or be agreed between the involved parties.

By default methods of evaluation used are the worst inclusion and the worst field method and for parameters given in Annex B.

4 Definitions

For the purpose of this prestandard the following definitions apply:

4.1 General

4.1.1 Particle: Single precipitate in general nonmetallic.

4.1.2 Inclusion: General designation of particles in association to be defined by size and proximity of particles. It describes a single, separated particle as well as an arrangement of at least 2 particles if the distance t (see figure 2a) is $\leq 10\ \mu$m and the distance e is $\leq 40\ \mu$m and the main axis of the particles are parallel within $\pm 10°$. In the case of an arrangement of only two globular particles each particle shall be considered as an individual inclusion. An inclusion can also be formed by two stringers if the distances t and e are $\leq 10\ \mu$m and $\leq 40\ \mu$m respectively (see figure 2b). Particles with $L < 3\ \mu$m or w $< 2\ \mu$m are not taken into account for the definition of an inclusion (see figure 2c).

Special cases

If elongated and more or less spherical particles are combined, see figure 2d, in general it is treated as one inclusion. Only in case 4, if $w_1 > 3 \times w_2$, then the particles w_1 and w_2 belong to are treated separately. For an example see figure 2e.

Some examples for inclusions are given in figure 2f.

4.1.3 Stringer: Arrangement of at least 3 particles normally aligned, forming an inclusion (see figures 2b, 2f), Examples see Annex C.

4.1.4 Test area: Area on the polished surface of the specimen to be evaluated. In general, the size of the test area is 200 mm².

4.2 Proximity

4.2.1 Distances between particles: Distance e between the particles in the direction of main deformation and distance *t* in the direction perpendicular to it (see figure 2a).

4.2.2 Distance between stringers: Similar to that for the distance between particles (see figure 2b).

4.2.3 Scattered: Random arrangement of particles. Example see annex C. This is defined in one field of view.

4.3 Parameters

4.3.1 Length: Dimension of an inclusion in the main direction of deformation. This value is always assumed to be greater than the width.

4.3.2 Diameter: Average dimension of inclusion classified according to column 6 (globular inclusion).

4.3.3 Width: It is the width of the ellipse having the same length and area as the particle.

For manual evaluation this value can only be estimated (see figure 2a). The width w of a multiparticle inclusion is given by the width of the greatest of the particles (see figure 2a).

The width of a stringer is defined as the width of an ellipse containing particles forming a stringer (see figure 1b). That width also is taken for defining *t* (see figure 2b). The width wi of the inclusions is given by the greatest width of the stringers forming the inclusion (see figure 2b).

4.3.4 Area: Area of the involved material defining the inclusion.

The area of involved material is built up by the area of the circumscribing ellipse of an inclusion (see figure 1b).

The area of an inclusion is calculated from its length *L* and its average width *w* according to the equation given in figure 1.

4.3.5 Shape factor: Exponent f in the equation

$$\frac{L^2}{a} = \frac{4}{\pi}\left(\frac{L}{c}\right)^f$$

For details see Annex D.

4.4 Classes

4.4.1 Elongated particles: Particles with elliptical shape, see figure 1a.

4.4.2 Globular particles: Circular or rectangular particles classified as column 6.

4.4.3 Type: The types of inclusions are separated according to their colour, shape and arrangement and not by chemical composition (see Annex A). The morphology also is based on the same characteristics.

4.5 Others

4.5.1 Lot: Unit of material processed at one time and subject to similar processing variables.

4.5.2 Restricted values: Values of the average field assessment restricted to inclusions greater than a defined length, shape factor or area.

5 Symbols and designations

symbol	unit	designation
a	μm²	area of inclusions
b		width of the plate
c	μm	factor, 1 μm
d		diameter of product
e	μm	interparticle distance (elongation axis)
f		shape factor

g		grey coloured (as sulphides)
h		pink coloured (as nitrides)
i		inclusion index
j		field index
k		column number
m		type of inclusion index
max		index of max. value of n, L, w, d, a (in j or s)
n		number of assessed particles, inclusions
n_s		number of assessed inclusions per specimen
o		black coloured (as oxides)
p		particle index
q		row number
r	µm	diameter of inclusions
s		specimen index
t	µm	interparticle distance (transverse axis)
u	µm	scale unit in microscope eyepiece
v		width of polished surface
w	µm	width of inclusions
x		variable
av or $\bar{}$		average value of n, L, w, a ....
α		scattered, elongated inclusion type
β		aligned, globular inclusion type
γ		aligned, elongated inclusion type
δ		scattered, globular inclusion type
A	µm²	area of field of view on the specimen
B		polished surface
D		main direction of deformation (e. g. rolling direction)
E	mm	length of test area
G	—	magnification
H	µm	length of measuring frame on the specimen
I		lengt of an stage micrometer
K	-,µm, µm²/mm²	average field assessment
L	µm	length of inclusions
M	-,µm, µm²/mm²	worst field assessment
N_j		number of fields
N_s		number of specimens
P		worst inclusion assessment
Q		factor for K-assessment
R		restricted values
W	mm	width of test area

Combined symbols can be written as index or on one line. Examples are:

K_L, KL	average field assessment for length
n_j, nj	number of inclusions in a field
$\bar{n}_j$, $\bar{n}j$	average number of inclusions per field

6 Sampling

Unless otherwise specified in the product standards, the following requirements apply.

6.1 Minimum reduction

The shape of the inclusions depends to a large extent on the degree of reduction of the steel. The chart can only be used if the shape of inclusions in the specimen can be compared with that given in the pictures of the chart.

NOTE: It is recommended that specimens should have a minimum reduction of 5 x. If the deformation is less than 5 x, care must be taken to differen tiate between porosity and inclusions, both of which may be present

6.2 Size and location of test area

The polished surface of the specimen used to determine the content of inclusions shall be a minimum of 400 mm² with a minimum length greater than 20 mm and a minimum width greater than 10 mm (e. g. 25 mm × 20 mm). It should be possible within this area to define a rectangular test area of 200 mm² for evaluation with a length to width ratio of 2 (e. g. 20 mm × 10 mm), the longer side of the test area shall be parallel to the direction of main deformation (e. g. rolling direction).

The sampling and the number of specimens shall be specified in the product standard or shall be subject to agreement between the parties.

In the absence of an agreement, the sampling procedure shall be as follows, see figure 3:

a) bar or billets with diameter above 50 mm, the test area shall be located halfway between the outer surface and the centre (see figure 3a).

b) bar with a diameter greater than 25 mm and less than or equal to 50 mm, the surface to be examined consists of half the diametral section (from the center to the edge of the specimen) (see figure 3b);

c) bar with a diameter less than or equal to 25 mm: the surface to be exami ned consists of the full diametral section of sufficient length to obtain a surface of about 400 mm² (see figure 3c);

d) plates with a thickness less than 25 mm, the specimen contains the whole thickness (see figure 3d);

e) plates with thickness between 25 mm and 50 mm: The specimen contains half the thickness, position between surface and centre;

f) plates with thickness greater than 50 mm: The specimen contains one quar ter of the thickness. The position is not defined.

The positions of the measuring planes for tubes are given in figure 3e.

For thin products one sample could comprise several specimens. In this case the test area is smaller than 200 mm² per specimen.

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

6.3 Number of specimens

Single specimens do not provide a representative index of the content of inclusions of a cast or a batch and therefore the test is to be carried out on a number of specimens. If the number of specimens to be taken is not defined in the product standard or by special agreement, the content of inclusions shall be determined on not less than six specimens.

6.4 Preparation of specimens

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.

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 appearance 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. The kind of lubricant can depend on inclusion type (water may not be an acceptable lubricant for certain types of inclusions). No particles of grinding or polishing agent shall be pressed into the polished surface. In certain cases it may be necessary for the specimen to be hardened before polishing in order to retain inclusions.

7 Test method

7.1 Magnification

The magnification G is defined only by the size of the measuring square frame on the specimen. To use the chart with different magnifications, the length H of the side of the measuring frame on the specimen shall have one of the three following values: H = 350 μm, H = 710 μm, H = 1 410 μm

These values shall be used with an accuracy of ±0.02 mm for manual evaluation. The area A of one measuring frame on the specimen is given in table 1:

Table 1

H in μm	A in mm²
350	0,13
710	0,5
1 410	2,0

Examples see Annex E.

The length of 710 μm is to be used if nothing else is specified. If it is not possible to use this value, other magnifications can be used and shall be recorded. The magnification shall not be changed during one measurement.

NOTE: The lengths of
H = 350 μm is corresponding to a magnification of 200 x
H = 710 μm is corresponding to a magnification of 100 x
H = 1 410 μm is corresponding to a magnification of 50 x.

7.2 Field of view

At a magnification corresponding to H = 710 μm the square frame is given by an etched glass in the eyepiece graticule, as defined in figure 4a. For broad field microscopes, the etched glass defined in figure 4b may be used.

Additional information is drawn on the edged glass see Annex F, information concerning the manufacturing of the graticules is given in Annex G.

One scale unit in the eyepiece is about 10 μm for H = 710 μm. The correct value must be checked by a calibration.

If a screen is used, the same rules are valid.

7.3 Definition of the pictures of the chart

7.3.1 Size and Shape

The shape of the inclusions is assumed to be an ellipse, see figure 1. From this ideal shape the actual pictures are drawn to have an appearance as realistic as possible with variation of size and shape, see figure 5. The rules for constructing the pictures are summarised in Annex H.

NOTE: Small inclusions are visible only in the pictures of the original size in the official chart, not in figure 5.

7.3.2 Parameters

For manual evaluation the parameters number n, length L and width w of the inclusions are taken into account. The area can be calculated using these parameters or estimated from the data of the pictures given in table 2 (see clause 8).

7.3.3 Arrangement of the pictures

The pictures of the chart are arranged in horizontal rows q and vertical columns k (see figure 5). Columns 1 to 5 contain ellipses with different width representing elongated inclusions. Column 6 are circles describing globular inclusions. Columns 7 to 10 present globular particles arranged as stringers. The dimensions correspond to the values given for columns 1 to 5. Column 11 shows just different numbers of inclusions per field to replace counting by estimation (see 7.4.2).

On the left the squares not numbered show inclusions with a width of 2 μm, on the top inclusions with a length of 3 μm, both are the lower limits of evaluation. Below the pictures the type of the inclusions according to Annex A is shown.

The pictures are upper limits of classes. The class is denoted by the number of row q and the column k in this sequence.

EXAMPLE:
The designation of class 3.4 denotes the class row 3, column 4.
For details see Annex K.

7.4 Procedure

7.4.1 General

The prepared specimen is put under the microscope and in general the magnification corresponding to a frame width H of 710 μm (100 x) is used. In each field of view inclusions are compared with the pictures of the chart estimating first the number of row and second the column of the class for inclusions in the field of view. For this comparison a chart in original size shall be used, not the pictures of figure 5. The pictures are upper limits of the classes (see clause 3 and Annex K). To make comparison more easy, the eyepiece graticules may be used (see figure 4). The scale dimensions are correct only for the magnification for which the eyepiece was designed for. In addition to their size inclusions may be classified by the colour, shape and arrangement (see Annex A).

7.4.2 Several inclusions of mixed sizes in one field

To make the manual evaluation more simple where many inclusions occur in one field of view, the following approximations can be employed.

7.4.2.1 Elongated inclusions

Length, width or area (indirectly). Up to 3 inclusions are evaluated separately. If there are more than three inclusions in one field of view, evaluation shall be done in three steps.

a) Inclusions with a length greater than a quarter of the length of the longest inclusion present are evaluated as individuals according to the chart.

b) For the rest of the inclusions the average length of all inclusions and the average width are determined. Chart classification (row, column and number) is established using these parameters.

c) The number of inclusions is recorded for the class defined in step b). This number can be estimated using column 11 (see figure 5).

7.4.2.2 Globular inclusions

If the inclusions are greater or equal than 11 μm, then each shall be evaluated separately. In other cases evaluation shall be done in three steps:

a) Inclusions with a diameter greater than half the diameter of the largest inclusions in the field are evaluated as individual according to the chart.

b) For the rest of the inclusions the average diameter is estimated and chart classification is done by comparison with the pictures of column 6.

c) The number of inclusions is determined and recorded for that class. This number can be estimated using column 11 (see figure 5).

7.4.3 Scanning

For the worst inclusion assessment and the worst field assessment the whole test area must be scanned field by field. For the average field assessment there are different methods (see 8.3).

7.4.4 Assessment and evaluation

Three types of assessments are defined and used in agreement with the customer or the product standard:

a) the worst inclusion assessment (see 8.1),
b) the worst field assessment (see 8.2),
c) the average field assessment (see 8.3).

For average field assessment the evaluation can be restricted to inclusions greater than a limit defined by length, diameter or area or made separately for each column. These restrictions shall be specified in the product standards.

7.4.5 Evaluation of different types of inclusions

This prestandard refers only to size, shape and arrangement of inclusions. As additional elements colours can be taken into account (see Annex A). More informations and examples are given in Annex C.

Classes of inclusion types and arrangement can be compared with those of other standards (see Annex L).

7.4.6 Default assumptions

If there is no other agreement, the parameters and assessments listed in Annex B are taken as default.

7.4.7 Recording of results

For recording and final calculations of results it is recommended to use the sheets of Annexes M, N and P or derived arrangements adopted to the needs of the laboratory.

As default heterogenous inclusions partly or completely encapsulated (type EAD) shall be considered as one particle.

The product standard or agreement between the parties shall establish for inclusions with mixed particles such as figure 2d, example 2, whether the two different types are one particle or two types of particles mixed. In the latter case both types of mixed particles are treated as inclusion and the particles shall be considered separately for evaluation.

Values of the final results which are smaller than 10 are recorded as real with two figures, all other values are rounded up to an integer.

8 Types of assessment

8.1 Worst inclusion method: method P

8.1.1 Principle

The whole test area must be scanned field by field. The field size is $H = 710\ \mu m$ in any case, see clause 7.1. On each test area, for each type of inclusion, only the inclusion having the greatest value of the selected parameter
(L, r or a) is evaluated by comparison with the chart and recorded.

An inclusion crossing the measuring frame can be resited by a stage movement to lie within the frame.

The result of the evaluation is the average of the individual values of the N_s assessed specimens.

The equations for this method are given in Annex Q.

Assessment and computation sheets with comments and examples are given in Annex M.

8.1.2 Evaluation of P_L (worst length)

Evaluation can be made as rating according to the length method P_L. In this case just the row number of the greatest inclusion in the test area is recorded following the pictures of the chart. The final result P_L is the average of the N_s samples.

8.1.3 Evaluation of P_r (worst diameter)

This evaluation is valid for globular inclusions. The assessment is similar to that of P_L, but restricted to column 6.

8.1.4 Evaluation of P_a (worst area)

Evaluation can be made as rating according to area, method P_a. Only the inclusion with the greatest area is recorded. This is realized by a classification according to length and width and using the appropriate row and column-number to pick up the area from table 2.

8.2 Worst field method: method M

8.2.1 Principle

The M value is evaluated by scanning the whole test area field by field. The field size is H = 710 μm (100 x), in any case (see 7.1). The evaluation is made per field according to the chart.

On each specimen and each type of inclusions only for the field containing the greatest value of the selected parameter (n, L, w or a) the corresponding row and column are recorded.

An inclusion crossing the measuring frame can be resited by a stage movement to lie within the frame.

The result of the evaluation is the average of the individual values of the N_s assessed specimens.

Assessment and computation sheets are given with comments and examples in the annex N. The equations this method is based on, are given in Annex Q.

8.2.2 Evaluation of M_n (rating according to number)

For each specimen only the greatest number of inclusions per field M_{ns} is recorded per inclusion type.

If there are few inclusions, they are counted. If not, their number can be estimated by using figure 5, column 11. For N_s specimens, M_n is the average of the individual values M_{ns}.

8.2.3 Evaluation of M_L (rating according to length)

For the test areas of each specimen s the worst field is the one with the maximum summated length of a particular inclusion type. For one specimen this value is M_{Ls}.

For N_s specimens, M_L is the average of the individual values M_{Ls}.

8.2.4 Evaluation of M_r (rating according to diameter)

For N_s specimens, M_r is the average of the individual values M_{rs} evaluated like the values of M_L.

8.2.5 Evaluation of M_a (rating according to area)

The worst field is the one with the maximum summated area of a particular inclusions type. For one specimen this value is M_{as}.

8.3 Average field method: method K

8.3.1 Principle

The K value is an average of a parameter for a statistically significant number of fields. The K value is evaluated on scanning the test area totally or until a desired level of confidence is reached (see clause 8.3.2).

The K value can be calculated:

a) for number, or number and length, or number and area for elongated inclusions,

b) for number, or number and diameter, or number and area for globular inclusions.

The total number of assessed fields, including empty fields, shall be counted.

Assessment and computation is done for a level of confidence of 60 %, if there is no other agreement or product standard.

The equations, this method is based on, are given in Annex Q, T and U. Assessment and computation sheets are given with comments and examples in Annex P.

8.3.2 Scanning of a specimen for average field assessment

The test area can be scanned randomly or field by field. The longer side of the test area (rolling direction) shall be orientated within ±10° parallel to the vertical direction (or the axis y, see figure 4). Random scanning as described in 8.3.2.2 shall be used only if all inclusions are taken into account, not for evaluation of restricted values.

8.3.2.1 Definition of assessment conditions

During the verification of the quality of specimen preparation or from experience, at x100 magnification, the operator will estimate number and average length or average diameter for the most critical types of inclusions. Then, Annex R allows to determine magnification and minimum number of fields to assess for a defined level of confidence.

8.3.2.2 Random scanning

Random scanning allows the operator drastically to reduce the number of fields to assess for a predetermined level of confidence. The following rules shall apply:

a) Random scanning concerns only the main direction of deformation

b) Each transverse scan shall be continuous across the width and contain the same number of fields until the number of inclusions and the number of fields reaches

1) 25 inclusions for 60 % level of confidence, with a minimum of 30 fields

2) 100 inclusions for 80 % level of confidence, with a minimum of 50 fields

Annex R defines the use of microscope stage for manual or programmed displacements. For programmed scan the location of the successive transverses shall be randomly choosen.

8.3.2.3 Complete scanning

As an alternative to random scanning the whole test area shall be scanned whatever the magnification.

For any evaluation of values including sizing an edge error correction shall be made to make sure that inclusions are counted only once (see Annex S).

8.3.3 Evaluation

8.3.3.1 Complete evaluation

The values of the parameter as defined by the classification (see Annex K), are upper values. For the evaluation of the average values the values of the parameters are averaged for each class. The calculation is given in Annex T. Only the result of that calculation is needed and therefore repeated in the recording sheets (see Annex P). Independent of the magnification used, the rating follows always the classification described by Annex K using the chart. Of course, an inclusion with length of 70 μm would be classified according to row 4 at a magnification of H = 1 410 μm (50x) to row 5 at a magnification of H = 710 μm (100x) and row 6 at a magnification of H = 350 μm (200x). But this is corrected by the averaging factor Q (see table U.1).

8.3.3.2 Restricted evaluation

Before evaluation it may be decided to record only inclusions above a certain value e. g. those of length above row 4 of the chart etc. Details are given in Annex P, tables P.6 and P.7 and Annex Q.3.

8.3.4 Evaluation of K_n, K_L for elongated and K_n, K_r for globular inclusions

For each specimen the number of inclusions are classified field by field for each type of inclusion according to the rows of the chart. An example is given in table P.2.

For the number of fields to be assessed, see 8.3.2. After finishing the scan, the total number of inclusions per row is recorded as in table P.2 with the number of fields evaluated. The total area scanned is derived from that.

The results are calculated using a second sheet, e. g. as in table P.3.

This second sheet gives all the informations to calculate K_n and K_L for α, γ, β elongated inclusions and K_n, K_r for δ globular inclusions. These sheets enable the calculation of the average inclusion size per type.

8.3.5 Evaluation of K_n and K_a

Each specimen is rated field by field, counting the number of inclusions according the row and column value.

For the number of fields see 8.3.2. Details of evaluation can be derived from Annex P or the equations given in Annexes Q, T and U.

The method of K_a can not be used to measure true volume fraction. This is defined in ISO 9042.

9 Test report

The test results shall be given in accordance with EN 45001 and the test report shall contain the following informations:

a) reference to this European Prestandard;

b) steel grade and when applicable symbol identifying the steelmaking process;

c) form and dimension of product from which the specimens have been taken;

d) method used as described in clause 8, together with any special condition;

e) result of the evaluation, according to the requirement of the product standard or by special agreements between the parties;

f) anything not being quite correct during the test;

g) the magnification used if other than 100 x.

Table 2: Length, width, area and length to width ratio L/w and shape factor for the pictures of the chart

			Single and aligned elongated inclusions and stringers of globular inclusions columns 1 to 5 and 7 to 10 Length $L \geq 3$ µm and width $w \geq 2$ µm					Globular inclusions column 6 diam $r \geq 3$ µm
Row *q*	*L* µm		1 or 7	2 or 8	3 or 9	4 or 10	5	6
1	5,5	*w* µm			2,0			5,5
		a µm²			9			24
		L/w			2,70			1
		f			0,58			0
2	11	*w* µm			3	8		11,0
		a µm²			25	71		95
		L/w			3,8	1,34		1
		f			0,56	0,12		0
3	22	*w* µm			4	12		22,0
		a µm²			71	200		380
		L/w			5,4	1,9		1
		f			0,55	0,21		0
4	44	*w* µm		2	6	16		44,0
		a µm²		71	200	565		1525
		L/w		22	7,6	2,7		1
		f		0,81	0,54	0,26		0
5	88	*w* µm		3	8	23	65	88,0
		a µm²		200	565	1600	4525	6100
		L/w		30	11	3,8	1,3	1
		f		0,76	0,53	0,3	0,07	0
6	176	*w* µm		4	12	33	93	176,0
		a µm²		565	1600	4525	12800	24500
		L/w		43	15	5,4	1,9	1
		f		0,73	0,53	0,33	0,12	0
7	353	*w* µm	2,0	6	16	46	131	
		a µm²	566	1600	4525	12800	36200	
		L/w	177	61	22	7,6	2,7	
		f	0,88	0,7	0,52	0,35	0,17	
8	705	*w* µm	3	8	23	65		
		a µm²	1600	4525	12800	36200		
		L/w	244	86	30	11		
		f	0,84	0,68	0,52	0,36		
9	1410	*w* µm	4	12	33	93		
		a µm²	4525	12800	36200	102400		
		L/w	345	122	43	15		
		f	0,81	0,66	0,52	0,38		