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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates —

Part 3 : Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Focusing microscope procedure

Préparation des subjectiles d'acier avant application de peintures et de produits assimilés — Caractéristiques de rugosité des subjectiles d'acier décapés —

Partie 3 : Méthode pour étalonner les échantillons de comparaison viso-tactile ISO et pour caractériser un profil de surface — Utilisation d'un microscope optique

Reference number
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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.

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.

International Standard ISO 8503-3 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates —

Part 3 : Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Focusing microscope procedure

0 Introduction

The performance of protective coatings of paint and related products applied to steel is significantly affected by the state of the steel surface immediately prior to painting. The principal factors that are known to influence this performance are

a) the presence of rust and mill scale;

b) the presence of surface contaminants, including salts, dust, oils and greases;

c) the surface profile.

International Standards ISO 8501, ISO 8502 and ISO 8503 have been prepared to provide methods of assessing these factors, while ISO 8504 provides guidance on the preparation methods that are available for cleaning steel substrates, indicating the capabilities of each in attaining specified levels of cleanliness.

These International Standards do not contain recommendations for the protective coating systems to be applied to the steel surface. Neither do they contain recommendations for the surface quality requirements for specific situations even though surface quality can have a direct influence on the choice of protective coating to be applied and on its performance. Such recommendations are found in other documents such as national standards and codes of practice. It will be necessary for the users of these International Standards to ensure that the qualities specified are

— compatible and appropriate both for the environmental conditions to which the steel will be exposed and for the protective coating system to be used;

— within the capability of the cleaning procedure specified.

The four International Standards referred to above deal with the following aspects of preparation of steel substrates :

ISO 8501 — *Visual assessment of surface cleanliness*;

ISO 8502 — *Tests for the assessment of surface cleanliness*;

ISO 8503 — *Surface roughness characteristics of blast-cleaned steel substrates*;

ISO 8504 — *Surface preparation methods.*

Each of these International Standards is in turn divided into separate parts.

The optical microscope is one of the most widely used instruments for measuring surface profile. The method can be used by any laboratory equipped with a good microscope that has a calibrated focusing mechanism meeting the requirements of 5.1. This procedure may also be used to determine the profile of a substrate after abrasive blast-cleaning either directly or from a replica.

This method is based on that developed in the USA by the Steel Structures Painting Council. It entails averaging a series of maximum peak-to-valley measurements obtained by focusing a specified microscope — first on the highest peak and then on the lowest valley in the same field of view, noting the distance of movement of the stage (or objective).

This method has the disadvantage of requiring a series of tedious measurements, but good precision and agreement between laboratories and between operators can be obtained by specifying closely the field of view and depth of field of the microscope. To avoid a widespread divergence in measuring profile within and between laboratories, this method requires a significant number of measurements as well as correct calibration, proper focus movement, standardized depth of field and field diameter of the microscope necessary to measure properly both coarse and fine profiles under a single set of conditions.

ISO 8503-4 describes the procedure using a stylus instrument. ISO 8503-1 specifies the requirements for ISO surface profile comparators and ISO 8503-2 describes their use. The many abrasive blast-cleaning procedures in common use are described in ISO 8504-2.

1 Scope and field of application

1.1 This part of ISO 8503 specifies the focusing microscope and describes the procedure for calibrating ISO surface profile comparators complying with the requirements of ISO 8503-1.

1.2 This part of ISO 8503 is also applicable to the determination of the surface profile, within the range $\overline{h}_y$ = 20 to 200 µm, of essentially planar blast-cleaned steel. The determination may be carried out on a representative section of the blast-cleaned substrate or, if direct observation of the surface is not feasible, on a replica of the surface (see annex E).

NOTE — Where appropriate, this procedure may be used for assessing the roughness profile of other abrasive blast-cleaned substrates.

An alternative procedure is described in ISO 8503-4.

2 References

ISO 4618, *Paints and varnishes — Vocabulary.*

ISO 8503, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates*

— *Part 1 : Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.*

— *Part 2 : Method for the grading of surface profile of abrasive blast-cleaned steel — Comparator procedure.*

— *Part 4 : Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure.*

ISO 8504-2, *Preparation of steel substrates before application of paints and related products — Surface preparation methods — Part 2 : Abrasive blast-cleaning.*[1]

3 Definitions

For the purpose of this part of ISO 8503, the definitions given in ISO 4618 and ISO 8503-1 apply.

4 Principle

Observation of the test surface over a specified field of view using a specified microscope. Adjustment of the microscope, by movement of the objective (or the stage), to focus on the highest peak within the field of view. Determination of the distance h_y moved by the objective (or the stage) in order to focus on the lowest valley within the same field of view.

Repetition of the procedure to obtain values for a further 19 different fields of view and calculation of the arithmetic mean of the distance h_y between the highest peak and lowest valley in each field of view as the mean maximum peak-to-valley height $\overline{h}_y$.

5 Apparatus

5.1 Optical microscope, having a fine focus adjustment with little or no backlash (play) (see clause A.5 in annex A). The adjustment shall give fine control of the movement of the objective or stage and shall be fitted with a graduated vernier scale having a scale value of not more than 1 µm. The microscope shall have an objective lens with a numerical aperture of not less than 0,5 together with an eyepiece lens to give a field of view greater than 0,5 mm in diameter. The field of view may be reduced by the use of a circular eyepiece reticle or by a stop in the lamphouse.

NOTE — Advice concerning the use of the microscope is given in annexes A and D. Annex A describes a procedure for determining the microscope backlash. Annex D explains the significance of the defined variables for the microscope. (See also the note to 5.2.)

5.2 Light source, fitted to the microscope (5.1) to illuminate the test surface perpendicular to its plane. Light filters may be used to minimize glare.

NOTE — These requirements for the apparatus (5.1 and 5.2) are generally met by microscopes for metallurgical purposes.

6 Test surfaces

6.1 ISO surface profile comparator

Visually check that each segment of the ISO surface profile comparator (see ISO 8503-1) that is to be calibrated is undamaged. Lightly clean the surface with a dry, fine bristle brush to remove any particles of dust and then, using a similar brush, wash the surface with petroleum spirit, 40/60 (commercial grade), to remove oil and grease residues. Allow to dry before carrying out the calibration.

Calibrate each segment of the comparator as described in clause 7.

6.2 Blast-cleaned steel substrates/replica

Visually check that the surface that is to be measured is undamaged. Lightly clean the surface with a dry, fine bristle brush to remove any particles of dust and then, using a similar brush, wash the surface with petroleum spirit, 40/60 (commercial grade), to remove oil and grease residues. Allow to dry before carrying out the procedure.

Determine the surface profile as described in clause 7.

NOTE — If a replica (see annex E) is to be measured, clean it only with a dry brush.

7 Procedure for measurement of maximum peak-to-valley height h_y

7.1 Locate the test surface (clause 6) under the objective of the microscope (5.1) so that the measurements are taken on a test area not less than 5 mm from any edge. Adjust the light

1) At present at the stage of draft.

source (5.2) to illuminate the test area, normal to the plane of the surface. Focus the microscope approximately on the surface.

7.2 Raise the objective until no part of the test area is in focus (see the notes). Then slowly lower the objective, using the fine adjustment knob, until the first point in the observed area just comes into focus. On the form given in annex C, record the reading r_1 on the vernier scale as the height of the highest peak in that field of view.

NOTES

1 On some microscopes, the objective is fixed and the stage is movable. Adjustment of focus is achieved by raising or lowering the stage.

2 It is recommended that focusing should always be carried out in the same direction (see clause D.2).

7.3 Lower the objective until no part of the test area is in focus (see the notes to 7.2). Then slowly raise the objective until the first point in the observed area just comes into focus. On the form given in annex C, record the reading r_2 on the vernier scale, corrected for any backlash (see annex A), as the depth of the lowest valley in that field of view. If the reading cannot be corrected for backlash in the microscope movement, continue to raise the objective until the lowest valley is no longer in focus. Then slowly lower the objective until the lowest valley is once more in focus. Record the reading r_2 on the vernier scale as the depth of the lowest valley in that field of view.

7.4 The difference between the readings $(r_1 - r_2)$ is the maximum peak-to-valley height h_y for that field of view.

7.5 Repeat the procedure described in 7.2, 7.3 and 7.4 until the maximum peak-to-valley height has been determined for 20 completely different fields of view, uniformly distributed over the test surface, but not less than 5 mm from any edge.

8 Calculation and expression of results

8.1 Calculate the mean value $\overline{h_y}$ and the standard deviation for the 20 maximum peak-to-valley readings h_y for each test surface.

If the standard deviation obtained is *less* than one-third of the mean, report the standard deviation and the result as the "mean maximum peak-to-valley height $\overline{h_y}$".

8.2 If the method is used to calibrate an ISO surface profile comparator and if the standard deviation obtained is *more* than one-third of the mean result, repeat the procedure (clause 7), and obtain the mean and standard deviation for the 40 readings. If the standard deviation is still more than one-third of the mean, reject the comparator as the profile is of inadequate uniformity.

8.3 If the method is used to determine the profile of a blast-cleaned surface, either directly or from a replica, report $\overline{h_y}$, together with the standard deviation and the maximum reading of h_y to indicate the degree of uniformity of the surface roughness.

9 Test report

The form of the test report is given in annex B and shall contain at least the following information :

a) the identification of the ISO surface profile comparator and the segments tested or, if the profile of a steel substrate was determined, the identification of the steel substrate and whether a replica of the substrate was used;

b) a reference to this part of ISO 8503 (ISO 8503-3);

c) the magnification of the objective lens, and its numerical aperture;

d) the magnification of the eyepiece lens and of any intermediate magnification;

e) the diameter of the field of view of the test area;

f) the total magnification of the microscope;

g) the result of the test as indicated in clause 8 and, if the profile of an ISO surface profile comparator was determined, the limits for the comparator (see 8503-1);

h) any deviation, by agreement or otherwise, from the procedure described and, if the profile of a steel substrate was determined on a replica, the method of preparation of the replica (see annex E);

i) the name of the operator;

j) the date of the test.

Annex A

Determination of backlash (play) in the microscope adjustment mechanism

(This annex forms an integral part of the Standard.)

A.1 Carry out the following procedure using the microcope (5.1) but with the magnification increased to between X 360 to X 450.

A.2 Place an ISO surface profile comparator (6.1) on the stage of the microscope so that the area to be examined is not less than 5 mm from any edge. Adjust the light source to illuminate the test area normal to the plane of the surface. Focus approximately the microscope on the surface.

A.3 Raise the objective (see note 1 to 7.2) until no part of the test areas is in focus. Slowly lower the objective using the fine adjustment knob, until the first point (i.e. the highest peak) in the observed area just comes into focus. Record the reading (p_1) of the vernier scale.

Repeat this procedure *without moving the comparator* until 20 readings have been obtained, and then calculate their mean ($\overline{p_1}$).

A.4 Without displacing the comparator, lower the objective until the highest peak is no longer in focus. Slowly raise the objective until the highest peak in the observed area just comes into focus. Record the reading (p_2) of the vernier scale.

Repeat this procedure without moving the comparator until 20 readings have been obtained, and then calculate their mean ($\overline{p_2}$).

A.5 Calculate the backlash as the difference ($\overline{p_1} - \overline{p_2}$) and provided that the value is not greater than 3 µm, use this value in 7.3. If the value is greater than 3 µm, reject the microscope.

Annex B

Test report for the calibration of ISO surface profile comparators and for the determination of surface profiles

(This annex forms an integral part of the Standard.)

1. Test laboratory and address					
2. Test surface identification a) ISO surface profile comparator b) steel substrate/replica[1)]					
3. International Standard reference	ISO 8503-3				
4. Microscope details Objective lens magnification Objective numerical aperture Intermediate magnification[2)] Eyepiece magnification Diameter of field of view Total magnification	 X............ NA .... X............ X............ ....mm X............				
5. Results[3)]	Nominal reading	Mean value $\bar{h}_y$ µm	Maximum reading of h_y µm	Standard deviation	
Segment 1					
Segment 2					
Segment 3					
Segment 4					
Steel substrate/replica[4)]					
6. Any deviations from the standard procedure[2)]					
7. Name and position of person authorizing the deviations (see 6 above)					
8. Date of present test(s)					
9. Date(s) of any previous test(s)[2)]					
10. Name of operator					

1) If profile measurement is of i) a steel substrate or ii) a replica, give details.

2) If applicable.

3) See separate form (annex C) for actual readings.

4) Delete as appropriate.

Annex C

Form for recording surface profile measurements made in accordance with ISO 8503-3

(This annex forms an integral part of the Standard.)

Test laboratory and address

Objective lens magnification X.............
Objective lens numerical aperture NA ....
Eyepiece magnification X.............
Intermediate magnification X.............
Diameter of field of view ....mm
Total magnification X.............

Item reference[1] a) ISO surface profile comparator
b) Steel substrate/replica[2]

Reading[3] No.	Segment 1[4]			Segment 2			Segment 3			Segment 4		
	r_1	r_2	h_y	r_1	r_2	h_y	r_1	r_2	h_y	r_1	r_2	h_y
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
Mean = $\overline{h}_y$												
Maximum h_y reading												
Minimum h_y reading												
Standard deviation												

1) Delete as appropriate.
2) If profile measurement is of i) a steel substrate or ii) a replica, give details.
3) All readings in micrometres.
4) Replace by "steel substrate" or "replica", if applicable.

Annex D

Guidance notes for calibrating ISO surface profile comparators using a focusing microscope

(This annex does not form an integral part of the Standard.)

D.1 Depth of field and field diameter

When using an optical microscope, the choice of lenses available to obtain the magnification required for observations dictates the depth of field and the maximum field diameter. The depth of field is controlled by the numerical aperture of the objective lens which permits the accurate determination of peak heights and valley depths. However, the smaller field diameter that results from the use of a high numerical aperture lens and the consequent higher magnification, may fail to contain an adequate representation of high peaks and low valleys. At lower magnifications, the field diameter is larger and hence representative peaks and valleys are more likely to be present, but the coarser depth of field may prevent a precise determination of their respective heights.

The distribution of the magnification between the objective and eyepiece lenses is important in controlling the depth of field. When a magnification of X 150 is required, the selection of a X 10 objective and a X 15 eyepiece would comply. However, a typical X 10 objective has a numerical aperture of 0,26 and would give a depth of field of about 7 µm. By selecting a X 20 objective with a numerical aperture of not less than 0,5, *the depth of field* is reduced to the acceptable value of 2 µm. The field diameter is in inverse relation to the total magnification, the latter being obtained by multiplying the magnification of the individual lenses in the microscope system. Many microscopes have a fixed intermediate lens which usually adds a factor of X 1,25 or X 1,5.

When these considerations are taken into account along with the desire to produce a test method for measuring the surface profiles of ISO comparators, it is necessary that standard requirements be specified in order to obtain figures aligning with visual and tactile assessments. By controlling the numerical aperture of the objective lens and the field of view, the magnification is indirectly controlled. To meet the requirement for an objective with a numerical aperture not less than 0,5 and a field of view greater than 0,5 mm diameter, a microscope with an objective lens of X 20, a numerical aperture of 0,5 and an eyepiece lens of X 10 is typical and provides a total magnification of X 200.

D.2 Focus movement

Normal microscopy procedures require the final focusing movement to be always made in the same direction. However, the procedure outlined in clause 7 suggests that, for a microscope with a fine adjustment mechanism that is free from backlash (play), the direction of the final focusing movement for the valley depths can be the opposite of that used when measuring the peak heights. This deviation is permitted in order to increase substantially the speed of operation, because a fine adjustment mechanism that is free from backlash would introduce no error when focusing from opposite directions.

Therefore, if the fine adjustment mechanism of the microscope has backlash, it is imperative either that the final focus movement be *always* made in the *same* direction to prevent the introduction of error or that the backlash determined in clause A.5 of annex A be used.

Obviously, the procedure for a microscope where its fine adjustment mechanism is free from backlash is much easier for the observer and is more efficient. Therefore, it is suggested that every effort be made to ensure the proper movement of the fine adjustment mechanism.

Annex A gives the procedure for determining the backlash in the fine adjustment. Using this procedure, a particular instrument can be inspected and the necessary corrections implemented.

D.3 Variability of surface profile

To obtain a representative value for the surface profile of abrasive blast-cleaned structural steel, it is necessary to average at least 20 maximum peak-to-valley heights h_Y obtained by using the procedure described in clause 7. This average, known as the mean maximum peak-to-valley height $\overline{h_Y}$, minimizes irregularities caused by rogue peaks, cracks, hackles, etc.

The standard deviation for a set of 20 peak-to-valley measurements that have been carried out correctly is usually between 15 % and 25 % of the mean of the measurements. Thus, a standard deviation greater than 33 % of the mean indicates an unacceptably high variability in the measuring procedure or in the test area, and a further set of peak-to-valley measurements is to be made to establish whether the initial set of readings was representative (see clause 8).

Annex E

Guidance notes for the preparation and measurement of replicas

(This annex does not form an integral part of the Standard.)

When the test method is used to verify the profile of a steel substrate, it is usually impractical to obtain a small sample of the actual surface whose profile is to be determined. In this case, it is still possible, by examining a replica of the steel surface, to determine the surface profile.

A replica produces the reverse of the metal surface (that is, the peaks of the steel substrate become the valleys of the replica and the valleys of the steel become the peaks of the replica), but this reversal does not affect the validity of the measurement methods described in ISO 8503-4 and this part of ISO 8503.

A variety of replicating techniques is available including solventless two-component organic polymers that cross-link to give a hard solid surface. These polymers may have disadvantages in that they do not penetrate into the deepest, sharpest valleys and that a release agent may be required. They provide, however, a hard enough surface to enable the stylus measurements described in ISO 8503-4 to be made.

A two-component pigmented silicone rubber product has also been used with success. Its initial viscosity and flexible nature when cross-linked mean that penetration into re-entrants of grit-blasted profiles, and subsequent removal, is good. Due to its softness, however, measurement is restricted to the microscope method described in this part of ISO 8503.

Before any replicating technique is used, it should be examined for accuracy by replicating at least five steel surfaces whose profiles have been determined directly. These steel surfaces should have been prepared by use of abrasive of the same type as that used on the surface to be tested, and they should have profiles that span the test surface profile range. It is preferable that the profile obtained from the replica should be within 10 % of that obtained on the steel surfaces.

If a replicating technique is used to determine the surface profile of a substrate, this should be stated when reporting the "mean maximum peak-to-valley height".

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