INTERNATIONAL STANDARD

ISO 8503-3

Second edition
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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 d'étalonnage des comparateurs viso-tactiles ISO et de classification d'un profil de surface — Utilisation d'un microscope optique

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Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8503-3 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 12, *Preparation of steel substrates before application of paints and related products*.

This second edition cancels and replaces the first edition (ISO 8503-3:1988), which has been editorially updated.

ISO 8503 consists of the following parts, under the general title *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 3: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Focusing microscope procedure*

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

— *Part 5: Replica tape method for the determination of the surface profile*

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

These International Standards do not contain provisions for the protective coating systems to be applied to the steel surface, nor for the surface quality provisions 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 provisions are found in other documents, such as national standards and codes of practice.

It is 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 is 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.

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 which has a calibrated focusing mechanism meeting the requirements of 5.1. This procedure can 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 (now the Society for Protective Coatings). 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 lens).

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.

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

1 Scope

This part of ISO 8503 specifies the optical microscope and describes the procedure for calibrating ISO surface profile comparators conforming to the requirements of ISO 8503-1.

This part of ISO 8503 is also applicable to the determination of the surface profile, within the range $\overline{h_y}$ = 20 µm to 200 µm, of essentially planar blast-cleaned steel. The determination can 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 can be used for assessing the roughness profile of other abrasive blast-cleaned substrates.

An alternative procedure is described in ISO 8503-4.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8503-1, *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*

3 Terms and definitions

For the purposes of this document, the definitions given in ISO 8503-1 apply.

4 Principle

The test surface is observed over a specified field of view using a specified microscope. The microscope is adjusted, by movement of the objective lens (or the stage), to focus on the highest peak within the field of view. The distance, h_y, moved by the objective lens (or the stage) in order to focus on the lowest valley within the same field of view is determined.

The procedure is repeated 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, $\overline{h_y}$, is performed.

5 Apparatus

5.1 Optical microscope, having a fine focus adjustment with little or no backlash (play) (see A.5).

The adjustment shall give fine control of the movement of the objective lens 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 can be reduced by the use of a circular eyepiece reticle or by a stop in the lamp house.

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 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) 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) which 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 which is being 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. If a replica (see Annex E) is to be measured, clean it only with a dry brush.

Determine the surface profile as described in Clause 7.

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

7.1 Locate the test surface (see Clause 6) under the objective lens 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 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 lens until no part of the test area is in focus (see the Notes below); then slowly lower the objective lens, 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.

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

NOTE 2 It is considered good practice for focusing to be carried out in the same direction (see D.2).

7.3 Lower the objective lens until no part of the test area is in focus (see the Notes to 7.2), then, slowly raise the objective lens 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 lens until the lowest valley is no longer in focus. Then, slowly lower the objective lens 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 value of the mean maximum peak-to-valley height, $\overline{h_y}$, and the standard deviation for the 20 maximum 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 (see 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) a reference to this part of ISO 8503, i.e. ISO 8503-3:2012;

b) all information necessary for 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;

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 ISO 8503-1);

h) any deviations from the procedure specified 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) any unusual features (anomalies) observed during the test;

k) the date of the test.

Annex A
(normative)

Determination of backlash (play) in the microscope adjustment mechanism

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

A.2 Place an ISO surface profile comparator (6.1) on the stage of the microscope so that the area being 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 lens (see Note 1 to 7.2) until no part of the test areas is in focus. Slowly lower the objective lens 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 lens until the highest peak is no longer in focus. Slowly raise the objective lens 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 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
(normative)

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

1.	Test laboratory and address				
2.	Test surface identification a) ISO surface profile comparator b) steel substrate/ replica[a]				
3.	International Standard reference	ISO 8503-3			
4.	Microscope details				
	Objective lens magnification	×			
	Objective lens numerical aperture	NA			
	Intermediate magnification[b]	×			
	Eyepiece lens magnification	×			
	Diameter of field of view	. . . . mm			
	Total magnification	×			
5.	Results[c]	Nominal reading	Mean value $\overline{h_y}$, µm	Maximum reading of h_y, µm	Standard deviation
	Segment 1				
	Segment 2				
	Segment 3				
	Segment 4				
	Steel substrate/replica[d]				
6.	Any deviations from the International Standard procedure[b]				
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)[b]				
10.	Name of operator				

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

b If applicable.

c See separate form (Annex C) for actual readings.

d Delete as appropriate.

Annex C
(normative)

Form for recording surface profile measurements made in accordance with this part of ISO 8503

Test laboratory and address			
Objective lens magnification	×	Diameter of field of view . . . . mm	
Objective lens numerical aperture	NA	Total magnification	× . . . .
Eyepiece lens magnification	×		
Intermediate magnification	×		
Item reference[a]	a) ISO surface profile comparator		
	b) Steel substrate/replica[b]		

Reading[c] no.	Segment 1[d]			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												

a Delete as appropriate.

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

c All readings in micrometres.

d Replace with “steel substrate” or “replica”, if applicable.

Annex D
(informative)

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

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 can 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 can 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 ×150 is required, the selection of a ×10 objective lens and a ×15 eyepiece lens can comply. However, a typical ×10 objective lens has a numerical aperture of 0,26 and gives a depth of field of about 7 µm. By selecting a ×20 objective lens 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 ×1,25 or ×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 lens with a numerical aperture not less than 0,5 and a field of view greater than 0,5 mm in diameter, a microscope with an objective lens of ×20, a numerical aperture of 0,5 and an eyepiece lens of ×10 is typical and provides a total magnification of ×200.

D.2 Focus movement

Normal microscopy procedures require the final focusing movement to always be 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, which is free from backlash, introduces 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 always be made in the same direction to prevent the introduction of error or that the backlash determined in A.5 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 which 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
(informative)

Guidance notes for the preparation and measurement of replicas

If 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 are available including solventless, two-component organic polymers which cross-link to give a hard solid surface. These polymers can have disadvantages in that they do not penetrate into the deepest, sharpest valleys and that a release agent can 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. Because of 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 being tested, and they should have profiles which span the test surface profile range. It is preferable that the profile obtained from the replica 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.

Bibliography

[1] ISO 8503-4, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure*

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

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