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Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel[1]

This standard is issued under the fixed designation D 4417; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the description of techniques for measuring the profile of abrasive blast cleaned surfaces in the laboratory, field, or in the fabricating shop. There are additional techniques suitable for laboratory use not covered by these test methods.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Test Method

2.1 The methods are:

2.1.1 *Method A*—The blasted surface is visually compared to standards prepared with various surface profile depths and the range determined.

2.1.2 *Method B*—The depth of profile is measured using a fine pointed probe at a number of locations and the arithmetic mean determined.

2.1.3 *Method C*—A composite plastic tape is impressed into the blast cleaned surface forming a reverse image of the profile, and the maximum peak to valley distance measured with a micrometer.

3. Significance and Use

3.1 The height of surface profile has been shown to be a factor in the performance of various coatings applied to steel. For this reason, surface profile should be measured prior to coating application to ensure that it meets that specified. The instruments described are readily portable and sufficiently sturdy for use in the field.

NOTE 1—Optical microscope methods serve as a referee method for surface profile measurement. Profile depth designations are based on the concept of mean maximum profile ($\bar{h}$ max); this value is determined by averaging a given number (usually 20) of the highest peak to lowest valley measurements made in the field of view of a standard measuring microscope. This is done because of evidence that coatings performance in any one small area is primarily influenced by the highest surface features in that area and not by the average roughness.[2]

4. Apparatus

4.1 *Method A*—A profile comparator consisting of a number of areas (each approximately one square inch in size), usually side by side, with a different profile or anchor pattern depth. Each area is marked giving the nominal profile depth in mils or micrometres. Typical comparator surfaces are prepared with steel shot, steel grit, or sand or other nonmetallic abrasive, since the appearance of the profile created by these abrasives may differ. The comparator areas are used with or without magnification of 5 to 10 power.

4.2 *Method B*—A dial gage[3] depth micrometer fitted with a pointed probe. The probe is machined at a 60° angle with a nominal radius of 50 µm. The base of the instrument rests on the tops of the peaks of the surface profile while the spring loaded tip projects into the valleys.

4.3 *Method C*—A special tape[4] containing a compressible foam attached to a noncompressible uniform plastic film. A burnishing tool is used to impress the foam face of the tape into the surface to create a reverse replica of the profile that is measured using a spring-loaded micrometer.

5. Test Specimens

5.1 Use any metal surface that, after blast cleaning, is free of

[1] These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.46 on Industrial Protective Painting.

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[2] John D. Keane, Joseph A. Bruno, Jr., Raymond E. F. Weaver, "Surface Profile for Anti-Corrosion Paints," Oct. 25, 1976, Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213.

[3] The sole source of supply of suitable depth micrometers known to the committee at this time is the surface profile gage, Model 123, Elcometer Instruments, Ltd., Edge Lane, Droylston, Manchester M35 6UB, United Kingdom, England. If you are aware of alternative suppliers, please proved this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committtee,[1]which you may attend.

[4] The sole source of supply of suitable replica tape, Press-O-Film, known to the committee at this time is Testex. 8 Fox Lane, Newark, DE 19711. If you are aware of alternative suppliers, please proved this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committtee,[1]which you may attend

loose surface interference material, dirt, dust, and abrasive residue.

6. Procedure

6.1 *Method A*:

6.1.1 Select the comparator standard appropriate for the abrasive used for blast cleaning.

6.1.2 Place the comparator standard directly on the surface to be measured and compare the roughness of the prepared surface with the roughness on the comparator segments. This can be done with the unaided eye, under 5 to 10 power magnification, or by touch. When using magnification, the magnifier should be brought into intimate contact with the standard, and the depth of focus must be sufficient for the standard and surface to be in focus simultaneously.

6.1.3 Select the comparator segment that most closely approximates the roughness of the surface being evaluated or, if necessary, the two segments to which it is intermediate.

6.1.4 Evaluate the roughness at a sufficient number of locations to characterize the surface as specified or agreed upon between the interested parties. Report the range of results from all locations as the surface profile.

6.2 *Method B*:

6.2.1 Prior to use set the gage to zero by placing it on a piece of plate float glass. Hold the gage by its base and press firmly against the glass. Adjust the instrument to zero.

6.2.2 To take readings, hold the gage firmly against the prepared substrate. Do not drag the instrument across the surface between readings, or the spring-loaded tip may become rounded leading to false readings.

6.2.3 Measure the profile at a sufficient number of locations to characterize the surface, as specified or agreed upon between the interested parties. At each location make ten readings and determine the mean. Then determine the mean for all the locations and report it as the profile of the surface.

6.3 *Method C*:

6.3.1 Select the correct tape range for the profile to be measured: coarse, 0 to 50 µm (0 to 2 mils) and extra coarse, 40 to 115 µm (1.5 to 4.5 mils).

6.3.2 Remove the wax paper backing and place the tape on the prepared surface with the foam side down, that is, put the dull side down.

6.3.3 Hold the tape firmly on the surface and rub the circular cut-out portion (approximately 6.5 mm (3⁄8 in.) diameter) with the burnishing tool until a uniform gray color appears.

6.3.4 Remove the tape and place it between the anvils of a spring-loaded micrometer. Measure the thickness of the tape (compressed foam and non-compressible plastic film combined). Subtract the thickness of the noncompressible plastic film to obtain the surface profile.

6.3.5 Measure the profile at a sufficient number of locations to characterize the surface, as specified or agreed upon between the interested parties. At each location make three readings and determine the mean. Then determine the mean for all the locations and report it as the profile of the surface.

7. Report

7.1 Report the range and the appropriate average (mean or mode) of the determinations, the number of locations measured, and the approximate total area covered.

8. Precision and Bias

8.1 *Test Method A*:

8.1.1 *Applicability*—Based on measurements of profiles on surfaces of 8 steel panels, each blast cleaned with 1 of 8 different abrasives to a white metal degree of cleaning, having known ratings of profile height ranging from 37 µm (1.5 mils) to 135 µm (5.4 mils), the correlation coefficient for Test Method A was found to be 0.75 and the coefficient of determination was found to be 0.54.

8.1.2 *Precision*—In an interlaboratory study of Test Method A in which 2 operators each running 2 tests on separate days in each of 6 laboratories tested 8 surfaces with a broad range of profile characteristics and levels, the intralaboratory coefficient of variation was found to be 20 % with 141 df and the interlaboratory coefficient was found to be 19 % with 40 df, after rejecting 3 results for one time because the range between repeats differed significantly from all other ranges. Based on these coefficients, the following criteria should be used for judging, at the 95 % confidence level, the acceptability of results:

8.1.2.1 *Repeatability*—Two results, each the mean of four replicates, obtained by the same operator should be considered suspect if they differ by more than 56 %.

8.1.2.2 *Reproducibility*—Two results, each the mean of four replicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 54 %.

8.2 *Test Method B*:

8.2.1 *Applicability*—Based on measurements of profiles on surfaces of 8 steel panels, each blast cleaned with 1 of 8 different abrasives to a white metal degree of cleaning, having known ratings of profile height ranging from 1.5 mils (37 µm) to 5.4 mils (135 µm), the correlation coefficient for Test Method B was found to be 0.99 and the coefficient of determination was found to be 0.93.

8.2.2 *Precision*—In an interlaboratory study of Test Method B in which 2 operators, each running 2 tests on separate days, in each of 5 laboratories tested 8 surfaces with a broad range of profile characteristics and levels, the intralaboratory coefficient of variation was found to be 19 % with 113 df and the interlaboratory coefficient was found to be 28 % with 32 df, after rejecting 3 results for one time because the range between repeats differed significantly from all other ranges. Based on these coefficients, the following criteria should be used for judging, at the 95 % confidence level, the acceptability of results:

8.2.2.1 *Repeatability*—Two results, each the mean of four replicates, obtained by the same operator should be considered suspect if they differ by more than 54 %.

8.2.2.2 *Reproducibility*—Two results, each the mean of four replicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 79 %.

8.3 *Method C (X-Coarse Tape)*:

8.3.1 *Applicability*—Based on measurements of profiles on surfaces of 8 steel panels, each blast cleaned with 1 of 8 different abrasives to a white metal degree of cleaning, having known ratings of profile height ranging from 37 µm (1.5 mils) to 135 µm (5.4 mils), the correlation coefficient for Test

Method C (X-Coarse Tape) was found to be 0.96 and the coefficient of determination was found to be 0.93.

8.3.2 *Precision*—In an interlaboratory study of Test Method C (X-Coarse Tape) in which 2 operators each running 2 tests on separate days in each of 6 laboratories tested 8 surfaces with a broad range of profile characteristics and levels, the intralaboratory coefficient of variation was found to be 9 % with 120 df and the interlaboratory coefficient 13 % with 32 df. Based on these coefficients, the following criteria should be used for judging, at the 95 % confidence level, the acceptability of results:

8.3.2.1 *Repeatability*—Two results, each the mean of four replicates, obtained by the same operator should be considered suspect if they differ by more than 25 %.

8.3.2.2 *Reproducibility*—Two results, each the mean of four replicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 37 %.

8.4 *Test Method C (Coarse Tape)*:

8.4.1 *Applicability*—Based on measurements of profiles on surfaces of 6 steel panels, each blast cleaned with 1 of 6 different abrasives to a white metal degree of cleaning, having known ratings of profile height ranging from 37 µm (1.5 mils) to 57 µm (2.3 mils), the correlation coefficient for Test Method C (Coarse Tape) was found to be 0.48 and the coefficient of determination was found to be 0.23.

8.4.2 *Precision*—In an interlaboratory study of Test Method C (Coarse Tape) in which 2 operators each running 2 tests on separate days in each of 5 laboratories tested 6 surfaces with a broad range of profile characteristics and levels, the intralaboratory coefficient of variation was found to be 11 % with 90 df and the interlaboratory coefficient 11 % with 24 df. Based on these coefficients, the following criteria should be used for judging, at the 95 % confidence level, the acceptability of results:

8.4.2.1 *Repeatability*—Two results, each the mean of four replicates, obtained by the same operator should be considered suspect if they differ by more than 30 %.

8.4.2.2 *Reproducibility*—Two results, each the mean of four replicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 28 %.

8.5 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in these test methods for measuring surface profile, bias cannot be determined.

NOTE 2—The test methods measure different values and the qualitative rating on which the applicability was determined also measures a different value. The mode is determined with the comparator of Test Method A. The height of a single valley below a plane at the level of the highest surrounding peaks is measured with the fine pointed probe of Test Method B. The distance from the bottoms of many of the deepest valleys to the tops of the highest peaks (maximum profiles) are measured with the composite plastic of Test Method C. The height of a single peak above an adjacent valley below is measured with a microscope for the qualitative rating that is compared with each of the methods in correlation calculations. Because the results for the microscope and for the fine pointed probe are measurements to an individual valley, the readings range over much broader limits than the results of the tape or the comparator.

9. Keywords

9.1 abrasive; abrasive blast cleaning; anchor pattern; surface profile; surface roughness