Designation: D4417 – 14

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

This standard is issued under the fixed designation D4417; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

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 Method B may also be appropriate to the measurement of profile produced by using power tools.

1.3 SSPC standard SSPC PA 17 provides additional guidance for determining conformance with surface profile requirements.

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

1.5 *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. Referenced Documents

2.1 *ASTM Standards:*[2]

D7127 Test Method for Measurement of Surface Roughness of Abrasive Blast Cleaned Metal Surfaces Using a Portable Stylus Instrument

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *SSPC Standard:*[3]

SSPC PA 17 Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements

3. Summary of Test Method

3.1 The methods are:

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

3.1.2 *Method B*—The depth of profile is measured using a fine pointed probe at a number of locations and the arithmetic mean of the maximum peak-to-valley distances is determined.

3.1.3 *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 thickness gage specifically designed for use with the replica tape method.

4. Significance and Use

4.1 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 methods A and B. 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.[4]

5. Apparatus

5.1 *Method A*—A profile comparator consisting of a number of areas (each approximately one square inch in size), usually

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

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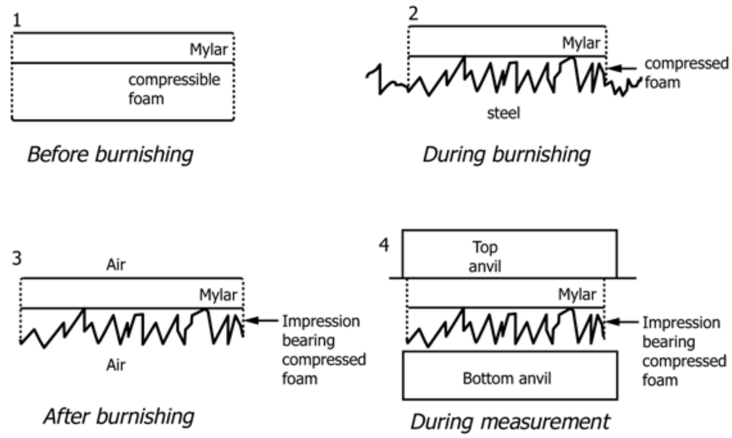
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656, http://www.sspc.org.

[4] 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.



1) The tape consists of a compressible foam coated onto an incompressible polyester substrate.
2) In use, the tape is compressed ("burnished") against the roughened surface to be measured.
3) After burnishing, the foam retains an impression of the surface.
4) Subsequent measurement of the replica's thickness, minus that of the substrate, yields surface roughness.

FIG. 1 Illustration of Replica Tape Principle of Measurement

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.

5.2 *Method B*—A depth micrometer fitted with a pointed probe. The probe is typically machined at a 60° included angle with a nominal radius of 50 µm and exerting a minimum force of 75 g. 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.

5.3 *Method C*—A replica tape[5] containing a compressible foam attached to a flexible, incompressible plastic substrate of uniform thickness. A burnishing tool, having a spherical rounded end approximately 8 mm (0.3 in.) in diameter, is used to impress the foam face of the tape into the surface to be measured, to create a reverse replica. The thickness of the reverse replica is then measured using a thickness gage specifically designed for use with this replica tape. This sequence of steps is illustrated in Fig. 1.

5.4 Thickness gages suitable for use in this application have plane parallel circular contact surfaces with the top contact surfaces with the top contact surface that touches the incompressible polyester side having a diameter of 6.3 mm (0.25 in.), a closing force of 100 grams-force ±15 g and an accuracy of at least ±5 µm (0.2 mils).

6. Test Specimens

6.1 Use any metal surface that, after blast cleaning, is free of loose surface interference material, dirt, dust, and abrasive residue.

7. Procedure

7.1 *Method A:*

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

7.1.2 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.

7.1.3 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.

7.1.4 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.

7.2 *Method B:*

7.2.1 Prior to use verify that the gage reads 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 if necessary.

7.2.2 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.

7.2.3 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 record the maximum value. Then determine the mean for all the location maximum values and report it as the profile measurement of the surface.

7.3 *Method C:*

7.3.1 Confirm that the target profile is within the primary profile measurement range for replica tape of 20 to 115 µm. Grades (thicknesses) of tape permit measurement outside this

[5] 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 International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

range, but these additional grades should only be used to check measurements near the ends of the primary range.

7.3.2 Follow manufacturer instructions to obtain the first (of two) profile readings.

7.3.3 The average of two "readings" is a "profile measurement." Manufacturer recommendations provide guidance on whether these two readings should both be obtained with the same tape grade or two different grades.

8. Report

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

9. Precision and Bias

9.1 *Test Method A:*

9.1.1 *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.

9.1.2 *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:

9.1.2.1 *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 %.

9.1.2.2 *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 %.

9.2 *Test Method B:*

9.2.1 *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 37 µm (1.5 mils) to 135 µm (5.4 mils), the correlation coefficient for Test Method B was found to be 0.99 and the coefficient of determination was found to be 0.93.

9.2.2 *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:

9.2.2.1 *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 %.

9.2.2.2 *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 %.

9.3 *Method C:*

9.3.1 The precision of Test Method C is based on a intralaboratory study conducted in 2011. Eleven laboratories participated in this study, analyzing materials representing five different property types. Each "test result" reported represents an individual determination and the participating labs reported three replicate test results for each material type. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report: RR:D01-1177.[6] Values in Table 1 are taken from the foregoing report.

9.3.2 The reproducibility standard deviation (S_R) Documented in Table 1 for each of five levels of profile, is key to assessing whether a given measurement is statistically different from either an upper or lower profile limit established in advance by the interested parties.

9.3.3 The term "reproducibility standard deviation" is used as specified in Practice E177.

9.3.4 A measured profile that is within either limit of a pre-specified range by an amount equal to S_R has a 68 % probability of satisfying specification. A profile within 1.5 S_R of a specified limit has a 86 % probability of satisfying specification and a profile within 2.0 S_R of a specified limit has a 95 % probability of satisfying the specification.

9.3.5 The precision statement was determined through statistical examination of 160 test results, reported by eleven laboratories, on five surfaces of differing profile covering the approximate profile range of 30 to 110 µm (1.2 to 4.4 mils). The five surfaces bore the internal control code numbers 102, 114, 124, 124, and 119.

9.4 *Bias*—At the time of this study, there was no generally accepted reference method suitable for determining the bias for this test method, therefore no formal statement regarding bias is being made.

TABLE 1 Profile Measurement Statistics

Coded Surface ID Number	Average Replica Tape Profile (mils)	Replica Tape Reproducibility Standard Deviation (mils) S_R
102	1.29	0.12
114	2.65	0.23
124	2.79	0.18
121	3.75	0.15
119	4.22	0.18

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1177. Contact ASTM Customer Service at service@astm.org.

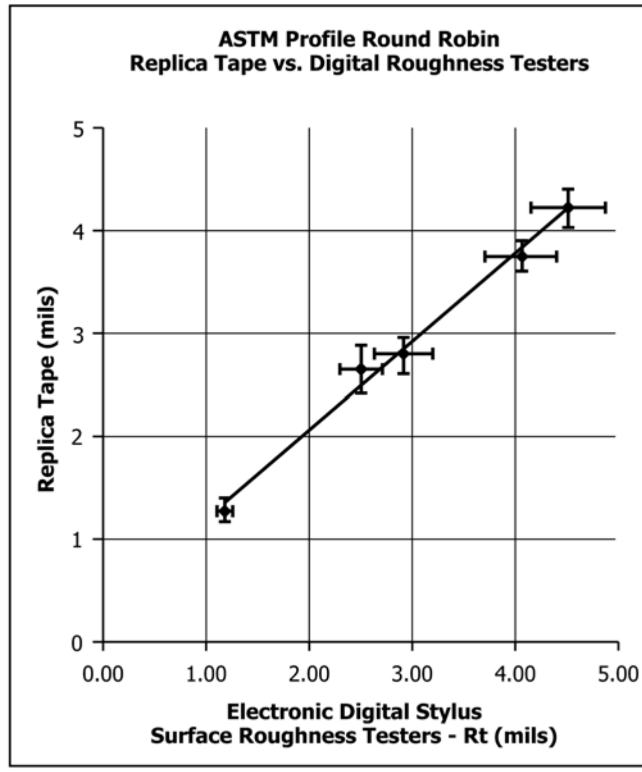
TABLE 2 Comparison of Test Methods with Test Method D7127 Electronic Stylus Profile Measurements for Bias Estimation

Coded Surface ID Number	Average Replica Tape Profile (mils)	Replica Tape Reproducibility Standard Deviation (mils) S_R	Average Test Method D7127 Determined Profile Rt (mils)	Test Method D7127 Rerpoducibility Standard Deviation (mils) S_R
102	1.29	0.12	1.18	0.076
114	2.65	0.23	2.50	0.210
124	2.79	0.18	2.91	0.286
121	3.75	0.15	4.06	0.345
119	4.22	0.18	4.52	0.356

9.4.1 Nevertheless, testing in support of Test Method D7127 relied on measurements of the same roughness test panels used to determine precision for method C of this standard. Comparison of data obtained using these two procedures gives a measure of relative method bias. Table 2 presents these data.

9.4.2 Fig. 2 is a plot of replica tape-determined profile against the Portable-Stylus-Instrument-determined parameter Rt. A least-square straight line fitted to profiles for the five surfaces measured using both methods has a slope of 0.9.

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.



Comparison method (horizontal axis) is that referenced in Test Method D7127, describing use of electronic stylus surface roughness testers. Grit blasted panels were measured using both method and plotted against one another. Each plotted point's x-value and horizontal error bar was deduced from 99 electronic stylus measurements (Test Method D7127). Each point's y-value and vertical error bar was deduced from 33 replica tape measurements (Test Methods D4417).

FIG. 2 Illustration of Replica Tape Surface Roughness Precision and Bias

10. Keywords

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

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