



Designation: ~~D4417 – 14~~ D4417 – 19

# Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel<sup>1</sup>

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 ( $\epsilon$ ) 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.~~ field. There are other 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.

NOTE 1—The Method B procedure in this standard was developed for use on flat surfaces. Depending on the radius of the surface, the results could have greater variability with lower values and averages.

1.3 SSPC standard ~~SSPC-PA~~ 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 the user of this standard to consult and establish appropriate safety, health, and health environmental practices and determine the applicability of regulatory limitations prior to use.~~

1.6 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

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:*<sup>3</sup>

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

2.3 *ASME Standard:*<sup>4</sup>

ASME B46.1-2002 Surface Texture, Surface Roughness Waviness and Lay

2.4 *ISO Standards:*<sup>5</sup>

ISO 4287: 1997 Geometrical Product Specifications (GPS)—Surface Texture: Profile Method—Terms, Definitions, and Surface Parameters

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Society for Protective Coatings (SSPC), 40 24th St., 6th Floor, 800 Trumbull Dr., Pittsburgh, PA 15222-4656, <http://www.sspc.org>.

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>5</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

### 3. Terminology

#### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *deadband, n*—that distance above and below the mean line that a continuous stylus trace line must cross in both directions (up and down) to count as a single peak.

3.1.2 *evaluation length, n*—a sequence of five consecutive stylus sampling lengths.

3.1.3 *H, n*—the average of the maximum peak-to-valley height distances obtained by measuring the thickness of replica tape.

##### 3.1.3.1 Discussion—

$H_t$  is the thickness measurement adjusted for tape non-linearity.

3.1.4 *Pd (peak density), n*—the number of peaks per unit area obtained from burnished replica tape.

3.1.5 *peak, n*—a high point in a surface profile.

3.1.6 *Rpc (peak count), n*—the number of peak/valley pairs, per unit of length, extending outside a “deadband” centered on the mean line of a stylus trace.

##### 3.1.6.1 Discussion—

For the purpose of *Rpc*, a peak is defined relative to an upper and lower height threshold. This is a single number (peak count threshold) and is the distance from a lower threshold to an upper threshold centered on the mean line of the profile.

3.1.7 *Rt, n*—the vertical distance between the highest peak and the lowest valley within any given stylus evaluation length.

3.1.8 *sampling length, n*—the nominal distance parallel to the surface within which surface parameters are determined.

3.1.9 *surface profile, n*—the height of the major peaks relative to the major valleys.

3.1.10 *traversing length, n*—seven sampling lengths comprising the evaluation length and the stylus pre-travel and post-travel segments.

### 4. Summary of Test Method

4.1 The methods are:

4.1.1 *Method A*—The ~~blasted~~ abrasive cleaned surface is ~~visually compared to standards prepared with commercial replicas of various surface profile depths prepared by different blast media and the range determined.~~ visually compared to standards prepared with commercial replicas of various surface profile depths prepared by different blast media and the range determined. The geometry of the specific abrasive cleaned surface can also be observed. This does not apply when combinations of blast media, such as shot and grit, are used.

4.1.2 *Method B*—The depth of profile relative to the peaks is measured using a fine-pointed probe at a number of locations and the arithmetic mean average of the maximum peak-to-valley distances (or alternatively, the average peak-to-valley distances) is determined.

4.1.3 *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.~~ profile. The average maximum peak-to-valley distance can be measured using a suitable thickness gage. The average of these distances can be determined from a group of measurements. Specially designed optical readers can also determine the peak density from the tape replica.

4.1.4 *Method D*—A trace measurement is taken by a portable stylus surface roughness instrument to obtain maximum peak-to-valley distance. The average of these distances is determined from a group of five traces. These devices can also determine peak count information.

### 5. Significance and Use

5.1 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 conformance of a prepared surface to profile requirements specified by the manufacturer of a protective coating or the coating job specification.~~ that it meets that specified conformance of a prepared surface to profile requirements specified by the manufacturer of a protective coating or the coating job specification. The instruments described are readily portable and sufficiently sturdy for use in the field.

NOTE 2—Methods C and D include determination of the peak count (number of profile peaks in a specified distance or unit area). According to research performed by Roper, Weaver and Brandon<sup>6</sup>, an increase in peak count can improve the adhesion of some coatings to the prepared steel, as well as provide greater resistance to corrosion undercutting once the coating becomes damaged in service.

NOTE 3—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 (*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 coating performance in any one small

<sup>6</sup> The Effect of Peak Count or Surface Roughness on Coating Performance, *JPCL* Vol. 22, No. 6, pp 52-64.

area is primarily influenced by the highest surface features in that area and not by the average roughness.<sup>7</sup>

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## 6. Apparatus

6.1 *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.

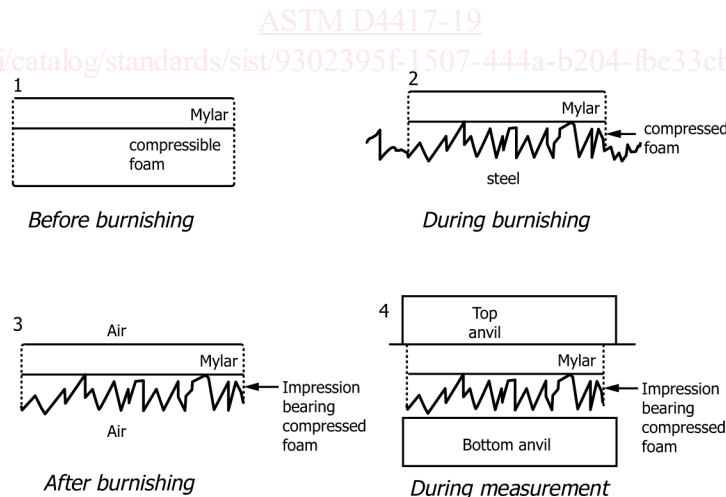
6.2 *Method B*—A depth micrometer fitted with a pointed probe. The probe is typically machined at a 60° included angle with a nominal radius of 50 μm and exerting a minimum force of 75 g. The base of the instrument rests on the tops of the peaks of the surface profile while the spring loaded tip projects into the valleys.

6.3 *Method C*—A replica tape<sup>8</sup> 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.

6.3.1 Thickness gages suitable for use in this application have plane parallel circular 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).

6.3.2 Peak density  $Pd$  is extracted from burnished replica tape with an instrument that counts bright spots on a photograph taken by a digital image sensor (camera).

6.4 *Method D*—Thickness gages suitable for use An apparatus consisting of a portable skidded or non-skidded electronic surface roughness measurement instrument (“tester”) capable of measuring  $Rt$  in this application have plane parallel circular contact surfaces with the top contact compliance with ISO 4287 and surfaces  $R_{pc}$  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) in compliance with ASME B46.1. The apparatus should have a vertical range of at least 300 μm (12 mil) and permit a sampling length of 2.5 mm (0.1 in.) and an evaluation length of 12.5 mm (0.5 in.) (Laboratory experience suggests this vertical range is a practical requirement to meet the provisions of 6.4.1).



- 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

<sup>7</sup> 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.

<sup>8</sup> 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 provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

6.4.1 The apparatus should include a stylus with a tip radius of 5  $\mu\text{m}$  (0.2 mil), and permit recording of  $R_t$  in the range 10 to 150  $\mu\text{m}$  (0.4 to 6 mil) and  $R_{pc}$  up to 180/cm (450/in.).

6.4.2 Surface deviations are sensed by the stylus and converted to electrical signals within the device. Internal processing converts these signals into standard surface characterization parameters, which are then displayed or printed.

## **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. Calibration and Standardization**

### 7.1 Method A:

7.1.1 Comparators require careful handling and if any surface wear is detected the comparator should be discarded.

### 7.2 Method B:

7.2.1 Before use, each instrument's accuracy shall be verified by the user in accordance with the instructions of the manufacturer, employing suitable standards and, if necessary, any deficiencies found shall be corrected.

### 7.3 Method C:

7.3.1 Before use, each replica tape micrometer's accuracy shall be verified by the user in accordance with the instructions of the manufacturer, employing suitable standards and, if necessary, any deficiencies found shall be corrected.

### 7.4 Method D:

7.4.1 Precision reproductions of standard surface profiles such as those used by the manufacturer of the equipment, or described in their operational literature, may be used as calibration standards for the apparatus.

## **8. Preparation of Apparatus**

### 8.1 Method A:

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

### 8.2 Method B:

8.2.1 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.

### 8.3 Method C:

8.3.1 Confirm that the target profile is within the primary profile measurement range for replica tape of 20 to 115  $\mu\text{m}$ . Grades (thicknesses) of tape permit measurement outside this range, but these additional grades should only be used to check measurements near the ends of the primary range.

### 8.4 Method D:

8.4.1 Set the apparatus to display the chosen parameters in accordance with the manufacturers' instructions.

8.4.2 The evaluation length should be set to five sampling lengths. The sampling length and evaluation length should be set to 2.5 mm (0.1 in.) and 12.5 mm (0.5 in.), respectively.

8.4.3 The traversing length of the apparatus should be set to include pre-travel and post-travel segments, usually equal to one sampling length at the beginning and one sampling length at the evaluation length. These portions of a traverse are discarded by the instrument in its calculation of surface parameters.

8.4.4 The low frequency ("long wavelength" or "cutoff") filter should be set to "Gaussian" or "Gaussian 50 %." In general, the default setting will be compliant.

8.4.5 If the apparatus has a high frequency ("short wavelength" or "Ls") filter, it should be set to "off."

8.4.6 The apparatus should be adjusted (if necessary) to a deadband width ( $C_1 = -C_2$ ) in the range 0.5 to 2.0  $\mu\text{m}$  (20 to 80  $\mu\text{in.}$ ). The choice of deadband for profiles as large as those discussed in this standard will have little effect on the measurements. In general, the default setting will be compliant.

8.4.7 The accuracy of the apparatus should be checked regularly using a calibration block available from the equipment manufacturer using their written procedure and at their recommended interval.

## **9. Preparation of the Sample**

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

9.2 Select an area of the surface to be tested that is visibly free from obvious defects such as scratches, deep marks, or other construction or corrosion defects.

9.3 Using a stiff nylon bristle brush, remove any dust or abrasive particles from the surface in the selected sample evaluation area.