

# Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape

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## ABSTRACT

*Revised in 2016! This NACE International standard practice describes and characterizes one procedure for measuring the surface profile of abrasive blast cleaned steel. The measurement technique uses a tape that replicates the surface profile. Other common methods of measuring surface profile are not discussed. The standard covers the areas of equipment and procedures, provides a definition of "surface profile," and includes an appendix that presents the results of a round-robin series of measurements illustrating the degree of accuracy of the procedure described in the standard. A second appendix statistically summarizes the data presented in the first appendix. This revision takes into account a chemical reformulation and associated modification to the manufacturer's instructions for use of replica tape that occurred in 2010.*

## KEYWORDS

*abrasive blast cleaned steel, ISO 8503-5, micrometer gauge, replica tape, surface profile, TG 419*



*In NACE standards, the terms shall, must, should, and may are used in accordance with the definitions of these terms in the NACE Publications Style Manual, 4th ed., Paragraph 7.4.1.9. Shall and must are used to state mandatory requirements. The term should is used to state something considered good and is recommended but is not mandatory. The term may is used to state something considered optional.*

## Foreword

Before the application of protective coatings to steel surfaces, the surfaces are frequently cleaned by abrasive impact. Such abrasive cleaning roughens the steel surface, assuring a surface profile (also known as an anchor pattern, anchor profile, or anchor-tooth profile). The resulting degree of surface roughness is affected by many variables, including the type, size, and shape of the abrasive used, its velocity and angle of impact, etc. This surface profile enhances coating adhesion.

Many techniques and instruments are currently used to measure the surface texture or surface profile; however, those providing the highest degree of precision are suitable only for use in a laboratory. Because a surface profile range is frequently specified and the recommended surface profile is different for various types of coatings, a means to measure surface profile at the work site is desirable.

The purpose of this NACE International standard practice is to describe and characterize one procedure for measuring the surface profile of abrasive blast cleaned steel. The measurement technique uses a tape that replicates the surface profile. The thickness of the tape (with the profile replicate) is then measured with a micrometric thickness gauge to determine the surface profile. Other common methods of measuring surface profile are not discussed.

The procedure described in this standard is limited to the measurement of the surface profile with a profile defined as 20 to 115  $\mu\text{m}$  (0.8 to 4.5 mil) and prepared to a white metal,<sup>1</sup> near-white metal,<sup>2</sup> or commercial blast-cleaned<sup>3</sup> surface finish.

The determination of surface profile depends on its definition. This procedure determines the surface profile only as it is defined in this standard (see Paragraph 2.1). If the surface profile is defined differently, the data presented in this standard may not be representative of user results. Individual measurements of the surface profile of an abrasive blast-cleaned metal surface vary significantly from area to area over a given surface.

Appendix A (Nonmandatory) presents the results of a round-robin series of measurements by several individuals, and illustrates the degree of accuracy of the procedure described in this standard over a part of the method's range. Appendix B (Nonmandatory) statistically summarizes the data shown graphically in Appendix A. Panels used in the tests shown in Appendix A were hot-rolled and nonrusted. The extraneous profile of severely rusted surfaces reduces the accuracy of the procedure. Measurements were taken on relatively flat areas where the surface appeared to be continuous and uniform.

This standard is intended for use by personnel who have a requirement to measure the surface profile of abrasive blast-cleaned steel using replica tape before applying a protective coating. This revision takes into account a chemical reformulation and associated modification to the manufacturer's instructions for use of replica tape that occurred in 2010.

This standard was originally prepared in 1987 by NACE Task Group T 6G 19, a component of Unit Committee T 6G, "Surface Preparation for Protective Coatings." The standard was reaffirmed in 1991 and 1995 by Unit Committee T-6G, and in 2002 by Specific Technology Group (STG) 04, "Protective Coatings and Linings—Surface Preparation." The NACE standard was revised in 2016 by TG 419 (formerly T-6G-19), which is administered by STG 04; and sponsored by STG 02, "Coatings and Linings, Protective—Atmospheric; and STG 03, "Coating and Linings, Protective—Immersion and Buried Service." This standard is issued by NACE under the auspices of STG 04.

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## Section 1: General

- 1.1** This standard describes a procedure using replica tape for on site measurement of the surface profile of abrasive blast-cleaned steel surfaces that have a surface profile of 20 to 115  $\mu\text{m}$  (0.8 to 4.5 mil), as defined in Section 2. The procedure has been demonstrated to correlate well with the measurements obtained by the defined laboratory procedure on nonrusted panels prepared in accordance with the specifications of NACE No. 1/SSPC<sup>(1)</sup>-SP 5<sup>1</sup> (White Metal), NACE No. 2/SSPC-SP 10<sup>2</sup> (Near-White Metal), or NACE No. 3/SSPC-SP 6<sup>3</sup> (Commercial Blast-Cleaned). Measurements obtained using replica tape have similarly been shown to correlate closely with profile measurements obtained using electronic stylus surface roughness testers.<sup>4</sup>

## Section 2: Definitions

- 2.1 Surface Profile:** the irregular peak and valley profile on a bare surface that can result from operations such as abrasive blast cleaning or power tool cleaning. [Also called anchor pattern.] For the purposes of this standard, surface profile is defined as that value obtained when the peak-to-valley profile of a surface is measured using an optical microscope as described in NACE Publication 6G176.<sup>4</sup>

The laboratory procedure described in NACE Publication 6G176 involves averaging a statistically significant number of readings (20 to 30) using an optical microscope, magnification of 250X to 280X, with a field of 0.41 to 0.46 mm (0.016 to 0.018 in) diameter, and recording the distance measured from the top of the highest peak to the bottom of the lowest valley in the field of view.

## Section 3: Introduction

### 3.1 Replica Tape

**3.1.1** Replica tape consists of a layer of crushable plastic microfoam coated onto an incompressible polyester substrate having a thickness of 51  $\mu\text{m} \pm 2 \mu\text{m}$  (2.0 mil  $\pm$  0.1 mil). Square pieces of this film measuring at least 10 mm (0.4 in) on each side are affixed to circular cut-outs in strips of adhesive-backed paper tape. The purpose of the adhesive-backed paper tape is to allow inspectors to secure the tape to the surface to be measured.

**3.1.2** Replica tape is available in two principal grades (or thicknesses), Coarse and X-Coarse. Together, the two grades permit measurement of the profile within the method's primary range of 20 to 115  $\mu\text{m}$  (0.8 to 4.5 mil). The Coarse grade covers the lower end and X-Coarse grade covers the higher end of the range. There is a range overlap window between the two that extends from 38 to 64  $\mu\text{m}$  (1.5 to 2.5 mil).

**3.1.3** Coarse Minus-grade replica tape is a check grade used to confirm measurements near the lower end (approximately 20  $\mu\text{m}$  [0.8 mil]) of the primary range.

**3.1.4** X-Coarse Plus-grade tape is a check grade used to confirm measurements near the higher end (approximately 115  $\mu\text{m}$  [4.5 mil]) of the primary range.

- 3.2** A micrometric thickness gauge specifically identified as being suitable for use with replica tape.

<sup>(1)</sup> SSPC: The Society for Protective Coatings, 800 Trumbull Drive, Pittsburgh, PA 15205.

**3.2.1** Suitable gauges have flat, circular contact surfaces (sometimes called “anvils”), 6.3 mm (0.25 in) in diameter, a closing force of approximately 110 gram force (gf) (4 ounce force [ozf]) and a measurement accuracy of at least  $\pm 5 \mu\text{m}$  ( $\pm 0.2 \text{ mil}$ ).

- 3.3** A compression tool (burnishing tool), consisting of a hard, smooth, rounded, approximately spherical (nominal diameter 8.0 mm [0.3 in]) surface that is used to compress the replica film against the surface to be measured. Ideally, the tool should be expressly identified as being for this purpose. Such tools sometimes take the form of a rod with a compression ball at one end.

## Section 4: Procedure

- 4.1** A clean representative surface site shall be identified. Surface dirt and dust shall be removed from the surface, because contaminants distort the results. The tape shall not be used on surfaces outside the range  $-10^\circ\text{C}$  to  $60^\circ\text{C}$  ( $14^\circ\text{F}$  to  $140^\circ\text{F}$ ).
- 4.2** Confirm that contact surfaces of the micrometer gauge are clean and free of contaminating particles.
- 4.3** The micrometer shall be nulled before beginning measurements. If adjusted to 0.0 when the contact surfaces are fully closed, care must be taken to subtract  $51 \mu\text{m}$  (2.0 mil), the thickness of the incompressible polyester substrate, from all subsequent readings. Alternatively, and preferably, the micrometer can be initially nulled to  $-51 \mu\text{m}$  ( $-2.0 \text{ mil}$ ). This has the effect of presubtracting the incompressible substrate contribution meaning that subsequent readings are a direct measure of the profile. Some gauges automatically subtract the  $51 \mu\text{m}$  (2.0 mil) incompressible substrate from all readings. If the manufacturer specifies a substrate thickness different from  $51 \mu\text{m}$ , that value should be used instead.
- 4.4** Select a tape grade based on the target profile. If the target profile is above  $50 \mu\text{m}$  (2.0 mil), select the X-Coarse grade tape. If the target profile is below  $50 \mu\text{m}$  (2.0 mil), select Coarse grade tape.
- 4.5** The wax paper backing shall be removed from the replica tape. The specimen of replica tape shall be inspected; the tape shall not be used if it is visibly damaged or distorted. The unexposed compressible foam in the circular cut out shall be measured with the micrometer as a procedural check. The premeasured thickness of the compressible foam is approximately  $80 \mu\text{m}$  (3.3 mil) for Coarse grade tape and about  $140 \mu\text{m}$  (5.5 mil) for X-Coarse grade.
- 4.6** The replica tape shall be placed on the blast-cleaned surface, dull-side down. The tape shall be held firmly to avoid movement. A suitably rounded compression tool (e.g., a hard plastic rod with a spherical end or the fully rounded corner of the tape dispenser) shall be rubbed, using a circular and X-Y motion, over the circular cut-out portion of the replica tape. The tape shall be rubbed repeatedly until the entire circular area has uniformly darkened and the impression assumes a pebble-grain appearance. Typically, complete rubbing takes 30 to 40 seconds.
- 4.7** The replica tape shall be removed and placed between the anvils of the micrometer to obtain a profile reading. If the reading obtained using Coarse or X-Coarse grade tape is in the 38 to  $64 \mu\text{m}$  (1.5 to 2.5 mil) overlap window, take a second reading with the OTHER grade. If both readings are within the 38 to  $64 \mu\text{m}$  (1.5 to 2.5 mil) overlap window, record the average of the two readings as the measured profile.

**4.7.1** If the reading obtained with either grade is outside the overlap window (i.e., between 20 and  $37 \mu\text{m}$  [0.8 and 1.4 mil] or between 65 and  $115 \mu\text{m}$  [2.6 and

**NOTE:** In the following paragraphs (4.7 through 4.8), a single measurement of a piece of replica tape shall constitute a “reading.” The average of two readings shall constitute a “measurement.”

4.5 mil]) it shall be averaged with a second reading (obtained using the same grade) to determine the measured profile.

**4.7.2** Some gauges perform a linearizing function that permits direct reading of the profile without resorting to the above-described averaging procedure. As in the above cases, two “readings” constitute a “measurement.”

**4.8** This procedure should be routinely verified using a surface with a known surface profile, such as a visual comparator. While a comparator cannot be used for exact calibration because of design differences, verification should ensure consistent, reproducible results.

## References

1. NACE No. 1/SSPC-SP 5 (latest revision), “White Metal Blast Cleaning” (Houston, TX: NACE and Pittsburgh, PA: SSPC).
2. NACE No. 2/SSPC-SP 10 (latest revision), “Near-White Metal Blast Cleaning” (Houston, TX: NACE and Pittsburgh, PA: SSPC).
3. NACE No. 3/SSPC-SP 6 (latest revision), “Commercial Blast Cleaning” (Houston, TX: NACE and Pittsburgh, PA: SSPC).
4. NACE Publication 6G176 (withdrawn), “Cleanliness and Anchor Patterns Available Through Centrifugal Blast Cleaning of New Steel” (Houston, TX: NACE). (Available from NACE as an Historical document only.)
5. ASTM<sup>(2)</sup> D4417 (latest revision), “Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel” (West Conshohocken, PA: ASTM).

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<sup>(2)</sup>ASTM International 100 Barr Harbor Drive, West Conshohocken, PA19428-2959.

# Appendix A

## Results of NACE Task Group T-6G-19

### Round-Robin Tests

#### (Nonmandatory)

#### NOTE:

This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the provisions herein.

- A1** Figures A1 through A6 depict the results of the round-robin tests performed by NACE Task Group T-6G-19. The solid line represents the profile as determined by the procedure described in NACE Publication 6G176.
- A2** NOTE: The round-robin tests were conducted exclusively using X-Coarse grade tape. The data presented below is useful as an indicator of the uncertainty associated with the replica tape method. This round-robin test was undertaken before adoption of the two-grade averaging procedure; however, it addresses only that part of the method's total range (above 65  $\mu\text{m}$  [2.5 mil]) that can be measured with X-Coarse grade tape alone. Other tests, such as ASTM D4417,<sup>5</sup> not described in this standard, suggest that similar levels of accuracy apply to portions of the method's range below 65  $\mu\text{m}$  (2.5 mil).

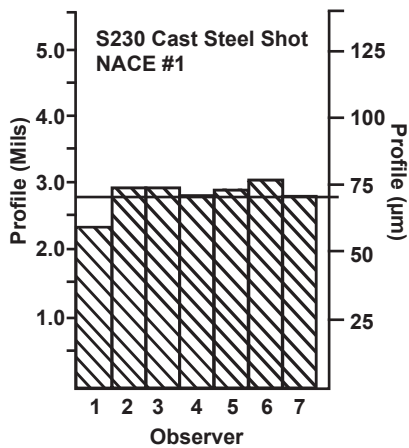


FIGURE A1

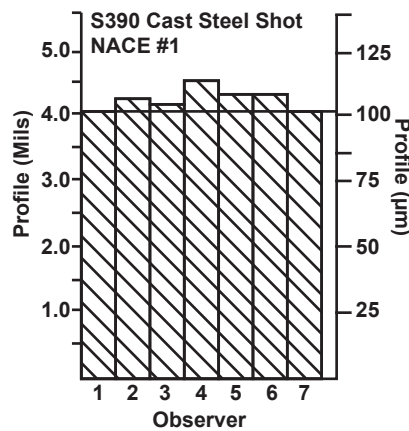


FIGURE A2

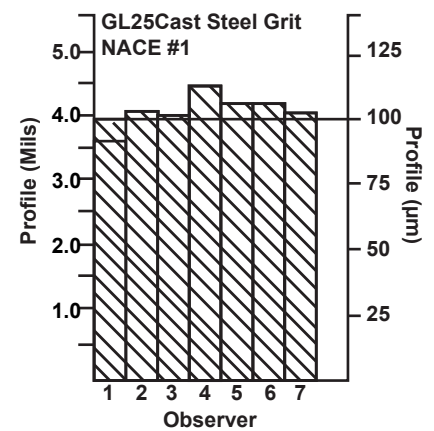


FIGURE A3

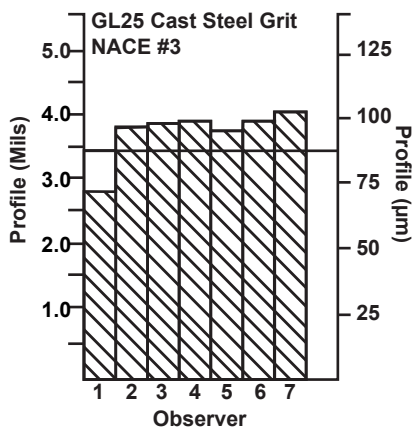


FIGURE A4

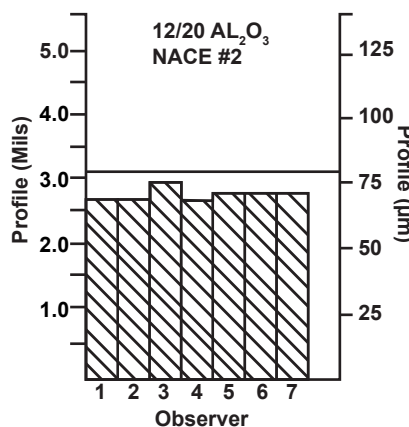


FIGURE A5

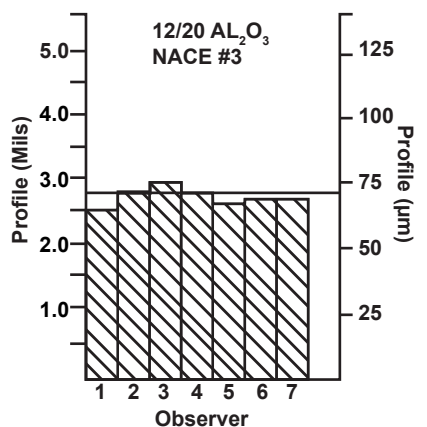


FIGURE A6

FIGURES A1-A6: Round Robin Test Results

## Appendix B Statistical Summary (Nonmandatory)

### NOTE:

*This appendix is considered nonmandatory, although it may contain mandatory language. It is intended only to provide supplementary information or guidance. The user of this standard is not required to follow, but may choose to follow, any or all of the provisions herein.*

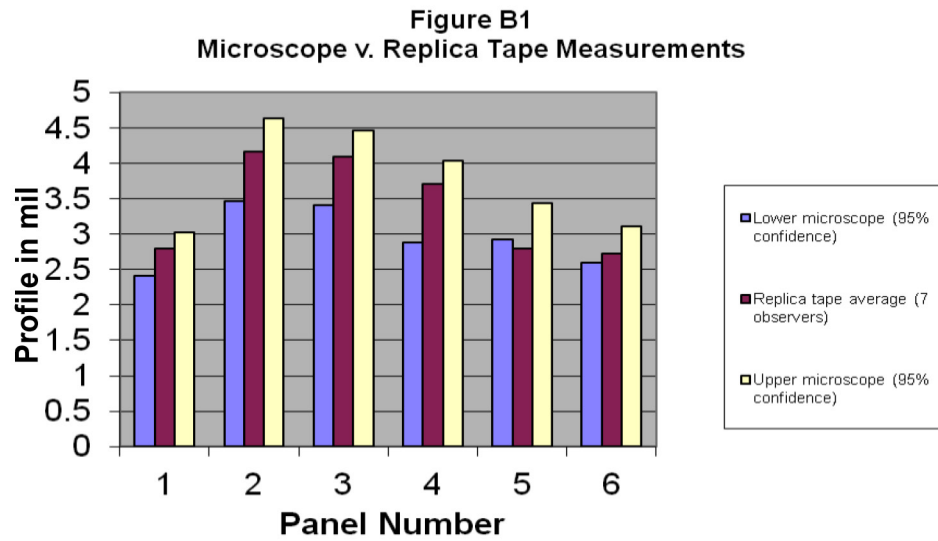
- B1** Table B1 gives a statistical summary of the results of the T-6G-19 round-robin tests. Figure B1 compares the surface profile measurements obtained using a microscope with those obtained using replica tape.
- B2** The average difference between microscope- and replica tape-determined profiles for these six surfaces is 0.4  $\mu\text{m}$  (0.02 mil). The average 95% confidence range for the microscope method is 20  $\mu\text{m}$  (0.80 mil). The average 95% confidence range for the replica tape method is 10  $\mu\text{m}$  (0.40 mil).

**TABLE B1**  
**Statistical Summary<sup>(A)</sup>**

|        |                               |                       |      | Microscope Readings<br>95% Confidence<br>Limits <sup>(B)</sup> |      |      | Replica Tape Readings<br>95% Confidence<br>Limits <sup>(B)</sup> |      |
|--------|-------------------------------|-----------------------|------|----------------------------------------------------------------|------|------|------------------------------------------------------------------|------|
| Number |                               |                       | Avg. | Low                                                            | High | Avg. | Low                                                              | High |
| 1.     | S230                          | NACE No. 1/SSPC-SP 5  | 2.72 | 2.41                                                           | 3.03 | 2.79 | 2.57                                                             | 3.00 |
| 2.     | S390                          | NACE No. 1/SSPC-SP 5  | 4.05 | 3.47                                                           | 4.63 | 4.17 | 4.01                                                             | 4.33 |
| 3.     | GL-25                         | NACE No. 1/SSPC-SP 5  | 3.94 | 3.41                                                           | 4.47 | 4.10 | 3.85                                                             | 4.35 |
| 4.     | GL-25                         | NACE No. 3/SSPC-SP 6  | 3.46 | 2.88                                                           | 4.04 | 3.71 | 3.32                                                             | 4.10 |
| 5.     | 12/20 $\text{Al}_2\text{O}_3$ | NACE No. 2/SSPC-SP 10 | 3.18 | 2.93                                                           | 3.44 | 2.79 | 2.69                                                             | 2.88 |
| 6.     | 12/30 $\text{Al}_2\text{O}_3$ | NACE No. 3/SSPC-SP 6  | 2.85 | 2.59                                                           | 3.11 | 2.73 | 2.58                                                             | 2.88 |

<sup>(A)</sup>This statistical summary was conducted using U.S. Customary units. To convert to metric units, use 1 mil = 25.4  $\mu\text{m}$ .

<sup>(B)</sup> 95% confidence limits. Example: Panel 1 microscope data, average = 2.72; 95% lower limit = 2.41; 95% upper limit = 3.03. This indicates 95% confidence that the average of an infinite number of microscope readings on Panel 1 would be between 2.41 and 3.03 mil.



**FIGURE B1: Microscope vs. Replica Tape Measurements**







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