Designation: B946 − 23

Standard Test Methods for Surface Roughness of Powder Metallurgy (PM) Products[1]

This standard is issued under the fixed designation B946; 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 measuring the surface roughness of powder metallurgy (PM) products at all stages of manufacturing from green compact to fully hardened finished component.

1.2 These test methods provide the definition and schematic of some common surface roughness parameters (R_a, R_t, and R_{zISO})

1.3 This standard specifies two different standardized procedures for measuring the surface roughness of PM parts.

1.3.1 Method 1 uses a conical stylus and a Gaussian filter.

1.3.2 Method 2 uses a chisel (knife) edge stylus.

1.3.3 Each test method results in a different measure of surface roughness and the results are not directly comparable.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

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 the user of this standard to establish appropriate safety, health, and 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:*[2]

E456 Terminology Relating to Quality and Statistics

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

2.2 *MPIF Standard:*[3]

MPIF Standard 58 Method for Determination of Surface Finish of Powder Metallurgy Products

2.3 *ASME Standard:*[4]

ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)

2.4 *ISO Standard:*[5]

ISO 16610-21 Geometric Product Specifications (GPS) – Filtration–Part 21: Linear Profile Filters: Gaussian Filters

3. Significance and Use

3.1 The surface roughness of PM parts is an important characteristic in relation to factors such as their load-bearing, wear, sealing, sliding, adhesion, electrical contact, and lubricant retention properties.

3.2 Surface roughness may also be critical for component assembly or system performance. Dimensional fit and mating surface interaction may require certain surface roughness requirements to meet performance specifications.

4. Interferences

4.1 Because many conventional PM materials contain open porosity at the surface, special consideration should be taken when measuring surface roughness. As most roughness parameters are defined by measuring the microscopic peaks and valleys, the porosity in sintered powder metallurgy products will negatively influence this value.

4.2 Because the direction of pressing may cause directionality in surface roughness values, the direction of measurement should be specified and reported.

5. Apparatus

5.1 *Method 1 (Conical Stylus):*

[1] These test methods are under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.05 on Structural Parts.

Current edition approved Feb. 1, 2023. Published February 2023. Originally approved in 2006. Last previous edition approved in 2016 as B946 – 11 (2016). DOI: 10.1520/B0946-23.

[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 Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540, http://www.mpif.org.

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

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

*A Summary of Changes section appears at the end of this standard

5.1.1 *Surface Finish Measuring Instrument*—Suitable for complying with ASME B46.1.

5.1.2 A profiling, contact, skidless instrument for measuring displacements of a stylus relative to an external datum.

5.1.3 Stylus with an appropriate radius (for example, 2 µm, 5 µm, or 10 µm (0.00008 in., 0.0002 in., or 0.0004 in.)).

NOTE 1—Because the stylus tip is subject to wear and mechanical damage, even when made of diamond, regular checks of the stylus are recommended. Techniques for checking the stylus condition are discussed in ASME B46.1.

5.2 *Method 2 (Chisel (Knife) Edge Stylus):*

5.2.1 *Surface Finish Measuring Instrument*—Suitable for complying with ASME B46.1.

5.2.2 *Stylus*—Chisel (knife) edge, 1.27 mm (0.050 in.) length and 0.010 mm ± 30 % (0.0004 in. ± 30 %) tip radius as shown in Fig. 1. The chisel tip shall be oriented so that its long edge is perpendicular to the direction of travel of the probe.

6. Sampling, Test Specimens, and Test Units

6.1 The test surface shall be clean and free of any oil, dirt, debris, or foreign material.

6.2 Sufficient surface area shall be available to permit multiple traverses by the measuring instrument.

6.3 The test surface shall be flat over a sufficient length (in accordance with instrument instructions) to allow proper movement of the stylus.

7. Procedure

7.1 *Method 1 (Conical Stylus):*

7.1.1 Measure the surface roughness in accordance with ASME B46.1 by using the following parameters:

7.1.2 The surface roughness parameter to be measured should be agreed upon by the producer and purchaser; for example, R_a, R_t, R_z.

NOTE 2—R_a, is the arithmetic average value of the filtered roughness profile determined from deviations about the centerline within the evaluation length l_m as shown in Fig. 2. R_t, is the maximum peak-to-valley height over the tested length (absolute value between the highest peak and lowest valley) as shown in Fig. 3. R_z, is the ten-point height, or the absolute value of the five highest peaks and five lowest valleys over the evaluation length as shown in Fig. 4. R_z is also known as the ISO 10-point height parameter.

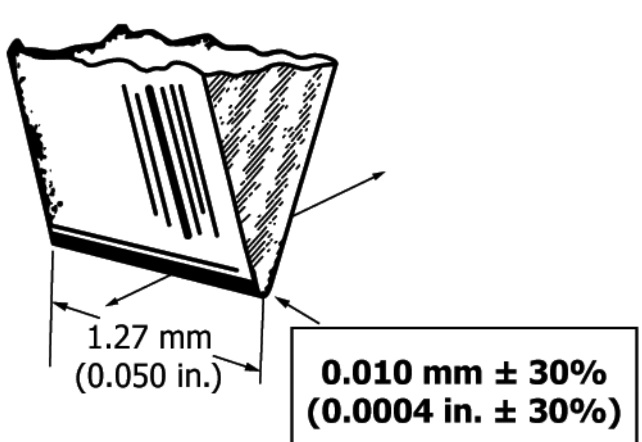

FIG. 1 Chisel (Knife) Edge Stylus for Surface Roughness Measurement

$$R_a = \frac{1}{l_m}\int_{x=0}^{x=l_m} |y|dx$$

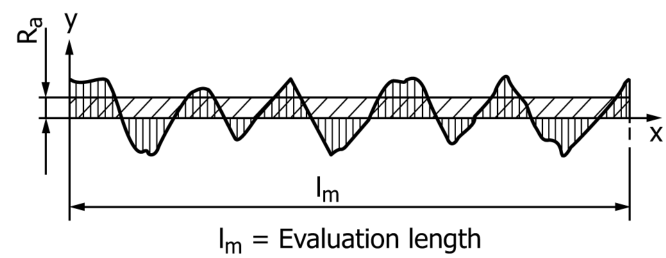

FIG. 2 R_a Arithmetic Mean Roughness Value

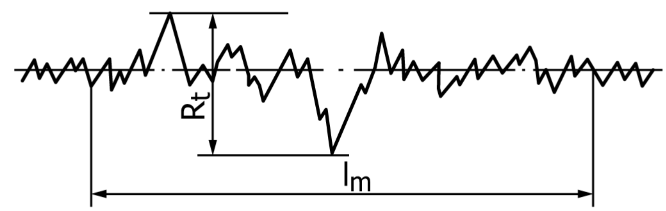

FIG. 3 R_t Maximum Peak-to-Valley Height

7.1.3 Use a stylus with a tip radius of either 2 µm, 5 µm, or 10 µm [0.00008 in., 0.0002 in., or 0.0004 in.] as agreed between the producer and purchaser.

7.1.4 Use a Gaussian filtered profile (for example, ISO 16610-21) with a cut-off agreed between the producer and the purchaser.

7.1.5 Use a total evaluation length that is five times the cut-off value. For example, if the cut-off is 0.8 mm (0.03 in.), the total evaluation length shall be 4 mm (0.16 in.).

7.1.6 The PM parts producer and the purchaser shall agree on the desired location and direction for the surface roughness measurement.

NOTE 3—If the roughness is higher than 4.0 R_a increase the cut-off so that the evaluation length is longer. This is because the surface is so irregular that a longer evaluation length is necessary to obtain a real statistical approach.

7.1.7 Place the surface finish instrument in a position suitable for measuring the test sample.

7.1.8 Zero and verify the instrument over the surface roughness range expected for the test sample.

7.1.9 Place the test sample under the stylus and then lower the stylus to the measuring position in accordance with the instrument instructions.

7.1.10 Measure the surface roughness of the test surface. A minimum of three traverses at different locations is recommended.

7.2 *Method 2 (Chisel (Knife) Edge Stylus):*

7.2.1 The surface roughness parameter to be measured should be agreed upon by the producer and purchaser; for example, R_a, R_t, R_z. In addition, the traverse length to be used should be agreed upon.

NOTE 4—R_a, is the arithmetic average value of the filtered roughness

$$R_{ZISO} = \frac{1}{5} \cdot \left(\sum_{i=1}^{5} |Y_{pi}| + \sum_{i=1}^{5} |Y_{vi}| \right)$$

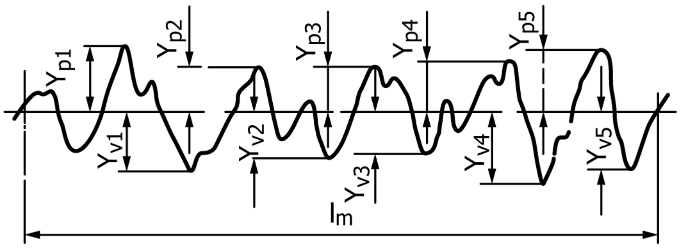

FIG. 4 R_{zISO} Ten-Point Height

profile determined from deviations about the centerline within the evaluation length I_m as shown in Fig. 2. R_t, is the maximum peak-to-valley height over the tested length (absolute value between the highest peak and lowest valley) as shown in Fig. 3. R_z, is the ten-point height, or the absolute value of the five highest peaks and five lowest valleys over the evaluation length as shown in Fig. 4. R_z is also known as the ISO 10-point height parameter.

7.2.2 The PM parts producer and the purchaser shall agree on the desired location and direction for the surface roughness measurement.

7.2.3 Place the surface finish instrument in a position suitable for measuring the test sample.

7.2.4 Calibrate the instrument over the surface roughness range expected for the test sample prior to testing.

7.2.5 Place the test sample under the stylus and then lower the stylus to the measuring position per the instrument instructions.

7.2.6 Measure the surface roughness of the test surface. A minimum of three traverses at different locations is recommended.

8. Report

8.1 *Method 1 (Conical Stylus):*

8.1.1 Express the results in micrometres as parameters such as R_a, R_k, or R_{pk} as defined in ASME B46.1. Depending on the type of instrument being used, other surface roughness measures may also be reported.

8.1.2 The stylus tip radius used.

8.1.3 The Gaussian filter used.

8.1.4 The total evaluation length used.

8.1.5 The cut-off used.

8.1.6 The location on the part where the measurements were made.

8.1.7 The direction of measurement with respect to the pressing direction.

8.2 *Method 2 (Chisel (Knife) Edge Stylus):*

8.2.1 Express the results to the nearest whole number in micrometres, as required by the specification. Unless otherwise indicated the surface roughness shall be R_a (average surface roughness), as illustrated in Fig. 2.

8.2.2 The traverse length used.

8.2.3 The number of traverses measured.

8.2.4 The average surface roughness of the traverses.

8.2.5 The location(s) on the part where the measurements were made.

8.2.6 The direction of measurement with respect to the pressing direction.

9. Precision and Bias

The Precision for this standard was developed by the Metal Powder Industries Federation (MPIF) and is used herein with their permission.

9.1 *Precision*—The precision of this test has been determined from an interlaboratory study performed in 2007 in which 11 Metal Powder Industries Federation laboratories participated.

9.2 FLC2-4808 sinter-hardened transverse rupture test specimens with a sintered density of 6.94 g/cm^3 and an apparent hardness of 45 HRC were used in the study. Each laboratory received a single TRS sample from this batch.

9.3 The analysis was based on three measurements per surface using a length of travel that varied from 0.098 in. (2.49 mm) to 0.5 in. (12.7 mm). Some laboratories used the recommended chisel (knife) edge stylus, others used the conventional full radius stylus point, and one laboratory provided data using both types of stylus.

9.3.1 *Repeatability Limit (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only 1 case in 20.

9.3.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

9.3.1.2 Repeatability limits are listed in Table 1.

9.3.2 *Reproducibility Limit (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only 1 case in 20.