National Institute of Standards & Technology

Certificate

Standard Reference Material® 2071b

Sinusoidal Roughness Specimen

Serial No.

This Standard Reference Material (SRM) is certified for roughness average (Ra) and surface spatial wavelength (D) and is intended for use as a standard for the calibration of stylus instruments used to measure surface roughness. A unit of SRM 2071b consists of a beveled steel block 25 mm x 34 mm x 12 mm, that was coated by an electroless nickel deposition process. A 23 mm x 28 mm area with a sinusoidal roughness profile (see Figure 1) was then machined onto the top surface (see Figure 2). The SRM has a nominal Knoop hardness of 500 kg/mm^2.

The certified Ra and D values and their associated expanded uncertainties are

Certified Roughness Average (Ra)	Certified Surface Wavelength (D)
0.3137 µm ± 0.0083 µm	99.99 µm ± 0.16 µm

Expiration of Certification: The wear induced by repeated contact measurement by stylus instruments will alter the certified values stated in this certificate. The frequency of replacement or verification of this SRM is determined by the user, based on the number of uses and severity of use. However, the specimen is expected to have a useful life of at least eight years **(August 2008)** from date of first use, provided that measurements are taken on clear, undamaged areas. If excessive wear is suspected, the SRM may be returned to NIST for verification. To verify certification of this SRM unit, contact the NIST Precision Engineering Division by telephone at (301) 975-3463 or by fax at (301) 869-0822.

The technical direction and physical measurements leading to certification of this SRM were provided by T.V. Vorburger, J.F. Song, T.B. Renegar, C.D. Foreman, Jr., and Y.B. Yuan (Guest Researcher) of the NIST Precision Engineering Division.

Guidance on statistical analysis was provided by M.C. Croarkin of the NIST Statistical Engineering Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the NIST Standard Reference Materials Program by R.J. Gettings.

Dennis A. Swyt, Chief
Precision Engineering Division

Gaithersburg, MD 20899
Certificate Issue Date: 23 August 2000

Nancy M. Trahey, Chief
Standard Reference Materials Program

This SRM was machined by Optical Filter Corporation of Keene, NH, using a single-point, diamond tool in a facing operation with a numerically controlled tool path. The surface profile is highly sinusoidal as shown in

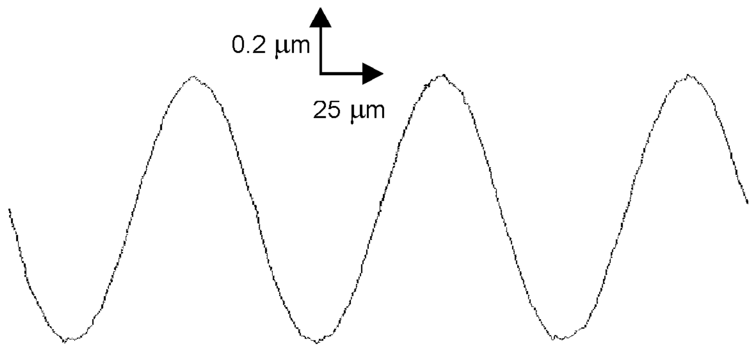


Figure 1. Representative surface profile trace of SRM 2071b. Dimensions are approximate.

NIST Certification Procedure: The certified Ra is the average absolute deviation of the surface peaks and valleys about the mean line. Ra is defined in the ASME B 46.1-1995 Surface Texture (Surface Roughness, Waviness, and Lay) [1]. D is the average period of the sinusoidal surface profile. This quantity may be used to calibrate instruments that measure the mean spacing of profile irregularities, RSm, a parameter discussed in the ISO Standards 4287-1997 [2].

The parameters Ra and D were calculated from roughness profiles of the SRM measured with a stylus instrument using procedures in ASME B 46.1. A Gaussian-type filter [3] with a cutoff of 0.8 mm was used to attenuate long surface spatial wavelengths. The sampling rate was one point per µm over the evaluation length of 4.0 mm. The stylus had a tip radius of 5 µm ± 1 µm as profiled by the razor blade trace method [4] and calculated in accordance with the ASME B 46.1 procedure. The contact force was approximately 4×10^{-4} N. This force should cause negligible damage to the hard metal surface; however, faint stylus traces may be visible on the surface.

The stylus instrument was interfaced to a laboratory computer and a laser interferometer; its vertical motion was calibrated using an interferometrically measured step. The instrument was operated in the skidless mode with an external reference datum.

The certified values represent averages of profile traces taken in pairs at each of nine distributed positions on the specimen as shown in Figure 2. The certification is valid for any unflawed position within the area defined by the extremes of the profile traces shown in Figure 2. Because of the curvature of the surface markings, the value for D outside the limits of the measured area is expected to increase.

Calibration Uncertainty: The quoted expanded uncertainty for both Ra and D is equal to twice the combined standard uncertainty. The combined standard uncertainty, calculated in accordance with NIST policy [5], is the quadratic sum of several components. These components are classified as either Type A uncertainties, which are evaluated by statistical methods, or Type B uncertainties, which are evaluated by other methods, such as by making estimates using models of measurement errors.

The combined standard uncertainty for Ra is the quadratic sum of four components of uncertainty. These are:

1. Type A standard uncertainty of 0.00090 µm, arising from the statistical variation in the measured Ra values due to instrument repeatability, instrument reproducibility from day-to-day, roughness non-uniformity over the measuring area of the specimen, and variability among the specimens;
2. Type A standard uncertainty of 0.00038 µm, arising from the possible variation in the measured Ra due to nonlinearity in the instrument response;
3. Type B standard uncertainty of 0.0020 µm, arising from uncertainty in the quoted height of the master step used to calibrate the instrument;
4. Type B uncertainty in the stylus tip radius, resulting in an estimated standard uncertainty of 0.0035 µm for Ra measurements.

The combined standard uncertainty for D is the quadratic sum of six components of uncertainty. These are:

1. A single Type A component that represents the instrument variability combined with the specimen geometrical non-uniformity, resulting in a standard uncertainty of 0.082 µm;
2. Type B uncertainty in the vacuum wavelength of the HeNe laser interferometer, resulting in a standard uncertainty of 0.000029 µm;
3. Type B uncertainty in the HeNe wavelength due to uncertainty in the temperature, pressure, and humidity of the laboratory, resulting in a standard uncertainty of 0.00133 µm;
4. Type B uncertainty in the temperature of the SRM itself, resulting in a standard uncertainty of 0.00135 µm;
5. Possible Type B cosine error in specimen alignment, resulting in a standard uncertainty of 0.00016 µm.
6 Possible Type B errors associated with Abbé offset resulting in a standard uncertainty of 0.0007 µm.

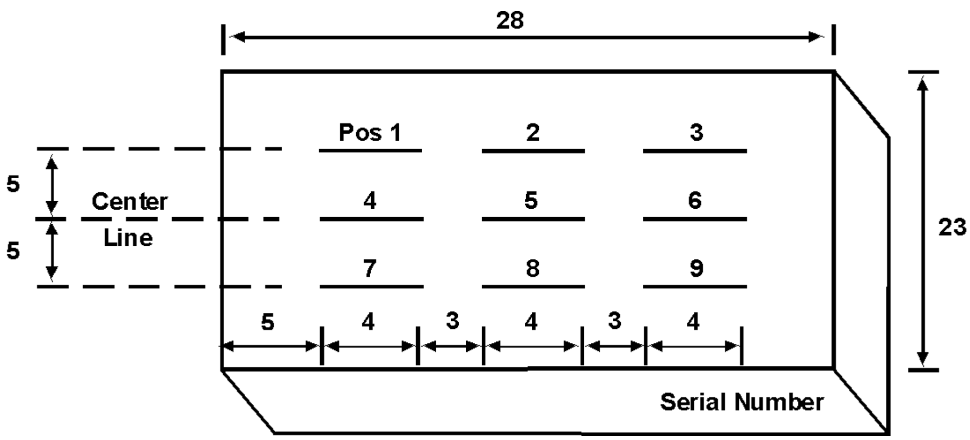


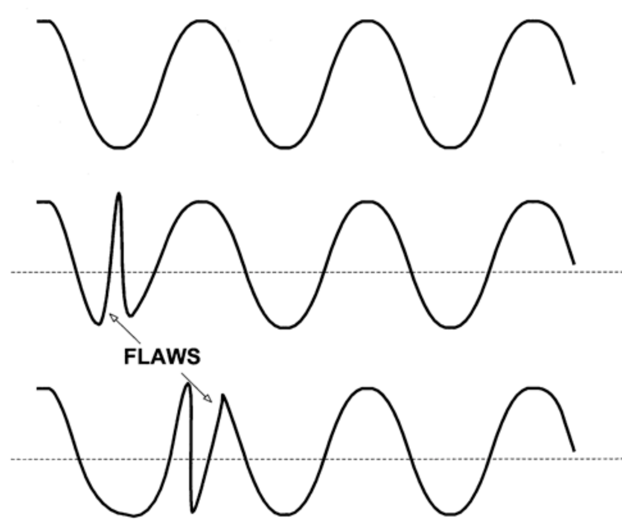
Figure 2. Measurement positions on machined area of SRM 2071b. All dimensions are in mm.

Instrument Calibration using SRM 2071b: This specimen is used to calibrate instruments that measure surface texture or to check the calibration of these types of instruments. The unit itself has calibrated values of Ra and D, a parameter that is nearly identical to the mean spacing of peak irregularities, RSm, for sinusoidal surfaces. Hence, the specimen may be used to calibrate both vertical (z) and lateral (x) scale factors of surface profiling instruments and to check the accuracy of those instruments to measure the Ra and RSm parameters.

Range of Usage: Each day the instrument is used, calibration checks should be made with the SRM both before and after the operator performs measurements of unknown specimens. Because the specimen has a single Ra value of approximately 0.3 µm and a single D value of approximately 100 µm, it is useful for checking instruments being used to measure Ra values between 0.1 µm and 0.5 µm or RSm values between 30 µm and 150 µm.

Instrument Parameters: When using the SRM, surface profiles should be measured parallel to the long axis of the specimen. The long-wavelength cutoff should be 0.8 mm. The profile evaluation length should be at least 4 mm. This length enables the instrument to measure enough peaks and valleys of the surface to provide the user with precise values of Ra and D. The cutoff filter should be the Gaussian type discussed in ISO Standard 11562 [6] and ASME B 46.1 [1]. Using the traditional 2RC filter decreases the measured Ra value by about 0.5 % with respect to the Gaussian filter.

Avoidance of Flaws: The specimens have been manufactured with very few visible flaws. The user should avoid



measuring paths on SRM 2071b that intersect flaws visible to the naked eye. In addition and more specifically, even single flaws in surface profiles, such as those shown in Figure 3, should be avoided because they can change the measured RSm value significantly (2.5 % if the surface profile contains 40 peaks and valleys), because the customary algorithms for calculating RSm rely on counting the crossings of the mean line (shown dashed here) by the surface profile. Single flaws such as these do not change the Ra values as significantly as they can change RSm, but the change in value for Ra is difficult to determine precisely without a detailed measurement of the shape of the flaw.

Figure 3. Avoidance of flaws in surface measurements.

REFERENCES

[1] ASME B 46.1-1995, *Surface Texture*, American Society of Mechanical Engineers, New York, (1995).

[2] ISO-4287-1997, *Geometrical Product Specifications (GPS) – Surface Texture: Profile Method – Terms, Definitions, and Surface Texture Parameters*, International Organization for Standardization (ISO), Geneva, Switzerland, (1997).

[3] Yuan, Y., "A Simplified Realization for the Gaussian Filter in Surface Metrology," *X International Colloquium on Surfaces*, Chemnitz, Germany, Jan. 31-Feb. 02, 2000, Dietzsch, M., Trumpold, H., eds., Shaker Verlag GmbH, Aachen, p. 133, (2000).

[4] Vorburger, T.V., Teague, E.C., Scire, F.E., and Rosberry, F.W., "Measurements of Stylus Radii," Wear **57**, p. 39, (1979).

[5] *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st Ed. ISO, Geneva, Switzerland, (1993); see also Taylor, B.N. and Kuyatt, C.E., "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, U.S. Government Printing Office, Washington DC, (1994); available at http://physics.nist.gov/Pubs/.

[6] ISO 11562-1996, *Geometrical Product Specifications (GFS) - Surface Texture: Profile Method - Metrological Characteristics of Phase Correct Filters*, International Organization for Standardization (ISO), Geneva, (1996).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet http://www.nist.gov/srm.