

ASME B46.1-2009
(Revision of ASME B46.1-2002)

Surface Texture (Surface Roughness, Waviness, and Lay)

AN AMERICAN NATIONAL STANDARD



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FOREWORD

The first standard on surface texture was issued in March 1940. The dates for the subsequent changes are as follows:

Revision — February 1947
Revision — January 1955
Revision — September 1962
Revision — August 1971
Revision — March 1978
Revision — March 1985
Revision — June 1995
Revision — October 2002

The current revision is the culmination of a major effort by the ASME Committee B46 on the Classification and Designation of Surface Qualities. A considerable amount of new material has been added, particularly to reflect the increasing number of surface measurement techniques and surface parameters in practical use. Overall, our vision for the ASME B46.1 Standard is twofold as follows:

- (a) to keep it abreast of the latest developments in the regime of contact profiling techniques where the degree of measurement control is highly advanced
- (b) to encompass a large range of other techniques that present valid and useful descriptions of surface texture

Technical drawings referring to a specific version of the ASME B46.1 Standard (e.g., ASME B46.1-2009) refers to the rules and definitions given in that version of the surface texture standard as indicated. For technical drawings that do not indicate a specific ASME B46.1 surface texture standard, the rules and definitions given in the ASME B46.1 revision in effect at the release date of the drawing must be used.

The ASME B46 Committee contributes to international standardization activities related to surface texture measurement and analysis as referenced in ISO/TR 14368:1995, Geometrical Product Specification (GPS) — Master Plan.

The present Standard includes 12 sections as follows:

Section 1, Terms Related to Surface Texture, contains a number of definitions that are used in other sections of the Standard. Furthermore, a large number of surface parameters are defined in addition to roughness average, R_a . These include rms roughness R_q , waviness height W_t , the mean spacing of profile irregularities RSm , and several statistical functions, as well as surface parameters for area profiling techniques.

Section 2, Classification of Instruments for Surface Texture Measurement, defines six types of surface texture measuring instruments including several types of profiling instruments, scanned probe microcopy, and area averaging instruments. With this classification scheme, it is possible that future sections may then provide for the specification on drawings of the type of instrument to be used for a particular surface texture measurement.

Section 3, Terminology and Measurement Procedures for Profiling, Contact, Skidless Instruments, is based on proposals in ISO Technical Committee 57 to define the characteristics of instruments that directly measure surface profiles, which then can serve as input data to the calculations of surface texture parameters.

Section 4, Measurement Procedures for Contact, Skidded Instruments, contains much of the information that was previously contained in ASME B46.1-1985 for specification of instruments primarily intended for measurement of averaging parameters such as the roughness average R_a .

Section 5, Measurement Techniques for Area Profiling, lists a number of techniques, many of them developed since the mid 1980's, for three dimensional surface mapping. Because of the diversity of techniques, very few recommendations can be given in Section 5 at this time to facilitate uniformity of results between different techniques. However, this section does allow



for the measurement of the area profiling parameters, S_a and S_q , as alternatives to the traditional profiling parameters.

Section 6, Measurement Techniques for Area Averaging, discusses the use of area averaging techniques as comparators to distinguish the surface texture of parts manufactured by similar processes. In future sections, surface parameters based directly on these techniques may be defined or surface specifications may be proposed that call for measurements by these types of instruments.

Section 7, Nanometer Surface Texture and Step Height Measurements by Stylus Profiling Instruments, addresses the use of contacting profilometry in the measurement of surface texture features whose height dimensions are typically measured within the scale of nanometers. Section 7 may be applicable to such industries as the semiconductor, data storage, and micro electro-mechanical systems (MEMS) manufacturers.

Section 8, Nanometer Surface Roughness as Measured With Phase Measuring Interferometric Microscopy, addresses the use of optical noncontact techniques for measuring highly polished surfaces. Section 8 may be applied to the measurement of such items as polished silicon wafers, optical components and precision mechanical components.

Section 9, Filtering of Surface Profiles, carries on with the traditional specifications of the 2RC cutoff filter and introduces the phase corrected Gaussian filter as well as band-pass roughness concepts.

Section 10, Terminology and Procedures for Evaluation of Surface Textures Using Fractal Geometry, introduces the field of fractal analysis as applied to measuring surface texture. Introductions of various techniques and terms are included to allow for lateral scale specific interpretation of surface texture.

Section 11, Specifications and Procedures for Precision Reference Specimens, describes different types of specimens useful in the calibration and testing of surface profiling instruments. It is based on ISO 5436, Part 1, Material Measures, and contains new information as well.

Section 12, Specifications and Procedures for Roughness Comparison Specimens, describes specimens that are useful for the testing and characterization of area averaging instruments.

ASME B46.1-2009 was approved by the American National Standards Institute on October 22, 2009.



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Classification and Designation of Surface Qualities

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Edition: Cite the applicable edition of the Standard for which the interpretation is being requested.
Question: Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings, which are necessary to explain the question; however, they should not contain proprietary names or information.

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EXECUTIVE SUMMARY

1 GENERAL

In cases of disagreement regarding the interpretation of surface texture measurements, it is recommended that measurements with skidless stylus based instruments with Gaussian filtering be used as the basis for interpretation. The following key measurement parameters must be established for proper surface texture specification and measurement.

2 FILTERING

The spatial wavelengths to be included in a surface texture measurement are generally limited by digital bandpass filtering. For measurement of roughness, short wavelength cutoff, λ_s , specifies the short spatial wavelength limit and is defined as the wavelength where the Gaussian filter will attenuate the true profile by 50%. Spatial wavelengths less than λ_s are severely attenuated and minimally contribute to the roughness measurement.

The roughness long wavelength cutoff, λ_c , specifies the long spatial wavelength limit and is defined as the wavelength where the Gaussian filter will attenuate the true profile by 50%. Spatial wavelengths greater than λ_c are severely attenuated and minimally contribute to the roughness measurement.

The ratio of λ_c to λ_s ($\lambda_c:\lambda_s$) is the bandwidth of the measurement. Some instruments allow the selection of λ_c and λ_s individually and/or the selection of a bandwidth, typically 100:1 or 300:1. The spatial wavelengths comprising the texture between λ_s and λ_c are minimally attenuated by the Gaussian filter.

The cutoffs, λ_c and λ_s , should be chosen by the designer in light of the intended function of the surface. When choosing λ_c and λ_s , one must be cognizant that the surface features not measured within the roughness cutoff bandwidth may be quite large and may affect the intended function of the surface. Thus in some cases it may be necessary to specify both surface roughness and waviness.

When surface waviness control is important, digital bandpass filtering is applied similarly as it is for roughness filtering. For waviness, the waviness short wavelength cutoff (λ_{sw}) and waviness long wavelength cutoff (λ_{cw}) are applied to obtain the waviness profile. An important consideration is the correspondence of the roughness long wavelength cutoff and the waviness short wavelength cutoff. When these respective cutoff values are not equal, the discrimination of the roughness and waviness features of a given surface can become confounded.

On all surface texture specifications as of January 1997, λ_c and λ_s must be stated. When λ_c and λ_s are not specified, guidelines are given in paras. 3-3.20.1 and 3-3.20.2 of ASME B46.1-2009 for the metrologist to establish λ_c and λ_s . These guidelines are intended to include the dominant features of the surface in the measurement whether these surface features are relevant to the function of the surface or not.

3 STYLUS TIP RADIUS

The stylus tip radius may be chosen by the designer or metrologist based on the value of λ_s (i.e., the short wave cutoff). For λ_s equal to 2.5 μm , the tip radius should typically be 2 μm or less. For λ_s equal to 8 μm , the tip radius should typically be 5 μm or less. For λ_s equal to 25 μm , the tip radius should typically be 10 μm or less.

4 STYLUS FORCE

The maximum static measuring force is determined by the radius of the stylus and is chosen to assure minimal damage to the surface and that constant contact is maintained with the surface. Specific recommendations for stylus force may be found in para. 3-3.5.2 of the ASME B46.1-2009 standard.

5 MEASUREMENT PARAMETERS

Many surface finish height parameters are in use throughout the world. From the simplest specification of a single roughness parameter to multiple roughness and waviness parameter specifications of a given surface, product designers have many options for specifying surface texture in order to control surface function. Between these extremes, designers should consider the need to control roughness height (e.g., R_a or R_z), roughness height consistency (e.g., R_{max}), and waviness height (e.g., W_t). Waviness is a secondary longer wavelength feature that is only of concern for particular surface functions and finishing processes. A complete description of the various texture parameters may be found in Section 1 of the B46.1-2009 standard.

6 SURFACE TEXTURE SYMBOLS

Once the various key measurement parameters are established, ISO 1302:2002, may be used to establish the proper indication on the relevant engineering drawings.

