ASME B46.1-2019

(Revision of ASME B46.1-2009)

Surface Texture
(Surface Roughness, Waviness, and Lay)

AN INTERNATIONAL STANDARD

The American Society of Mechanical Engineers

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CONTENTS

Nonmandatory Appendices

Figures

Tables

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 — March 1985
Revision — January 1955	Revision — June 1995
Revision — September 1962	Revision — October 2002
Revision — August 1971	Revision — October 2009
Revision — March 1978	

The current revision is the culmination of a major effort by the ASME B46 Committee 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, the vision for ASME B46.1 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 edition of ASME B46.1 (e.g., ASME B46.1-2009) refer to the rules and definitions given in that edition of the surface texture standard as indicated. For technical drawings that do not indicate a specific edition of the 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 shall 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) — Masterplan.

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. A large number of surface parameters are defined in addition to roughness average, *Ra*. These include rms roughness *Rq*, waviness height *Wt*, the mean spacing of profile elements *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 microscopy, and area averaging instruments. With this classification scheme, future Sections may 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 by 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 *Ra*.

Section 5, Measurement Techniques for Area Profiling, lists a number of techniques, many of them developed since the mid-1980s, 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, *Sa* and *Sq*, 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 later 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 semiconductor, data storage, and microelectromechanical 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 B46.1-2019 was approved by the American National Standards Institute on October 22, 2019.

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Classification and Designation of Surface Qualities

(The following is the roster of the Committee at the time of approval of this Standard.)

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Secretary, B46 Standards Committee
The American Society of Mechanical Engineers
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http://go.asme.org/Inquiry

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

This Standard is always open for comment and the Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Proposing a Case. Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

Interpretations. Upon request, the B46 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B46 Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the B46 Standards Committee at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.
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. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable.
Proposed Reply(ies):	Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.
Background Information:	Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

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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 band-pass filtering. For measurement of roughness, short-wavelength cutoff, λs, 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 λs are severely attenuated and minimally contribute to the roughness measurement.

The roughness long-wavelength cutoff, λc, 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 λc are severely attenuated and minimally contribute to the roughness measurement.

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

The cutoffs, λc and λs, should be chosen by the designer in light of the intended function of the surface. When choosing λc and λs, 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 band-pass filtering is applied similarly as it is for roughness filtering. For waviness, the waviness short-wavelength cutoff, λsw, and waviness long-wavelength cutoff, λcw, 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, λc and λs must be stated. When λc and λs are not specified, guidelines are given in paras. 3-3.20.1 and 3-3.20.2 for the metrologist to establish λc and λs. 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 λs (i.e., the short-wavelength cutoff). For λs equal to 2.5 μm, the tip radius should typically be 2 μm or less. For λs equal to 8 μm, the tip radius should typically be 5 μm or less. For λs 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.

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 to control surface function. Between these extremes, designers should consider the need to control roughness height (e.g., *Ra* or *Rz*), roughness height consistency (e.g., *Rmax*), and waviness height (e.g., *Wt*). 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.

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.