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.

SOLUS 1018

ASME B46.1-2019
SUMMARY OF CHANGES

Following approval by the ASME B46 Committee and ASME, and after public review, ASME B46.1-2019 was approved by the American National Standards Institute on October 22, 2019.

In ASME B46.1-2019, the figures and tables have been redesignated based on their parent paragraph, and the cross-references have been updated accordingly. ASME B46.1-2019 includes the following additional changes identified by a margin note, **(19)**.

Page	*Location*	*Change*
1	1-1.4	Address of ISO updated
3	1-3.3	Definitions of *profile element*, *profile peak*, *profile peak height*, *profile valley*, and *profile valley depth* revised
7	Figure 1-3.3-1	Former Figure 1-6 revised
9	1-4.2	Definitions of *mean spacing of profile elements*, *peak density*, *SAE peak*, and *spacing parameter* revised
10	Figure 1-4.2-1	Former Figure 1-13 revised
13	1-4.4	In first equation, symbol between *dZ* and *dx* corrected to division symbol
20	Figure 1-6.5-1	Former Figure 1-23 revised
24	3-2	Address of ISO updated
29	Table 3-3.20.1-1	Former Table 3-1 editorially revised
29	Table 3-3.20.2-1	Former Table 3-2 editorially revised
31	4-2	Address of ISO updated
36	5-2	Address of ISO updated
38	7-2	Address of ISO updated
47	9-2	Address of ISO updated
51	Table 9-4.3.2-1	Former Table 9-1 editorially revised
63	11-2	Address of ISO updated
71	Table 11-7.3-1	Former Table 11-5 revised
72	Table 11-7.3-3	Former Table 11-7 revised
73	Table 11-7.3-4	Former Table 11-8 revised
75	12-2	Address of ISO updated
82	Nonmandatory Appendix B, B-5	Added
91	Nonmandatory Appendix D	D-1 added and subsequent sections redesignated
94	Nonmandatory Appendix E	E-1 added and subsequent sections redesignated
104	Nonmandatory Appendix G	Section headings G-1 and G-2 editorially added
117	Nonmandatory Appendix J	Updated
118	Nonmandatory Appendix K	Added

Section 1
Terms Related to Surface Texture

1-1 GENERAL

1-1.1 Scope

This Standard is concerned with the geometric irregularities of surfaces. It defines surface texture and its constituents: roughness, waviness, and lay. It also defines parameters for specifying surface texture.

The terms and ratings in this Standard relate to surfaces produced by such means as abrading, casting, coating, cutting, etching, plastic deformation, sintering, wear, and erosion.

1-1.2 Limitations

This Standard is not concerned with error of form and flaws, but discusses these two factors to distinguish them from surface texture.

This Standard is not concerned with luster, appearance, color, corrosion resistance, wear resistance, hardness, subsurface microstructure, surface integrity, and many other characteristics that may govern functional considerations in specific applications.

This Section does not recommend specific surface roughness, waviness, or type of lay suitable for specific purposes, nor does it specify the means by which these irregularities may be obtained or produced. Criteria for selection of surface qualities and information on instrument techniques and methods of producing, controlling, and inspecting surfaces are included in the other Sections and in the Appendices.

Surface texture designations as delineated in this Standard may not provide a sufficient set of indices for describing performance. Other characteristics of engineering components such as dimensional and geometrical characteristics, material, metallurgy, and stress must also be controlled.

1-1.3 SI Values

Values of quantities stated in the SI[1] (metric) system are to be regarded as standard. Approximate nonmetric equivalents are shown for reference.

1-1.4 References (19)

Unless otherwise specified on the engineering drawing or other relevant documents, this Standard is to be used in conjunction with ISO 1302:2002, which prescribes engineering drawing and other related documentation practices for specifying surface texture. Relevant standards that may be used in design and measurement are the following:

ASME B89.6.2-1973 (R2003), Temperature and Humidity Environment for Dimensional Measurement

ASME Y14.5M-1994 (R2004), Dimensioning and Tolerancing, Engineering Drawings and Related Documentation Practices

Publisher: The American Society of Mechanical Engineers (ASME), Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ISO 1302:2002, Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation

Publisher: International Organization for Standardization (ISO), Central Secretariat, Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland (www.iso.org)

Nonmandatory Appendix J, Table J-1 is a partial list of specific industry standards that reference surface texture specifications. Users are encouraged to submit additional industry standards to be considered as references in Nonmandatory Appendix J.

References to other useful works are included as footnotes.

1-1.5 Cleanliness

Normally, surfaces to be measured should be free of any foreign material that would interfere with the measurement.

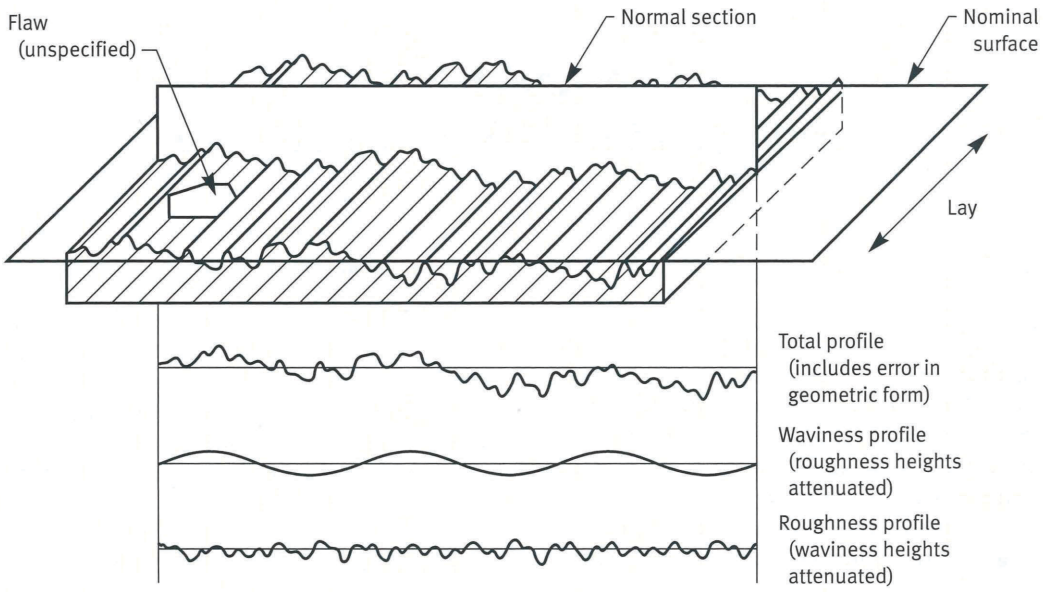
1-2 DEFINITIONS RELATED TO SURFACES

1-2.1 Surfaces

measured surface: a representation of the real surface obtained by the use of a measuring instrument.

[1] Le Système International d'Unités.

Figure 1-2.1-1 Schematic Diagram of Surface Characteristics



nominal surface: the intended surface boundary (exclusive of any intended surface roughness), the shape and extent of which are usually shown and dimensioned on a drawing or descriptive specification (see Figure 1-2.1-1).

real surface: the actual boundary of an object. Its deviations from the nominal surface stem from the processes that produce the surface.

surface: the boundary that separates an object from another object, substance, or space.

1-2.2 Components of the Real Surface

The real surface differs from the nominal surface to the extent that it exhibits surface texture, flaws, and errors of form. It is considered as the linear superposition of roughness, waviness, and form with the addition of flaws.

error of form: widely spaced deviations of the real surface from the nominal surface, which are not included in surface texture. The term is applied to deviations caused by such factors as errors in machine tool ways, guides, or spindles; insecure clamping or incorrect alignment of the workpiece; or uneven wear. Out-of-flatness and out-of-roundness[2] are typical examples.

flaws: unintentional, unexpected, and unwanted interruptions in the topography typical of a surface. Topography is defined in para. 1-5.1. However, these topographical interruptions are considered to be flaws only when agreed upon in advance by buyer and seller. If flaws are specified, the surface should be inspected by some mutually agreed-upon method to determine whether flaws are present and whether they are to be rejected or accepted prior to performing final surface roughness measurements. If specified flaws are not present, or if flaws are not specified, then interruptions in the surface topography of an engineering component may be included in roughness measurements.

lay: the predominant direction of the surface pattern, ordinarily determined by the production method used (see para. 1-6.5 and Figure 1-6.5-1).

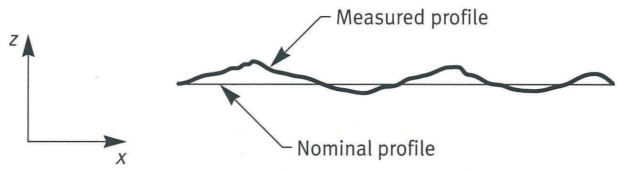
roughness: the finer spaced irregularities of the surface texture that usually result from the inherent action of the production process or material condition. These might be characteristic marks left by the processes listed in Nonmandatory Appendix B, Figure B-2-1.

surface texture: the composite of certain deviations that are typical of the real surface. It includes roughness and waviness.

waviness: the more widely spaced component of the surface texture. Waviness may be caused by such factors as machine or workpiece deflections, vibration, and chatter. Roughness may be considered as superimposed on a wavy surface.

[2] ASME/ANSI B89.3.1-1972 (R1997), Measurement of Out-of-Roundness.

Figure 1-3.1-1 Measured Versus Nominal Profile



1-3 DEFINITIONS RELATED TO THE MEASUREMENT OF SURFACE TEXTURE BY PROFILING METHODS

The features defined in para. 1-2.2 are inherent to surfaces and are independent of the method of measurement. Methods of measurement of surface texture can be classified generally as contact or noncontact methods and as three-dimensional (area) or two-dimensional (profile) methods.

1-3.1 Profiles

form-suppressed profile: a modified profile obtained by various techniques to attenuate dominant form such as curvature or tilt. An example of a mechanical technique involves the use of a skidded instrument (see Section 4).

measured profile: a representation of the real profile obtained by a measuring instrument (see Figure 1-3.1-1). The profile is usually drawn in an *x-z* coordinate system.

modified profile: a representation of the measured profile for which various mechanisms (electrical, mechanical, optical, or digital) are used to minimize certain surface texture characteristics and emphasize others. Modified profiles differ from unmodified, measured profiles in ways that are selectable by the instrument user, usually for the purpose of distinguishing surface roughness from surface waviness.

By previous definition (see para. 1-2.2), roughness irregularities are more closely spaced than waviness irregularities. Roughness can thus be distinguished from waviness in terms of spatial wavelengths along the path traced. See para. 1-3.4 for a definition of spatial wavelength. No unique spatial wavelength is defined that would distinguish roughness from waviness for all surfaces.

nominal profile: a profile of the nominal surface; a straight line or smooth curve (see Figure 1-3.2-2).

primary profile: a modified profile after the application of the short-wavelength filter, λs (see Section 9).

NOTE: This corresponds to *P* (profile) parameters per ISO 4287:1997.

profile: the curve of intersection of a normal sectioning plane with the surface (see Figure 1-2.1-1).

profiling method: a surface scanning measurement technique that produces a two-dimensional graph or profile of the surface irregularities as measurement data.

real profile: a profile of the real surface.

roughness profile: the modified profile obtained by filtering to attenuate the longer spatial wavelengths associated with waviness (see Figure 1-2.1-1).

waviness profile: the modified profile obtained by filtering to attenuate the shorter spatial wavelengths associated with roughness and the longer spatial wavelengths associated with the part form.

1-3.1.1 Aspect Ratio. In displays of surface profiles generated by instruments, heights are usually magnified many times more than distances along the profile (see Figure 1-3.1.1-1).[3] The sharp peaks and valleys and the steep slopes seen on such profile representations of surfaces are thus greatly distorted images of the relatively gentle slopes characteristic of actual measured profiles.

1-3.2 Reference Lines

mean line (M): the reference line about which the profile deviations are measured. The mean line may be determined in several ways as discussed below.

filtered mean line: the mean line established by the selected cutoff filter (see para. 1-3.5) and its associated analog or digital circuitry in a surface measuring instrument. Figure 1-3.2-1 illustrates the electrical filtering of a surface profile. It shows the unfiltered profile in Figure 1-3.2-1, sketch (a), along with the filtered mean line or waviness profile. The difference between the unfiltered profile and the waviness profile is the roughness profile shown in Figure 1-3.2-1, sketch (b).

least squares mean line: a line having the form of the nominal profile and dividing the profile so that, within a selected length, the sum of the squares of the profile deviations from this line is minimized. The form of the nominal profile could be a straight line or a curve (see Figure 1-3.2-2).

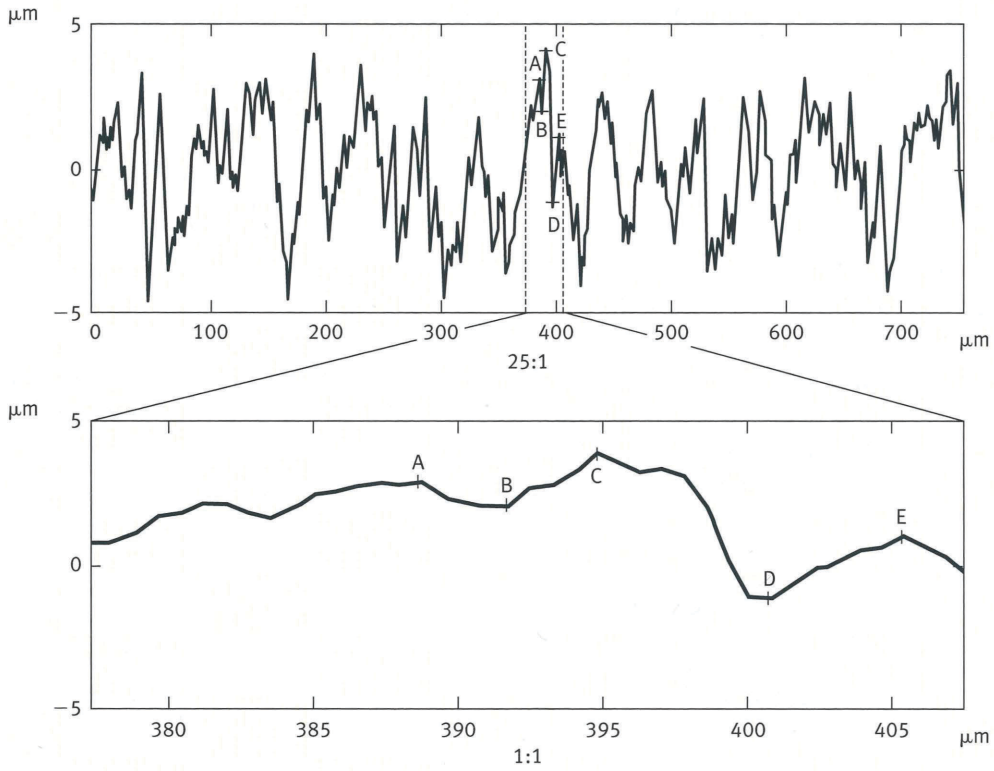
1-3.3 Peaks and Valleys, Height Resolution, and Height Range (19)

height (z) range: the largest overall peak-to-valley surface height that can be accurately detected by a measuring instrument. This is a key specification for a measuring instrument.

profile element: a profile peak followed by a profile valley or a profile valley followed by a profile peak (see Figure 1-3.3-1).

[3] R. E. Reason, *Modern Workshop Technology, 2 — Processes,* H. W. Baker, ed., 3rd edition (London: Macmillan, 1970): Chapter 23.

Figure 1-3.1.1-1 Stylus Profile Displayed With Two Different Aspect Ratios



profile peak: the portion of a profile that lies above the mean line and between two intersections of the profile with the mean line (see Figure 1-3.3-1).

profile peak height: maximum height of the profile peak (see Figure 1-3.3-1).

profile valley: the portion of a profile that lies below the mean line and between two intersections of the profile with the mean line (see Figure 1-3.3-1).

profile valley depth: maximum depth of the profile valley (see Figure 1-3.3-1).

system height (z) resolution: the minimum step height that can be distinguished from background noise by a measuring system. This is a key specification for a measuring instrument. The system background noise can be evaluated by measuring the apparent root mean square (rms) roughness of a surface whose actual roughness is significantly smaller than the system background noise.

1-3.4 Spacings

roughness spacing: the average spacing between adjacent peaks of the measured roughness profile within the roughness sampling length (defined in para. 1-3.5).

sampling interval,[4] d_o*:* the lateral point-to-point spacing of a digitized profile (see Figure 1-4.1.1-1). The minimum spatial wavelength to be included in the profile analysis should be at least five times the sampling interval.

spacing: the distance between specified points on the profile measured along the nominal profile.

spatial wavelength, λ*:* the lateral spacing between adjacent peaks of a purely sinusoidal profile.

spatial (x) resolution: for an instrument, the smallest surface spatial wavelength that can be resolved to 50% of its actual amplitude. This is determined by such characteristics of the measuring instrument as the sampling interval, radius of the stylus tip, or optical probe size. This is a key specification for a measuring instrument.

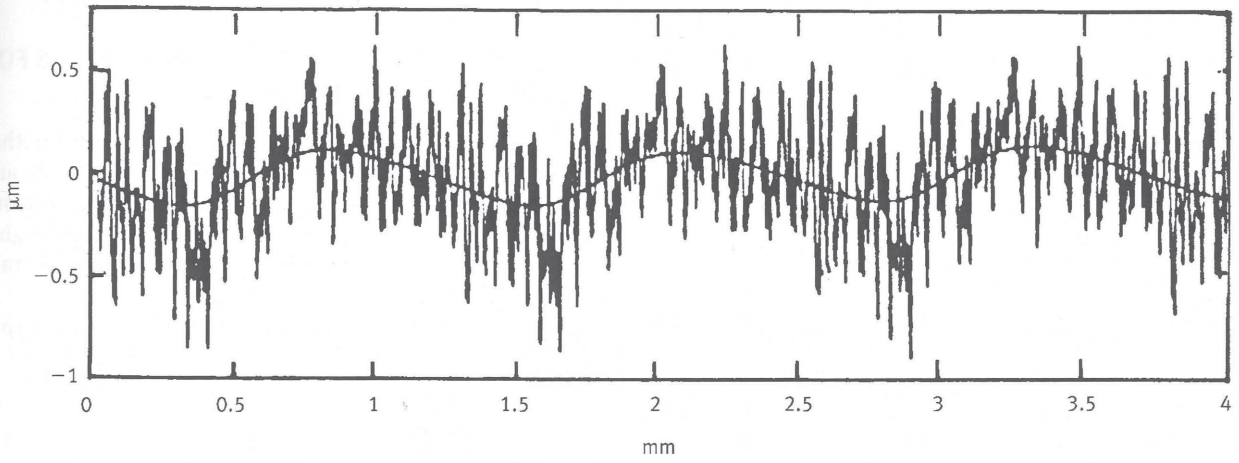
NOTE: Concerning resolution, the sensitivity of an instrument to measure the heights of small surface features may depend on the combination of the spatial resolution and the feature spacing,[5] as well as the system height resolution.

waviness spacing: the average spacing between adjacent peaks of the measured waviness profile within the waviness long-wavelength cutoff (defined in para. 1-3.5).

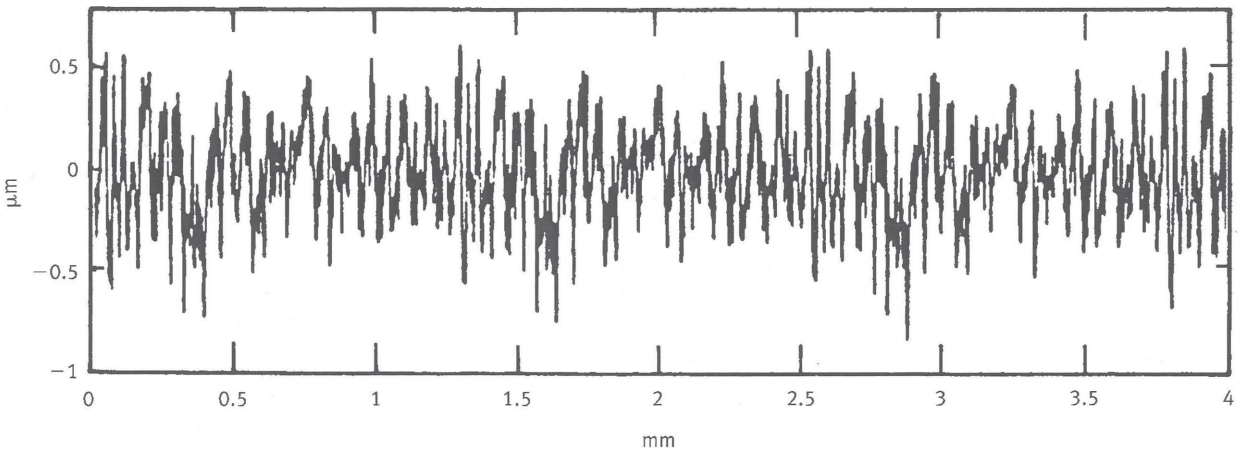
[4] L. P. Sanchez Fernandez, "Interpolation With Splines and FFT in Wave Signals," *Research in Computing Science*, Vol. 10 (2004): 387–400.

[5] J. M. Bennett and L. Mattsson, *Introduction to Surface Roughness and Scattering* (Washington, DC: Optical Society of America, 1989): 22.

Figure 1-3.2-1 Filtering a Surface Profile



(a) Unfiltered Profile and Filtered Mean Line



(b) Roughness Profile

1-3.5 Measurement and Analysis Lengths

evaluation length, L: length in the direction of the *X*-axis used for assessing the profile under evaluation. The evaluation length for roughness is termed *Lr* and the evaluation length for waviness is termed *Lw*.

roughness long-wavelength cutoff,[6] *λc:* the nominal rating in millimeters (mm) of the electrical or digital filter that attenuates the long wavelengths of the surface profile to yield the roughness profile (see Sections 3, 4, and 9). When an electrical or digital filter is used, the roughness long-wavelength cutoff value determines and is equal to the roughness sampling length (i.e., $lr = \lambda c$). The range of selectable roughness long-wavelength cutoffs is a key specification for a surface measuring instrument.

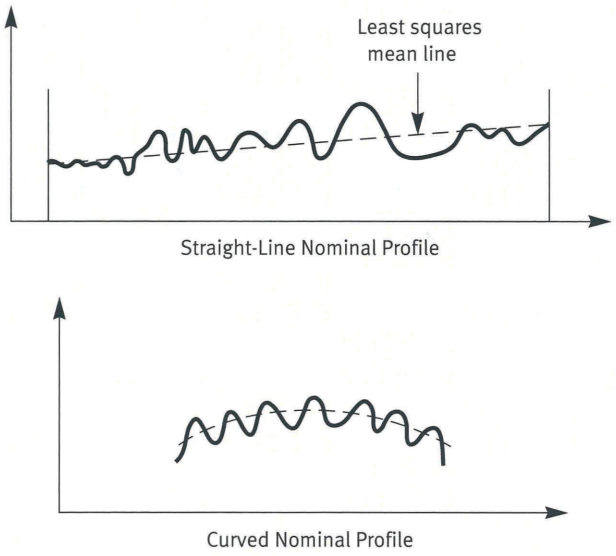
roughness sampling length,[7] *lr:* the sampling length specified to separate the profile irregularities designated as roughness from those irregularities designated as waviness. The roughness sampling length may be determined by electrical analog filtering, digital filtering, or geometrical truncation of the profile into the appropriate lengths.

roughness short-wavelength cutoff, λs: the spatial wavelength shorter than which the fine texture for the surface roughness profile is attenuated.

[6] In most electrical averaging instruments, the cutoff can be selected. It is a characteristic of the instrument rather than the surface being measured. In specifying the cutoff, care must be taken to choose a value that will include all the surface irregularities that one desires to evaluate.

[7] See also Sections 4 and 9 and Nonmandatory Appendix A.

Figure 1-3.2-2 Examples of Nominal Profiles



sampling length, l: length in the direction of the *X*-axis used for identifying the widest irregularities that are of interest for the profile under evaluation. The sampling length is always less than or equal to the evaluation length. The sampling length for roughness is termed *lr* and the sampling length for waviness is termed *lw*.

traversing length: the length of profile that is traversed by a profiling instrument to establish a representative evaluation length. Because of end effects in profile measurements, the traversing length must be longer than the evaluation length (see Figure 1-3.5-1).

waviness long-wavelength cutoff, λcw: the spatial wavelength longer than which the widely spaced undulations of the surface profile are attenuated to separate form from waviness. When an electrical or digital filter is used, the waviness long-wavelength cutoff value determines and is equal to the waviness sampling length (i.e., $lw = \lambda cw$). The range of selectable waviness long-wavelength cutoffs is a key specification for a surface measuring instrument.

waviness sampling length,[6] *lw:* the sampling length specified to separate the profile irregularities designated as waviness from those irregularities designated as form. The waviness sampling length may be determined by electrical analog filtering, digital filtering, or geometrical truncation of the profile into the appropriate lengths.

waviness short-wavelength cutoff, λsw: the spatial wavelength shorter than which the roughness profile fluctuations of the surface profile are attenuated by electrical or digital filters. This rating is generally set equal in value to the corresponding roughness long-wavelength cutoff ($\lambda sw = \lambda c$).

Typical values for the various measurement and analysis lengths are discussed in Sections 3 and 9.

1-4 DEFINITIONS OF SURFACE PARAMETERS FOR PROFILING METHODS

Key quantities that distinguish one profile from another are their height deviations from the nominal profile and the distances between comparable deviations. Various mathematical combinations of surface profile heights and spacings have been devised to compare certain features of profiles numerically.

Nonmandatory Appendix H provides example computer subroutines for the calculation of several of these parameters.

1-4.1 Height (*z*) Parameters

height parameter: a general term used to describe a measurement of the profile taken in a direction normal to the nominal profile. Height parameters are expressed in micrometers (μm).[8]

1-4.1.1 Roughness Height Parameters

average maximum height of the profile, Rz: the average of the successive values of Rt_i calculated over the evaluation length.

average maximum profile peak height, Rpm: the average of the successive values of Rp_i calculated over the evaluation length.

maximum height of the profile, Rt: the vertical distance between the highest and lowest points of the profile within the evaluation length (see Figure 1-4.1.1-1).

$$Rt = Rp + Rv$$

maximum profile peak height, Rp: the distance between the highest point of the profile and the mean line within the evaluation length (see Figure 1-4.1.1-1).

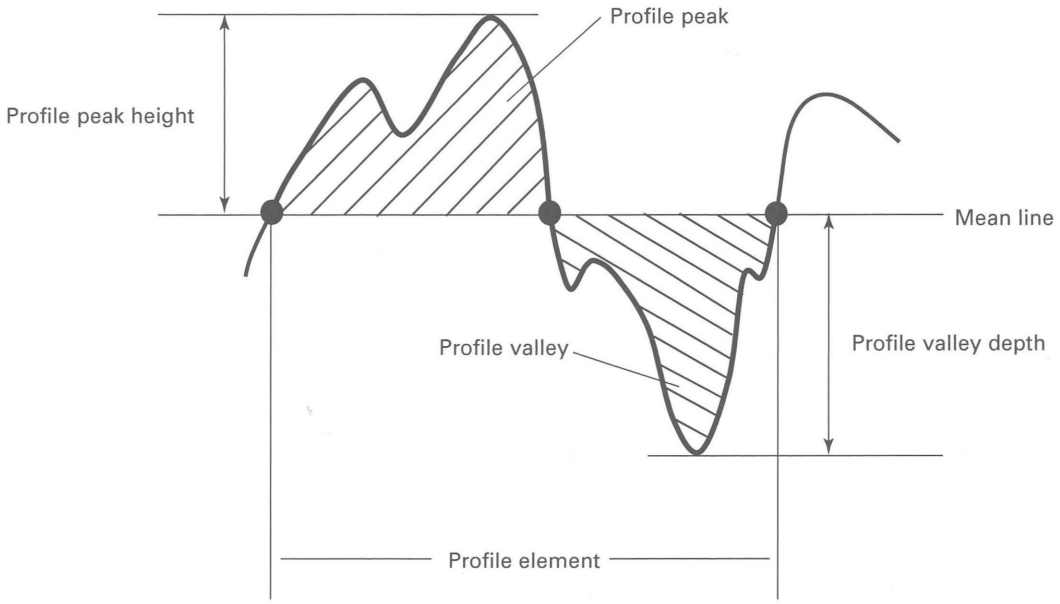
maximum profile valley depth, Rv: the distance between the lowest point of the profile and the mean line within the evaluation length (see Figure 1-4.1.1-1).

maximum roughness depth, Rmax: the largest of the successive values of Rt_i calculated over the evaluation length (see Figure 1-4.1.1-2).

profile height function, Z(x): the function used to represent the point-by-point deviations between the measured profile and the reference mean line (see Figure 1-4.1.1-3). For digital instruments, the profile

[8] A micrometer is one-millionth of a meter (0.000001 m). A microinch is one-millionth of an inch (0.000001 in.). For written specifications or reference to surface roughness requirements, micrometer can be abbreviated as μm, and microinch may be abbreviated as μin. One microinch equals 0.0254 μm (μin. = 0.0254 μm). The nanometer (nm) and the angstrom unit (Å) are also used in some industries; 1 nm = 0.001 μm, 1Å = 0.1 nm.

Figure 1-3.3-1 Profile Peak, Valley, and Element



(19)

Figure 1-3.5-1 Surface Profile Measurement Lengths

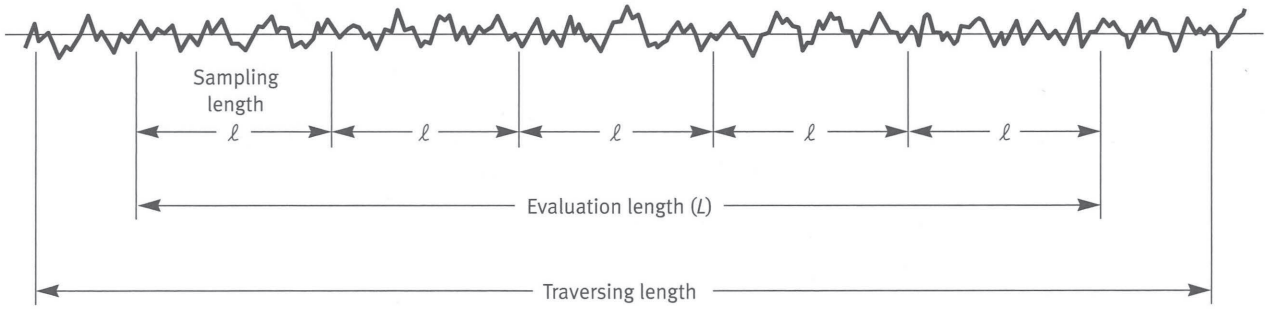


Figure 1-4.1.1-1 *Rt*, *Rp*, and *Rv* Parameters

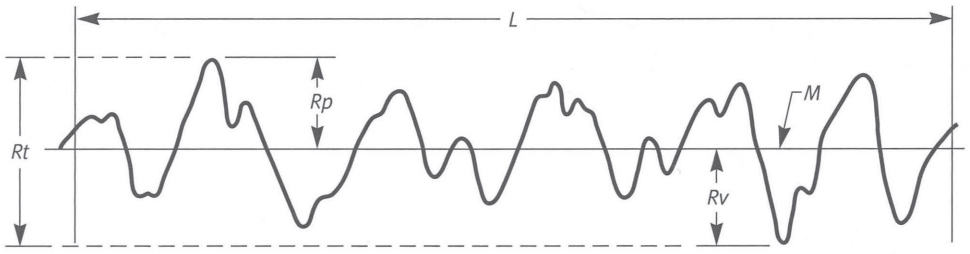


Figure 1-4.1.1-2 The *Rt* and *Rmax* Parameters

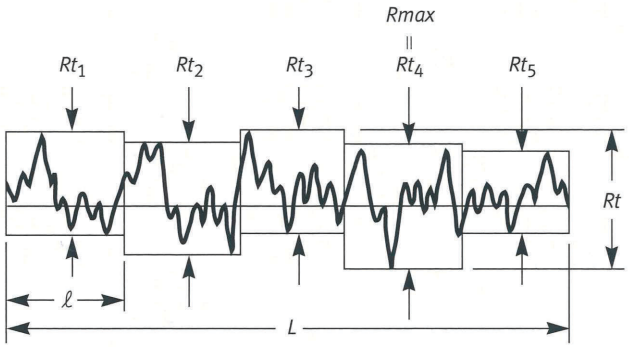
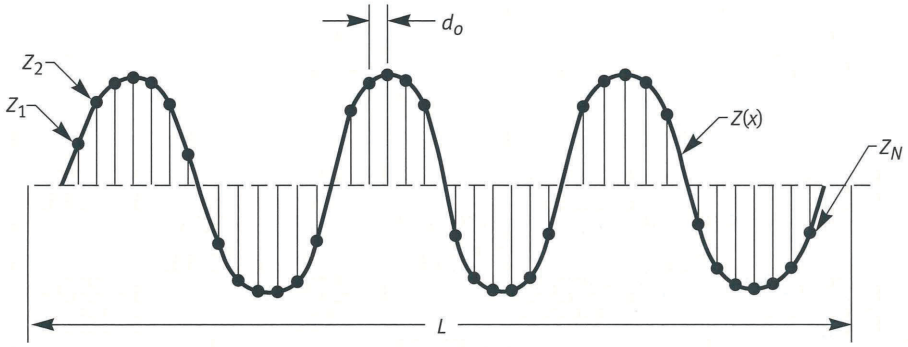


Figure 1-4.1.1-3 Illustration for the Calculation of Roughness Average *Ra*



Ra = average deviation of roughness profile *Z*(*x*) from the mean line
= total shaded area/*L*

Z(x) is approximated by a set of digitized values (Z_i) recorded using the sampling interval (d_o).

root mean square (rms) roughness, Rq: the root mean square average of the profile height deviations taken within the evaluation length and measured from the mean line. Analytically, it is given by the following equation:

$$Rq = \left[(1/L)\int_0^L Z(x)^2 dx\right]^{1/2}$$

The digital approximation is as follows:

$$Rq = [(Z^2{}_1 + Z^2{}_2 + Z^2{}_3 + \ldots + Z^2{}_N)/N]^{1/2}$$

roughness average,[9] *Ra:* the arithmetic average of the absolute values of the profile height deviations recorded within the evaluation length and measured from the mean line. As shown in Figure 1-4.1.1-3, *Ra* is equal to the sum of the shaded areas of the profile divided by the evaluation length *L*, which generally includes several sampling lengths or cutoffs. For graphical determinations of roughness, the height deviations are measured normal to the chart centerline.

Analytically, *Ra* is given by the following equation:

$$Ra = (1/L)\int_0^L |Z(x)|dx$$

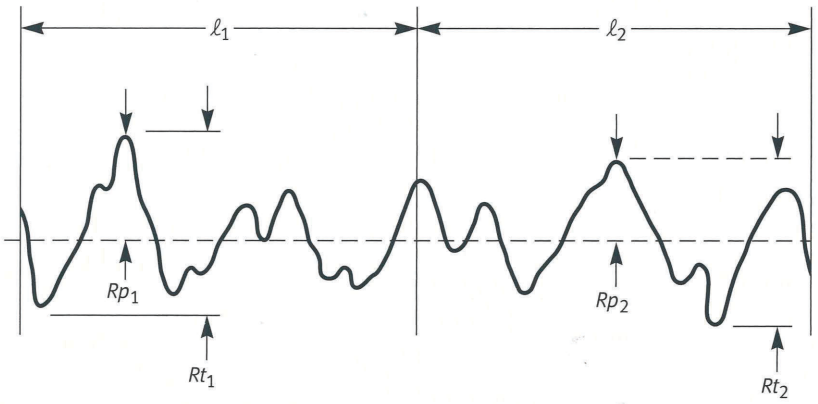
For digital instruments an approximation of the *Ra* value may be obtained by adding the individual Z_i values without regard to sign and dividing the sum by the number of data points *N*.

$$Ra = (|Z_1| + |Z_2| + |Z_3| + \ldots + |Z_N|)/N$$

Rp_i: the distance between the highest point of the profile and the mean line within a sampling length segment labeled *i* (see Figure 1-4.1.1-4).

[9] Roughness average is also known as centerline arithmetic average (AA) and centerline average (CLA).

Figure 1-4.1.1-4 Surface Profile Containing Two Sampling Lengths, l_1 and l_2, Also Showing the Rp_i and Rt_i Parameters



Rt_i: the vertical distance between the highest and lowest points of the profile within a sampling length segment labeled *i* (see Figure 1-4.1.1-4).

1-4.1.2 Waviness Height Parameters

waviness height, Wt: the peak-to-valley height of the modified profile from which roughness and part form have been removed by filtering, smoothing, or other means (see Figure 1-4.1.2-1). The measurement is to be taken normal to the nominal profile within the limits of the waviness evaluation length.

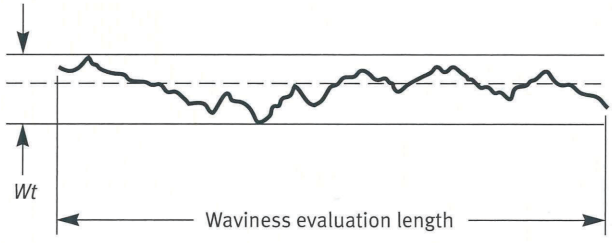
(19) 1-4.2 Spacing Parameters

mean spacing of profile elements, RSm: the mean spacing of the profile elements calculated in both directions along the evaluation length.

$$RSm = (1/n)\sum_{i=1}^{n} Sm_i$$

The parameter *RSm* requires height and spacing discrimination. Profile elements are initiated or completed by full crossings of the mean discrimination band. Each profile element must also exceed a minimum lateral width.

Figure 1-4.1.2-1 The Waviness Height, *Wt*



If not otherwise specified, the default height for the mean discrimination band shall be 10% of *Rz* (i.e., ±5% of *Rz* from the mean line) and the default minimum profile element width shall be 1% of the sampling length; both conditions shall be met.

NOTES:
(1) The default discrimination tolerances may not be appropriate for certain types of surfaces, such as plateau honed surfaces.
(2) In Figure 1-4.2-1, see graphical and annotated examples of the application of the height and width discrimination rules.

peak count level[10]*:* the vertical distance between the boundary lines described in the definition of SAE peak (see Figure 1-4.2-2).

peak density,[10] *Rpc:* the number of SAE peaks per unit length measured at a specified peak count level over the evaluation length.

SAE peak[10]*:* a profile irregularity wherein the profile intersects consecutively a lower and an upper boundary line. The boundary lines are located parallel to and equidistant from the profile mean line (see Figure 1-4.2-2), and are set by a designer or an instrument operator for each application.

spacing parameter: a distance that characterizes the lateral spacing of the individual profile elements.

1-4.3 Shape Parameters and Functions

amplitude density function, ADF*(z)* or *p(z):* the probability density of surface heights. The amplitude density function is normally calculated as a histogram of the digitized points on the profile over the evaluation length (see Figure 1-4.3-1).

[10] SAE J911 — March 1998 (Society of Automotive Engineers).

(19)

Figure 1-4.2-1 The Mean Spacing of Profile Elements, *RSm*

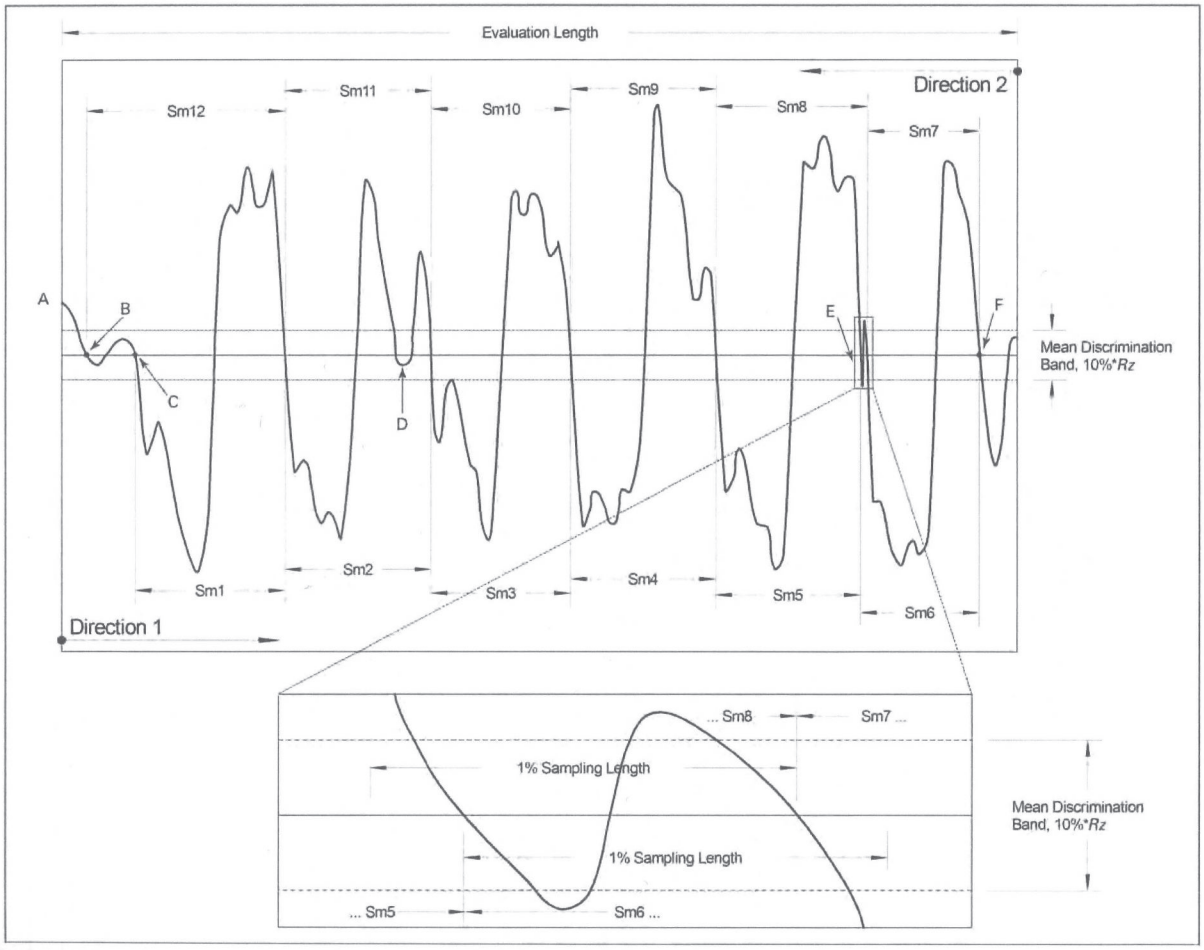


Figure 1-4.2-1 The Mean Spacing of Profile Elements, *RSm* (Cont'd)

Legend:

A = the start of the profile.

B = in Direction 1, the first mean line crossing of the profile; it does not count as the beginning of a valid profile element because the profile does not fully cross the mean discrimination band.

= in Direction 2, the termination point for Sm12; it is the last mean line crossing prior to the last full crossing of the mean discrimination band.

C = the start of Sm1; it is the last mean line crossing prior to a full crossing of the mean discrimination band.

D = a candidate mean line crossing where the profile does not exceed the lower limit of the mean discrimination band. Because it is not a full crossing, it does not count in either direction.

E = a candidate profile element where both the upper and lower limits of the mean discrimination band are crossed but the width of the candidate profile element is insufficient to meet the width requirement (see inset graph). This section of the profile will be combined with the next profile element.

F = the end of Sm6 and the beginning of Sm7. Such congruence is not always the case, as illustrated in C and B for Sm1 and Sm12.

NONMANDATORY APPENDIX I
A COMPARISON OF ASME AND ISO SURFACE TEXTURE PARAMETERS

Table I-1 is a summary of the various ASME B46.1-2019 roughness/waviness parameters as they relate to ISO 4287:1997 parameters. When an ASME B46.1-2019 parameter is identical to an ISO 4287:1997 parameter, the entries appear juxtaposed in the Table. When an ASME B46.1-2019 parameter is similar but not identical to an ISO 4287:1997 parameter, the entries appear in different rows. In many cases, the parameters are similar in principle but differ based on whether the evaluation length or sampling length is used for the calculation.

ISO 4287:1997 uses the *P* symbol to designate parameters related to the unfiltered profile, the *R* symbol to designate filtered roughness parameters, and the *W* symbol to designate filtered waviness parameters. ASME B46.1-2019 is primarily concerned with roughness parameters as designated by the *R* symbol and additional terms as defined. ASME B46.1-2019 also references one waviness parameter, *Wt*.

Table I-1 ASME B46.1-2019 Parameters

ASME B46.1-2019		ISO 4287:1997	
Parameter	**Length Defined Over**	**Parameter**	**Length Defined Over**
Traversing length	...	...	...
Evaluation length, *L*	...	Evaluation length, *ln*	...
Roughness sampling length, *lr*	...	Sampling length, *lr*	...
Waviness sampling length, *lw*	...	Sampling length, *lw*	...
Roughness long-wavelength cutoff, λc	...	Profile filter, λc	...
Roughness short-wavelength cutoff, λs	...	Profile filter, λs	...
Waviness long-wavelength cutoff, λcw	...	Profile filter, λf	...
Waviness short-wavelength cutoff, λsw	...	...	...
Profile peak	...	Profile peak	...
Profile valley	...	Profile valley	...
Profile element	...	Profile element	...
Profile height function, $Z(x)$	...	Ordinate value, $Z(X)$	...
Roughness average, *Ra* (*AA*, *CLA*)	Evaluation	Arithmetical mean deviation of the assessed profile, *Ra*	Sampling
Root mean square roughness, *Rq*(rms)	Evaluation	Root mean square deviation of the assessed profile, *Rq*	Sampling
Maximum profile peak height, *Rp*	Evaluation	...	...
Maximum profile valley depth, *Rv*	Evaluation	Maximum profile valley depth, *Rv* [Note (1)]	Sampling
Maximum height of the profile, *Rt*	Evaluation	Total height of profile, *Rt*	Evaluation
Distance between the highest point of the profile and mean line, *Rpi*	Sampling	Maximum profile peak height, *Rp*	Sampling
Average maximum profile peak height, *Rpm*	Evaluation	...	...
Vertical distance between the highest and lowest points of the profile, *Rti*	Sampling	Maximum height of the profile, *Rz* [Note (2)]	Sampling
Average maximum height of the profile, *Rz*	Evaluation	...	...
Maximum roughness depth, *Rmax*	Evaluation	...	...
Waviness height, *Wt*	Evaluation	Total height of profile, *Wt*	Evaluation
Mean spacing of profile irregularities, *RSm* [Notes (3), (4)]	Evaluation	Mean width of profile elements, *RSm* [Note (3)]	Sampling
SAE peak, peak count level, peak density, *Rpc*	Evaluation	...	...
Amplitude density function, ADF(z)	Evaluation	Profile height amplitude curve	Evaluation
Profile bearing length at a specified level, *p*	Evaluation	Material length of the profile, *Ml*(c), at a given level, *c*	Evaluation
Profile bearing length ratio, *tp*, at a given level, *p*	Evaluation	Material ratio of the profile, *Rmr*(c), at a given level, *c*	Evaluation
Bearing area curve, BAC	Evaluation	Material ratio curve of the profile	Evaluation
Difference in the heights for two profile bearing length ratios *tp*, *Htp*	Evaluation	Profile section height difference, *Rδc*	Evaluation
Skewness, *Rsk*	Evaluation	Skewness of the assessed profile, *Rsk*	Sampling
Kurtosis, *Rku*	Evaluation	Kurtosis of the assessed profile, *Rku*	Sampling

Table I-1 ASME B46.1-2019 Parameters (Cont'd)

ASME B46.1-2019		ISO 4287:1997	
Parameter	**Length Defined Over**	**Parameter**	**Length Defined Over**
Power spectral density, PSD(f)	Evaluation	...	...
Autocovariance function, ACV(τ)	Evaluation	...	...
Autocorrelation function, ACF(τ)	Evaluation	...	...
Correlation length	Evaluation	...	...
Average absolute slope, $R\Delta a$	Evaluation	...	...
Root mean square slope, $R\Delta q$	Evaluation	Root mean squared slope of assessed profile, $R\Delta q$	Sampling

GENERAL NOTES:

(a) All ASME B46.1 area profiling parameters have no counterpart in ISO 4287:1997.

(b) ASME B46.1 parameters are defined and calculated over the evaluation length. In contrast, ISO parameters defined over the sampling length, in accordance with ISO 4287:1997, are calculated over the evaluation length, in accordance with ISO 4288:1996, which states, "an average parameter estimate is calculated by taking the arithmetic mean of the parameter estimates from all of the individual sampling lengths."

NOTES:

(1) In ISO 4287:1984, maximum profile valley depth, *Rm*.

(2) In ISO 4287:1984, maximum height profile, *Ry*.

(3) Height and spacing discrimination are applied to the counting of profile elements.

(4) Counting of the irregularities based on each crossing of the mean line without height and spacing discrimination was called *Sm* in ASME B46.1-1995 and earlier editions.