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Geometrical product specifications (GPS) — Surface texture: Areal —

Part 600: Metrological characteristics for areal topography measuring methods

Spécification géométrique des produits (GPS) — État de surface: Surfacique —

Partie 600: Caractéristiques métrologiques pour les méthodes de mesure par topographie surfacique

Reference number
ISO 25178-600:2019(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

A list of all parts in the ISO 25178 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is a geometrical product specification standard and is to be regarded as a general GPS standard (see ISO 14638). It influences the chain link F of the chains of standards on areal surface texture and profile surface texture.

The ISO/GPS matrix model given in ISO 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to the specifications made in accordance with this document, unless otherwise indicated.

For more detailed information of the relation of this document to other standards and the GPS matrix model, see Annex B.

This document describes the metrological characteristics of areal topography methods designed for the measurement of surface topography maps. Several standards (ISO 25178-601, ISO 25178-602, ISO 25178-603, ISO 25178-604, ISO 25178-605 and ISO 25178-606) have already been developed to define terms and metrological characteristics for individual methods. Although we have striven for consistency throughout the series, some slight differences can appear between them. Therefore Technical Committee ISO/TC 213 decided in 2012 to concentrate all common aspects into one standard – this document – and to describe in ISO 25178-601 to ISO 25178-606 only the terms relevant to each individual method. For the existing standards of ISO 25178-601 to ISO 25178-606 it will be necessary to adapt this decision within the next revision. Until then it will be possible to have different definitions for a single term. Further, if any differences between the current ISO 25178-601 to ISO 25178-606 are discovered that give rise to conflict, then parties involved in the conflict should agree how to handle the differences.

NOTE Portions of this document describe patented systems and methods. This information is provided only to assist users in understanding basic principles of areal surface topography measuring instruments. This document is not intended to establish priority for any intellectual property, nor does it imply a license to any proprietary technologies described herein.

Geometrical product specifications (GPS) — Surface texture: Areal —

Part 600: Metrological characteristics for areal topography measuring methods

1 Scope

This document specifies the metrological characteristics of areal instruments for measuring surface topography. Because surface profiles can be extracted from surface topography images, most of the terms defined in this document can also be applied to profiling measurements.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 All areal topography measuring methods

3.1.1
areal reference
component of the instrument that generates a reference surface with respect to which the surface topography is measured

3.1.2
coordinate system of the instrument
right handed orthogonal system of axes (x,y,z) consisting of:

— the z-axis oriented nominally parallel to the z-scan axis (for optical systems with z-scan), the optical axis (for non-scanning optical systems) or the stylus trajectory (for stylus or scanning probe instruments);

— an (x,y) plane perpendicular to the z-axis.

Note 1 to entry: See Figure 1.

Note 2 to entry: Normally, the x-axis is the tracing axis and the y-axis is the stepping axis. (Valid for instruments that scan in the horizontal plane.)

Note 3 to entry: See also *specification coordinate system* [ISO 25178-2:2012, 3.1.2] and *measurement coordinate system* [ISO 25178-6:2010, 3.1.1].

Note 4 to entry: Certain types of optical instruments do not possess a physical areal guide.

Note 5 to entry: The *z*-axis is sometimes referred to as the *vertical* axis, and the *x*- and *y*-axes are sometimes referred to as the *horizontal* axes.

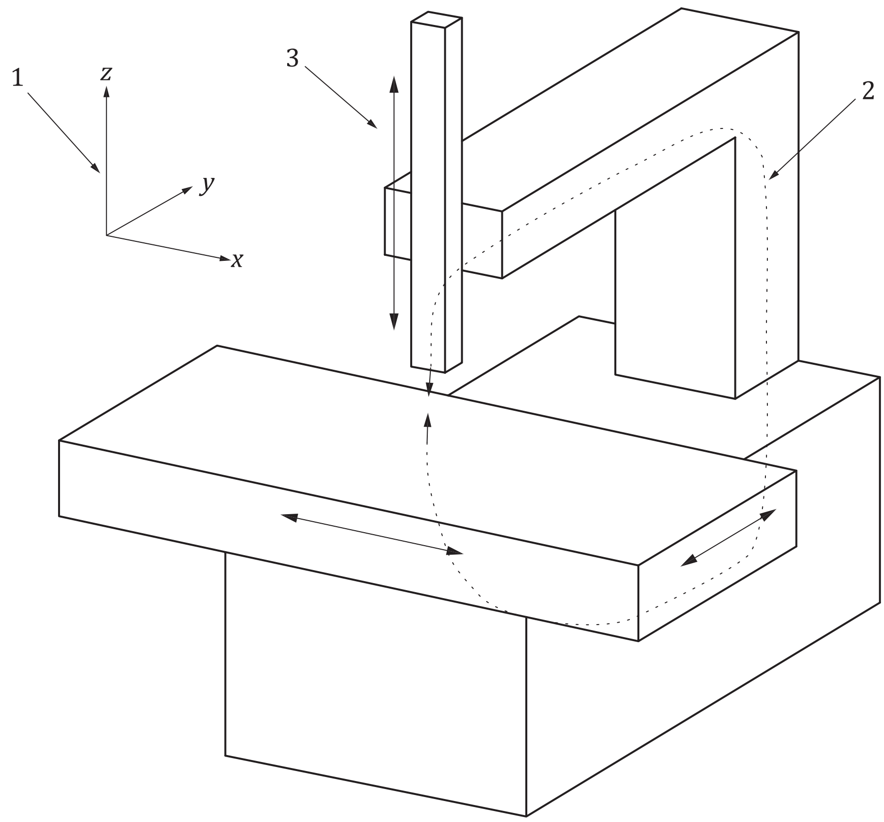
3.1.3
***z*-scan axis**
<measuring instrument> instrument axis used to scan in the *z*-direction to measure the surface topography

Note 1 to entry: The *z*-scan axis is nominally but not necessarily parallel to the *z*-axis of the coordinate system of the instrument.

3.1.4
measurement area
area that is measured by a surface topography instrument

Note 1 to entry: For point optical sensors and stylus methods, the measurement area is typically the scan area of the lateral translation stage(s). For topography microscopes the measurement area can be a single field of view as determined by the objective or a larger area realized by stitching or only part of a field of view as specified by the operator.

Note 2 to entry: For related concepts, *evaluation area* and *definition area*, see ISO 25178-2:2012, 3.1.9 and 3.1.10.



Key

1 coordinate system of the instrument

2 measurement loop

3 *z*-scan axis

Figure 1 — Coordinate system and measurement loop of the instrument

3.1.5
measurement loop
closed chain which comprises all components connecting the workpiece and the probe, for example the means of positioning, the work holding fixture, the measuring stand, the drive unit and the probing system

Note 1 to entry: See Figure 1.

Note 2 to entry: The measurement loop will be subjected to external and internal disturbances that influence the measurement uncertainty.

3.1.6
real surface
<of a workpiece> set of features which physically exist and separate the entire workpiece from the surrounding medium

Note 1 to entry: The real surface is a mathematical representation of the surface that is independent of the measurement process.

Note 2 to entry: See also *mechanical surface* [ISO 25178-2:2012, 3.1.1.1 or ISO 14406:2010, 3.1.1] and *electromagnetic surface* [ISO 25178-2:2012, 3.1.1.2 or ISO 14406:2010, 3.1.2].

Note 3 to entry: The electro-magnetic surface determined with different optical methods can be different. Examples of optical methods are found in ISO 25178-602 to ISO 25178-607.

[SOURCE: ISO 17450-1:2011, 3.1, modified — Notes to entry added.]

3.1.7
surface probe
device that converts the surface height into a signal during measurement

Note 1 to entry: In earlier standards this was termed *transducer*.

3.1.8
measuring volume
range of the instrument stated in terms of the limits on all three coordinates measurable by the instrument

Note 1 to entry: For areal surface texture measuring instruments, the measuring volume is defined by:

— the measuring range of the x- and y- drive units;

— the measuring range of the z-probing system.

3.1.9
response function
F_x, F_y, F_z
function that describes the relation between the actual quantity and the measured quantity

Note 1 to entry: The response curve is the graphical representation of the response function. See Figure 2.

Note 2 to entry: An actual quantity in x (respectively y or z) corresponds to a measured quantity x_M (respectively y_M or z_M).

Note 3 to entry: The response function can be used for adjustments and error corrections.

3.1.10
amplification coefficient
α_x, α_y, α_z
slope of the linear regression line obtained from the response function

Note 1 to entry: See Figure 2.

Note 2 to entry: There will be amplification coefficients applicable to the x, y and z quantities.

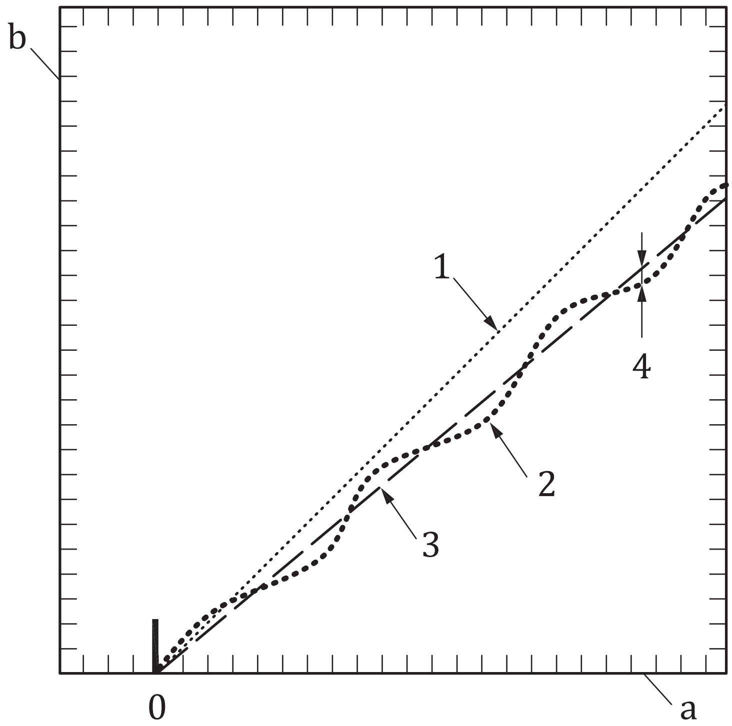
Note 3 to entry: The ideal response is a straight line with a slope equal to 1, which means that the values of the measurand are equal to the values of the input quantities.

Note 4 to entry: See also *sensitivity of a measuring system* (VIM, 4.12[10]).

Note 5 to entry: This quantity is also termed *scaling factor*.

3.1.11
linearity deviation
l_x, l_y, l_z
maximum local difference between the line from which the amplification coefficient is derived and the response function

Note 1 to entry: For example, see element 4 in Figure 2.



Key

a actual input quantities
b measured quantities
0 coordinate origin
1 ideal response curve
2 actual response curve of the instrument
3 line from which the amplification coefficient α (slope) is calculated
4 local linearity deviation (l)

Figure 2 — Example of linearity deviation of a response curve

3.1.12
flatness deviation
z_{FLT}
deviation of the measured topography of an ideally flat object from a plane

Note 1 to entry: Flatness deviation can be caused by residual flatness of an imperfect areal reference or by imperfection in the optical setup of an instrument.

3.1.13
***x*-*y* mapping deviation**
$\Delta_x (x,y)$, $\Delta_y (x,y)$
gridded image of *x*- and *y*-deviations of actual coordinate positions on a surface from their nominal positions

Note 1 to entry: The mapping deviations can be used to calculate the *x*- and *y*- linearity deviations, and *x*-*y* axis perpendicularity.

3.1.14
instrument noise
N_I
internal noise added to the output signal caused by the instrument if ideally placed in a noise-free environment

Note 1 to entry: Internal noise can be due to electronic noise, such as that arising in amplifiers, or optical noise, such as that arising from stray light.

Note 2 to entry: The S-filter according to ISO 25178-3 can reduce the high spatial frequency components of this noise.

Note 3 to entry: For some instruments, instrument noise cannot be completely separated from other types of measurement noise because the instrument only takes data while moving. If so, any measured noise includes a dynamic component. See also *static noise* (3.2.6) and *dynamic noise* (3.2.7).

Note 4 to entry: Because noise is a bandwidth-related quantity, its magnitude depends on the time over which it is measured or averaged.

3.1.15
measurement noise
N_M
noise added to the output signal occurring during the normal use of the instrument

Note 1 to entry: 3.1.14 Notes to entry 2 and 4 also apply to this definition.

Note 2 to entry: Measurement noise includes the instrument noise as well as components arising from the environment (thermal, vibration, air turbulence) and other sources.

Note 3 to entry: Figure 3 provides an illustration of typical sources of noise and shows the contrast between laboratory conditions producing instrument noise and measurement noise.

3.1.16
surface topography repeatability
closeness of agreement between successive measurements of the same surface topography under the same conditions of measurement

Note 1 to entry: Surface topography repeatability provides a measure of the likely agreement between repeated measurements normally expressed as a standard deviation.

Note 2 to entry: See VIM[10], 2.15 and 2.21, for a general discussion of repeatability and related concepts.

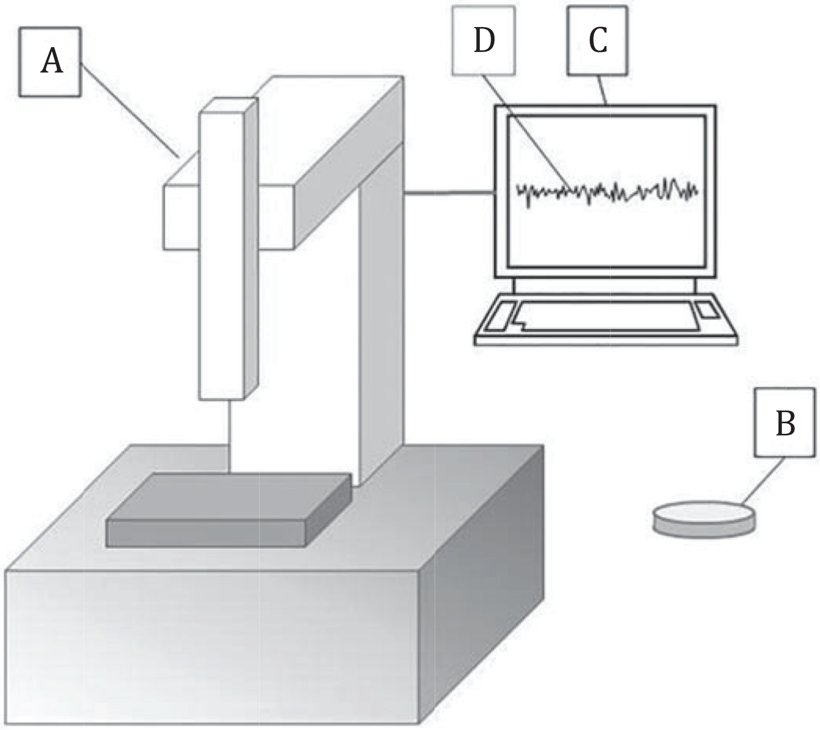
Note 3 to entry: Evaluation of surface topography repeatability is a common method for estimating measurement noise and other time-varying errors, such as drift.

3.1.17
***x*-sampling interval**
D_x
distance between two adjacent measured points along the *x*-axis

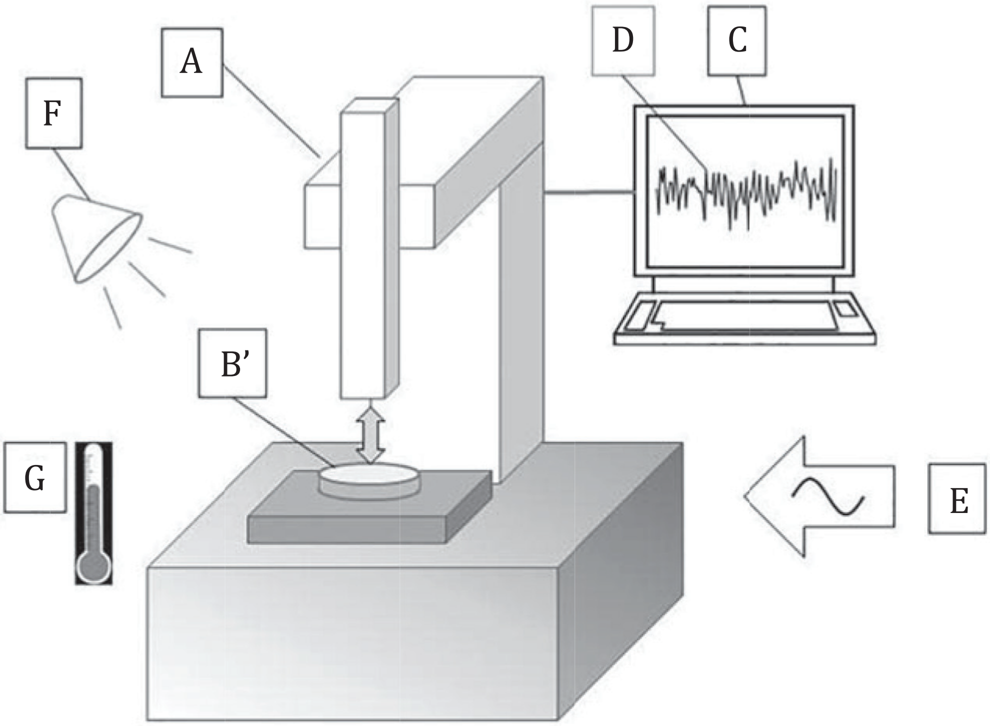
Note 1 to entry: In many microscopy systems the sampling interval is determined by the distance between sensor elements in a camera, called pixels[11], and by the magnification of the optical setup. For such systems, the terms 'pixel pitch' and 'pixel spacing' are often used interchangeably with the term 'sampling interval'. Another term, 'pixel width', indicates a length associated with one side (*x* or *y*) of the sensitive area of a single pixel and is always smaller than the pixel spacing.

Note 2 to entry: Another term, 'sampling zone', is sometimes used to indicate the length or region over which a height sample is determined. This quantity can be different from the sampling interval.

Note 3 to entry: *x* is replaced by *y* in the term and the symbol when referring to the *y*-axis.



a) Conditions under which the instrument noise might be assessed for some types of instruments



b) Conditions under which the measurement noise might be assessed for some types of instruments

Key

A	instrument	D	signal
B	sample	E	environmental vibration
B′	sample plus interaction	F	external light sources
C	data processing	G	thermal changes

Figure 3 — Typical sources of instrument noise and measurement noise

3.1.18
digitisation step in *z*
D_Z
smallest height variation along the *z*-axis between two ordinates of the extracted surface

Note 1 to entry: The term *extracted surface* is defined in ISO 12180-1:2011, 3.2.1.

3.1.19
instrument transfer function
ITF
f_{ITF}
curve describing an instrument's height response as a function of the spatial frequency of the surface topography

Note 1 to entry: Ideally, the ITF tells us what the measured height of a sinusoidal grating of a specified spatial frequency ν would be relative to the true height of the grating.

Note 2 to entry: For several types of optical instruments, the ITF can be a nonlinear function of height except for heights much smaller than the optical wavelength.

Note 3 to entry: A number of methods can be used to characterize properties of the instrument transfer function with a single parameter. See 3.1.20 for an introduction.

Note 4 to entry: See also References [12] and [13].

3.1.20
topographic spatial resolution

W_R

<surface topography> metrological characteristic describing the ability of a surface topography measuring instrument to distinguish closely spaced surface features

Note 1 to entry: The topographic spatial resolution designates an important property of a surface topography measuring instrument, but several parameters and functions can be used to actually quantify the topographic spatial resolution, depending on the application and the method of measurement. These include:

— lateral period limit D_{LIM} (see 3.1.21 and ISO 25178-3);

— stylus tip radius r_{TIP} (see ISO 25178-601);

— lateral resolution R_l (see 3.1.22);

— width limit for full height transmission W_l (see 3.1.23);

— small scale fidelity limit T_{FIL} (see 3.1.27);

— Rayleigh criterion (see 3.3.8);

— Sparrow criterion (see 3.3.9);

— Abbe resolution limit (see 3.3.10).

Note 2 to entry: Other quantities can also be defined for characterizing topographic spatial resolution.

Note 3 to entry: Another related term is *structural resolution*.

3.1.21
lateral period limit

D_{LIM}

spatial period of a sinusoidal profile at which the height response of the instrument transfer function falls to 50 %

Note 1 to entry: The lateral period limit is one measure for describing spatial or lateral resolution of a surface topography measuring instrument and its ability to distinguish and measure closely spaced surface features. The value of the lateral period limit depends on the heights of surface features and on the method used to probe the surface. Maximum values for this parameter are listed in ISO 25178-3:2012, Table 3, in comparison with recommended values for short wavelength (s-) filters and sampling intervals.

Note 2 to entry: Spatial period is the same concept as *spatial wavelength* and is the inverse of *spatial frequency*.

Note 3 to entry: One factor related to the value of D_{LIM} for optical tools is the Rayleigh criterion (3.3.8). Another is the degree of focus of the objective on the surface.

Note 4 to entry: One factor related to the value of D_{LIM} for contact tools is the stylus tip radius, r_{TIP} (see ISO 25178-601). For a discussion of spatial resolution issues involving stylus instruments, see Reference [14].

3.1.22
lateral resolution

R_l

smallest distance between two features which can be recognized

3.1.23
width limit for full height transmission

W_l

width of the narrowest rectangular groove whose step height is measured within a given tolerance

Note 1 to entry: When evaluating R_l and W_l by measurement, instrument properties, such as

— the sampling interval in x and y,

— the digitisation step in z, and

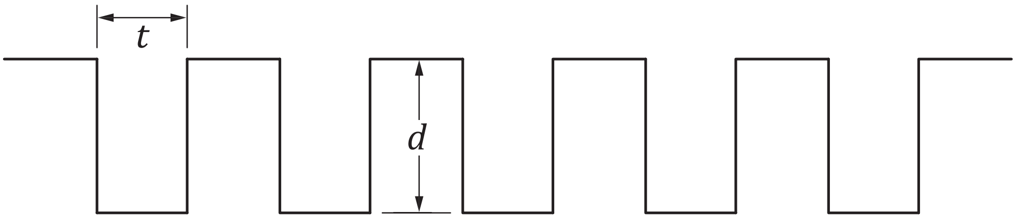
— the S-filter (see ISO 25178-2:2012, 3.1.4.1),

are normally chosen so that they do not influence the result.

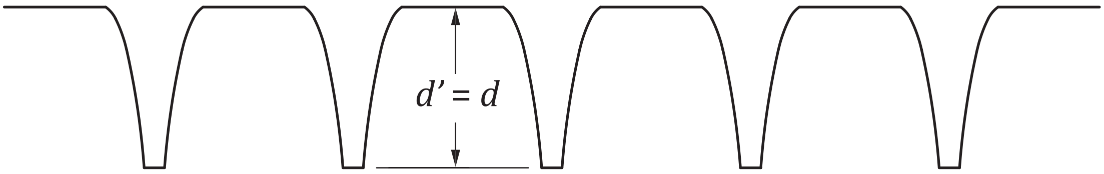
Note 2 to entry: Implementation of this concept depends on both the width and step height of the grooved surface used. When evaluating W_l by measurement, the depth of the rectangular groove is normally chosen to be close to that of the surface to be measured.

Note 3 to entry: This concept is mainly useful for contacting (stylus) instruments. See Figure 4 for examples.

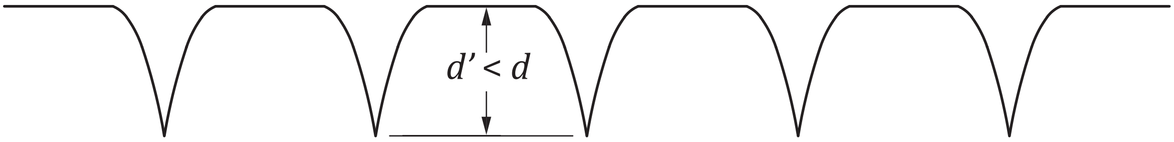
Note 4 to entry: For a discussion of spatial resolution issues related to measurement of sinusoidal surfaces by stylus instruments, see Reference [14].



a) Rectangular grid with groove width *t* and depth *d*



b) Profile measured with a stylus instrument when *t* is greater than W_l; the depth of the grid is measured correctly



c) Profile measured when *t* is less than W_l; the depth of the grid is attenuated and points in the bottoms of the valleys are not accessible by the stylus

Key

t groove width

d groove depth

d' measured groove depth

W_l width limit for full height transmission

Figure 4 — Examples of results for measurement of narrow grooves

3.1.24

maximum measurable local slope

Φ_{MS}

greatest local slope of a surface feature that can be assessed by the probing system

Note 1 to entry: The term *local slope* is defined in ISO 4287:1997, 3.2.9.

Note 2 to entry: This property depends on both the surface texture to be measured and the measuring instrument. For more information see Annex A.

3.1.25
hysteresis
x_{HYS}, y_{HYS}, z_{HYS}
property of measuring equipment, or characteristic whereby the indication of the equipment or value of the characteristic depends on the orientation of the preceding stimuli

Note 1 to entry: Hysteresis can also depend, for example, on the distance travelled after the orientation of stimuli has changed.

Note 2 to entry: For lateral scanning systems, the hysteresis is mainly a repositioning error.

[SOURCE: ISO 14978:2018, 3.5.11, modified — Notes to entry added.]

3.1.26
topography fidelity
T_{FI}
<line profiling> <areal topography> closeness of agreement between a measured surface profile or measured topography and one whose uncertainties are insignificant by comparison

Note 1 to entry: When the concept of topography fidelity is applied to profiles, the term *profile fidelity* is sometimes used.

3.1.27
small scale fidelity limit
T_{FIL}
smallest lateral surface feature for which the reported topography parameters deviate from accepted values by less than specified amounts

Note 1 to entry: Deviations can be positive or negative.

Note 2 to entry: A practical value for the maximum deviation could be 10 %, for example.

Note 3 to entry: This property depends on the type of surface feature under investigation.

3.1.28
metrological characteristic
<measuring equipment> characteristic of measuring equipment, which can influence the results of measurement

Note 1 to entry: Calibration of metrological characteristics is often necessary[15][16][17].

Note 2 to entry: The metrological characteristics have an immediate contribution to measurement uncertainty.

[SOURCE: ISO 14978:2018, 3.5.2, modified — Notes to entry replaced.]

3.2 *x*- and *y*-scanning systems

3.2.1
areal reference guide
component(s) of the instrument that generate(s) the reference surface, in which the probing system moves relative to the surface being measured according to a theoretically exact trajectory

Note 1 to entry: In the case of *x*- and *y*-scanning areal surface texture measuring instruments, the areal reference guide establishes a *reference surface* [ISO 25178-2:2012, 3.1.8]. It can be achieved through the use of two linear and perpendicular *reference guides* [ISO 3274:1996, 3.3.2] or one reference surface guide.

3.2.2
lateral scanning system
system that performs the scanning of the surface to be measured in the (*x*,*y*) plane

Note 1 to entry: There are essentially four components to a surface texture scanning instrument system: the *x*-axis drive, the *y*-axis drive, the *z*-measurement probe and the surface to be measured.

Note 2 to entry: When a measurement consists of a single field of view of a microscope, *x*- and *y*-scanning is not used. However, when several stationary fields of view, overlapping along the lateral directions, are linked together by stitching methods[18], the system is customarily considered to be a scanning system.

3.2.3
***x*-drive unit**
component of the instrument that moves the probing system or the surface being measured along the reference guide on the *x*-axis and returns the horizontal position of the measured point in terms of the lateral *x*-coordinate of the profile

Note 1 to entry: *x* is replaced by *y* in the term when referring to the *y*-axis.

3.2.4
lateral position sensor
component of the drive unit that provides the lateral position of the measured point

Note 1 to entry: The lateral position is customarily measured or inferred by using, for example, a linear encoder, a laser interferometer or a counting device coupled with a micrometer screw.

3.2.5
speed of measurement
V_x
speed of the probing system relative to the surface to be measured during the measurement along the *x*-axis

3.2.6
static noise
N_S
combination of the *instrument noise* (3.1.14) and environmental noise on the output signal when the instrument is not scanning laterally

Note 1 to entry: Environmental noise is caused by, for example, seismic, sonic or external electromagnetic disturbances.

Note 2 to entry: Notes to entry 2 and 4 in 3.1.14 also apply to this definition.

Note 3 to entry: Static noise is included in *measurement noise* (3.1.15).

3.2.7
dynamic noise
N_D
noise occurring during the motion of the drive units on the output signal

Note 1 to entry: Notes to entry 2 and 4 in 3.1.14 also apply to this definition.

Note 2 to entry: Dynamic noise includes *static noise* (3.2.6).

Note 3 to entry: Dynamic noise is included in *measurement noise* (3.1.15).

3.3 Optical systems

3.3.1
light source
optical device emitting light with an appropriate range of wavelengths in a specified spectral region

3.3.2
measurement optical bandwidth
$B_{\lambda 0}$
range of wavelengths of light used to measure a surface

Note 1 to entry: Instruments are normally constructed with light sources with a limited optical bandwidth and/or with additional filter elements to further limit the optical bandwidth.

Note 2 to entry: Bandwidth is quantifiable in different ways, such as the full width at half maximum (FWHM) or the full width between 1/e points, where e (2,713...) is the base of the natural logarithms.

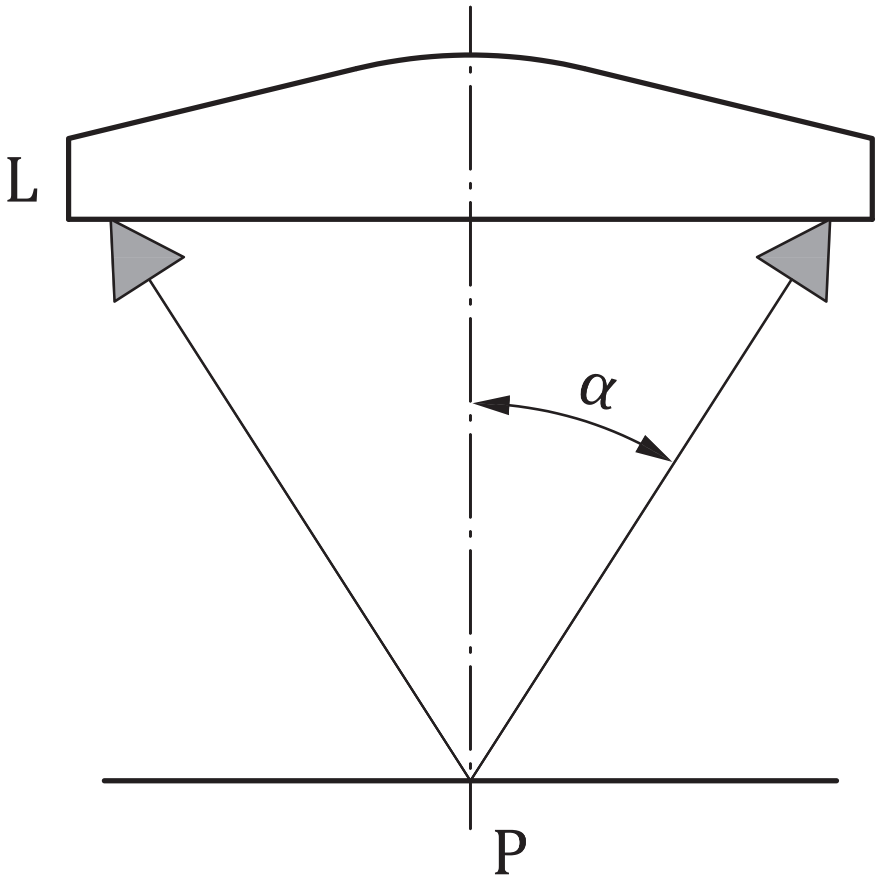
3.3.3
measurement optical wavelength
λ_0
effective value of the wavelength of the light used to measure a surface

Note 1 to entry: The measurement optical wavelength is affected by conditions such as the light source spectrum, spectral transmission of the optical components and spectral response of the image sensor array.

3.3.4
angular aperture
maximum angle of the cone of light entering an optical system emerging from a point on the surface being measured

3.3.5
half aperture angle
α
one half of the angular aperture

Note 1 to entry: This angle is sometimes called half cone angle, see Figure 5.



Key

L lens or optical system

P focal point

α half aperture angle

Figure 5 — Half aperture angle

3.3.6
numerical aperture
A_N
sine of the half aperture angle multiplied by the refractive index n of the surrounding medium

$$A_N = n(\lambda) \sin\alpha$$

Note 1 to entry: In air for visible light, $n \cong 1$ but has a slight dependence on optical wavelength and on ambient temperature and pressure[19][20].

Note 2 to entry: Typically the numerical aperture is specified for the wavelength that is in the middle of the measurement optical bandwidth.

3.3.7
optical lateral resolution
quantity that characterizes the influence of the optical system on the topographic spatial resolution

Note 1 to entry: The optical lateral resolution depends, among other factors, on the configuration of the lenses, mirrors, light source bandwidth and degree of coherence of the optical system.

Note 2 to entry: Factors other than the optical lateral resolution, including data sampling, processing or interpretation methods, also influence the topographic spatial resolution.

3.3.8
Rayleigh criterion
quantity characterizing the optical lateral resolution given by the separation of two point sources at which the first diffraction minimum of the intensity image of one point source coincides with the maximum of the other

Note 1 to entry: The Rayleigh criterion is normally applied to incoherent imaging systems. For a theoretically perfect, incoherent optical system with a filled objective pupil, the Rayleigh criterion of the optical system is equal to 0,61 λ_0/A_N.

Note 2 to entry: This parameter is useful for characterizing the instrument response to features with heights much less than λ_0 for optical topography measuring instruments.

Note 3 to entry: See also References [12], [21] and [22].

3.3.9
Sparrow criterion
quantity characterizing the optical lateral resolution given by the separation of two point sources at which the second derivative of the intensity distribution vanishes between the two imaged points

Note 1 to entry: For a theoretically perfect, incoherent optical system with filled objective pupil, the Sparrow criterion of the optical system is equal to 0,47 λ_0/A_N, approximately 0,77 times the *Rayleigh criterion* (3.3.8).

Note 2 to entry: Under the same measurement conditions as Note 1 to entry, the Sparrow criterion is nearly equal to the spatial period of 0,5 λ_0/A_N, for which the theoretical instrument response falls to zero.

Note 3 to entry: For a theoretically perfect, coherent (e.g. laser-based) optical system, the Sparrow criterion of the optical system is equal to 0,73 λ_0/A_N.

Note 4 to entry: This parameter is useful for characterizing the instrument response to features with heights much less than λ_0 for optical topography measuring instruments.

Note 5 to entry: Several spatial resolution concepts defined here and earlier are discussed in References [23] and [24].

3.3.10
Abbe resolution limit
quantity characterizing the optical lateral resolution given by the smallest diffraction grating pitch that can be detected by the optical system

Note 1 to entry: For a theoretically perfect, incoherent optical system with a filled objective pupil, the Abbe resolution limit of the optical system is equal to 0,5 λ_0/A_N.

Note 2 to entry: For a theoretically perfect, coherent (e.g. laser-based) optical system, the Abbe resolution limit of the optical system is equal to λ_0/A_N.

3.4 Optical properties of the workpiece

3.4.1
surface film
material deposited onto another surface whose optical properties are different from that surface

Note 1 to entry: Depending on their materials and thickness, surface films can be opaque, partially transparent or highly transparent, or can exhibit more complex spectral properties. Transparency depends also on the optical wavelengths used in the system.

Note 2 to entry: The surface film can also be called the *surface layer*.

3.4.2
thin film
film whose thickness is such that the top and bottom surfaces cannot be readily separated by the optical measuring system

Note 1 to entry: For some measurement systems with special properties and algorithms, the thicknesses of thin films can be derived.

3.4.3
thick film
film whose thickness is such that the top and bottom surfaces can be readily separated by the optical measuring system

3.4.4
optically smooth surface
<GPS> surface from which the reflected light is primarily specular and scattered light is not significant

Note 1 to entry: An optically smooth surface behaves like a mirror.

Note 2 to entry: A surface that acts as optically smooth under certain conditions, such as wavelength range, numerical aperture or pixel resolution, can act as optically rough when one or more of these conditions change.

Note 3 to entry: An alternative definition in ISO 10110-8:2010, 3.3, emphasizes the point that an optically smooth surface has height variation of the surface texture that is considerably smaller than the wavelength of light.

3.4.5
optically rough surface
<GPS> surface that does not behave as an optically smooth surface, i.e. where scattered light is significant

Note 1 to entry: A surface that acts as optically rough under certain conditions, such as wavelength range, numerical aperture or pixel resolution, can act as optically smooth when one or more of these conditions change.

3.4.6
optically non-uniform material
sample with different optical properties in different regions

Note 1 to entry: An optically non-uniform material can result in measured phase differences across the field of view that can be erroneously interpreted as differences in surface height.

4 Standard metrological characteristics for surface texture measurement

The metrological characteristics for areal surface texture measuring instruments are listed in Table 1. When topographic spatial resolution is specified, the specific parameter (see 3.1.20) shall be stated explicitly.

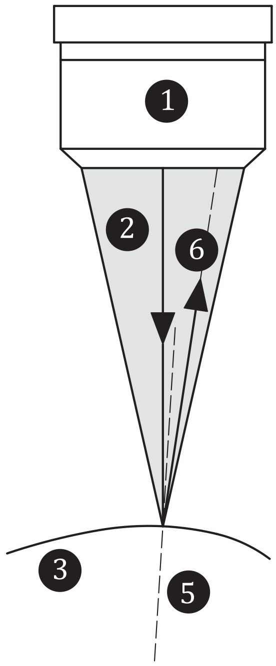
Table 1 — Metrological characteristics for surface texture measurement methods

Metrological characteristic	Symbol	Definition	Main potential error along
Amplification coefficient	α_x, α_y, α_z	3.1.10 (see Figure 2)	x, y, z
Linearity deviation	l_x, l_y, l_z	3.1.11 (see Figure 2)	x, y, z
Flatness deviation	z_{FLT}	3.1.12	z
Measurement noise	N_{M}	3.1.15	z
Topographic spatial resolution	W_{R}	3.1.20	z
x-y mapping deviations (Note 1)	$\Delta_x(x,y)$, $\Delta_y(x,y)$	3.1.13	x, y
Topography fidelity	T_{FI}	3.1.26	x, y, z
NOTE 1 Depending on the measurement application, other axis motion errors (see ISO 230-1, ISO 10360-7 and ISO 10360-8) can also be significant, but are not listed here for surface texture measurement.			
NOTE 2 The maximum measurable slope is an important limitation to be specified for a surface topography measurement instrument. However, a user does not need to measure this parameter unless it is part of a measurement model.			

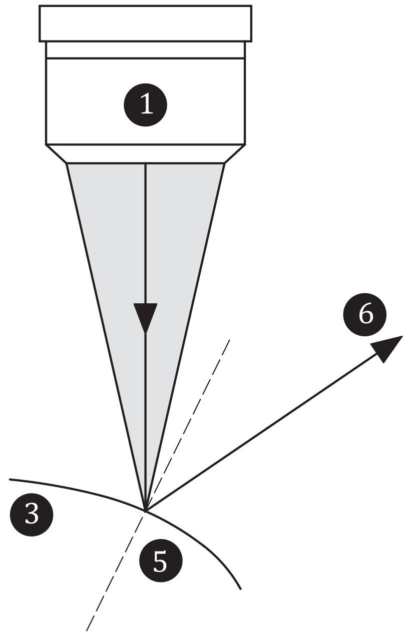
Annex A
(informative)

Maximum measurable local slope vs. A_N

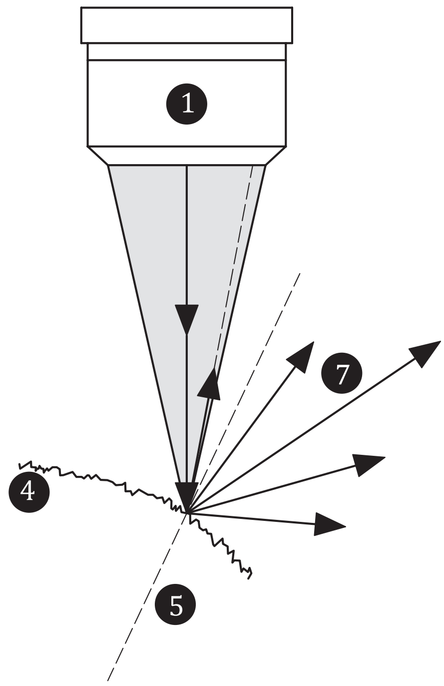
For some types of optical instruments, the numerical aperture of the objective largely determines the maximum local slope measurable on a surface. Figure A.1 shows three cases for an optical system in which illumination fills the objective pupil. In Figure A.1 a), most of the reflected light returns through the objective and is detected. In Figure A.1 b), light reflected from the tilted surface does not return through the objective and no signal is produced. In Figure A.1 c), larger slopes are measurable for rough surfaces that scatter light broadly; some of the scattered light might enter the imaging objective and provide sufficient signal. In this case, the maximum measurable slope can be greater than the limit imposed by the numerical aperture.



a) Surface providing signal



b) Surface with significant tilt with respect to the optical axis such that no light signal returns through the objective to the detector



c) Surface with sufficient roughness to scatter some light into the objective

Key

1 objective
2 incident light, centred around the optical axis
3 optically smooth surface
4 optically rough surface
5 surface normals
6 reflected light
7 scattered light

Figure A.1 — Considerations that determine maximum measurable slope

It is possible to use dry objectives with up to 0,95 A_N providing a maximum measurable local surface slope up to 72 degrees. Larger slopes can be measured with higher A_N objectives, such as water immersion or oil immersion, although they might not be practical for three-dimensional measurements of technical surfaces.

Annex B
(informative)

Relation to the GPS matrix model

B.1 General

The ISO GPS matrix model given in ISO 14638 gives an overview of the ISO GPS system of which this document is a part, see Reference [25].

The fundamental rules of ISO GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise indicated.

B.2 Information about this document and its use

This document defines the methods, specific terminology and metrological characteristics for instruments used to measure areal surface texture.

B.3 Position in the GPS matrix model

This document is a general ISO GPS standard, which influences chain link F of the chains of standards on profile and areal surface texture in the GPS matrix model (see Table B.1). The rules and principles given in this document apply to all segments of the ISO GPS matrix which are indicated with a filled dot (•).

Table B.1 — Position in the ISO GPS Standards matrix model

	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibration
Size							
Distance							
Form							
Orientation							
Location							
Run-out							
Profile surface texture						•	
Areal surface texture						•	
Surface imperfections							

B.4 Related international standards

The related International Standards are those of the chains of standards indicated in Table B.1.

Bibliography

[1] ISO 3274:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

[2] ISO 4287:1997, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

[3] ISO 14406:2010, *Geometrical product specifications (GPS) — Extraction*

[4] ISO 17450-1:2011, *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

[5] ISO 14978:2018, *Geometrical product specifications (GPS) — General concepts and requirements for GPS measuring equipment*

[6] ISO 25178-2:2012, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 2: Terms, definitions and surface texture parameters*

[7] ISO 25178-3:2012, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 3: Specification operators*

[8] ISO 25178-6:2010, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 6: Classification of methods for measuring surface texture*

[9] ISO 25178-601:2010, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 601: Nominal characteristics of contact (stylus) instruments*

[10] JCGM 200:2012, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM), 3rd edition*

[11] Umbaugh S.E. Computer Imaging: Digital Image Analysis and Processing. CRC Press, Boca Raton, FL, 2005

[12] de Groot P. Phase Shifting Interferometry. In: Leach R. *Optical Measurement of Surface Topography*. Springer-Verlag, Berlin, 2011

[13] de Groot P., & Colonna de Lega X. "Interpreting interferometric height measurements using the instrument transfer function," in *Proc. FRINGE: 5th International Workshop on Automatic Processing of Fringe Patterns* (Springer, Berlin, 2005) pp 30 - 37

[14] Bennett J.M., & Mattsson L. *Introduction to Surface Roughness and Scattering* (Optical Society of America, Washington, DC, 1989) Sec. 3.A.2

[15] Giusca C.L., Leach R.K., Helery F., Gutauskas T., Nimishakavi L. Calibration of the scales of areal surface topography measuring instruments: Part 1 — Measurement noise and residual flatness. Meas. Sci. Technol. 2012, **23** p. 035008

[16] Giusca C.L., Leach R.K., Helery F. Calibration of the scales of areal surface topography measuring instruments: Part 2 – Amplification coefficient, linearity and squareness. Meas. Sci. Technol. 2012, **23** p. 065005

[17] Giusca C.L., & Leach R.K. Calibration of the scales of areal surface topography measuring instruments: Part 3 – Resolution. Meas. Sci. Technol. 2013, **24** p. 105010

[18] Wyant J.C., & Schmit J. Large Field of View, High Spatial Resolution, Surface Measurements. Int. J. Mach. Tools Manuf. 1998, **38** (5-6) pp. 691–698

[19] Smith W.J. Modern Optical Engineering. Chapter 1. McGraw-Hill, New York, Third Edition, 2000

[20] Born M., & Wolf E. *Principles of Optics*, fifth edition (Pergamon, Oxford, 1975) Sec. 2.3.4

[21] Smith W.J. Modern Optical Engineering. Chapter 6. McGraw-Hill, New York, Third Edition, 2000

[22] Born M., & Wolf E. *Principles of Optics*, fifth edition (Pergamon, Oxford, 1975) Sec. 7.6.3

[23] Colonna de Lega X., & de Groot P. "Lateral resolution and instrument transfer function as criteria for selecting surface metrology instruments," OSA Proc. Optical Fabrication and Testing OTu1D 2012 (Optical Society of America, Washington, DC)

[24] de Groot P., Colonna de Lega X., Sykora D.M., Deck L. The Meaning and Measure of Lateral Resolution for Surface Profiling Interferometers. Opt. Photonics News. 2012, **23** (4) pp. 10–13

[25] ISO 14638, *Geometrical product specifications (GPS) — Matrix model*

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