INTERNATIONAL STANDARD

ISO 25178-601

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

Part 601: **Nominal characteristics of contact (stylus) instruments**

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

Partie 601: Caractéristiques nominales des instruments à contact (à palpeur)

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 25178-601 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO 25178 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Surface texture: Areal*:

— *Part 2: Terms, definitions and surface texture parameters*

— *Part 3: Specification operators*

— *Part 6: Classification of methods for measuring surface texture*

— *Part 7: Software measurement standards*

— *Part 601: Nominal characteristics of contact (stylus) instruments*

— *Part 602: Nominal characteristics of non-contact (confocal chromatic probe) instruments*

— *Part 603: Nominal characteristics of non-contact (phase-shifting interferometric microscopy) instruments*

— *Part 701: Calibration and measurement standards for contact (stylus) instruments*

The following parts are under preparation:

— *Part 604: Nominal characteristics of non-contact (coherence scanning interferometry) instruments*

— *Part 605: Nominal characteristics of non-contact (point autofocusing) instruments*

Introduction

This part of ISO 25178 is a geometrical product specification standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain link 5 of the chain of standards on roughness profile, waviness profile, primary profile and areal surface texture.

For more detailed information of the relation of this standard to the GPS matrix model, see Annex C.

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

Part 601: Nominal characteristics of contact (stylus) instruments

1 Scope

This part of ISO 25178 defines the metrological characteristics of contact (stylus) areal surface texture measuring instruments.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the cited editions apply. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 10360-1, *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 1: Vocabulary*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3274, ISO 4287, ISO 10360-1 and ISO/IEC Guide 99 and the following apply.

3.1 General terms and definitions

3.1.1
coordinate system of the instrument
right hand orthonormal system of axes (X,Y,Z) defined as:

— (X,Y) is the plane established by the areal reference guide of the instrument;

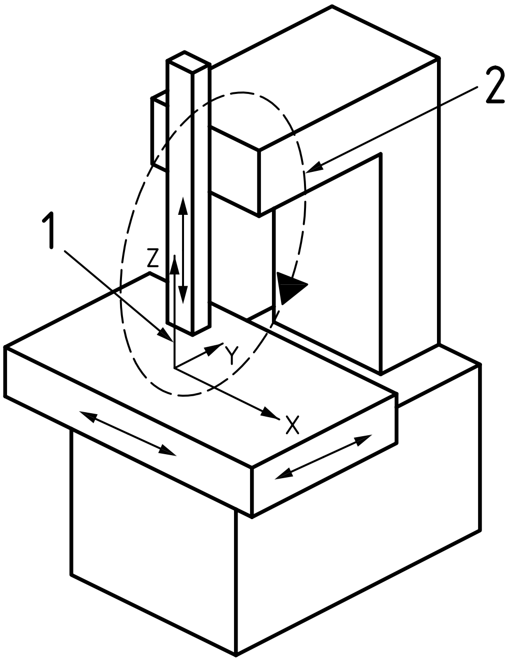
— Z-axis is in the plane of the stylus trajectory and is perpendicular to the (X,Y) plane (see Figure 1)

NOTE Normally, the X-axis is the tracing direction and the Y-axis is the stepping axis.

3.1.2
measurement loop
closed chain which comprises all components connecting workpiece and the stylus tip, e.g. the means of positioning, the workholding fixture, the measuring stand, the drive unit, the probing system (pick-up)

See Figure 1.

NOTE The measurement loop will be subjected to external and internal disturbances which influence the measurement uncertainty.



Key
1 coordinate system of the instrument
2 measurement loop

Figure 1 — Coordinate system and measurement loop of the instrument

3.1.3
user adjustment
⟨of a measuring instrument⟩ adjustment employing only the means available to the user

NOTE This is an operation normally carried out by the user. It involves the use of a material measure, usually supplied with the instrument. The result of this operation automatically or manually adjusts certain parameters in order that the instrument operates correctly.

3.1.4
residual correction error
difference between the value of a quantity obtained after correcting the systematic error and the real value of this quantity

NOTE The residual error is composed of random errors and uncorrected systematic errors.

3.2 Terms and definitions relative to lateral scanning system

3.2.1
lateral scanning system
system that performs the scanning of the surface to be measured in the (X,Y) plane

NOTE Typically, the lateral scanning system is composed of the **drive unit X** (3.2.3) and **drive unit Y** (3.2.4).

3.2.2
areal reference guide
component of the instrument that generates the reference surface, in which the **probing system** (3.3.1) moves relative to the surface being measured according to a theoretically exact trajectory

NOTE In the case of areal surface texture measuring instruments, the reference guide establishes a reference surface (see ISO 25178-2). It can be achieved through the use of two perpendicular reference guides (see ISO 3274:1996, 3.3.2) or one reference surface guide.

3.2.3
drive unit X
component of the instrument that moves the **probing system** (3.3.1) or the surface to be measured along the reference guide on the X-axis and provides the horizontal position of the stylus tip in terms of the lateral X coordinate of the profile

3.2.4
drive unit Y
component of the instrument that moves the **probing system** (3.3.1) or the surface to be measured along the reference guide on the Y-axis and provides the horizontal position of the stylus tip in terms of the lateral Y coordinate of the profile

3.2.5
lateral position sensor
component of the drive unit that provides the lateral position of the pivot

NOTE 1 See Figure 2 for the definition of the pivot.

NOTE 2 The lateral position can be measured using, for example, a linear encoder, a laser interferometer, or a counting device coupled with a micrometer screw.

3.3 Terms and definitions relative to the probing system

3.3.1
probing system
⟨surface texture⟩ component of the instrument consisting of the **stylus** (3.3.4), the pivot, the **probe** (3.3.2) and the **digitizing system** (3.3.3)

NOTE 1 The axis of rotation around the pivot is parallel to the Y axis.

NOTE 2 The probing system is commonly called a “pick up”.

3.3.2
probe
⟨surface texture⟩ device that converts the height into a signal during measurement

NOTE In earlier standards this was termed a “transducer”.

3.3.3
digitizing system
device which converts analogue signals into digital ones

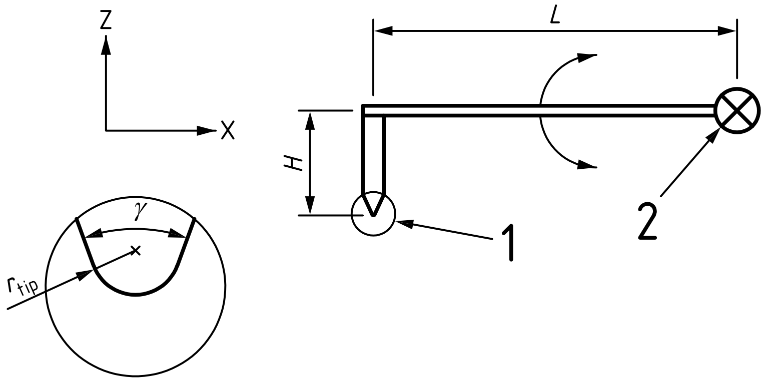
NOTE 1 The digital signal as a function of the x and y coordinates forms the extracted mechanical surface.

NOTE 2 The digitizing system should not cause any intentional surface modification.

NOTE 3 In a typical system, the digitizing system is usually an analogue to digital converter.

3.3.4
stylus
mechanical device consisting of a tip and an arm

NOTE The typical stylus is shown in Figure 2.



Key

1 stylus tip
2 pivot
L length of the arm
H height of the stylus
r_{tip} radius of the tip
γ cone angle of the tip

NOTE The above design is the most common. Other designs are also used, e.g. flexures, linear probes, etc.

Figure 2 — Characterization of the typical stylus

3.3.5
error due to arcuate motion
vector error generated by the rotation of the **stylus** (3.3.4) around the pivot

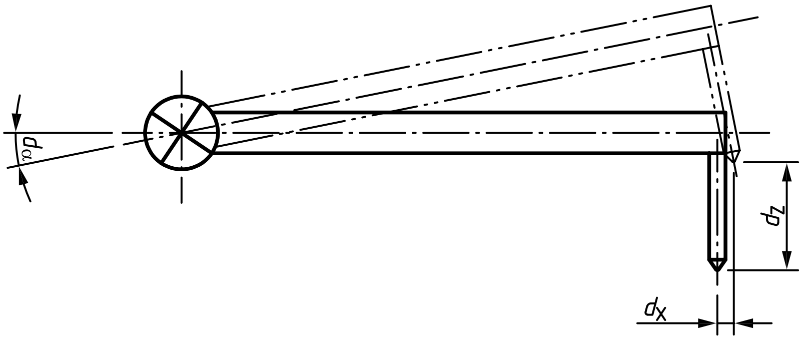
See Figure 3.

NOTE 1 The vector error consists of a lateral and horizontal component.

NOTE 2 The arcuate motion generates an error of the measured profile.

NOTE 3 The horizontal error which results from the arcuate motion is a function of the vertical displacement and may be neglected depending on the required accuracy.

NOTE 4 The probe only measures one quantity (typically Z or the angle of the stylus arm) which does not give enough information for the assessment of both X and Z quantities. The knowledge of the stylus geometry and either X or Z quantity allows this assessment by using a mathematical adjustment.



Key

d_α rotation angle around the pivot

d_X horizontal error function of d_Z and stylus geometry

d_Z vertical displacement

Figure 3 — Arcuate motion

3.4 Metrological characteristics of the instrument

3.4.1
measuring volume
range of the instrument stated in terms of the limits on all three coordinates measured by the instrument

NOTE For areal surface texture measuring instruments, the measuring volume is defined by

— the measuring range of the **drive unit X** (3.2.3) and the **drive unit Y** (3.2.4),

— the measuring range of the **probing system** (3.3.1).

3.4.2
response curve
F_x, F_y, F_z
graphical representation of the function that describes the relation between the actual quantity and the measured quantity

See Figure 4.

NOTE 1 An actual quantity in X (respectively Y or Z) corresponds to a measured quantity x_m (respectively y_m or z_m).

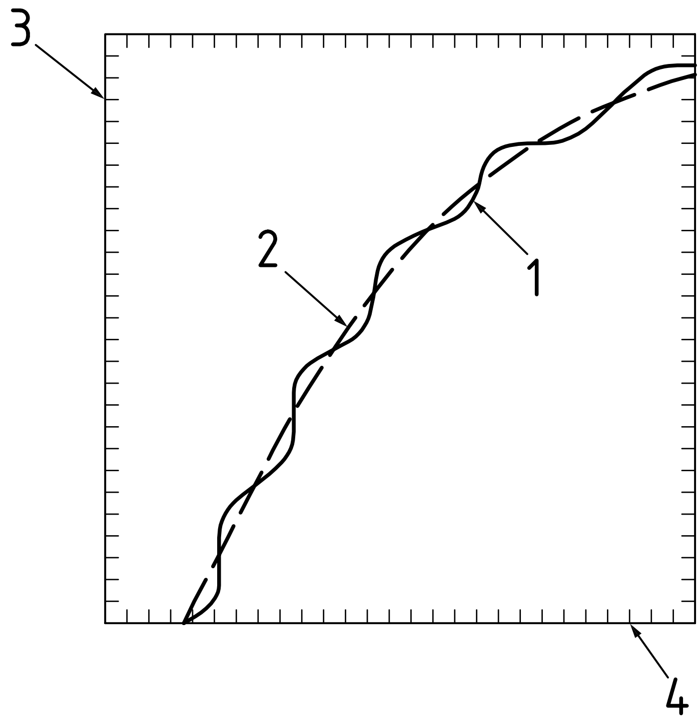
NOTE 2 The response curve can be used for adjustments and error corrections.

3.4.3
amplification coefficient
α_x, α_y, α_z
slope of the linear regression curve obtained from the **response curve** (3.4.2)

See Figure 5.

NOTE 1 There will be amplification coefficients applicable to the X, Y and Z quantities.

NOTE 2 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.



Key

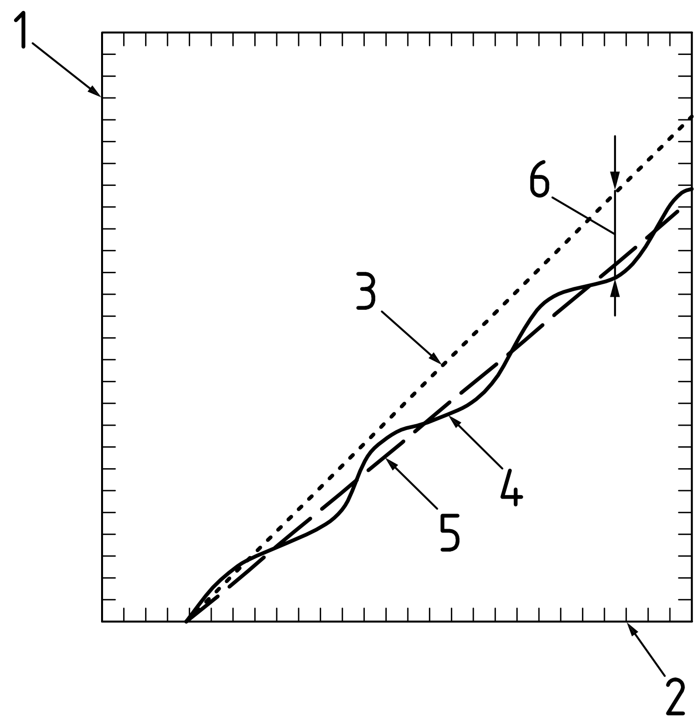
1 response curve

2 assessment of the response curve by polynomial approximation

3 measured quantities

4 input quantities

Figure 4 — Example of a non-linear response curve



Key

1 measured quantities

2 input quantities

3 ideal response curve

4 linearized response curve

5 straight line whose slope is the amplification coefficient α

6 local residual correction error before adjustment

Figure 5 — Example of a linearization of a response curve

3.4.4
instrument noise
internal noise added to the output signal caused by the instrument if ideally placed in a noise-free environment

NOTE 1 Internal noise can be due to electronic noise such as, e.g., amplifiers.

NOTE 2 This noise typically has high frequencies which limit the ability of the instrument to detect small scale surface texture.

NOTE 3 The S-filter specified in ISO 25178-3 may reduce this instrument noise.

3.4.5
static noise
N_s
sum of the instrument and environmental noise on the output signal without any motion of the lateral scanning system

NOTE 1 Environmental noise is caused by, e.g., seismic, sonic and external electromagnetic disturbances.

NOTE 2 Notes 2 and 3 in 3.4.4 apply to 3.4.5 as well.

3.4.6
dynamic noise
N_d
noise occurring during the motion of the drive units on the output signal

NOTE 1 Notes 2 and 3 in 3.4.4 apply to 3.4.6 as well.

NOTE 2 Dynamic noise includes the **static noise** (3.4.5).

3.4.7
sampling interval in X
D_x
distance between two adjacent measured points along the X-axis

NOTE The sampling interval in X is usually determined by the **drive unit X** (3.2.3).

3.4.8
sampling interval in Y
D_y
distance between two adjacent measured points along the Y-axis

NOTE The sampling interval in Y is usually determined by the **drive unit Y** (3.2.4).

3.4.9
digitization step in Z
D_z
smallest height variation along the Z-axis between two ordinates of the extracted surface

NOTE According to the technology which is used, the digitization step can be determined by:

- the resolution of the analog to digital converter (ADC);
- the phase interpolation of the interferometer;
- the interpolation algorithm of the encoder.

3.4.10
lateral resolution
R_l
smallest separation distance between two features which can be detected

3.4.11
width limit for full height transmission

W_l

width of the narrowest rectangular groove whose measured height remains unchanged by the measurement

NOTE 1 The width limit of transmission of height is a function of the shape (see Figure 6).

NOTE 2 The width limit of transmission of height is mainly dependent on the stylus geometry (r_{tip} and γ).

NOTE 3 Metrological characteristics including:

- the **sampling interval in X** (3.4.7) and the **sampling interval in Y** (3.4.8);
- the **digitization step in Z** (3.4.9);
- the filter use;

should be adapted in such a way that they do not influence the **lateral resolution** (3.4.10) and the width limit for full height transmission.

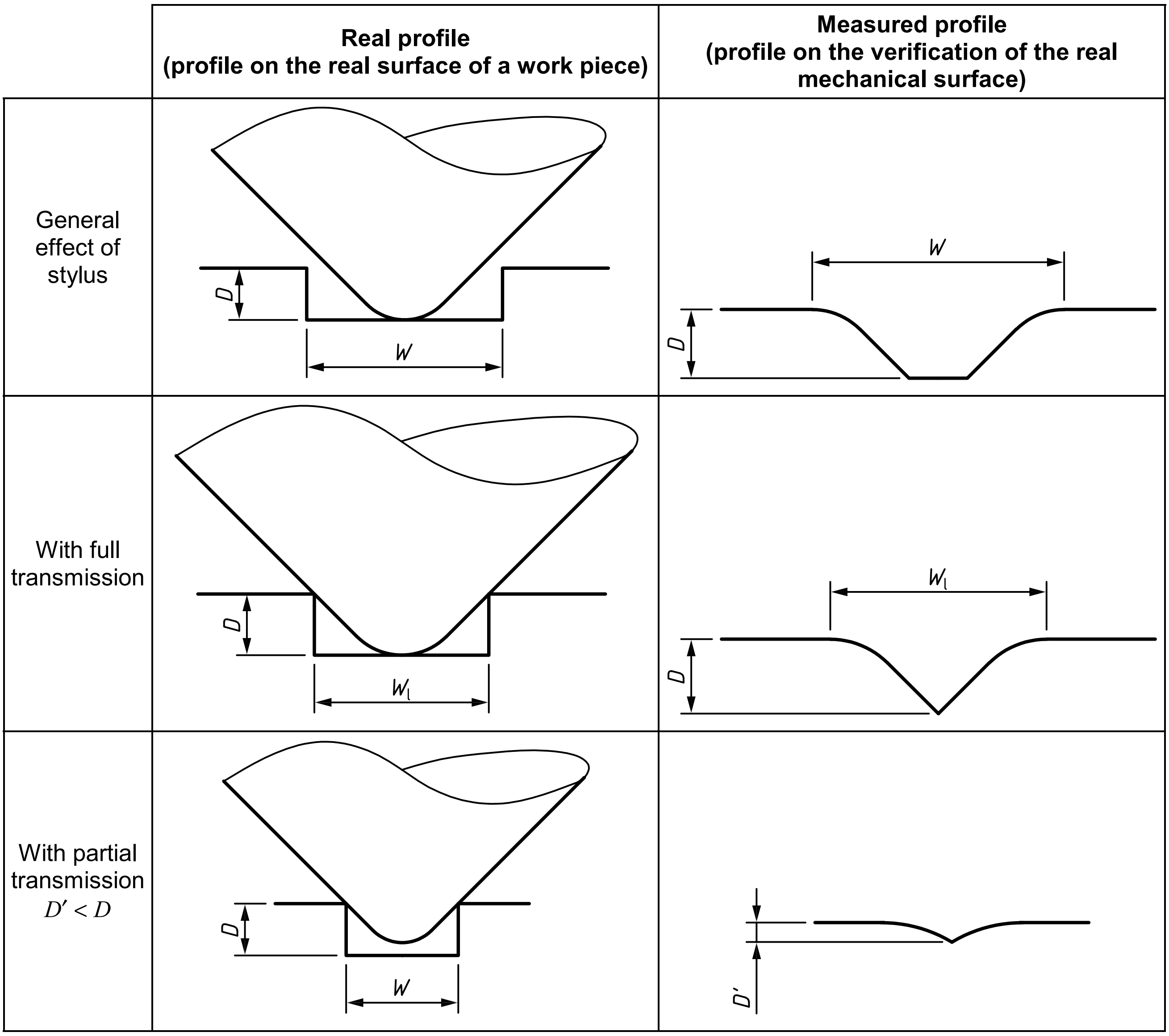


Figure 6 — Width limit of transmission of height

3.4.12
maximum local slope
greatest local slope of a surface feature that can be assessed by the probing system

NOTE 1 The term “local slope” is defined in ISO 4287.

NOTE 2 The maximum local slope is limited by the angle and the arcuate motion of the stylus.

3.4.13
speed of measurement
v_x
speed of the probing system relatively to the surface to be measured during the measurement along the X-axis

3.4.14
dynamic of the probing system
dyn
mechanical and electrical dynamic properties of the probing system which together influence the output signal

3.4.15
critical dynamic of the probing system
$v_{\mathrm{dyn,c}}$
maximum value of the tracing speed above which the output signal is distorted

NOTE 1 The critical dynamic is dependant on the mechanical inertia of the moving parts and the surface to be measured.

NOTE 2 Below the critical dynamic, a range of speeds of measurement are generally acceptable.

4 Summary of metrological characteristics

Typical metrological characteristics which influence the measurement uncertainty for areal surface texture measuring instruments are given in Table 1.

Table 1 indicates the axes which are affected by deviations of metrological characteristics.

Table 1 — Metrological characteristics

Component	Element	Metrological characteristic(s)		Error along
Probing system	Stylus	H	vertical height from the pivot to the stylus tip	X and Z
		L	horizontal length from the pivot to the stylus tip	X and Z
		r_{tip}	tip radius	X, Y and Z
		γ	cone angle	X, Y and Z
		R_{l}	lateral resolution	X and Y
		W_{l}	width limit of transmission of height	Z
	Probe	α_z	amplification coefficient	Z
		D_z	vertical digitization step	Z
	Probe and pivot	z_{HYS}	vertical hysteresis	Z
		$v_{\text{dyn,c}}$	critical dynamic of the probing system	X and Z
		F_{z}	response curve	Z
	Pivot	Jy	lateral component of the Y tracking error of the stylus in respect to the pivot	X and Y
Lateral scanning system	Position sensor (linear encoder, micrometric screw, …)	F_x, F_y	response curves	X (or Y)
		α_x, α_y	amplification coefficients	X (or Y)
		D_x, D_y	lateral sampling intervals	X (or Y)
		x_{HYS}	hysteresis of repositioning in X, between two adjacent profiles	X
		y_{HYS}	hysteresis of repositioning in Y	Y
	Areal reference guide (height component)	$z_{\text{FLT(X,Y)}}$	height component of the flatness deviation of the movement in the XY plane $z_{\text{FLT(X,Y)}}$ contains in particular:	Z
		$z_{\text{STR(X)}}$	height component of the straightness deviation along the X-axis	
		$z_{\text{STR(Y)}}$	height component of the straightness deviation along the Y-axis	
	Areal reference guide (lateral component)	Δ_{PER}	perpendicularity deviation between X and Y axes	X and Y
		$y_{\text{STR(X)}}$	lateral component Y of the straightness along the X-axis	X and Y
		$x_{\text{STR(Y)}}$	lateral component X of the straightness along the Y-axis	X and Y
Instrument		N_{s}	static noise	Z
		N_{d}	dynamic noise	Z

Annex A
(normative)

Classification of the different configurations for areal surface texture scanning instruments

There are essentially four aspects 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. There are different ways in which these may be configured and thus there will be a difference between different configurations as explained in Table A.1.

NOTE Whilst this part of ISO 25178 is concerned with contact probing systems, the lateral scanning system may also be suitable for a non-contact single point probing system.

Table A.1 — Reference guides (X and Y)

		Drive unit				
		Two reference guides (X and Y)			One areal reference guide	
		PX o CY[a]	PX o PY[a]	CX o CY[a]	PXY[a]	CXY[a]
Probing system	Without arcuate error correction	PX o CY – A	PX o PY – A	CX o CY – A	PXY – A	CXY – A
	Without arcuate error or with corrected arcuate error	PX o CY – S	PX o PY – S	CX o CY – S	PXY – S	CXY – S

NOTE For two given functions *f* and *g*, *f* o *g* is the composite function of *f* and *g*.

[a] PX = probing systems moving along the X-axis
PY = probing systems moving along the Y-axis
PX o CY = probing system moving along the X-axis and component moving along the Y-axis
PX o PY = probing systems moving along the X and Y axes
PXY = probing systems moving in the XY plane
CX = component moving along the X-axis
CY = component moving along the Y-axis
CX o CY = component moving along the X and Y axes
CXY = Component moving in the XY plane.

Annex B
(informative)

Features of an areal surface texture measuring instrument

B.1 General

Surface texture instruments enable the assessment of quantities in X, Y and Z from which areal surface texture parameters are calculated (see Figure B.1).

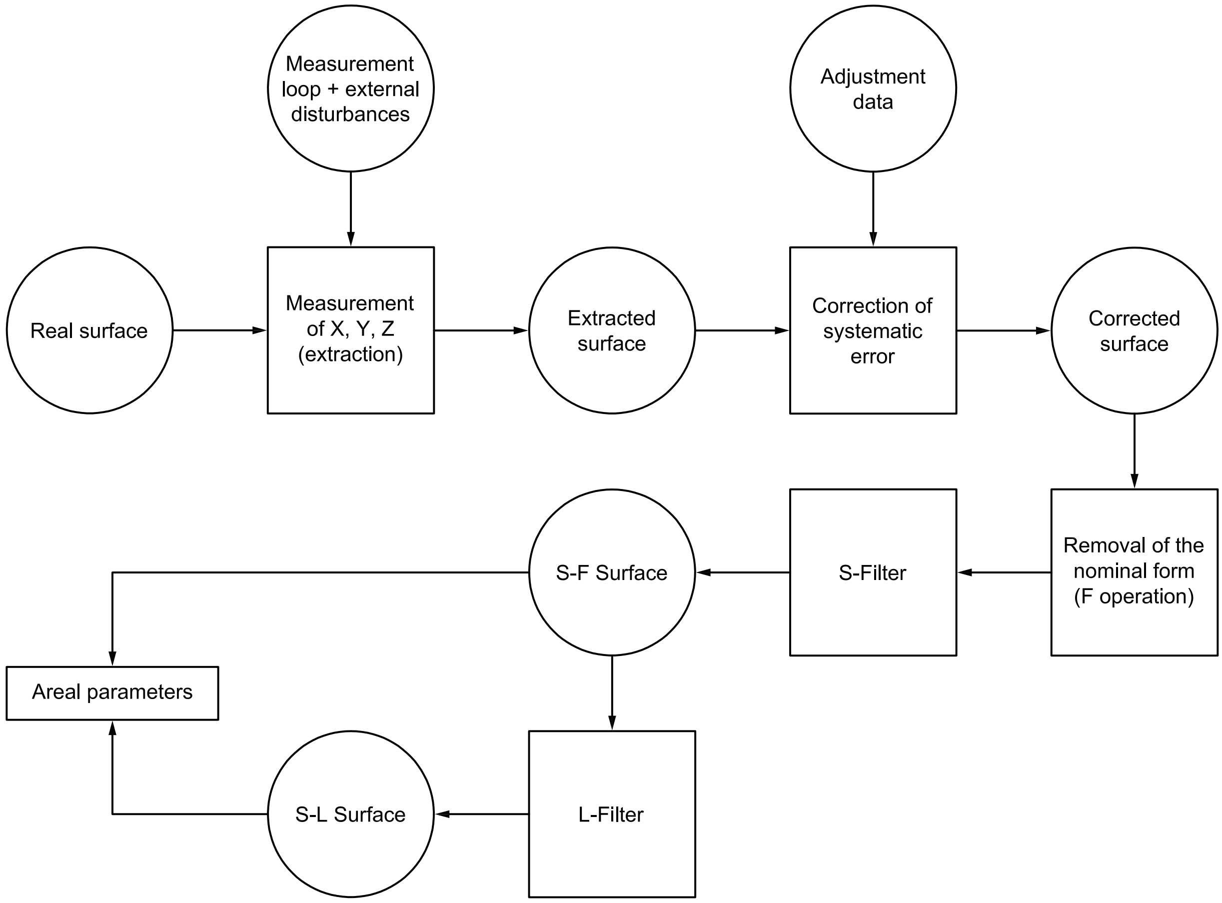


Figure B.1 — Typical measurement method applied to an areal surface texture measuring instrument

Quantities in X and Y characterize the lateral position of the measured point.

The quantity Z characterizes the height of the measured point.

The knowledge of these three quantities gives the ability to calculate various areal surface texture parameters.

NOTE The extracted surface is equivalent to the traced surface as defined in ISO 3274.

B.2 Contact (stylus) areal surface texture measuring instruments

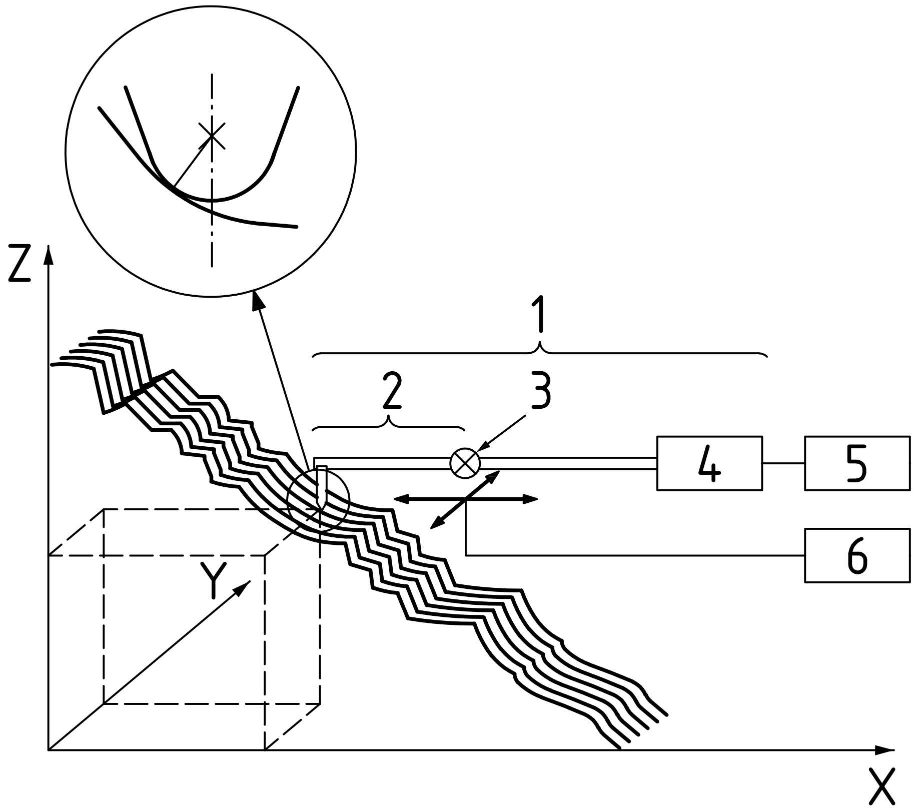
An areal surface texture measuring instrument is composed of a lateral scanning system and a probing system.

Contact (stylus) areal surface measuring instruments use a contact probing system equipped with a stylus for determining heights.

Such instruments are also able to perform profile measurements. There are two types of instrument:

— instruments whose vertical range of measurement allows only the measurement of the surface texture on flat workpieces or on surfaces with small form deviation; typically, the vertical measuring range is less than 1 mm;

— instruments whose vertical range of measurement allows measurement of the surface texture on surfaces intentionally not flat, with large form deviation or measurement of contour; typically, the vertical measuring range is several millimetres;



Key

1 probing system

2 stylus

3 pivot

4 probe

5 digitizing system

6 drive units (including areal reference guide and lateral position sensors)

NOTE 1 The contact point may occur at any position on the spherical portion of the tip.

NOTE 2 The measurement of the surface using a ball is equivalent to applying a morphological operation as defined in ISO/TS 16610-40[4].

Figure B.2 — Contact (stylus) areal surface texture instruments

B.3 Measurement process

A typical areal surface texture measuring instrument uses the following measurement process:

— the probing system performs profile acquisition through continuous measurement along the X-axis over a length l_x;

— after the profile has been measured, the probing system returns to its starting position;

— the perpendicular drive unit (along the Y-axis) steps by one sampling interval distance along the Y-axis;

— the above three steps are repeated until the measurement is completed;

— the extracted surface is then obtained. It contains n profiles separated from each other by the Y sampling interval, each profile containing m points separated by the X sampling interval.

It is also possible to perform the measurement without returning the probe back to the starting position after each profile. The next profile may be scanned in the opposite direction compared to the previous scan. In this case, it is recommended to check that the repositioning hysteresis is compatible with the acceptable measurement uncertainty. Nevertheless, a typical probing system is generally designed for measuring in only one direction.

Recommendations for choosing evaluation areas and sampling distances are found in ISO 25178-3.

Annex C
(informative)

Relationship to the GPS matrix model

C.1 General

For full details about the GPS matrix model, see ISO/TR 14638.

C.2 Information about this part of ISO 25178 and its use

This part of ISO 25178 defines the metrological characteristics of contact (stylus) areal surface texture instruments.

C.3 Position in the GPS matrix model

This part of ISO 25178 is to be regarded as a general GPS document. It influences the chain link 5 of the chain of standards on roughness profile, waviness profile, primary profile and areal surface texture, as illustrated in Figure C.1.

Global GPS standards

Fundamental GPS standards	**General GPS matrix**						
	Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
	Size						
	Distance						
	Radius						
	Angle						
	Form of line independent of datum						
	Form of line dependent on datum						
	Form of surface independent of datum						
	Form of surface dependent on datum						
	Orientation						
	Location						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile					X	
	Waviness profile					X	
	Primary profile					X	
	Surface imperfections						
	Edges						
	Areal surface texture					X	

Figure C.1 — Position in the GPS matrix model

C.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Figure C.1.

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[2] ISO 14660-1:1999, *Geometrical product specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

[3] ISO/TR 14638, *Geometrical product specification (GPS) — Masterplan*

[4] ISO 14978:2006, *Geometrical product specifications (GPS) — General concepts and requirement for GPS measuring equipment*

[5] ISO/TS 16610-40, *Geometrical product specifications (GPS) — Filtration — Part 40: Morphological profile filters: Basic concepts*

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1) To be published.

2) In preparation.

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