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

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

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

Partie 701: Étalonnage et étalons de mesure pour les instruments à contact (à palpeur)

Reference number
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Contents

Page

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 25178-701 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 6 of the chains of standards on areal surface texture.

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

This part of ISO 25178 concerns the areal surface texture measuring instruments for which it defines

— the systematic errors linked with main metrological characteristics of the instrument if they are not given by the manufacturer,

— the calibration operation mode,

— the analysis of the results for the assessment of the potential errors, and

— the decision rules for corrective actions.

It allows the evaluation of the part of the measurement uncertainty which is linked with the metrological characteristics of the instrument and which influences the assessment of areal surface texture parameters.

These metrological characteristics are verified by testing the instrument with the measurement standards defined hereafter or with the measurement standards described in ISO 5436-1 and ISO 5436-2, and with complementary standards like optical flats.

The aim is to assess the errors in the corrected X, Y and Z quantities by using material measurement standards having simple geometry (i.e. optical flat, sphere, etc.) for which

— the uncertainty is lower than for surface texture standards,

— their characteristics are independent of the surface texture parameters.

The calibration procedure reports on the status of the measurement equipment. Depending on the report, the user can decide to perform the corrective actions or to alert the equipment manufacturer.

The method is as follows:

a) assessment of the errors on the fundamental corrected quantities X, Y and Z;

b) assessment of the uncertainty due to the mathematical algorithms used for filtering and for computation of parameters, checked with the help of software measurement standards as defined in ISO 5436-2 and ISO 25178-7.

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

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

1 Scope

This part of ISO 25178 specifies

— the characteristics of material measures used as measurement standards,

— the estimation methods of the residual errors, and

— the calibration methods and tests for acceptance and periodical re-verification

for areal surface texture contact (stylus) measurement instruments.

2 Normative references

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

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

ISO 5436-1:2000, *Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards — Part 1: Material measures*

ISO 5436-2, *Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards — Part 2: Software measurement standards*

ISO 12085, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Motif parameters*

ISO 12179:2000, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Calibration of contact (stylus) instruments*

ISO/TS 12181-1, *Geometrical Product Specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

ISO/TS 12780-1, *Geometrical Product Specifications (GPS) — Straightness — Part 1: Vocabulary and parameters of straightness*

ISO/TS 12781-1, *Geometrical Product Specifications (GPS) — Flatness — Part 1: Vocabulary and parameters of flatness*

ISO/TS 14253-2, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

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

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

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

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 3274, ISO 25178-2, ISO 25178-601 and ISO/IEC Guide 99 apply.

4 General

A material measurement standard can be used for two different purposes:

— calibration of the metrological characteristics, followed by assessment of the measurement uncertainty;

— user adjustment of the instrument (see ISO 25178-601), which establishes correction factors of the measured quantities.

Both of these depend on the metrological characteristics of the measurement standards.

The measurement standards presented below are suitable for both purposes; nevertheless, they have been especially designed for the assessment and for the correction of systematic errors. This is due to the fact that the characteristics of those standards permit the calibration of quantities such as X, Y and Z through the assessment and the verification of adjustment coefficients C_x, C_y and C_z (see ISO 25178-601).

However, these material measurement standards do not permit the assessment of errors due to filtering and computation algorithms. These algorithms can be tested using software measurement standards (see ISO 5436-2 and ISO 25178-7).

Moreover, most of the material measurement standards presented below permit the verification and the correction of the perpendicular deviation between X and Y drive units.

The measurement standards defined in ISO 5436-1 are designed for the calibration of quantities which permit the assessment of profile parameters.

This part of ISO 25178 provides default methods for the assessment of the software measurement standards. Nevertheless, the method and the characteristics of the measurement standard should be supplied by the manufacturer.

5 Measurement standards

5.1 Types of standards

The different types of measurement standards are given in Table 1.

Table 1 — Type of measurement standards

Type	Name
ER1	Measurement standard with two parallel grooves
ER2	Measurement standard with four grooves forming a rectangle
ER3	Measurement standard with a circular groove
ES	Measurement standard with a sphere/plane intersection
CS	Measurement standard with a contour profile
CG	Crossed-grating measurement standard

It is necessary to choose a measurement standard having characteristics in accordance with the metrological characteristics of the instrument under consideration. Therefore, a non-exhaustive list of significant characteristics is supplied below for each measurement standard.

5.2 Description of the measurement standards

5.2.1 Type ER: Groove standard

5.2.1.1 General

The ER standards contain two or more triangular grooves.

These grooves are characterized by:

— the depth, d;

— the angle between the flanks, α;

— the intersection line of their respective flanks.

The parallelism and the perpendicularity of grooves and the distance between grooves are determined from the intersection line of the flanks.

The angle α should be greater than the cone angle of the stylus.

The groove bottom radius r_f should be greater than the tip radius r_{tip} of the stylus.

The depth d of the grooves is defined according to ISO 5436-1:2000, 7.2.

5.2.1.2 Requirements for the ER measurement standard

The design characteristics of the measurement standards shall be compatible with the considered application (e.g. geometry of stylus tips).

The following geometrical characteristics shall not significantly affect the measurement:

— flatness of the real integral surface relative to the reference plane, P, of the standard;

— form deviation of the groove(s);

— groove bottom radius, r_f;

— form deviation of the flanks of the triangles;

— parallelism between grooves;

— perpendicularity between grooves;

— local slope at any point.

Roughness shall be considered not to affect the measurement.

The bisector of the groove(s) or the triangles (line, plane or cylinder) shall be nominally perpendicular to the reference plane of the standard.

For type ER2 measurement standards, an orientation mark with an angle of 45° with respect to the grooves can be added on the standard to identify a preferred measurement direction.

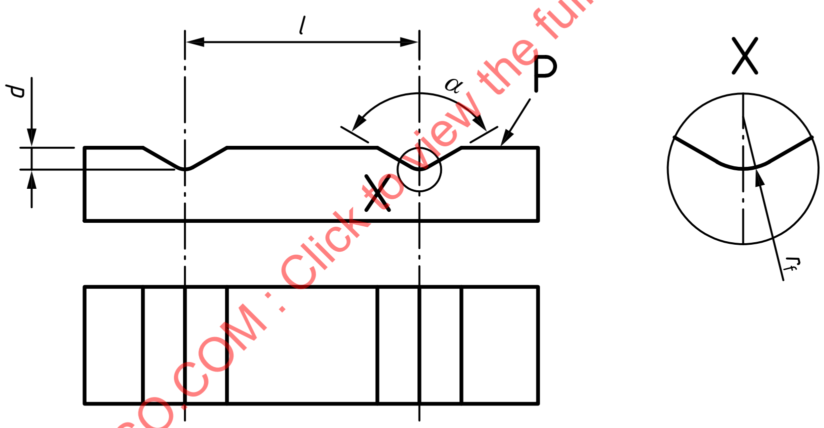
5.2.1.3 Type ER1: Two-parallel-grooves standards

5.2.1.3.1 Purpose

The two-parallel-grooves standards are used for calibrating the vertical and the horizontal amplification coefficients of the measuring instrument.

5.2.1.3.2 Design characteristics

This measurement standard has two parallel grooves (see Figure 1).



Key

d depth of grooves

l distance between grooves

α angle of the groove flanks

P reference plane

r_f groove bottom radius

Figure 1 — Two-parallel-grooves standard, ER1

5.2.1.3.3 Definition of the measurands

The measurands are:

l the groove spacing,

d the depth of the grooves, defined according to ISO 5436-1:2000, 7.2.

5.2.1.4 Type ER2: Rectangular-groove measurement standards

5.2.1.4.1 Purpose

The rectangular-groove standards are used for calibrating:

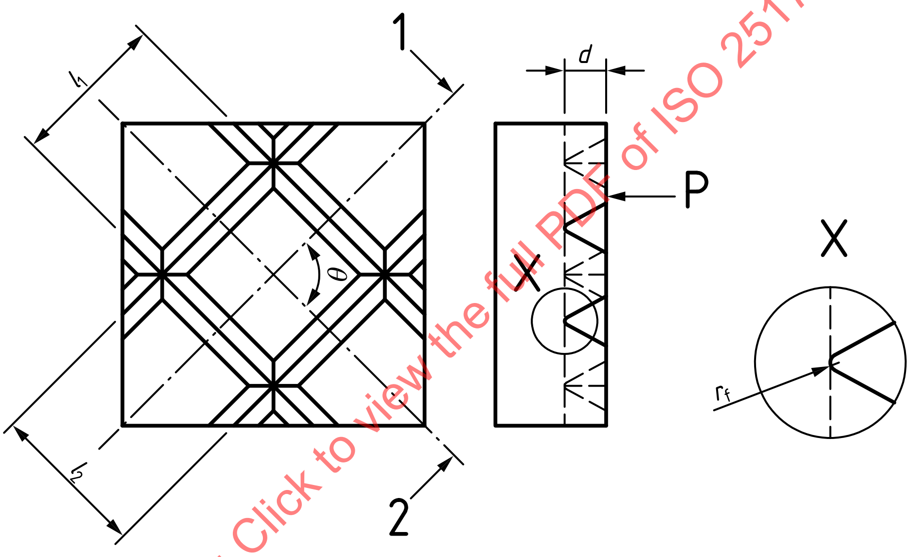
— the vertical amplification α_z;

— the horizontal amplification, α_x, α_y;

— the perpendicularity of both X- and Y-axes of the measuring instrument, Δ_{PER}.

5.2.1.4.2 Design characteristics

This measurement standard is composed of four grooves forming a rectangle (see Figure 2).



Key

1, 2 symmetry lines of parallel grooves

d depth of grooves

l_1, l_2 groove spacing

θ angle between the grooves

P reference plane

r_f groove bottom radius

Figure 2 — Rectangular-groove measurement standard, ER2

5.2.1.4.3 Definition of the measurands

The measurands are:

l_1, l_2 the spacing between the grooves;

d the depth of the grooves, defined according to ISO 5436-1:2000, 7.2;

θ the angle between the grooves, defined as the intersection of the two median lines of the two sets of parallel grooves (see Figure 2).

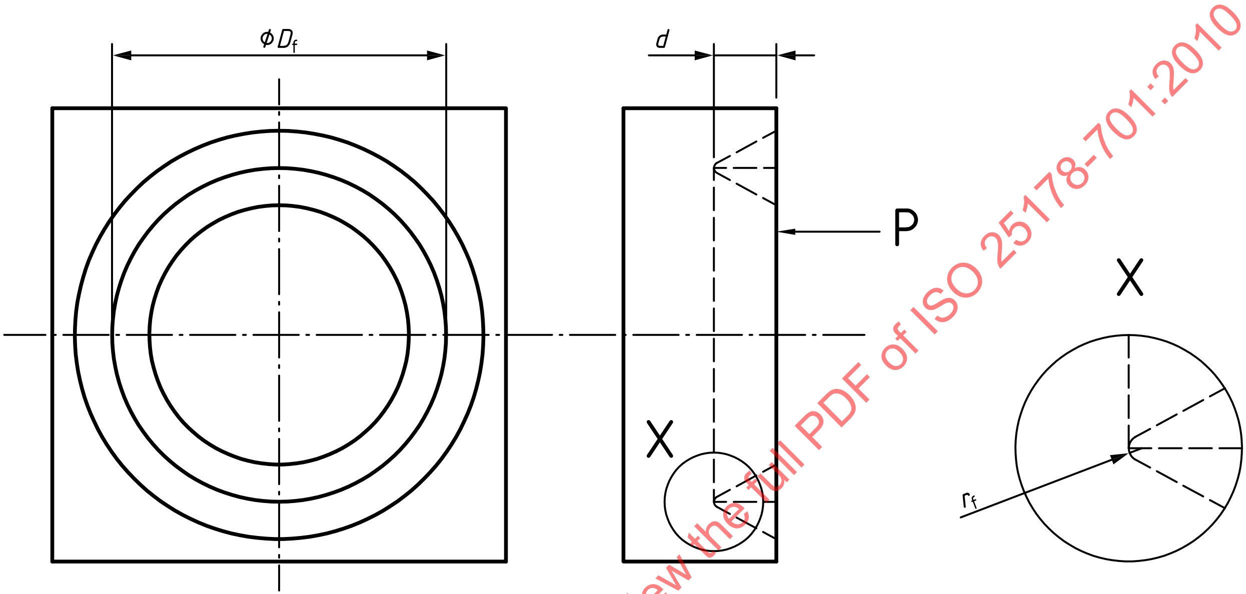
5.2.1.5 Type ER3: Circular-groove standards

5.2.1.5.1 Purpose

The circular-groove standards are used for calibrating the vertical and the horizontal amplification coefficients and the perpendicularity of both X- and Y-axes of the measuring instrument.

5.2.1.5.2 Design characteristics

This measurement standard has a circular groove (see Figure 3).



Key

d depth of grooves
D_f diameter of the groove
P reference plane
r_f groove bottom radius

Figure 3 — Circular-groove standard, ER3

5.2.1.5.3 Definition of the measurands

The measurands are:

D_f the diameter of the groove, defined as the diameter of the intersection circle of the two flanks of the groove;

d the depth of the grooves, defined according to ISO 5436-1:2000, 7.2.

5.2.2 Type ES: Sphere/plane measurement standard

5.2.2.1 Purpose

The sphere/plane standards are used for calibrating:

— the vertical amplification, α_z;

— the horizontal amplification, α_x, α_y;

— the perpendicularity of both X- and Y-axes of the measuring instrument, Δ_{PER};

— the response curve of the probing system, F_x, F_y;

— the geometry of the stylus (H and L);

— the radius of the stylus tip, r_{tip};

— the cone angle, γ.

5.2.2.1.1 Requirements for the ES measurement standards

The following geometrical characteristics shall not significantly affect the measurement:

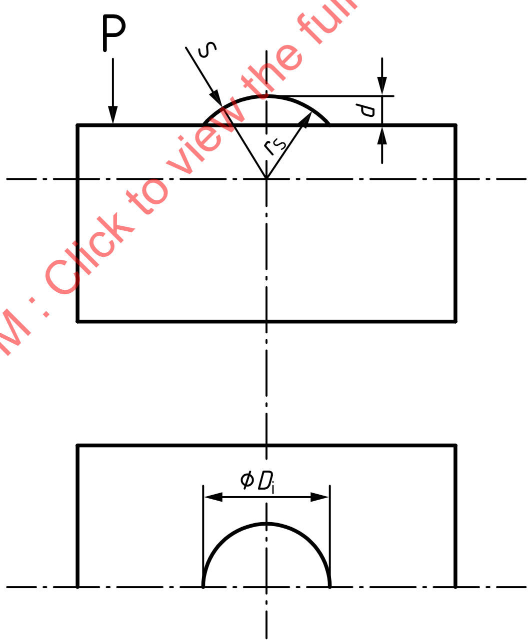
— the flatness of the real integral surface relative to the plane P;

— the form deviation of the real integral surface relative to the sphere S;

— the roughness of the real integral surface relative to the plane P and the sphere S.

5.2.2.2 Design characteristics

This measurement standard is composed of a part of a sphere S and a plane P (see Figure 4).



Key

d distance from the top of the sphere to the plane P

S part of a sphere

P datum plane

r_S radius of the sphere

D_i intersection diameter

Figure 4 — Sphere/plane measurement standard, ES

5.2.2.3 Definition of the measurands

The measurands are:

d the largest distance of a point of the sphere to the plane P;

r_S the radius of the sphere;

D_i the diameter of the circle obtained by the intersection between the sphere S and the plane P (see Figure 4). It is a function of the height d and the radius r of the sphere. Its assessment is obtained as follows:

$$D_i = 2\sqrt{{r_S}^2 - (r_S - d)^2}$$

5.2.3 Type CS: Contour standard

5.2.3.1 Purpose

The contour standards are used for overall calibration along one lateral axis of the measuring instrument.

5.2.3.2 Requirements for the CS measurement standards

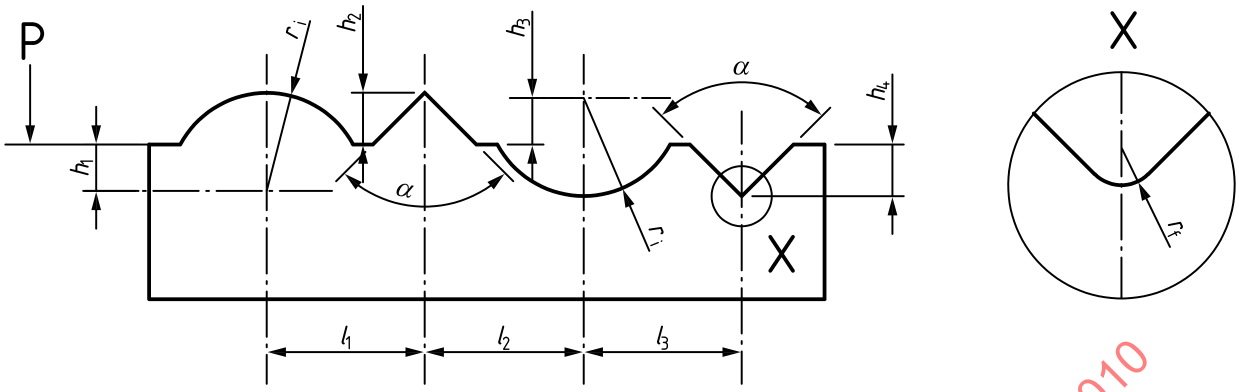
The following geometrical characteristics shall be considered not to affect the measurement:

- flatness of the real integral surface relative to the reference plane, P;
- flatnesses of the two flanks of the groove(s);
- roundness of the real integral line relative to the portions of circles;
- groove bottom radius, r_f;
- flatnesses of the two flanks of the wedges/triangles;
- local slope at any point;
- roughness of the real integral surface relative to the reference plane, P, and portions of circles and flanks of the wedges/triangles and the grooves.

5.2.3.3 Design characteristics

This measurement standard is composed of a profile including different geometrical patterns (see Figure 5):

- at least two circular arcs (1 convex, 1 concave);
- at least two wedges/triangles (1 convex, 1 concave).



Key

r_i radii of the circular arcs

α angles of the triangles

P reference plane

$l_1,\ldots, l_n$ distances between the different patterns

$h_1,\ldots, h_n$ heights between the different patterns with respect to the reference plane P

Figure 5 — Example of a contour standard, CS

5.2.3.4 Definition of the measurands

The measurands are:

r the radius of the circular arcs;

α the angle between the flanks of the wedges/triangles and grooves;

$l_1,\ldots, l_n$ the distances (measured in a parallel direction to the plane P) between the centres of the circles and/or the intersections of the flanks of the triangles;

$h_1,\ldots, h_n$ the heights (measured in a perpendicular direction to the plane P) between the centres of the circles and/or the intersections of the flanks of the triangles.

5.2.4 Type CG: Crossed-grating measurement standard

5.2.4.1 General

The CG standards are orthogonal crossed gratings or two-dimensional array patterns with nominally equal pitch in each direction.

The standards are characterized by

— the average pitch in the X-axis,

— the average pitch in the Y-axis,

— the angle between the X- and Y-axes.

The profile of the standards for XY measurements is not prescribed. Waffle pattern gratings that have flat bottomed grooves may also be characterized by the average depth.

5.2.4.2 Type CG1: X/Y-crossed-grating

5.2.4.2.1 Purpose

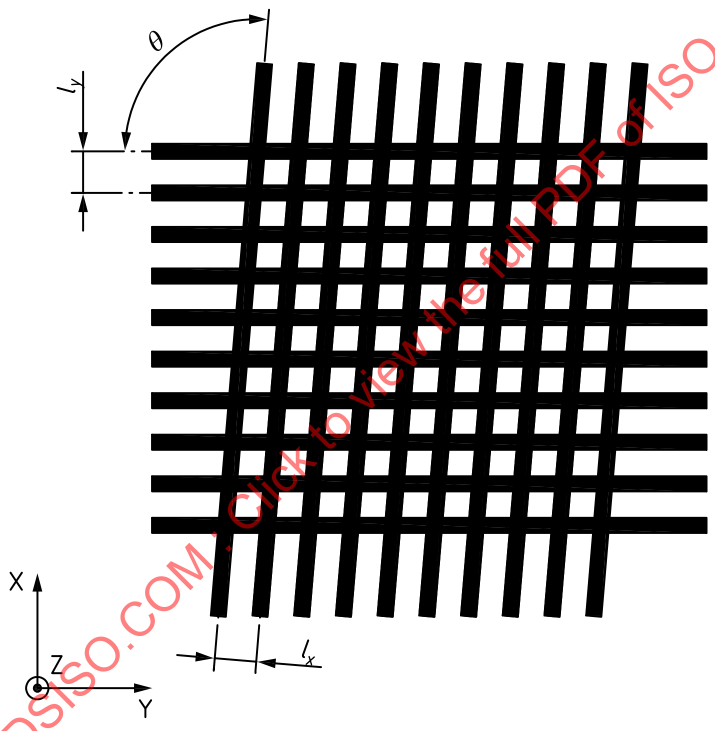
The X/Y-crossed-grating standards are used for calibrating:

— the horizontal amplification coefficients, α_x, α_y;

— the perpendicularity of the X- and Y-axes of the measuring instrument, Δ_{PER}.

5.2.4.2.2 Design characteristics

The measurement standard has a two-dimensional array pattern that may be made up of raised lines, grooves or dots (see Figure 6). The standard should be marked to identify the X- and Y-axes. The active area of the standard should be defined, either by reference marks on the standard or in the certificate of calibration of the standard.



Key

l_x pitch in the X-axis
l_y pitch in the Y-axis
θ angle between the X- and Y-axes

Figure 6 — X/Y-crossed-grating standard, CG1

5.2.4.2.3 Definition of the measurands

The measurands are:

l_x, l_y the average pitches in the X- and Y-axes over the defined active area of the standard;

θ the average angle between the X- and Y-axes over the defined active area of the standard.

5.2.4.3 Type CG2: X/Y/Z standard

5.2.4.3.1 Purpose

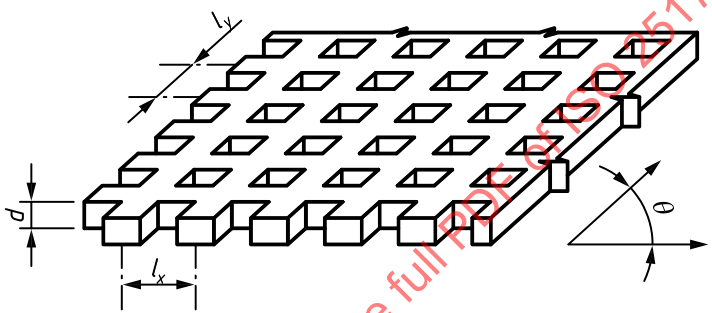
The X/Y/Z-crossed-grating standards are used for calibrating

— the horizontal and vertical amplification coefficients, α_x, α_y, α_z;

— the perpendicularity of the X- and Y-axes of the measuring instrument, Δ_{PER}.

5.2.4.3.2 Design characteristics

The measurement standard is a two-dimensional arrangement of pits with flat bottoms, often referred to as a waffle pattern. The standard should be marked to identify the X- and Y-axes (see Figure 7). The active area of the standard should be defined, either by reference marks on the standard or in the certificate of calibration of the standard.



Key

l_x pitch of the X-axis

l_y pitch of the Y-axis

θ angle between the X- and Y-axes

d depth of the pits

Figure 7 — X/Y/Z crossed-grating standard, CG2

5.2.4.3.3 Definition of the measurands

The measurands are:

l_x, l_y is the average pitch of the X- and Y-axes over the defined active area of the standard;

θ is the average angle between the X- and Y-axes over the defined active area of the standard;

d is the average depth of the flat bottomed pits, over the defined active area of the standard.

6 Calibration and periodical verification procedures

6.1 Conditions and preliminary adjustments

6.1.1 General

6.1.1.1 Like most other instruments, those dedicated to the measurement of areal surface texture are used in a measurement room or directly in the workshop.

This clause describes the tests for the metrological characteristics defined in Clause 4.

6.1.1.2 Depending on the application and based on the calibration history of the instrument under verification and the acceptable measurement uncertainty, the user should decide which part of the calibration is needed.

6.1.1.3 The uncertainty of the measurement standards used during the tests shall be taken into account (see ISO/TS 14253-2 and ISO 12179 for examples).

6.1.1.4 Measurements shall be performed for each stylus used for the intended application.

6.1.2 Measurement conditions

Measurement procedures shall be specified on the calibration certificate of the measurement standard.

The measurement conditions of the surfaces are in accordance with those given ISO 25178-1 and ISO 25178-601, with the following additional specifications:

— the manufacturer recommended measurement speed shall be used;

— in task specific calibrations, the characteristics of the material measurement standards shall be determined by taking into account the characteristics of the surface to be measured;

— for the assessment of surface texture parameters, the filter type and nesting indexes to be used should be the ones stated on the material measurement standard certificate;

— for the assessment of instrument measurement noise relating to the computation of "motif" parameters, it is possible to permit less than the minimum requirement of 150 increments for vertical digitization as defined in ISO 12085;

— measurement standards having an orientation mark shall be oriented such as the mark is aligned with the X-axis of the measuring instrument.

In accordance with ISO 12179, the measurement conditions used for periodical verification should be the same as those used in the application situation.

6.1.3 Preliminary adjustment of the instrument

The set up instructions that are specified in the calibration certificate should be followed.

6.1.4 Number of measurements

A measuring plan specifying, e.g., the number of measurements and the distribution over the measurement standard shall be given by the certificate of the measurement standard.

The deviation from the values stated in the calibration certificate shall be recorded.

A sufficient number of measurements is required to achieve the requested measurement uncertainty. Repeated measurements are necessary due to the variability of the measurement standard, the variability of the measurement procedure, and the repeatability of the contact (stylus) instrument.

6.2 Sequence of tests

6.2.1 Measurement of the static noise

The purpose is to assess the instrument noise and the environmental noise (noises transmitted through the floor, acoustic and electro-magnetic noise).

The measurement is carried out without movement; the stylus shall be in contact with any specimen (see Table 2).

This test should be performed at the worst expected conditions.

Table 2 — Measurement of the static noise

Type of measurement	Profile
Standard used	Any specimen
Measurement conditions	Equivalent measurement length[a] and nesting indexes shall be selected in accordance with the intended applications covered by the calibration. The contact force on the specimen shall be the same as in a measurement.
Assessed parameters	Typically, for calibration, the maximum height of profile, Rz
Measurement method	The maximum magnification of the instrument is used.
Results	The average values of the obtained parameters shall be added to the maximum permissible error (MPE) of the equivalent parameters defined in 6.2.3.2.

[a] The calculation of the parameters requires that the quantities be expressed in units of length; afterwards, the measurement time is converted to equivalent measurement length.

6.2.2 Calibration of the user adjustment

6.2.2.1 Calibration of the vertical adjustment

6.2.2.1.1 Calibration using a groove standard

See Table 3.

Table 3 — Calibration of the vertical adjustment using a groove standard

Type of measurement	Profile
Standard used	Standard A1 or A2 (according to ISO 5436-1) or ER or CG2
Measurement conditions	According to the supplied certificate
Assessed parameters	Depth d of the groove
Results	The relative deviation between the average value of the parameter d and the conventional true value shall be recorded.

6.2.2.1.2 Calibration using a sphere

This verification applies to the measuring instruments having a large vertical range of measurement and more specifically having an arc error correction (See Table 4).

Table 4 — Calibration of the vertical adjustment using a sphere

Type of measurement	Profile
Standard used	Standard E1 (according to ISO 5436-1) or ES
Measurement conditions	Z vertical range: A significant part of the vertical range of the probe shall be used and adapted to the maximum height which can be measured with the stylus.
Assessed parameters	Radius r_d
	Roundness deviation: Assessment of $RONt$[a] (according to ISO/TS 12181-1)
Results	The relative deviation between the average values of the radius r_d and parameters $RONt$[a] and the conventional true value shall be recorded.

[a] $RONt$, as defined in ISO/TS 12181-1, is the value of the largest positive local roundness deviation added to the absolute value of the largest negative local roundness deviation. If the instrument considered does not allow the computation of the parameter $RONt$, it is possible to assess the parameter Wt, computed after low pass filtering of the profile, or the parameter Wte (total depth of waviness) in accordance with ISO 12085, after applying a form removal using a least square circle.

6.2.2.2 Calibration of the horizontal adjustment

6.2.2.2.1 Calibration using a groove standard

This calibration applies to measuring instruments that have a limited vertical measuring range and no arcuate motion correction (see Table 5).

Table 5 — Calibration of the horizontal adjustment using a groove standard

Type of measurement	Areal
Standard used	Standard ER2, ER3, CG1 or CG2
Measurement conditions	Measurement area: given in the standards certificate
Assessed parameters	For ER2: distances l_1 and l_2 between the grooves
	For ER3: diameters D_f along the X-axis and the Y-axis
Measurement method	Measurements to be performed in several areas within the X-Y range
Results	The relative deviation between the average value of the assessed parameter and the conventional true value shall be recorded.

6.2.2.2.2 Calibration using a sphere/plane standard

This calibration applies to measuring instruments having a large vertical measuring range and an arcuate motion correction (see Table 6).

Table 6 — Calibration of the horizontal adjustment using a sphere/plane standard

Type of measurement	Areal
Standard used	Standard ES
Measurement conditions	Measurement area: given in the standards certificate
Assessed parameters	Diameters D_i along X-axis and Y-axis
Results	The relative deviation between the average value of the assessed parameter and the conventional true value shall be recorded.

6.2.2.3 Estimation of the perpendicularity deviation

See Table 7.

Table 7 — Estimation of the perpendicularity deviation

Type of measurement	Areal
Standard used	Standard ER2, ER3 or ES
Measurement conditions	Measurement area, filtering, horizontal sampling interval: given in the standard certificate
Assessed parameters	Δ_{PER} (see ISO 25178-601)
Measurement method	Areal measurement of the standard in the central zone of the X and Y measuring ranges
Results	The maximum perpendicularity deviation, Δ_{PER}, shall be recorded.

6.2.3 Calibration of the characteristics

6.2.3.1 Estimation of the flatness deviation

See Table 8.

Table 8 — Estimation of the flatness deviation

Type of measurement	Areal and profile
Standard used	Optical flat (levelled in both X- and Y-axes in accordance with ISO 12179:2000, 7.1)
Measurement conditions	Measurement area: all the available measuring range of the instrument without actuating the limit switches
Assessed parameters	Assessment of *FLT*t[a] in accordance with ISO/TS 12781-1 Assessment of *STR*t[b] in accordance with ISO/TS 12780-1
Results	The maximum flatness deviation, *FLT*t, and maximum straightness deviation, *STR*t, along the X-axis and Y-axis, shall be recorded.

a *FLT*t, as defined in ISO/TS 12781-1, is the value of the largest positive local flatness deviation added to the absolute value of the largest negative local flatness deviation. If the instrument does not allow the computation of the *FLT*t parameter, it is possible to assess the parameter *S*t computed on the low-pass filtered surface S-filter after applying an F-filter.

b *STR*t, as defined in ISO/TS 12780-1, is the value of the largest positive local straightness deviation added to the absolute value of the largest negative local straightness deviation.

6.2.3.2 Measurement of the dynamic noise

See Table 9.

Table 9 — Measurement of the dynamic noise

Type of measurement	Areal
Standard used	Optical flat (aligned to the reference surface in accordance with ISO 12179:2000, 7.1)
Measurement conditions	Measurement of an area with a size compatible with the required nesting indexes of the filters Measurement of a profile with a length along the scanning axis compatible with the required nesting indexes of the filters
Assessed parameters	Typically, the maximum height of profile, Rz, assessed on the S-L surface
Measurement method	— One measurement at one corner of the measuring X-Y range — One measurement in the middle of the measuring X-Y range — One measurement at the opposite corner of the measuring X-Y range The maximum magnification of the instrument is used.
Results	The assessed parameter shall be recorded.

6.2.3.3 Estimation of the hysteresis along the X-axis (or Y-axis)

See Table 10.

The hysteresis may depend on the measurement speed. It is therefore recommended to apply the method to different speeds.

Table 10 — Estimation of the hysteresis

Type of measurement	Areal
Standard used	Standard A or E (according to ISO 5436-1) or ER2 or ER3.
Measurement conditions	Measurement area: given in the standards certificate The smallest sampling interval D_x along the scanning axes shall be chosen
Assessed parameters	x_{HYS} (or y_{HYS}): total deviation of the X (or Y) position of the bottom of the groove over the whole surface
Measurement method	This measurement shall be performed without movement of the Y-axis (or X-axis) such as any profile along the X-axis (or Y-axis) are measured at the same location of the groove. This measurement shall be performed with a minimum of two speeds related to the applications.
Results	The parameter x_{HYS} (or y_{HYS}) shall be recorded. If the instrument is not able to assess these parameters, it is possible to assess the hysteresis graphically.

6.2.3.4 Calibration with a roughness standard

See Table 11.

Table 11 — Calibration with a roughness standard

Type of measurement	Profile
Standard used	Roughness standard
Measurement conditions	See ISO 12179.
Assessed parameters	See ISO 12179.
Measurement method	See ISO 12179.
Results	The relative deviation between the assessed parameters and the conventional true values shall be recorded.

Annex A
(informative)

Assessment of the residual errors

Definitions of the metrological characteristics are given in Table A.1 as well as the methods of estimating the residual errors.

NOTE The material measurement standards of types A, B, C and E mentioned below are defined in ISO 5436-1. The material measurement standards of types ES and ER mentioned below are described in Clause 5 of this part of ISO 25178.

Table A.1 — Assessment of the residual errors

Element	Symbol	Definition	Assessment method
Stylus	H	height from the pivot to the centre of the stylus tip	Measurement of an E[a] or ES[a] measurement standard
	L	horizontal length from the pivot to the centre of the stylus tip	Measurement of an E[a] or ES[a] standard
	r_{tip}	tip radius	Measurement of — an E[a] or ES[a] standard with concave and convex match pair like a CS standard, or — a C standard with a small spacing — a B standard
	γ[b]	cone angle	Assessment of the average value of the measured angles in both X and Y direction using a microscope NOTE The purpose of this assessment is to avoid contact with the cone when measuring.
	R_l	lateral resolution	Measurement of a narrow groove[b]
	W_l	width limit of transmission of height	Measurement of a groove[c]
Probe	α_z	amplification coefficient	Measurement of an E[a] or ES[a] standard Measurement of an A or ER standard
	D_z[d]	vertical digitization step	Measurement of an optical flat
Probe and pivot	z_{HYS}	vertical hysteresis	Measurement of an E[a] standard
	$v_{dyn,c}$	critical dynamic of the probing system	Measurement of a downward step
	F_z	response curve	Measurement of an E[a] or ES[a] standard Measurement of gauge blocks
Pivot	J_y	lateral component of the Y tracking error of the stylus with respect to the pivot	Areal measurement of an E[a] or ER2 standard.

Table A.1 (*continued*)

Element	Symbol	Definition	Assessment method
Position sensor (linear encoder, micrometric screw, …)	F_x, F_y	Response curves	Measurement using a reference length measurement system (i.e. laser interferometer), or a spacing standard, along the X -or Y-axes.
	α_x, α_y	Amplification coefficients	Measurement of an A, C, ER or ES[a] standard Measurement using a reference length measurement system (i.e. laser interferometer), or a spacing standard, along the X- or Y-axes.
	D_x, D_y	Lateral sampling intervals	This characteristic is given by the manufacturer of the instrument[e].
	x_{HYS}	Hysteresis of repositioning in X, between two adjacent profiles	Measurement of an A, ER, E[a] or ES[a] standard
	y_{HYS}	Hysteresis of repositioning in Y	Measurement of an A, ER, E[a] or ES[a] standard
Areal reference guide (vertical component)	$z_{FLT(X,Y)}$	Height component of the flatness deviation of the movement in the XY plane	Measurement of an optical flat over the whole measurement area
	$z_{STR(X)}$	Height component of the straightness deviation along the X-axis	Measurement of straightness deviation over the whole X range using an optical flat
	$z_{STR(Y)}$	Height component of the straightness deviation along the Y-axis	Measurement of straightness deviation over the whole Y range using an optical flat
Areal reference guide (horizontal component)	Δ_{PER}	Perpendicularity deviation between X- and Y-axes	Measurement of an ER2, ER3 or ES[a] standard
	$y_{STR(X)}$	Lateral component Y of the straightness deviation along the X-axis	Measurement of straightness deviation over the whole X range using an optical flat in a vertical position
	$x_{STR(Y)}$	Lateral component X of the straightness deviation along the Y-axis	Measurement of straightness deviation over the full range Y using an optical flat in a vertical position
Instrument	N_s	Static noise[f]	Static measurement (the probe is in contact with a surface and does not move)
	N_d	Dynamic noise[f]	Measurement along the X- and Y-axis using an optical flat

NOTE The combination of one of the above mentioned standards with X, Y, Z and rotary high accuracy stages may allow the calibration of numerous metrological characteristics.

[a] Not suitable for instruments not having arcuate motion compensation (those instruments usually have a small vertical range of measurement).

[b] In practice, the lateral resolution is limited by the sampling interval and by the digitizing step.

[c] The knowledge of the radius and cone angle of the tip allows the assessment of the width limit of transmission of height.

[d] The use of a high resolution analog-to-digital converter (ADC) improves vertical digitization.

[e] The decrease of the sampling interval reduces the error linked to that characteristic.

[f] It is not possible to correct measurement noise, nevertheless the S-filter reduces it.