

# INTERNATIONAL STANDARD

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**5436-1**

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## **Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards —**

### **Part 1: Material measures**

*Spécification géométrique des produits (GPS) — État de surface: Méthode  
du profil; Étalons —*

*Partie 1: Mesures matérialisées*



Reference number  
ISO 5436-1:2000(E)

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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 3.

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 part of ISO 5436 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5436-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 5436-1, together with ISO 5436-2, cancels and replaces (ISO 5436:1985), which has been technically revised.

ISO 5436 consists of the following parts, under the general title *Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards*:

- *Part 1: Material measures*
- *Part 2: Software measurement standards*

Annex A of this part of ISO 5436 is for information only.

## Introduction

This part of ISO 5436 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain link 6 of the chain of standards on roughness, waviness and primary profile.

For more detailed information of the relation of this part of ISO 5436 to the GPS matrix model, see annex A.

This part of ISO 5436 introduces a new measurement standard, namely Type E, to calibrate the profile co-ordinate system.

NOTE "Measurement standards" were formerly referred to as "calibration specimens".



# Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards —

## Part 1: Material measures

### 1 Scope

This part of ISO 5436 specifies the characteristics of material measures used as measurement standards (etalons) for the calibration of metrological characteristics of instruments for the measurement of surface texture by the profile method as defined in ISO 3274.

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 5436. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 5436 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

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

ISO 4288:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture.*

ISO 10012-1:1992, *Quality assurance requirements for measuring equipment — Part 1: Metrological confirmation system for measuring equipment.*

ISO 12085:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Motif parameters.*

ISO/TS 14253-2:1999, *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.*

BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML. *International vocabulary of basic and general terms used in metrology (VIM)*, 1993.

BIPM, IEC IFCC, ISO, IUPAC, IUPAP, OIML. *Guide to the expression of uncertainty in measurement (GUM)*, 1993.

### 3 Terms and definitions

For the purposes of this part of ISO 5436, the terms and definitions given in ISO 3274, ISO 4287 and VIM apply.

## 4 Design requirements

### 4.1 Material

The material used for measurement standards A to E shall be hard enough to ensure adequate life in relation to cost (manufacturing and calibration). Its surface shall be smooth and flat enough not to affect the evaluation.

### 4.2 Size of measurement standard

The measurement window shall be large enough to provide for the total length of traverse required for all intended determinations. The measurement window consists of that region of the total surface over which calibration measurements are made. One or more kinds of measurement standards may be provided on a single block. To ensure the best possible economic conditions, overall dimensions of measurement standards are not given.

## 5 Types, purposes and metrological characteristics of measurement standards

### 5.1 General

The calibration of the existing wide range of instruments in all modes of operation calls for more than one type of measurement standard. Each measurement standard may have a limited range of application according to its own characteristics and those of the instrument to be calibrated. The validity of the calibration of an instrument will be dependent on the correct association of these characteristics.

To cover the range of requirements, five types of measurement standards are described, each of which may have a number of variants (see Table 1).

**Table 1 — Types and names of measurement standards**

Type	Name
A	Depth measurement standard
B	Tip condition measurement standard
C	Spacing measurement standard
D	Roughness measurement standard
E	Profile coordinate measurement standard

### 5.2 Type A — Depth measurement standard

These measurement standards are for calibrating the vertical profile component of stylus instruments.

#### 5.2.1 Type A1 — Wide grooves with flat bottoms

These measurement standards have a wide calibrated groove with a flat bottom, a ridge with a flat top, or a number of such separated features of equal or increasing depth or height. Each feature is wide enough to be insensitive to the shape or condition of the stylus tip (see Figure 1).

#### 5.2.2 Type A2 — Wide grooves with rounded bottoms

These measurement standards are similar to type A1, except that the grooves have rounded bottoms of sufficient radius to be insensitive to the shape or condition of the stylus tip (see Figure 2).



### 5.3 Type B — Tip condition measurement standard

These measurement standards are primarily for calibrating the condition of the stylus tip.

#### 5.3.1 Type B1

These measurement standards have a narrow groove or a number of separated grooves proportioned to be increasingly sensitive to the dimensions of the stylus tip. The narrow grooves have rounded bottoms of sufficient radius to be sensitive to the shape or condition of the stylus tip.

#### 5.3.2 Type B2

These measurement standards have two groove patterns of nominally equal  $R_a$  values, one being sensitive and the other insensitive to the dimensions of the stylus tip (see Figures 3 and 4).

#### 5.3.3 Type B3

These measurement standards have a fine protruding edge. Uncoated razor blades, for example, have edge widths of approximately 0,1  $\mu\text{m}$  or less. The stylus condition may be assessed by traversing such a specimen and recording the surface profile.

### 5.4 Type C — Spacing measurement standard

These measurement standards are used primarily for calibrating vertical profile components. They may also be used for calibrating horizontal profile components if the spacing of the grooves is held within limits acceptable for this purpose. The purpose of the series of measurement standards is to enable the transmission characteristics to be checked for a number of spacings and amplitudes.

They have a grid of repetitive grooves of simple shape (either sinusoidal, triangular or arcuate).

An essential requirement of type C measurement standards is that standardized measurement standards of differing waveform are nevertheless compatible, in the sense that they will all lead to the same state of instrument calibration or verification, provided they are used correctly.

### 5.5 Type D — Roughness measurement standard

#### 5.5.1 General

These measurement standards are for overall calibration of instruments.

**NOTE** The variation over the area of a type D standard is typically higher than that of a type C standard. Therefore it is normally necessary to average a statistically determined number of appropriately positioned tracings to get the full benefit of the D standard.

#### 5.5.2 Type D1 — Unidirectional irregular profile

These measurement standards have irregular profiles (for example as obtained by grinding) in the direction of traverse, but they have the convenience of an approximately constant cross-section perpendicular to the direction of traverse.

The measurement standards simulate work pieces containing a wide range of crest spacings, but reduce the number of traverses needed to give a good average value. They provide, for reassurance, a final overall check on calibration.

**5.5.3 Type D2 — Circular irregular profile**

These circular measurement standards have irregular profiles in the radial direction, but they have the convenience of an approximately constant cross-section along their circumference.

**5.6 Type E — Profile coordinate measurement standard**

These measurement standards are intended for calibrating the profile co-ordinate system of the instrument.

**5.6.1 Type E1 — Precision sphere or hemisphere**

These measurement standards consist of a sphere or hemisphere.

**5.6.2 Type E2 — Precision prism**

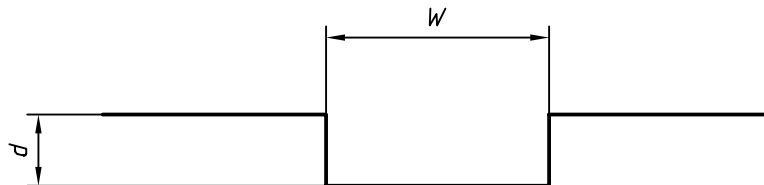
These measurement standards consist of a prism with a trapezium cross-section. The base of the trapezium is the longer of the parallel surfaces. The top surface and the two surfaces generated by the sides of the trapezium are the measuring surfaces. The angles of the two side measuring surfaces are designed so that the stylus tip is in contact with the surface throughout the measuring instrument's range.

**6 Measurement standard requirements**

**6.1 Type A — Depth measurement standard**

**6.1.1 Type A1 — Wide grooves with flat bottoms**

The wide grooves with flat bottoms on these measurement standards are characterized by their width  $W$  and their depth  $d$  (see Figure 1).

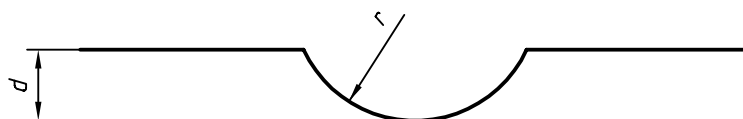


NOTE Wide ridges with flat tops are equivalent.

**Figure 1 — Type A1 groove**

**6.1.2 Type A2 — Wide grooves with rounded bottoms**

The wide grooves with rounded bottoms on these measurement standards are characterized by their radius  $r$  and their depth  $d$  (see Figure 2).



**Figure 2 — Type A2 groove**

### 6.1.3 Basis of assessment

The basis of assessment for types A1 and A2 is given in 7.1 and 7.2; requirements regarding statements of mean values are given in clause 8.

## 6.2 Type B — Tip condition measurement standard

### 6.2.1 Type B1

The narrow grooves with rounded bottoms on these measurement standards are characterized by their radius  $r$  and their depth  $d$ .

### 6.2.2 Type B2

These measurement standards have two or more groove patterns formed on a common base.

#### 6.2.2.1 Sensitive groove pattern (see Figure 3)

Isosceles triangular grooves with sharp peaks and valleys, with  $RSm$  and apex angle  $\alpha$  proportioned to make  $Ra$  dependent on the size of the stylus tip.

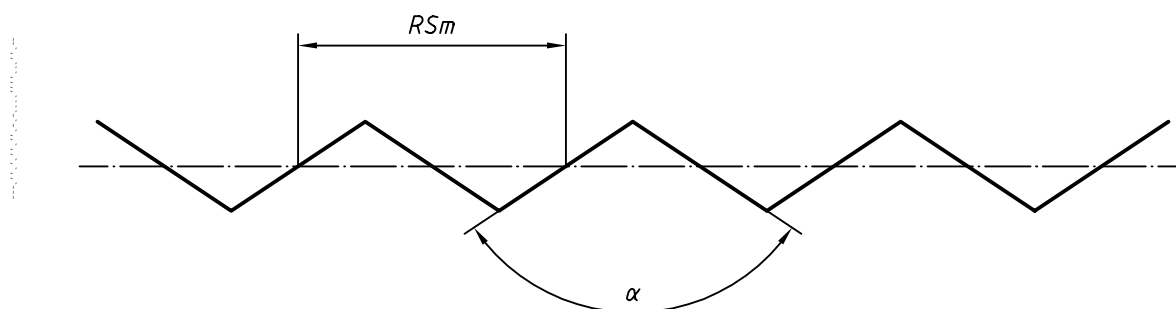


Figure 3 — Type B2 grooves (sensitive groove pattern)

#### 6.2.2.2 Insensitive groove pattern (see Figure 4)

Approximately sinusoidal or arcuate grooves, proportioned to make  $Ra$  substantially independent of the stylus tip.

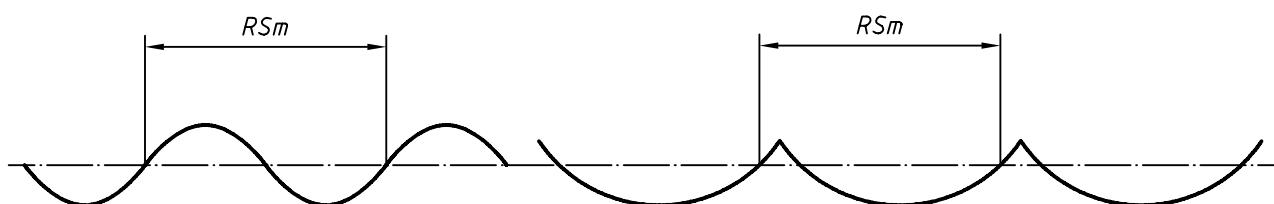


Figure 4 — Type B2 grooves (insensitive groove pattern)

#### 6.2.2.3 Basis of assessment

The basis of assessment for type B2 is given in 7.3.

### 6.2.3 Type B3

The radius and apex angle of the protruding edge are smaller than the radius and apex angle of the stylus to be assessed.

The basis of assessment for type B3 is given in 7.4.

### 6.3 Type C — Spacing measurement standard

#### 6.3.1 Type C1 — Grooves having a sine wave profile (see Figure 5)

These measurement standards are characterized by  $RSm$  and  $Ra$ . The values shall be chosen such that attenuation by the stylus or filter is negligible.

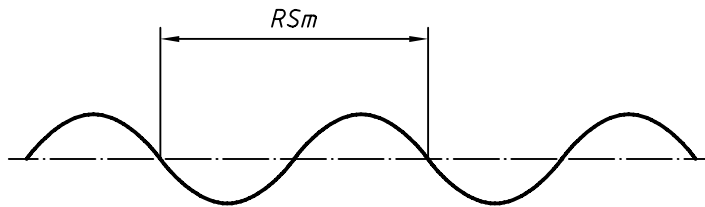


Figure 5 — Type C1 grooves

The basis of assessment for type C1 is given in 7.5.

#### 6.3.2 Type C2 — Grooves having an isosceles triangular profile (see Figure 6)

These measurement standards are characterized by  $RSm$  and  $Ra$ . The values shall be chosen such that attenuation by the stylus or filter is negligible.

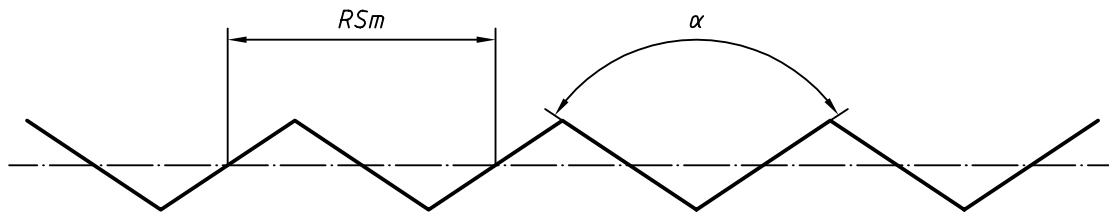


Figure 6 — Type C2 grooves

The basis of assessment for type C2 is given in 7.5.

#### 6.3.3 Type C3 - Simulated sine wave grooves (see Figure 7)

These measurement standards are characterized by  $RSm$  and  $Ra$ . These are simulated sine waves, which include triangular profiles with rounded or truncated peaks and valleys, the total root mean square (r.m.s.) harmonic content of which shall not exceed 10 % of the r.m.s. value of the fundamental.

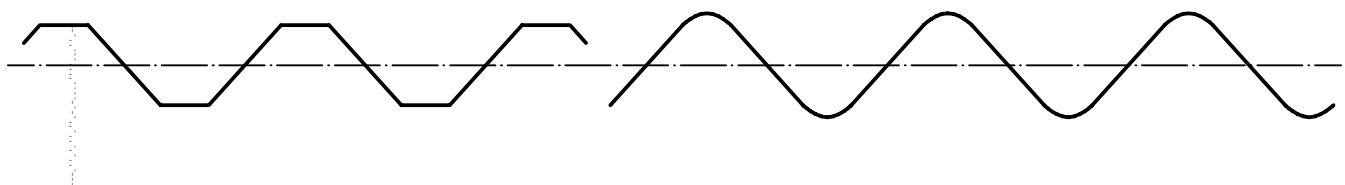


Figure 7 — Type C3 grooves

The basis of assessment for type C3 is given in 7.5.

### 6.3.4 Type C4 — Grooves having an arcuate profile (see Figure 8)

These measurement standards are characterized by  $PSm$  and  $Pa$ . The values shall be chosen such that attenuation by the stylus or filter is negligible.

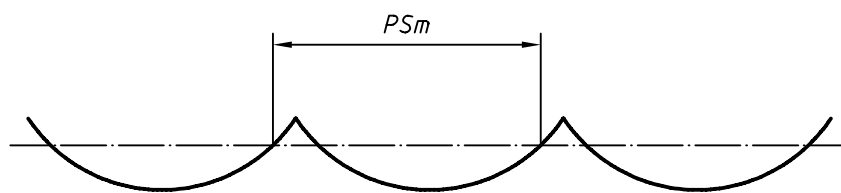


Figure 8 — Type C4 grooves

The basis of assessment for type C4 is given in 7.5.

## 6.4 Type D — Roughness measurement standard

### 6.4.1 Type D1 — Unidirectional irregular profiles (see Figure 9)

These measurement standards are characterized by  $Ra$  and  $Rz$ . These have irregular ground profiles which are repeated every  $5\lambda c$  in the longitudinal direction of the measurement standard. Normal to the measuring direction of the measurement standard, the profile shape is constant.

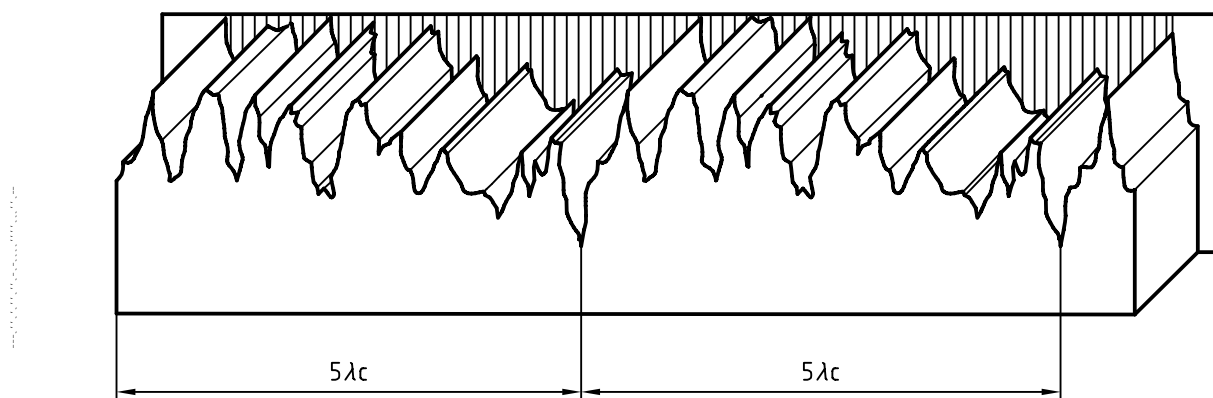
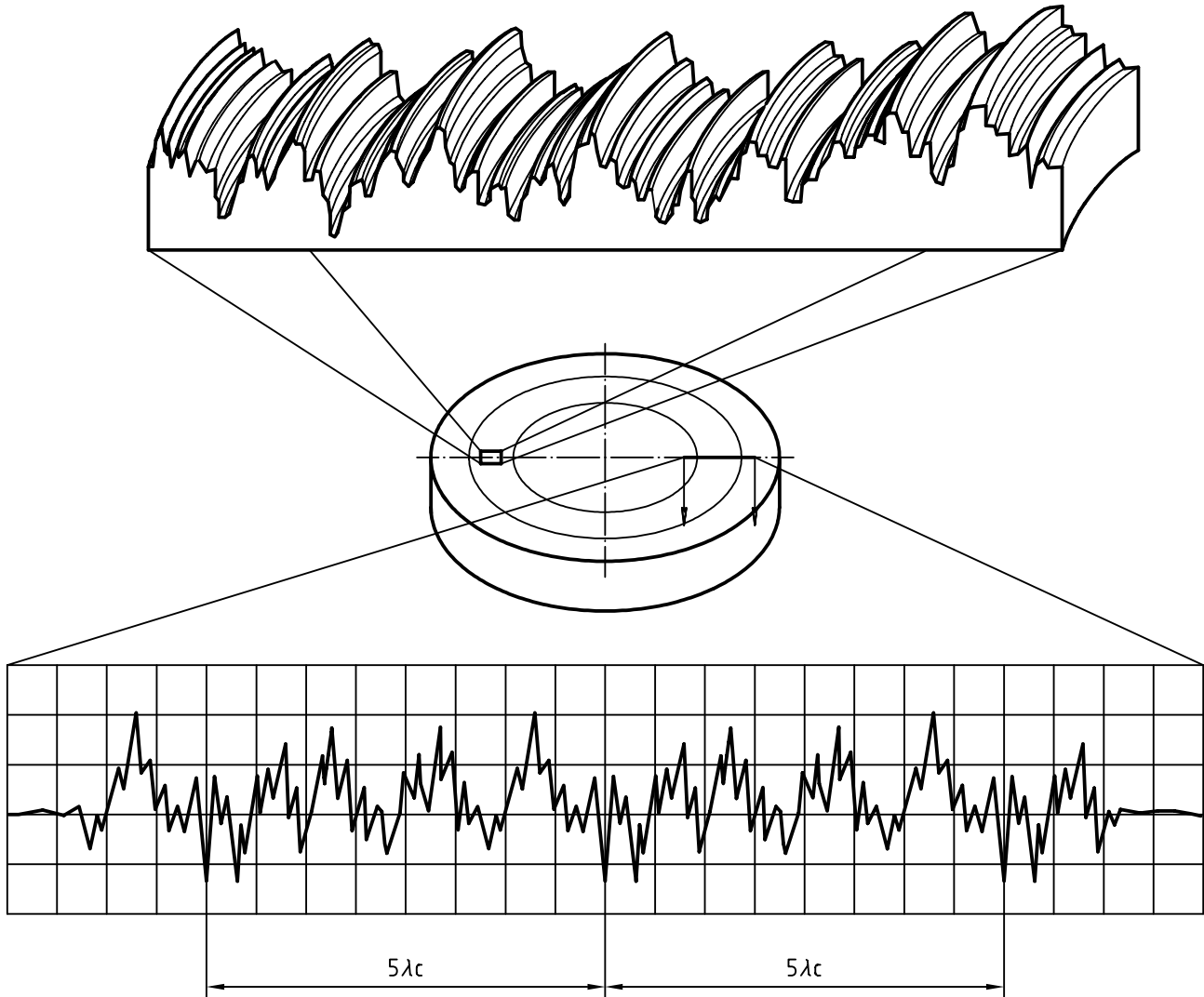


Figure 9 — Type D1 grooves (profile repetition at  $5\lambda c$  intervals)

The basis of assessment for type D1 is given in 7.5.

**6.4.2 Type D2 - Circular irregular profile** (see Figure 10)

These measurement standards are characterized by  $R_a$  and  $R_z$ . These have irregular profiles which are repeated every  $5\lambda_c$  in the radial direction of the measurement standard. Normal to the measuring direction of the measurement standard (in the circumferential direction), the profile shape is constant.



**Figure 10 — Type D2 grooves**

The basis of assessment for type D2 is given in 7.5.

**6.5 Type E — Profile coordinate measurement standard**

**6.5.1 Type E1 — Precision sphere or hemisphere**

These measurement standards are characterized by their radius and  $P_t$ .

**NOTE** The radius of the sphere (or hemisphere) should be sufficient to allow the spherical portion of the stylus tip to remain in contact (and not another part of the stylus) during a symmetrical traverse from either side of the highest point of the sphere (or hemisphere) through the full measuring range of the instrument within the traverse length.

## 6.5.2 Type E2 — Precision prism

These measurement standards are characterized by the angles between the surfaces and  $P_t$  on each surface.

NOTE The size and shape of the trapezium cross-section should be sufficient to allow the spherical portion of the stylus tip to remain in contact (and not another part of the stylus) through a symmetrical traverse over the prism through the full measuring range of the instrument within the traverse length of the instrument. The length of the top plane of the measurement standard should be sufficient to level in a stable manner (see Figure 11).

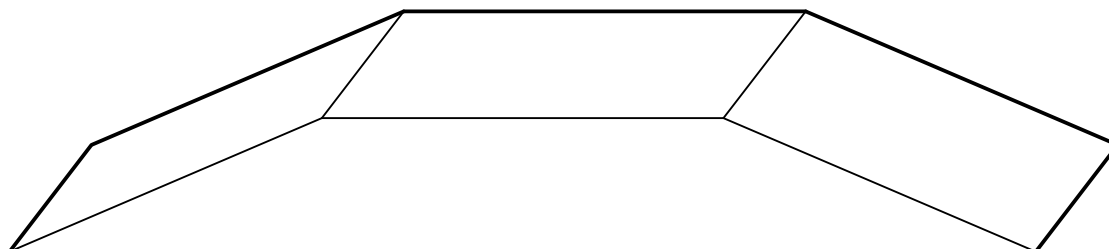


Figure 11 — Type E2 — Precision prism

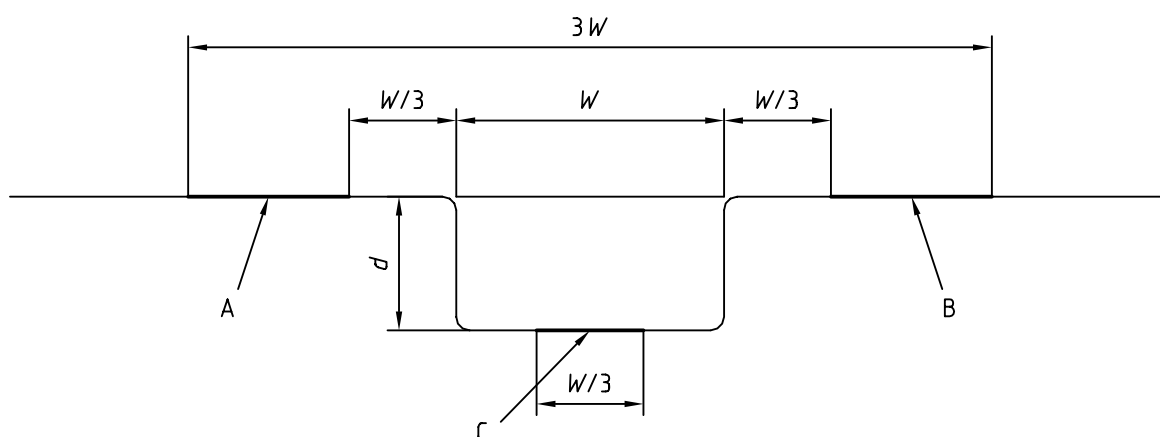
## 7 Definition of the measurands for the measurement standards

### 7.1 Type A1

The equation:

$$Z = \alpha \times X + \beta + h \times \delta$$

with unknowns  $\alpha$ ,  $\beta$  and  $h$ , is fitted by the method of least squares to a profile equal in length to three times the width of the groove (see Figure 12). The variable  $\delta$  takes the value +1 in regions A and B and the value -1 in region C (see Figure 12). The depth of the groove  $d$  is twice the estimated value of  $h$



NOTE Wide ridges with flat tops are equivalent.

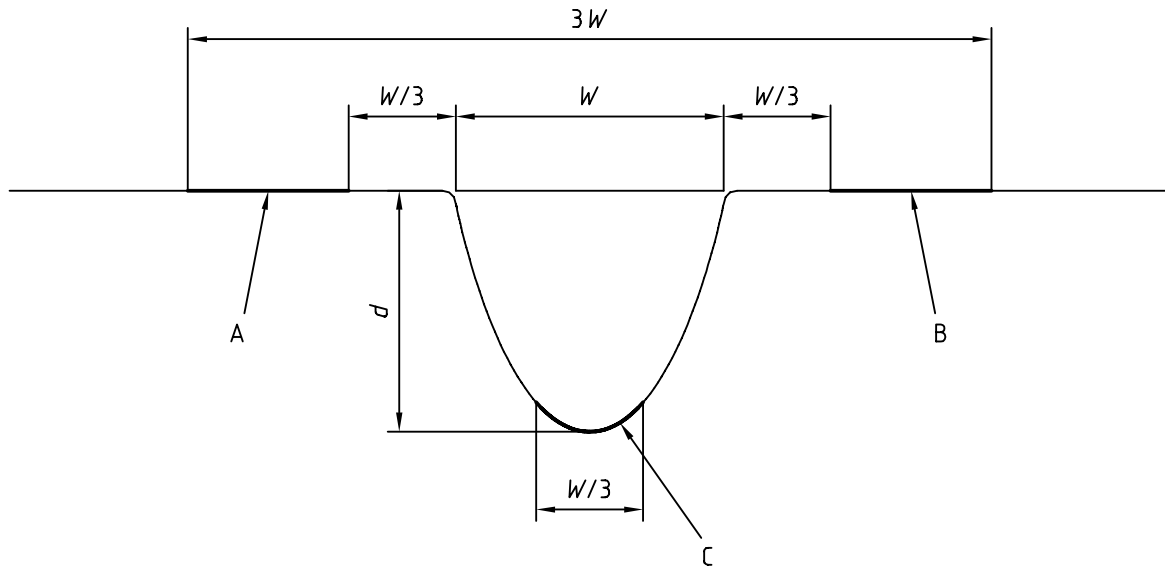
Figure 12 — Assessment of calibrated values for type A1

To avoid the influence of any rounding of the corners, the upper surface on each side of the groove shall be ignored for a length equal to one-third of the width of the groove. The surface at the bottom of the groove is assessed only over the central third of its width. The portions to be used for assessment purposes are those shown at A, B and C in Figure 12.

A significant number of traces, not less than five, shall be taken evenly distributed over the measuring window (avoiding defects).

**7.2 Type A2**

A least squares mean line representing the upper level is drawn over the groove. A least squares circle is fitted through the centre third of the width of the groove. The depth is assessed from the line to the lowest point of the fitted circle (see Figure 13).



**Figure 13 — Assessment of calibrated values for type A2**

The portions to be used for assessment purposes are those shown at A, B and C in Figure 13.

A significant number of traces, not less than five, shall be taken evenly distributed over the measuring window (avoiding defects).

**7.3 Type B2**

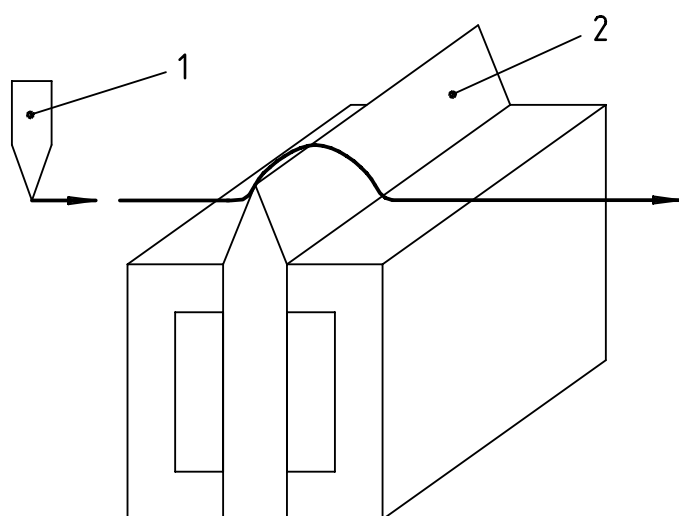
The ratio of the mean *Ra* of the sensitive grid and the mean *Ra* of the insensitive grid shall be calibrated using a substantially sharp tip (< 2 μm nominal radius) and a Gaussian filter having a λc cut-off according to the certificate and if not otherwise specified according to the rules given in ISO 4288.

A significant number of traces, not less than 18, shall be taken evenly distributed over the measuring window (avoiding defects), all instrument adjustments remaining constant throughout the determination.

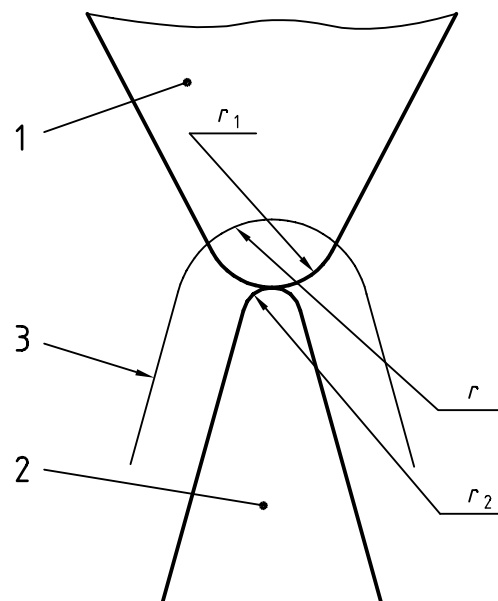
**7.4 Type B3**

The stylus condition may be measured by traversing a sharp protruding edge, such as a razor blade, as shown in Figure 14. If *r*<sub>1</sub> is the stylus tip radius and *r*<sub>2</sub> is the radius of the razor blade edge, the recorded profile has a radius *r* = *r*<sub>1</sub> + *r*<sub>2</sub>. If, in addition, *r*<sub>2</sub> is much less than *r*<sub>1</sub>, then the recorded radius is approximately equal to the stylus tip radius itself. This method can only be used with direct profile recording instruments with very slow traversing speed capability.





Schematic diagram of razor blade trace for profiling the shape of a stylus tip to determine its radius



The output profile essentially represents the stylus tip shape if the radius and apex angle of the razor blade are much finer

#### Key

- 1 Stylus
- 2 Razor blade
- 3 Recorded profile

**Figure 14 — Use of Type B3 measurement standard**

### 7.5 Types C1 to C4, and D

The profile shall be traced and parameters shall be calculated according to the appropriate ISO standards (ISO 3274, ISO 4287, ISO 4288 and ISO 12085).

A significant number of traces, not less than 12, shall be taken evenly distributed over the measuring window (avoiding defects).

The declared parameter values issued with each measurement standard refer to a smooth straight datum and filtered profiles derived from the trace according to ISO 3274. Although the wider grooves are generally insensitive to the dimensions of the stylus tip, sensitivity in this respect may become appreciable for the narrowest grooves, and for this reason the parameter values shall be declared with reference to the stylus tip.

### 7.6 Type E1

A profile shall be taken symmetrically about the crown and be as long as possible within the limits that the measuring range of the instrument and the probe geometry will allow.

The radius shall be determined, via a least squares mean arc fitted to the profile, together with  $P_t$ .

### 7.7 Type E2

A symmetrical profile parallel to the edges shall be taken which includes the top surface and the two side surfaces of the trapezium and be as long as possible within the limits that the measuring range of the instrument and the probe geometry will allow.

The angles between the top surface and the sides of the trapezium shall be determined, via least squares mean line fits of the respective surfaces, together with the out of flatness values for the three faces.

## 8 Measurement standard certificate

After each measurement standard has been individually calibrated, it shall be accompanied by at least the minimum required of information for measurement standards as defined in ISO 10012-1 and where applicable the following information:

- a) the effective radius of the stylus tip(s) to which each calibrated value applies;
- b) details of calibration, including the number of observations taken;
- c) for each relevant metrological characteristic the calibrated mean value with its estimated expanded uncertainty,  $U$  (according to GUM or ISO/TS 14253-2 or both);
- d) for each relevant metrological characteristic the standard deviation from the mean;
- e) any other reference conditions to which each calibration applies, for example the basis of digital evaluation (ordinate discretization, vertical quantization), and whether the values declared refer to direct measurement or are obtained therefrom.

As far as possible the required information specified above shall be marked on each measurement standard; but if there is insufficient space, the values may be stated separately and uniquely identified with the measurement standard, for example by means of a serial number.

NOTE 1 The nominal value is used only as an aid to identification. The difference between the nominal value and the conventional true value does not constitute an error.

NOTE 2 The conventional true value is the value to be used for calibrating an instrument. It is the measured mean value of the appointed number and distribution of traces taken across the measuring window of the measurement standard, corrected for any predetermined errors in the calibrating equipment, as far as these are known. Visible defects in the measuring window should be avoided. Some degree of uncertainty in the calibrated mean value is permitted to allow for the possibility of residual errors in the calibrating equipment which are unknown and for which correction cannot be made, but whose limits would be estimable.

## Annex A (informative)

### Relation to the GPS matrix model

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

#### A.1 Information about this part of ISO 5436 and its use

This part of ISO 5436 defines measurement standards for the calibration of contact (stylus) instruments for the measurement of surface texture by the profile method as defined in ISO 3274.

#### A.2 Position in the GPS matrix model

This part of ISO 5436 is a general GPS standard, which influences chain link 6 of the chain of standards on roughness, waviness and primary profile in the general GPS matrix, as illustrated in Figure A.1.

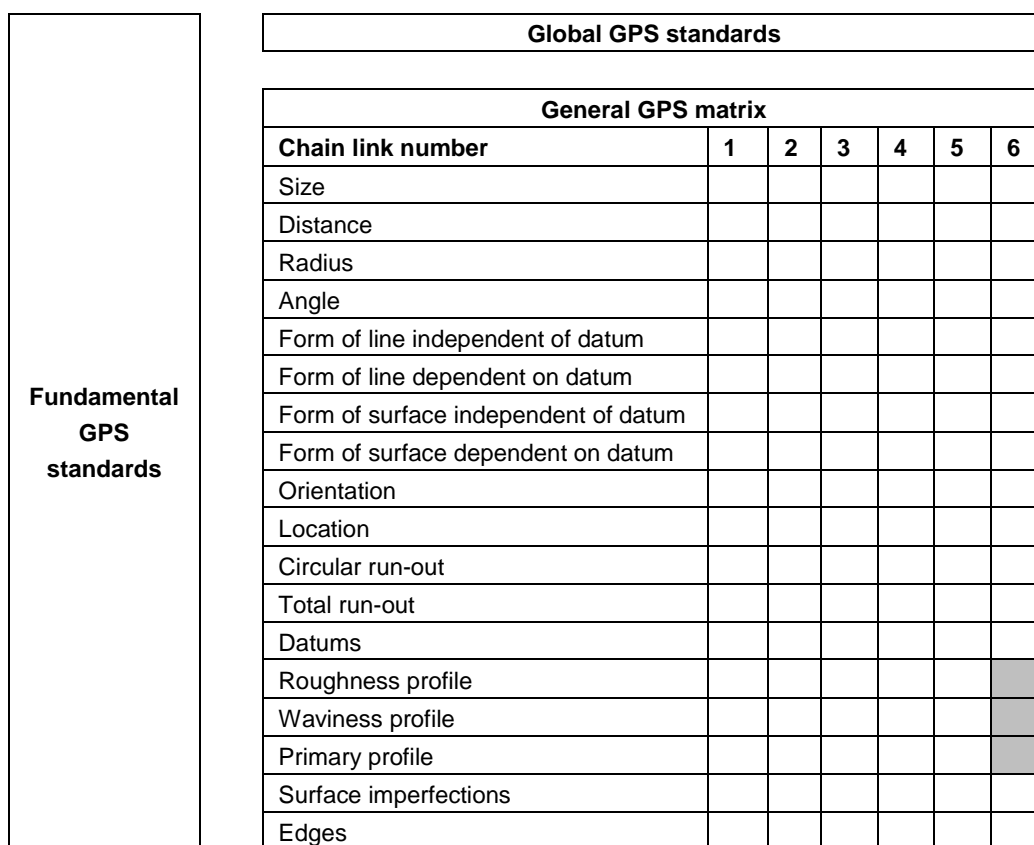


Figure A.1

#### A.3 Related standards

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

## Bibliography

- [1] ISO/TR 14638:1995, *Geometrical product specifications (GPS) — Masterplan*.



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