INTERNATIONAL STANDARD ISO 4288:1996
TECHNICAL CORRIGENDUM 1

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Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture

TECHNICAL CORRIGENDUM 1

Spécification géométrique des produits (GPS) — État de surface: Méthode du profil — Règles et procédures pour l'évaluation de l'état de surface

RECTIFICATIF TECHNIQUE 1

Technical Corrigendum 1 to International Standard ISO 4288:1996 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification.*

Page 1

Clause 2

Replace "ISO 4287:1996" with "ISO 4287:1997".

Page 5

Table 3

In the first column, change the unit of *RSm* from "μm" to "mm".

Page 7

Figure B.1

Replace "Data" with "Datums".

ICS 17.040.20 **Ref. No. ISO 4288:1996/Cor.1:1998(E)**

Descriptors: surface condition, roughness, roughness measurement, inspection.

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INTERNATIONAL STANDARD

ISO 4288

Second edition
1996-08-01

Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture

Spécification géométrique des produits (GPS) — État de surface: Méthode du profil — Règles et procédures pour l'évaluation de l'état de surface

Reference Number
ISO 4288:1996(E)

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Contents

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Annexes

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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.

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.

International Standard ISO 4288 was prepared jointly by Technical Committees ISO/TC 57, *Metrology and properties of surfaces*, Subcommittee SC 1, *Geometrical parameters — Instruments and procedures for measurement of surface roughness and waviness*, ISO/TC 3, *Limits and fits* and ISO/TC 10, *Technical drawings, product definition and related documentation*, Subcommittee SC 5, *Dimensioning and tolerancing*.

This second edition cancels and replaces the first edition (ISO 4288:1985) which has been technically revised.

It differs from the previous edition in that filter cut-off values are chosen based on the workpiece texture rather than the drawing indication. Furthermore, this International Standard includes rules for the determination of parameters other than Ra and Rz. This second edition covers roughness profile parameters, primary profile parameters and comparison of measured motif parameter values with given specification.

It is envisaged that an amendment will be prepared covering M-system waviness profile parameters, for which there are currently no standardized rules.

Annexes A, B and C of this International Standard are for information only.

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Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a general GSP standard (see ISO/TR 14638). It influences the chain links 3 and 4 of the chains of standards for roughness profile and primary profile.

For more detailed information of the relation of this International Standard to other standards and the GPS matrix model see annex B.

The discrimination between periodic and non-periodic profiles is subjective and left to the discretion of the user.

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Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture

1 Scope

This International Standard specifies the rules for comparison of the measured values with the tolerance limits for surface texture parameters defined in ISO 4287, ISO 12085, ISO 13565-2 and ISO 13565-3.

It also specifies the default rules for selection of cut-off wavelength, λc, for measuring roughness profile parameters according to ISO 4287 by using stylus instruments according to ISO 3274.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1302:1992, *Technical drawings — Method of indicating surface texture.*

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

ISO 4287:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and parameters of surface texture.*

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

ISO 13565-1:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method; surfaces having stratified functional properties — Part 1: Filtering and general measurement conditions.*

ISO 13565-2:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method; surfaces having stratified functional properties — Part 2: Height characterization using the linear material ratio curve.*

ISO 13565-3:— [1], *Geometrical Product Specifications (GPS) — Surface texture: Profile method; surfaces having stratified functional properties — Part 3: Height characterization using the material probability curve.*

ISO 14253-1: — [1], *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring instruments — Part 1: Decision rules for proving conformance or non-conformance with specifications.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 3274, ISO 4287, ISO 12085, ISO 13565-2 and ISO 13565-3 apply.

1) To be published.

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4 Parameter estimation

4.1 Parameters defined over the sampling length

4.1.1 Parameter estimate

An estimate of the parameter's value is calculated using the measured data from only one sampling length.

4.1.2. Average parameter estimate

An average parameter estimate is calculated by taking the arithmetic mean of the parameter estimates from all the individual sampling lengths.

When the standard number of five sampling lengths is used for roughness profile parameters, no suffix needs to be added to the symbol. For a parameter evaluated over a number of sampling lengths other than five, that number shall be added as a suffix to the parameter symbol (eg. *Rz*1, *Rz*3).

4.2 Parameters defined over the evaluation length

For parameters defined over the evaluation length (*Pt*, *Rt* and *Wt*), an estimate of a parameter's value is calculated by using measurement data from an evaluation length equal to the standardized number of sampling lengths.

4.3 Curves and related parameters

For curves and related parameters, an estimate of a parameter's value is calculated by using measurement data from one curve, which has been computed based on the evaluation length.

4.4 Default evaluation lengths

If not otherwise indicated on the drawing or in the technical product documentation, the evaluation length is as follows:

— *R*-parameters: the evaluation length is defined in clause 7;

— *P* parameters: the evaluation length is equal to the length of the feature being measured;

— motif-parameters: the evaluation length is defined in clause 5 of ISO 12085:1996;

— parameters defined in ISO 13565-2 and ISO 13565-3: the evaluation length is defined in clause 7 of ISO 13565-1:1996.

5 Rules for comparison of the measured values with the tolerance limits

5.1 Areas on the feature to be inspected

The surface texture of the workpiece under inspection can appear homogeneous or be quite different over various areas. This can be seen by visual examination of the surface. In cases where the surface texture appears homogeneous, parameter values determined over the entire surface shall be used for comparison with the requirements specified on the drawings or in the technical product documentation.

If there are separate areas with obviously different surface texture, the parameter values which are determined on each area shall be used separately for comparison with the requirements specified on the drawings or in the technical product documentation.

For requirements specified by the upper limit of the parameter, those separate areas of the surface shall be used which appear to have the maximum parameter value.

5.2 The 16 %-rule

For requirements specified by the upper limit (see ISO 1302:1992, 6.2.3) of a parameter, the surface is considered acceptable if not more than 16 % of all the measured values (see notes 1 and 2) of the selected parameter, based upon an evaluation length, exceed the value specified on the drawings or in the technical product documentation.

For requirements specified by the lower limit of the surface parameter, the surface is considered acceptable if not more than 16 % of all the measured values (see notes 1 and 2) of the selected parameter, based upon an evaluation length, are less than the value specified on the drawings or in the technical product documentation.

To designate the upper and the lower limits of the parameter, the symbol of the parameter shall be used without the "max." index.

NOTES

1 Annex A provides simplified practical guidance for comparing measured values with upper and lower limits.

2 In cases where the values of the roughness profile parameter of the surface being inspected follow a normal distribution, the determination of the upper limit as a limit which may be exceeded by 16 % of the measured values of the roughness profile parameter conforms with the limit determined by the value $\mu + \sigma$, where μ is the arithmetic mean value of the roughness profile parameter and σ is the standard deviation of the values. The greater the value of σ, the further from the specified limit (the upper value) the mean value of the roughness profile parameter needs to be. (See figure 1.)

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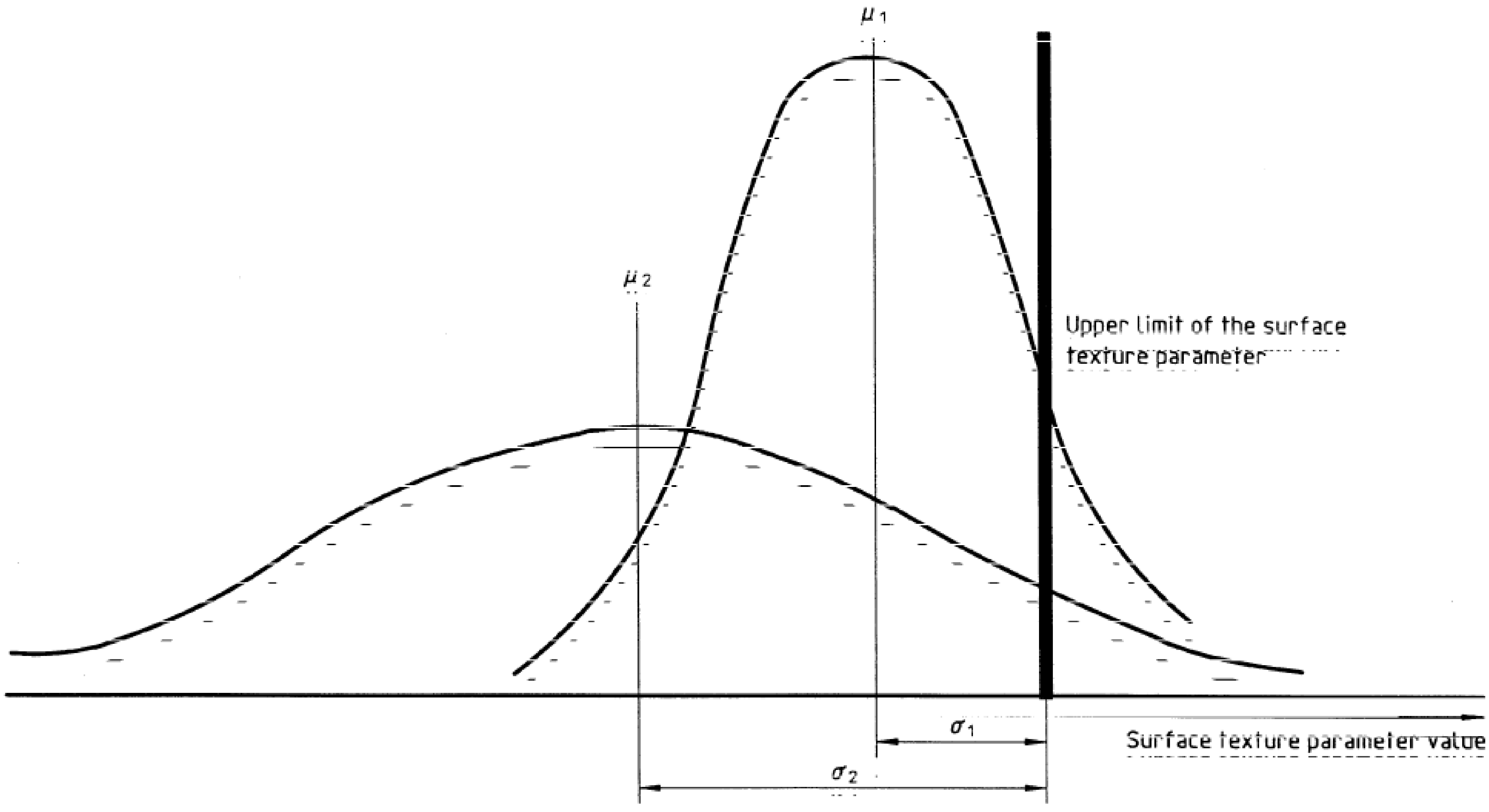

Figure 1

5.3 The max.-rule

For requirements specified by the maximum value (see ISO 1302:1992, 6.2.2) of the parameter during inspection, none of the measured values of the parameter over the entire surface under inspection shall exceed the value specified on the drawings or in the technical product documentation.

To designate the maximum permissible value of the parameter, the "max." index has to be added to the symbol of the parameter (for example $Rz1\text{max.}$).

5.4 Uncertainty of measurement

For proving conformance or non-conformance with specification, measured values of parameters shall be compared with the specified limiting values taking into account the uncertainty of measurement according to the rules given in ISO 14253-1. In case of comparing results of measurement with upper and lower limits, the uncertainty of measurement shall be estimated without taking into account the inhomogeneity in the surface which is already accounted for in the 16 % allowance.

6 Parameter evaluation

6.1 General

Surface texture parameters are not useful for the description of surface defects. Therefore, surface defects, e.g. scratches and pores, shall not be considered during inspection of surface texture.

To decide whether or not a workpiece surface is in accordance with specification, a set of single values of the surface texture parameter, each determined from an evaluation length, shall be used.

The reliability of the decision as to whether or not the surface being inspected meets the specification, and the precision of the mean value obtained for the surface texture parameter of the same surface, depend on the number of sampling lengths within the evaluation lengths with which the single value of the surface texture parameter is obtained and also on the number of evaluation lengths, i.e. the number of measurements along the surface.

6.2 Roughness profile parameters

For R-parameters according to ISO 4287, if the evaluation length does not equal five sampling lengths, their upper and lower limits shall be recalculated and related to an evaluation length equal to five sampling lengths. In figure 1 each σ shown is equal to the individual σ_5.

The relation of σ_n to σ_5 is given by the following equation:

$$\sigma_5 = \sigma_n \sqrt{n/5}$$

where n is the number (less than 5) of sampling lengths used.

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The greater the number of measurements and the longer the evaluation length, the greater is the reliability of the decision as to whether the surface being inspected meets the specification, and the lower is the uncertainty of the parameter mean value.

However, an increase in the number of measurements leads to an increase in both the time and the cost of measurement. Therefore, the inspection procedure shall necessarily reflect a compromise between reliability and cost. (See annex A).

7 Rules and procedures for inspection using stylus instruments

7.1 Basic rules for the determination of cut-off wavelength for the measurement of roughness profile parameters

When the sampling length is specified in the requirement on the drawing or in the technical product documentation, the cut-off wavelength, λc, shall be chosen equal to this sampling length. When no roughness specification exists (on a drawing or in technical product documentation) or the sampling length is not specified in a given roughness specification, the cut-off wavelength is chosen by procedures given in 7.2.

7.2 Measurement of roughness profile parameters

When the direction of measurement is not specified, the workpiece shall be positioned so that the direction of the section corresponds to the maximum values of height of the roughness parameters (*Ra*, *Rz*). This direction will be normal to the lay of the surface being measured. For isotropic surfaces, the direction of the section can be arbitrary.

Measurements shall be carried out on that part of the surface on which critical values can be expected; this can be assessed by visual examination. Separate measurements shall be distributed equally over this part of the surface to obtain independent measurement results.

To determine roughness profile parameter values, first view the surface and decide whether the roughness profile is periodic or non-periodic. Based on this determination, one of the procedures specified in 7.2.1 and 7.2.2 shall be followed unless otherwise indicated. If special measurement procedures are used, they shall be described in the specifications and in the measurement protocol.

7.2.1 Procedure for non-periodic roughness profile

For surfaces with a non-periodic roughness profile, the following procedure shall be followed.

a) Estimate the unknown roughness profile parameter *Ra*, *Rz*, *Rz*1max. or *RSm* by any means preferred, for example visual inspection, roughness comparison specimens, graphical analysis of a total profile trace, etc.

b) Estimate the sampling length from table 1, 2 or 3, using the *Ra*, *Rz*, *Rz*1max. or *RSm* estimated in step a).

c) With a measuring instrument, obtain a representative measurement of *Ra*, *Rz*, *Rz*1max. or *RSm*, using the sampling length estimated in step b).

d) Compare the measured value of *Ra*, *Rz*, *Rz*1max. or *RSm*, with the range of values of *Ra*, *Rz*, *Rz*1max. or *RSm* in table 1, 2 or 3 corresponding to the estimated sampling length. If the measured value is outside the range of values for the estimated sampling length, then adjust the instrument to the respective higher or lower sampling length setting indicated by the measured value. Then measure a representative value using this adjusted sampling length and compare again with the values in table 1, 2 or 3. At this point the combination suggested by table 1, 2 or 3 of the measured value and the sampling length should have been reached.

e) Obtain a representative value of *Ra*, *Rz*, *Rz*1max. or *RSm*, for one sampling length setting shorter if this shorter sampling length setting has not previously been evaluated in step d). Check to see if the resulting combination of *Ra*, *Rz*, *Rz*1max. or *RSm* and sampling length is also that specified by table 1, 2 or 3.

f) If only the final setting of step d) corresponds to table 1, 2 or 3, then both the sampling length setting and the *Ra*, *Rz*, *Rz*1max. or *RSm* value are correct. If step e) also produces a combination specified by table 1, 2 or 3, then this shorter sampling length setting and corresponding *Ra*, *Rz*, *Rz*1max. or *RSm* value are correct.

g) Obtain a representative measurement of the desired parameter(s) using the cut-off wavelength value (sampling length) estimated in the preceding steps.

7.2.2 Procedure for periodic roughness profile

For surfaces with a periodic roughness profile, the following procedure shall be used.

a) Estimate graphically the parameter *RSm* of the surface of unknown roughness.

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b) Determine the recommended cut-off wavelength value for the estimated parameter *RSm* using table 3.

c) If necessary e.g. in cases of disputes, measure the *RSm* value using the cut-off wavelength value determined according to b).

d) If the *RSm* value from step c) relates, according to table 3, to a smaller or greater cut-off wavelength value than in step b), use the smaller or greater cut-off wavelength value.

e) Obtain a representative measurement of the desired parameter(s) using the cut-off wavelength value (sampling length) estimated in the preceding steps.

Table 1 — Roughness sampling lengths for the measurement of *Ra*, *Rq*, *Rsk*, *Rku*, *RΔq* and curves and related parameters for non-periodic profiles (for example ground profiles)

Ra µm	**Roughness sampling length** *lr* mm	**Roughness evaluation length** *ln* mm
(0,006) < *Ra* ≤ 0,02	0,08	0,4
0,02 < *Ra* ≤ 0,1	0,25	1,25
0,1 < *Ra* ≤ 2	0,8	4
2 < *Ra* ≤ 10	2,5	12,5
10 < *Ra* ≤ 80	8	40

Table 2 — Roughness sampling lengths for the measurement of *Rz*, *Rv*, *Rp*, *Rc* and *Rt* of non-periodic profiles (for example ground profiles)

Rz[1)] *Rz*1max.[2)] µm	**Roughness sampling length** *lr* mm	**Roughness evaluation length** *ln* mm
(0,025) < *Rz*, *Rz*1max. ≤ 0,1	0,08	0,4
0,1 < *Rz*, *Rz*1max. ≤ 0,5	0,25	1,25
0,5 < *Rz*, *Rz*1max. ≤ 10	0,8	4
10 < *Rz*, *Rz*1max. ≤ 50	2,5	12,5
50 < *Rz*, *Rz*1max. ≤ 200	8	40

1) *Rz* is used when measuring *Rz*, *Rv*, *Rp*, *Rc* and *Rt*.

2) *Rz*1max. is used only when measuring *Rz*1max., *Rv*1max., *Rp*1max. and *Rc*1max.

Table 3 — Roughness sampling length for the measurement of *R*-parameters of periodic profiles, and *RSm* of periodic and non-periodic profiles

RSm µm	**Roughness sampling length** *lr* mm	**Roughness evaluation length** *ln* mm
0,013 < *RSm* ≤ 0,04	0,08	0,4
0,04 < *RSm* ≤ 0,13	0,25	1,25
0,13 < *RSm* ≤ 0,4	0,8	4
0,4 < *RSm* ≤ 1,3	2,5	12,5
1,3 < *RSm* ≤ 4	8	40

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Annex A
(informative)

Simplified procedure for roughness inspection

A.1 General

The following example illustrates one of a number of methods of roughness inspection.

It shall be recognized that this procedure is only an approximation to the full procedure defined in the main body of this International Standard.

A.2 Visual test

Visually inspect workpiece surfaces to select those where it is obvious that inspection by more precise methods is unnecessary, for example because the roughness is obviously better or obviously worse than that specified, or because a defect which substantially influences the function of the surface is present.

If the visual test does not allow a decision to be taken, tactile and visual comparisons with roughness comparison specimens may be carried out.

A.3 Measurement test

If the comparison test does not allow a decision to be taken, measurements should be carried out on that part of the surface on which critical values can be expected, according to visual examination.

A.3.1 Where the indicated parameter symbol does not contain the suffix "max" initially, the surface will be accepted and the test procedure stopped if

— the first measured value does not exceed 70 % of the specified value (indicated on the drawing);

— the first three measured values do not exceed the specified value;

— not more than one of the first six measured values exceeds the specified value;

— not more than two of the first twelve measured values exceed the specified value;

otherwise the workpiece is to be rejected.

Sometimes, for example before rejecting high-value workpieces, more than 12 measurements may be taken, for example 25 measurements with up to four exceeding the specified value.

A.3.2 Where the indicated parameter symbol does contain the suffix "max", usually at least three measurements are taken, either from that part of the surface from which the highest values are expected (for example where a particularly deep groove is visible), or equally spaced if the surface gives the impression of homogeneity.

A.3.3 The most reliable results of roughness inspection are achieved using measuring instruments. Therefore, the inspection of critical details should be performed using measuring instruments from the very beginning.

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Annex B
(informative)

Relation to the GPS matrix model

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

B.1 Information about the International Standard and its use

This International Standard gives rules for

— comparison of the measured values with the tolerance limits for surface texture parameters;

— default selection of λc for measuring roughness profile parameters using stylus instruments;

— roughness profile and primary profile parameters and comparison of measured motif parameter-values with given specifications.

In this International Standard,

— filter cut-off values are chosen based on the workpiece texture rather than the drawing indication;

— rules for the determination of parameters other than Ra and Rz are included.

B.2 Position in the GPS matrix model

This International Standard is a general GPS standard, which influences chain links 3 and 4 of the chain of standards on roughness profile and primary profile in the general GPS matrix, as graphically illustrated in figure B.1.

B.3 Related International Standards

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

Fundamental GPS Standards

Global 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						
Circuit run-out						
Total run-out						
Data						
Roughness profile						
Waviness profile						
Primary profile						
Surface defects						
Edges						

Figure B.1

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Annex C
(informative)

Bibliography

[1] ISO/TR 14638:1995, *Geometrical Product Specification (GPS) — Masterplan.*

[2] *VIM — International vocabulary of basic and general terms in metrology.* BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993.

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