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Geometrical Product Specifications (GPS) — Surface texture: Profile method; Surfaces having stratified functional properties —

Part 3:
Height characterization using the material probability curve

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Spécification géométrique des produits (GPS) — État de surface: Méthode du profil; surfaces ayant des propriétés fonctionnelles différentes suivant les niveaux —

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Partie 3: Caractérisation des hauteurs par la courbe de probabilité de matière

Reference numbe
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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 13565-3 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification.*

ISO 13565 consists of the following parts under the general title *Geometrical product specifications (GPS) — Surface texture: Profile method; Surfaces having stratified functional properties*:

— *Part 1: Filtering and general measurement conditions*

— *Part 2: Height characterization using the linear material ratio curve*

— *Part 3: Height characterization using the material probability curve*

Annex A forms an integral part of this part of ISO 13565. Annexes B to F are for information only.

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Introduction

This part of ISO 13565 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences the chain link 2 of the chains of standards on roughness profile and primary profile.

For more detailed information on the relation of this standard to the GPS matrix model see annex E.

This part of ISO 13565 provides a numerical characterization of surfaces consisting of two vertical random components, namely, a relatively coarse "valley" texture and a finer "plateau" texture. This type of surface is used for lubricated, sliding contact, for example in cylinder liners and fuel injectors. The calculations necessary to determine the parameters *Rpq*, *Rvq*, and *Rmq* (*Ppq*, *Pvq*, and *Pmq*) used to characterize these two components separately involves the generation of the material probability curve, the determination of its linear regions, and the linear regressions through these regions.

The parameters are undefined for surfaces not consisting of two such components.

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Geometrical Product Specifications (GPS) — Surface texture: Profile method; Surfaces having stratified functional properties —

Part 3:
Height characterization using the material probability curve

1 Scope

This part of ISO 13565 establishes the evaluation process for determining parameters from the linear regions of the material probability curve, which is the Gaussian representation of the material ratio curve. The parameters are intended to aid in assessing tribological behaviour, for example of lubricated, sliding surfaces, and to control the manufacturing process.

2 Normative references

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The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 13565. At the time of publication, the editions indicated were valid. All Standards are subject to revision, and parties to agreements based on this part of ISO 13565 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.

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

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

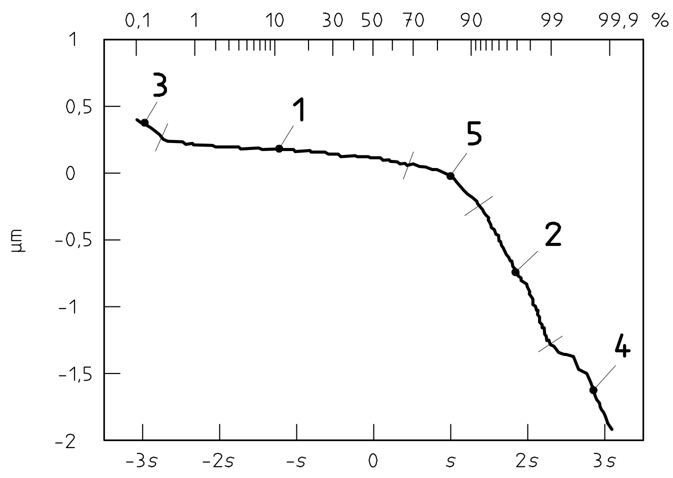
ISO 13565-2:1996, *Geometrical Product Specifications (GPS) — Surface Texture: Profile method; Surfaces having stratified functional properties — Part 2: Height characterization using the linear material ratio curve.*

3 Definitions

For the purposes of this part of ISO 13565, the definitions given in ISO 3274, ISO 4287, ISO 13565-2 and the following apply.

3.1
material probability curve
a representation of the material ratio curve in which the profile material length ratio is expressed as Gaussian probability in standard deviation values, plotted linearly on the horizontal axis

NOTE — This scale is expressed linearly in standard deviations according to the Gaussian distribution. In this scale the material ratio curve of a Gaussian distribution becomes a straight line. For stratified surfaces composed of two Gaussian distributions, the material probability curve will exhibit two linear regions (see 1 and 2 in figure 1).



Key

1 Plateau region
2 Valley region
3 Debris or outlying peaks in the data (profile)
4 Deep scratches or outlying valleys in the data (profile)
5 Unstable region (curvature) introduced at the plateau to valley transition point based on the combination of two distributions

Figure 1 — Material probability curve

3.2
Rpq (*Ppq*) **parameter**
slope of a linear regression performed through the plateau region

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See figure 2.

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NOTE — *Rpq* (*Ppq*) can thus be interpreted as the *Rq* (*Pq*)-value (in micrometres) of the random process that generated the plateau component of the profile.

3.3
Rvq (*Pvq*) **parameter**
slope of a linear regression performed through the valley region

See figure 2.

NOTE — *Rvq* (*Pvq*) can thus be interpreted as the *Rq* (*Pq*)-value (in micrometres) of the random process that generated the valley component of the profile.

3.4
Rmq (*Pmq*) **parameter**
relative material ratio at the plateau to valley intersection

See figure 2.

4 Procedure

The roughness profile used for determining the parameters *Rpq*, *Rvq* and *Rmq* shall be calculated in accordance with ISO 13565-1. This roughness profile is different from that in ISO 4287. The profile for determining the parameters *Ppq*, *Pvq* and *Pmq* shall be the primary profile.

Three non-linear effects can be present in the material probability curve as shown in figure 1 for measured surface data from a two-process surface. These effects shall be eliminated by limiting the fitted portions of the material probability curve, using only the statistically sound, Gaussian portions of the material probability curve excluding a number of influences.

In figure 1 the non-linear effects originate from:

— debris or outlying peaks in the data (profile) (labelled 3);

— deep scratches or outlying valleys in the data (profile) (labelled 4); and

— unstable region (curvature) introduced at the plateau to valley transition point based on the combination of two distributions (labelled 5).

These exclusions are intended keep the parameters more stable for repeated measurements of a given surface. Figure 2 shows a profile with its corresponding material probability curve and its plateau and valley regions and the parts of the surface that defines the two regions. The profile has a peak that is outlying and the figure shows how it does not influence the parameters. Figure 2 also shows how the bottom parts of the deepest groves, which will vary significantly depending on where the measurements are made on a surface, are disregarded when determining the parameters.

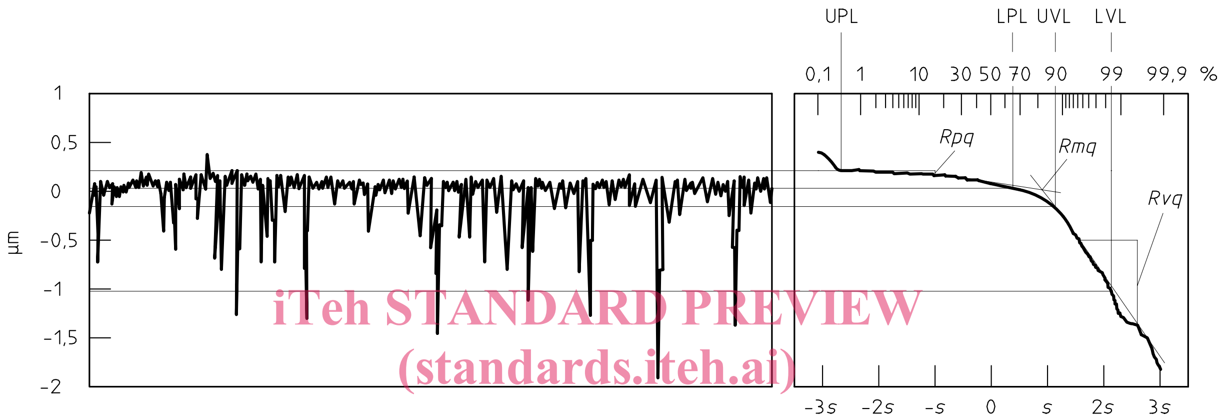

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Figure 2 — Roughness profile with its corresponding material probability curve and the regions used in the definitions of the parameters *Rpq*, *Rvq*, and *Rmq*

5 Measurement process requirements

6 Drawing indications

The parameters specified in this part of ISO 13565 shall be indicated on drawings in accordance with ISO 1302.

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Annex A
(normative)

Procedures for determining the limits of the linear regions

Clauses A.1 through A.3 specify the procedures for determining the upper plateau limit, UPL, and the lower valley limit, LVL. Clauses A.4 through A.6 specify the procedures for determining the lower plateau limit, LPL, and the upper valley limit, UVL . Clause A.7 specifies the procedure for determining the calculation of parameters.

A.1 Initial conic fit

A conic section is initially fitted through the material probability curve since it is a very good approximation of the expected form of the material probability curve of surfaces consisting of two vertical random components. This initial conic fit provides a framework for subsequent operations on the material probability curve.

Fit a conic section

$$z = Ax^2 + Bxz + Cz^2 + Dx + E$$

where

z is the profile height;

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x is the material probability expressed in standard deviations;

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through the entire curve (see figure A.1).

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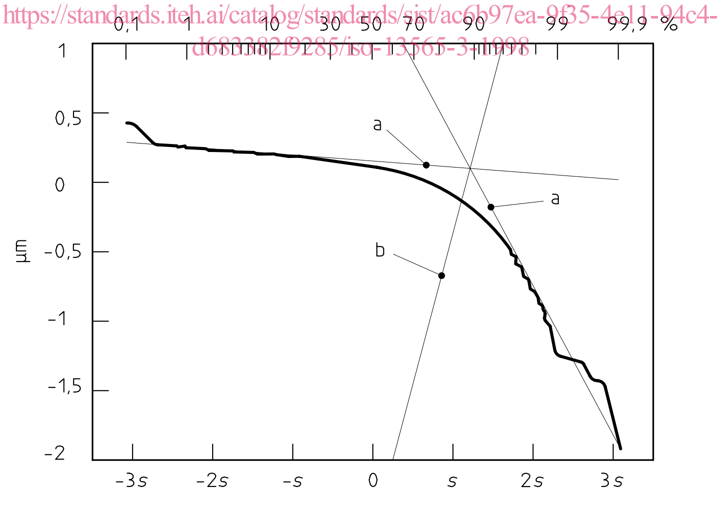

Figure A.1 — Conic section based on the entire material probability curve

A.2 Estimation of plateau to valley transition

Determine the asymptotes of the conic section (lines designated "a" in figure A.1). Bisect the asymptotes with a line (line designated "b" in figure A.1). The intersection of this line with the conic section serves as an initial estimate of the plateau to valley transition (see A in figure A.2).

A.3 Determination of UPL and LVL

The second derivative is computed at each point of the material probability curve starting at the transition point "c" and working upward through the plateau region and downward through the valley region.

The second derivative at each point is computed using a "window" of 0,05 standard deviations ($\pm$ 0,025 $\times$ s around the point at which the derivative is to be recorded). See B in figure A.2.

NOTE — The number of points within the window will vary as it is passed through the curve.

For the valley region and the plateau region individually:

— find 25 % of the number of points to one side of the point "c"; call this value i;

— working out from point "c", the standard deviation, s_i, is computed for the second derivative values using i points on one side;

— the value of the second derivative at the next point (D_{i+1}) is divided by the standard deviation, s_i:

$$T = \frac{D_{i+1}}{s_i}$$

— if $T \leqslant 6$, increment i by 1, recompute s_i and T;

— if $T > 6$, data point i is the limit of that region (UPL for the plateau region and LVL for the valley region, respectively). See also C in figure A.2.

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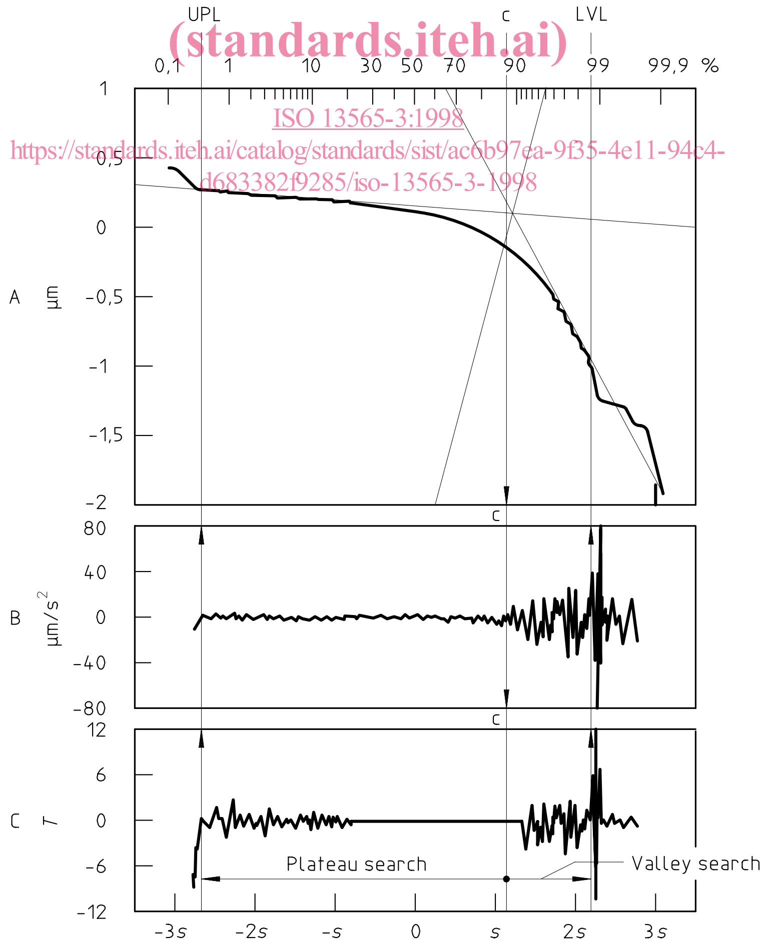


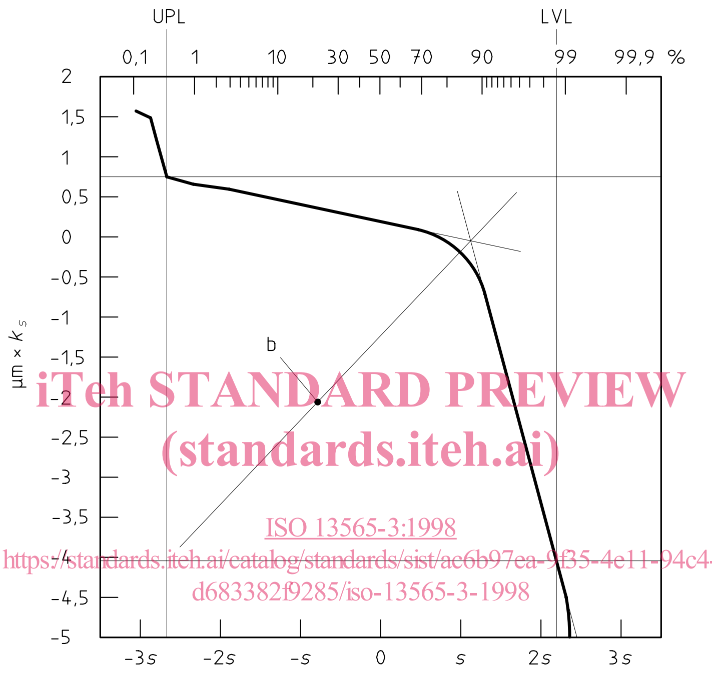
Figure A.2 — Bisection of the asymptotes is the initial transition point between the two regions of the material probability curve and the corresponding second derivatives

A.4 Normalization of the bounded region

The Z-axis of the material probability curve is normalized such that the bounded region (region between UPL and LVL) is "square" (see annex D). This insures consistent bisection of the conic section asymptotes (see figure A.3).

A.5 Second conic section fit

The conic section is now regressed through the region within UPL and LVL. The asymptotes are constructed (see figure A.3).



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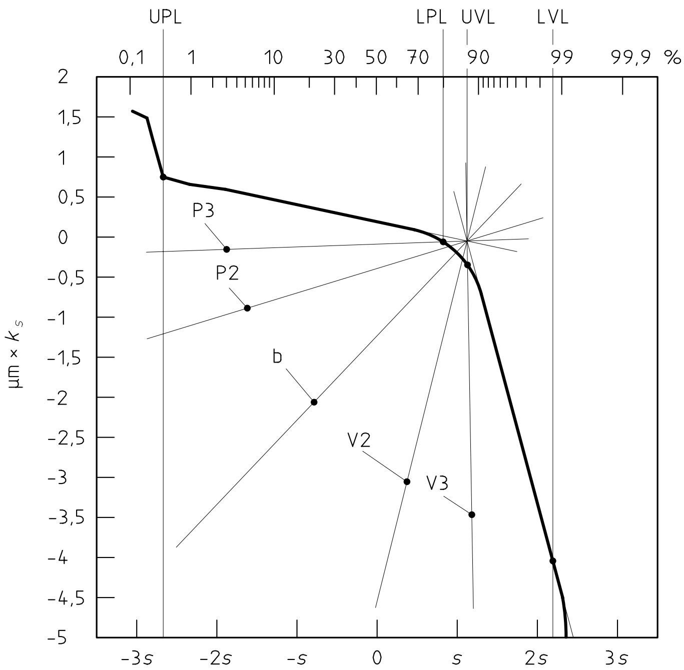
NOTE — For k_s, see annex D.

Figure A.3 — Conic section determined within the upper plateau limit, UPL, and the lower valley limit, LVL — Normalized material probability curve

A.6 Determination of LPL and UVL

To determine the lower plateau limit, LPL , and the upper valley limit, UVL , the asymptotes are bisected three times (b: first time; P2 and V2: second time; P3 and V3: third time). The intersection of these lines (P3 and V3) with the conic section of the material probability curve determines the LPL and UVL (see figure A.4).



NOTE — For k_s

Figure A.4 — Determination of the lower plateau limit, LPL, and the upper valley limit, UVL — Normalized material probability curve

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A.7 Calculation of parameters

A linear regression is then performed within each region of the original, non-normalized material probability curve (see figure A.5).

Rpq (*Ppq*) is the slope of a linear regression ($z = A_p s + B_p$) performed through the plateau region. *Rpq* (*Ppq*) can thus be interpreted as the *Rq*-value (in micrometres) of the random process that generated the plateau component of the profile.

Rvq (*Pvq*) is the slope of a linear regression ($z = A\ s + B_v$) performed through the valley region. *Rvq* (*Pvq*) can thus be interpreted as the *Rq*-value (in micrometres) of the random process that generated the valley component of the profile.

Rmq (*Pmq*) is the bearing ratio at the plateau to valley intersection. That is:

$$Rmq = \frac{B_v - B_p}{A_p - A_v}$$