INTERNATIONAL STANDARD

ISO 25178-2

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

Part 2: Terms, definitions and surface texture parameters

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

Partie 2: Termes, définitions et paramètres d'états de surface

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 290, *Dimensional and geometrical product specification and verification,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 25178-2:2012), which has been technically revised. The main changes to the previous edition are described in Annex E.

A list of all parts in the ISO 25178 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences the chain link B of the chains of standards on areal surface texture.

The ISO/GPS matrix model given in ISO 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to the specifications made in accordance with this document, unless otherwise indicated.

For more detailed information of the relation of this document to other standards and the GPS matrix model, see Annex I. An overview of standards on profiles and areal surface texture is given in Annex H.

This document develops the terminology, concepts and parameters for areal surface texture.

Throughout this document, parameters are written as abbreviations with lower-case suffixes (as in Sq or Vmp) when used in a sentence and are written as symbols with subscripts (as in S_q or V_{mp}) when used in formulae, to avoid misinterpretations of compound letters as an indication of multiplication between quantities in formulae. The parameters in lower case are used in product documentation, drawings and data sheets.

Parameters are calculated from coordinates defined in the specification coordinate system, or from derived quantities (e.g. gradient, curvature).

Parameters are defined for the continuous case, but in verification they are calculated on discrete surfaces such as the primary extracted surface.

A short history of the work done on areal surface texture can be found in Annex C.

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

Part 2:
Terms, definitions and surface texture parameters

1 Scope

This document specifies parameters for the determination of surface texture by areal methods.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 16610-1:2015, *Geometrical product specifications (GPS) — Filtration — Part 1: Overview and basic concepts*

ISO 17450-1:2011, *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16610-1:2015 and ISO 17450-1:2011 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General terms

3.1.1
skin model
<of a workpiece> model of the physical interface of the workpiece with its environment

[SOURCE: ISO 17450-1:2011, 3.2.2]

3.1.2
surface texture
<areal> geometrical irregularities contained in a *scale-limited surface* (3.1.9)

Note 1 to entry: Surface texture does not include those geometrical irregularities contributing to the form or shape of the surface.

3.1.3
mechanical surface
boundary of the erosion, by a sphere of radius *r*, of the locus of the centre of an ideal tactile sphere, also with radius *r*, rolled over the *skin model* (3.1.1) of a workpiece

[SOURCE: ISO 14406:2010, 3.1.1, modified — Notes to entry removed.]

3.1.3.1
electromagnetic surface
surface obtained by the electromagnetic interaction with the *skin model* (3.1.1) of a workpiece

[SOURCE: ISO 14406:2010, 3.1.2, modified — Notes to entry removed.]

3.1.3.2
auxiliary surface
surface, other than mechanical or electromagnetic, obtained by an interaction with the *skin model* (3.1.1) of a workpiece

Note 1 to entry: A mathematical surface (softgauge) is an example of an auxiliary surface.

Note 2 to entry: Other physical measurement principles, such as tunnelling microscopy or atomic force microscopy, can also serve as an auxiliary surface. See Figure 1 and Annex G.

3.1.4
specification coordinate system
system of coordinates in which surface texture parameters are specified

Note 1 to entry: If the nominal form of the surface is a plane (or portion of a plane), it is common (practice) to use a rectangular coordinate system in which the axes form a right-handed Cartesian set, the *x*-axis and the *y*-axis also lying on the nominal surface, and the *z*-axis being in an outward direction (from the material to the surrounding medium). This convention is adopted throughout the rest of this document.

3.1.5
primary surface
surface portion obtained when a surface portion is represented as a specified primary mathematical model with specified *nesting index* (3.1.6.4)

Note 1 to entry: In this document, an S-filter is used to derive the primary surface. See Figure 1.

[SOURCE: ISO 16610-1:2015, 3.3, modified — Note 1 to entry added.]

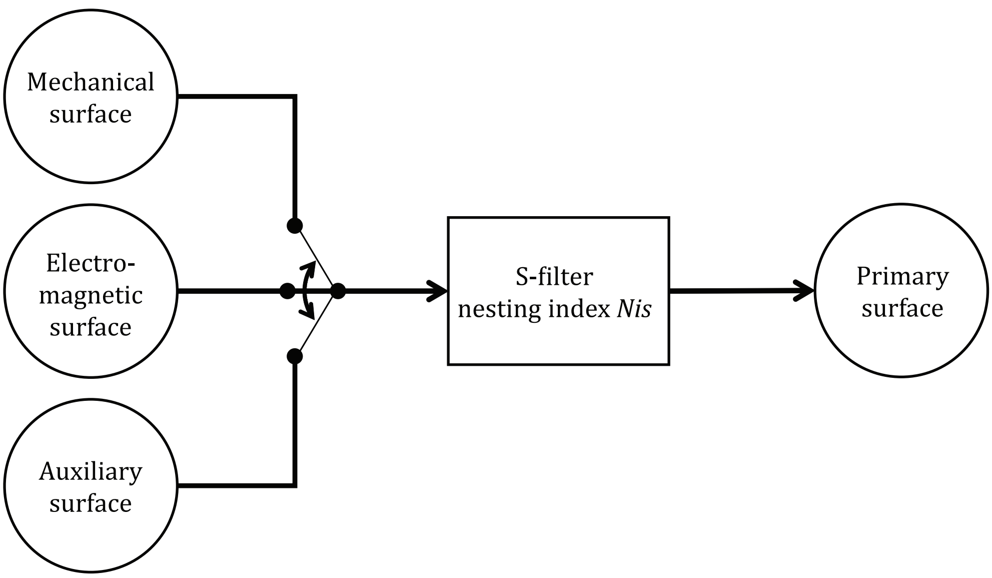


Figure 1 — Definition of primary surface

3.1.5.1
primary extracted surface
finite set of data points sampled from the *primary surface* (3.1.5)

[SOURCE: ISO 14406:2010, 3.7, modified — Notes to entry removed.]

3.1.6
surface filter
filtration operator applied to a surface

3.1.6.1
S-filter
surface filter (3.1.6) which removes small-scale lateral components from the surface, resulting in the *primary surface* (3.1.5)

3.1.6.2
L-filter
surface filter (3.1.6) which removes large-scale lateral components from the *primary surface* (3.1.5) or *S-F surface* (3.1.7)

Note 1 to entry: When the L-filter is not tolerant to form, it needs to be applied on an S-F surface; when it is tolerant to form, it can be applied either on the primary surface or on an S-F surface.

3.1.6.3
F-operation
operation which removes form from the *primary surface* (3.1.5)

Note 1 to entry: Some F-operations (such as association) have a very different action to that of filtration. Though their action can limit the larger lateral scales of a surface, this action is very fuzzy. It is represented in Figure 2 using the same convention as for a filter.

Note 2 to entry: Some L-filters are not tolerant to form and require an F-operation first as a prefilter before being applied.

Note 3 to entry: An F-operation can be a filtration operation such as a robust Gaussian filter.

3.1.6.4
nesting index
N_{is}, N_{ic}, N_{if}
number or set of numbers indicating the relative level of nesting for a particular primary mathematical model

[SOURCE: ISO 16610-1:2015, 3.2.1, modified — definition revised and notes to entry removed.]

3.1.7
S-F surface
surface derived from the *primary surface* (3.1.5) by removing the form using an *F-operation* (3.1.6.3)

Note 1 to entry: Figure 2 illustrates the relationship between the S-F surface and the S-filter and F-operation.

Note 2 to entry: If filtered with N_{is} nesting index to remove the shortest wavelengths from the surface, the surface is equivalent to a “primary surface”. In this case, N_{is} is the areal equivalent of the λs cut-off. See key reference 4 in Figure 2 and Annex G.

Note 3 to entry: If filtered with N_{ic} nesting index to separate longer from shorter wavelengths, the surface is equivalent to a “waviness surface”. In this case, N_{ic} is the areal equivalent of the λc cut-off. See key reference 5 in Figure 2 and Annex G.

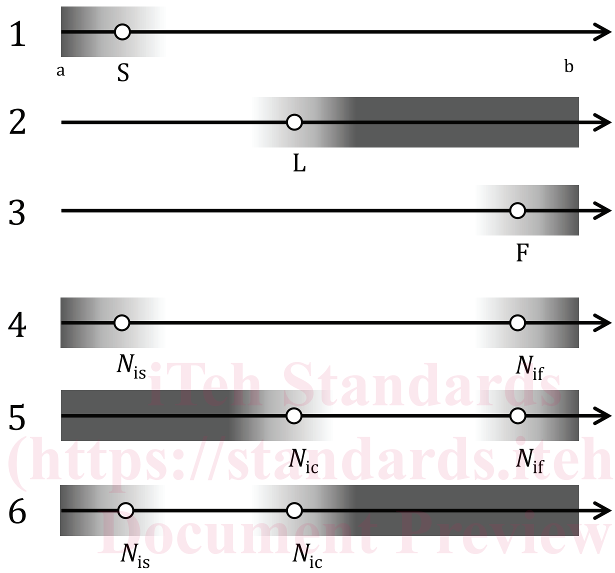
Note 4 to entry: The concepts of “roughness” or “waviness” are less important in areal surface texture than in profile surface texture. Some surfaces can exhibit roughness in one direction and waviness in the perpendicular direction. That is why the concepts of S-L surface and S-F surface are preferred in this document.

3.1.8
S-L surface
surface derived from the *S-F surface* (3.1.7) by removing the large-scale components using an *L-filter* (3.1.6.2)

Note 1 to entry: Figure 2 illustrates the relationship between the S-L surface and the S-filter and L-filter.

Note 2 to entry: If the S-filter nesting index N_{is} is chosen to remove the shortest wavelengths from the surface and the L-filter nesting index N_{ic} is chosen in order to separate longer from shorter wavelengths, the surface is equivalent to a “roughness surface”. See key reference 6 in Figure 2 and Annex G.

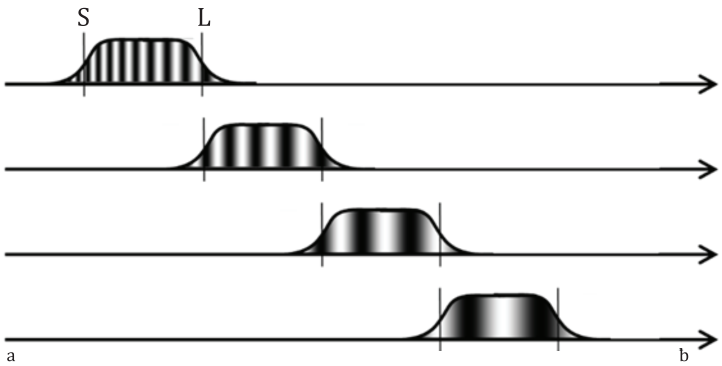
Note 3 to entry: A series of S-L surfaces can be generated with narrow bandwidth using an S-filter and an L-filter of close nesting indices (or equal), in order to achieve a multiscale exploration of the surface. See Figure 3.



Key

1 S-filter
2 L-filter
3 F-operation
4 S-F surface
5 S-F surface
6 S-L surface
A small scale
B large scale

Figure 2 — Relationships between the S-filter, L-filter, F-operation and S-F and S-L surfaces



Key

S S-filter

L L-filter

A small scale

B large scale

Figure 3 — Example of bandpass filters used to generate a bank of S-L surfaces

3.1.9
scale-limited surface
S-F surface (3.1.7) or *S-L surface* (3.1.8)

3.1.10
reference surface
<surface texture> surface associated to the *scale-limited surface* (3.1.9) according to a criterion

Note 1 to entry: This reference surface is used as the origin of heights for surface texture parameters.

EXAMPLE Plane, cylinder and sphere.

3.1.11
evaluation area
A
$\tilde{A}$
portion of the *scale-limited surface* (3.1.9) for specifying the area under evaluation

Note 1 to entry: See ISO 25178-3 for more information.

Note 2 to entry: Throughout this document, the symbol A is used for the numerical value of the evaluation area and the symbol $\tilde{A}$ for the domain (of integration or definition).

3.2 Geometrical parameter terms

3.2.1
field parameter
parameter defined from all the points on a *scale-limited surface* (3.1.9)

Note 1 to entry: Field parameters are defined in Clause 4.

3.2.2
feature parameter
parameter defined from a subset of predefined topographic features from the *scale-limited surface* (3.1.9)

Note 1 to entry: Feature parameters are defined in Clause 5.

3.2.3
V-parameter
material volume or void volume *field parameter* (3.2.1)

3.2.4
S-parameter
field parameter (3.2.1) or *feature parameter* (3.2.2) that is not a *V-parameter* (3.2.3)

3.2.5
height
ordinate value
$z(x,y)$
signed normal distance from the *reference surface* (3.1.10) to the *scale-limited surface* (3.1.9)

Note 1 to entry: Throughout this document, the term "height" is either used for a distance or for an absolute coordinate. For example, *Sz*, maximum height, is a distance and *Sp*, maximum peak height, is an absolute height.

3.2.5.1
depth
opposite value of *height* (3.2.5)

3.2.6
local gradient vector

$$\left(\frac{\partial z(x,y)}{\partial x},\frac{\partial z(x,y)}{\partial y}\right)$$

first derivative along x and y of the *scale-limited surface* (3.1.9) at position (x, y)

Note 1 to entry: See Annex D for implementation details.

3.2.7
local mean curvature
arithmetic mean of the principal curvatures at position (x, y)

Note 1 to entry: Principal curvatures are two numbers, k_1 and k_2, representing the maximum and minimum curvatures at a point. The local mean curvature is therefore $\frac{k_1+k_2}{2}$.

Note 2 to entry: See Annex D for implementation details.

3.2.8
material ratio
$M_r(c)$
ratio of the area A_c of the surface portion intersected by a plane at level *c*, to the *evaluation area* (3.1.11), A

Note 1 to entry: The curve representing material ratio as a function of the level is also called Abbott Firestone curve.

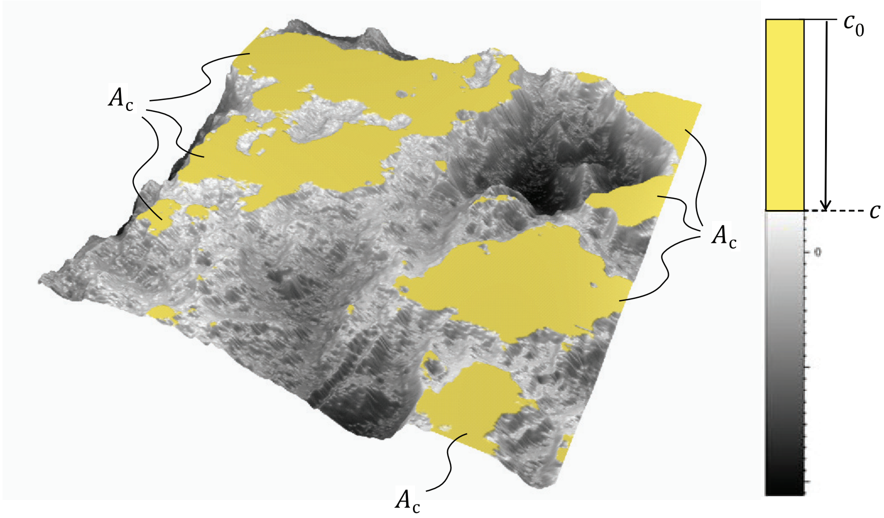
Note 2 to entry: The level *c* is usually defined as a height taken with respect to a reference c_0. By default, the reference is at the highest point of the surface. In the first edition of this document, the reference height was set to the *reference surface* (3.1.10).

Note 3 to entry: The material ratio may be given as a percentage or a value between 0 and 1.

Note 4 to entry: See Figure 4 and Formula (1).

Note 5 to entry: See Annex D for the determination of the material ratio curve.

$$M_r(c)=\frac{A_c(c)}{A}.100\ \% \qquad (1)$$



Key

c intersecting level

c_0 reference height

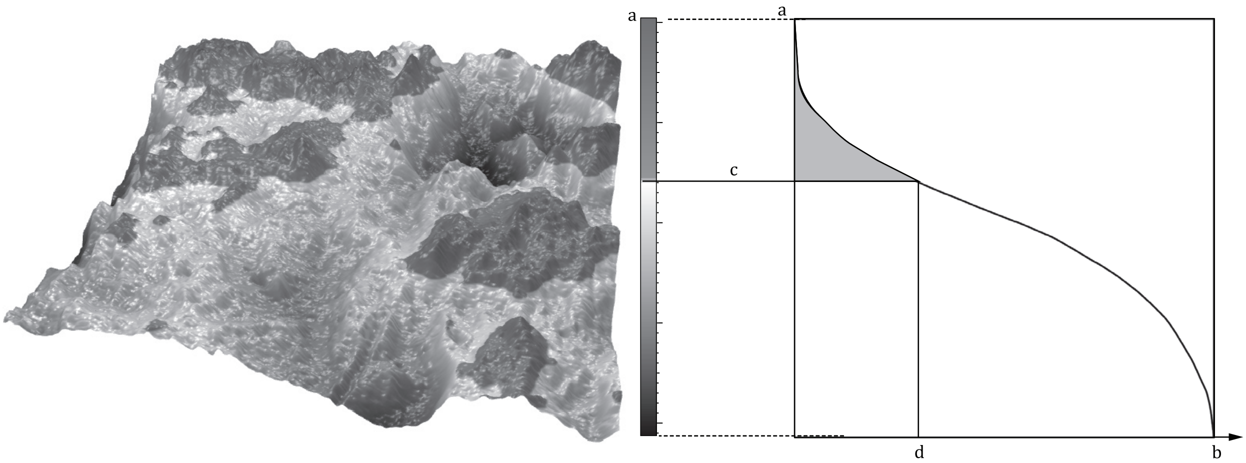
A_c areal portions intersected by plane at height c

Figure 4 — Area of the surface portion intersected by plane at level *c*

3.2.9
areal material ratio curve
material ratio function
function representing the areal *material ratio* (3.2.8) of the *scale-limited surface* (3.1.9) as a function of a level c

Note 1 to entry: This function can be interpreted as the cumulative probability function of the ordinates $z(x,y)$ within the evaluation area. See Annex D.

Note 2 to entry: See Figure 5.



Key

A height

B areal material ratio

C intersection level c

D material ratio at level c

Figure 5 — Material ratio curve

3.2.10
inverse material ratio

$C(p)$

intersecting level at which a given areal *material ratio* (3.2.8) p is satisfied

Note 1 to entry: See Formula (2).

$$C(p) = M_r^{-1}(p) \quad (2)$$

3.2.11
height density curve

height density function

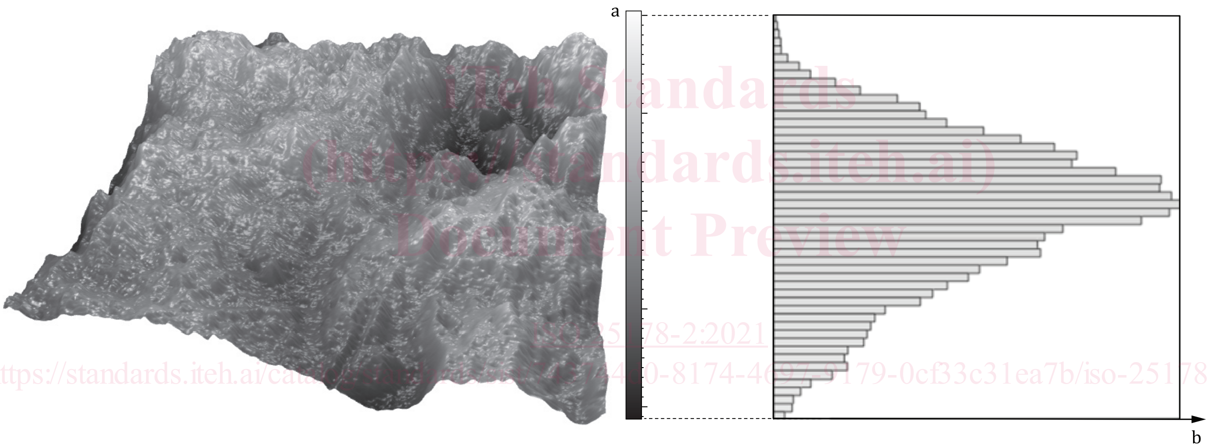
$h(c)$

curve representing the density of points laying at level c on the *scale-limited surface* (3.1.9)

Note 1 to entry: When represented as a histogram with bins, the percentage per bin depends on their width.

Note 2 to entry: See Figure 6 and Formula (3).

$$h(c) = -\frac{dM_r(c)}{dc} \quad (3)$$



Key

A height

B density

Figure 6 — Height density curve

3.2.12
core surface

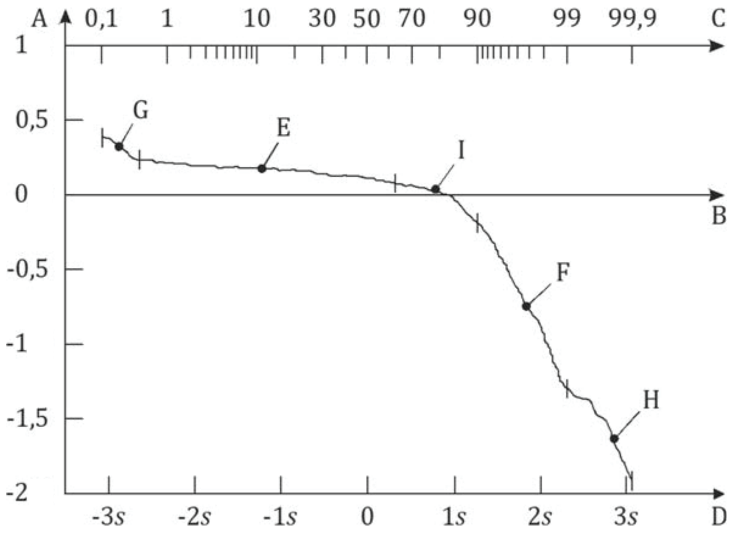
scale-limited surface (3.1.9) excluding core-protruding hills and dales

Note 1 to entry: The terms hills and dales in this definition refer to 3.3.1.2 and 3.3.2.2 but are defined by graphical construction. See Figure 14 and Annex B.3.

3.2.13
areal material probability curve

representation of the *areal material ratio curve* (3.2.9) in which the areal material area ratio is expressed as a Gaussian probability in standard deviation values, plotted linearly on the horizontal axis

Note 1 to entry: This scale is expressed linearly in standard deviations according to the Gaussian distribution. In this scale, the areal material ratio curve of a Gaussian distribution becomes a straight line. For stratified surfaces composed of two Gaussian distributions, the areal material probability curve will exhibit two linear regions (see E and F in Figure 7).



Key

A amplitude

B reference line

C material ratio expressed as a Gaussian probability in per cent

D material ratio expressed as a Gaussian probability in standard deviation

E plateau region

F dale region

G outlying hills (possibly including debris or dirt particles)

H outlying dales (possibly deep scratches)

I unstable region (curvature) introduced at the plateau-to-dale transition point based on the combination of two distributions horizontal axis *s* is the standard deviation

Figure 7 — Areal material probability curve

3.2.14
autocorrelation function
$f_{ACF}(t_x, t_y)$
function which describes the correlation between a surface and the same surface translated by (t_x, t_y)

Note 1 to entry: The autocorrelation used here is normalized between −1 and 1. The maximum value is always met but the minimum may not always be at −1, it depends on the surface (it may be −0,76).

Note 2 to entry: See Formula (4).

$$f_{\mathrm{ACF}}\left(t_{\mathrm{x}}, t_{\mathrm{y}}\right)=\frac{\frac{1}{B}\iint_{\tilde{B}} z(x,y)\,z\left(x+t_x, y+t_y\right)dxdy}{\frac{1}{A}\iint_{\tilde{A}} z^2(x,y)\,dxdy} \quad (4)$$

where $\tilde{B}$ is the intersecting area of the two surfaces at shifts t_x and t_y.

3.2.15
Fourier transformation
$F(p, q)$
operator which transforms *ordinate values* (3.2.5) of the *scale-limited surface* (3.1.9) into Fourier space

Note 1 to entry: The Fourier transformation defined here is using a limited support $\tilde{A}$, therefore it approximates the mathematical function called Fourier transformation which has an infinite support.

Note 2 to entry: See Formula (5).

