INTERNATIONAL STANDARD

ISO 25178-3

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

Part 3:

Specification operators

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

Partie 3: Opérateurs de spécification

Reference number
ISO 25178-3:2012(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 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 25178-3 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 70: Physical measurement standards*

— *Part 71: 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 604: Nominal characteristics of non-contact (coherence scanning interferometry) instruments*

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

The following parts are under preparation:

— *Part 1: Indication of surface texture*

— *Part 605: Nominal characteristics of non-contact (point autofocus probe) instruments*

— *Part 606: Nominal characteristics of non-contact (focus variation) instruments*

Introduction

This part of ISO 25178 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 3 of the chains of standards on areal surface texture.

The ISO/GPS Masterplan given in ISO/TR 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 specifications made in accordance with this document, unless otherwise indicated.

For more detailed information on the relation of this part of ISO 25178 to the GPS matrix model, see Annex E.

This part of ISO 25178 specifies the specification operators according to ISO 17450-2.

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

Part 3:

Specification operators

1 Scope

This part of ISO 25178 specifies the complete specification operator for surface texture (scale limited surfaces) by areal methods.

2 Normative references

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

ISO 14406:2010, *Geometrical Product Specifications (GPS) — Extraction*

ISO 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO/TS 16610-1:2006, *Geometrical Product Specifications (GPS) — Filtration — Part 1: Overview and basic concepts*

ISO 16610-21:2011, *Geometrical product specifications (GPS) — Filtration — Part 21: Linear profile filters: Gaussian filters*

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

ISO 17450-2:— [1], *Geometrical Product Specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators, uncertainties and ambiguities*

ISO 25178-2:2012, *Geometrical Product Specifications (GPS) — Surface texture: Areal — Part 2: Terms. definitions and surface texture parameters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given ISO 14660-1, ISO 16610-1, ISO/TS 14406, ISO 17450-1, ISO 17450-2 and ISO 25178-2 and the following apply.

3.1
lateral period limit
<optical> spatial period of a sinusoidal profile at which the optical response falls to 50 %

NOTE The lateral period limit depends on the heights of surface features and the optical method used to probe the surface.

1) To be published.

4 Complete specification operator

4.1 General

The complete specification operator (see ISO 17450-2) consists of all the operations required for an unambiguous specification. It consists of a full set of unambiguous specification operations in an unambiguous order. For areal surface texture, the complete specification operator defines the type of surface, method of extraction, association method and filtration for surface texture by areal methods.

If form error is to be included in the measurand, then a S-F surface shall be specified; otherwise, an S-L surface shall be specified.

4.2 Method of extraction

4.2.1 Evaluation area

4.2.1.1 General

The evaluation area consists of a rectangular portion of the surface over which an extraction is made.

The orientation of the evaluation area shall be controlled by the specification.

NOTE 1 If the nesting index is the same in orthogonal directions, then the orientation does not matter.

NOTE 2 The orientation of the evaluation area is typically influenced by the form; this means that the sides of the rectangular area are parallel/orthogonal to the nominal geometry (e.g. cylinder axis, sides of a rectangular flat, etc.).

4.2.1.2 S-F surface

For an S-F surface, if not otherwise specified, the evaluation area shall be a square.

If the F-operation is a filtration operation, then the length of the sides of the square evaluation area is the same length as the filter “nesting index”.

If the F-operation is an association operation, then the length of the side of the square evaluation area is used as a substitute for the F-operation nesting index value. This chosen value for the F-operation nesting index is used for all subsequent operations.

The value of the nesting index for the F-operation is normally chosen from the following series:

...; 0,1 mm; 0,2 mm; 0,25 mm; 0,5 mm; 0,8 mm; 1,0 mm; 2,0 mm; 2,5 mm; 5,0 mm; 8,0 mm; 10 mm; ...

NOTE 1 An example of an F-operation with a nesting index is a spline filter. The total least squares fit of the nominal form is an example of an F-operation without a predefined nesting index.

NOTE 2 The value of the F-operation nesting index is typically chosen to be five times the scale of the coarsest structure of interest.

4.2.1.3 S-L surface

For an S-L surface, if not otherwise specified, the evaluation area shall be a square whose sides are the same length as the L-filter nesting index value.

The value of the nesting index for the L-filter is normally chosen from the following series:

...., 0,1 mm; 0,2 mm; 0,25 mm; 0,5 mm; 0,8 mm; 1,0 mm; 2,0 mm;2,5 mm; 5,0 mm; 8,0 mm; 10 mm; ...

NOTE The value of the L-filter nesting index is typically five times the scale of the coarsest structure of interest.

4.2.2 Type of surface

The default surface is the mechanical surface (see ISO 14406) obtained with a radius chosen in accordance with the F-operation or L-filter and S-filter nesting index values given in Tables 1 and 2.

Table 1 — Relationships between the F-operation or L-filter and S-filter nesting index values and the bandwidth ratio

F-operation or L-filter nesting index value mm	S-filter nesting index value mm	Approximate bandwidth ratio between the F-operation or L-filter and S-filter nesting index values
…	…	…
0,1	0,001	100:1
	0,000 5	200:1
	0,000 2	500:1
	0,000 1	1 000:1
0,2	0,002	100:1
	0,001	200:1
	0,000 5	400:1
	0,000 2	1 000:1
0,25	0,002 5	100:1
	0,000 8	300:1
	0,000 25	1 000:1
0,5	0,005	100:1
	0,002	250:1
	0,001	500:1
	0,000 5	1 000:1
0,8	0,008	100:1
	0,002 5	300:1
	0,000 8	1 000:1
1	0,01	100:1
	0,005	200:1
	0,002	500:1
	0,001	1 000:1
2	0,02	100:1
	0,01	200:1
	0,005	400:1
	0,002	1 000:1
2,5	0,025	100:1
	0,008	300:1
	0,002 5	1 000:1
5	0,05	100:1
	0,02	250:1
	0,01	500:1
	0,005	1 000:1
8	0,08	100:1
	0,025	300:1
	0,008	1 000:1
…	…	…

4.2.3 S-filter

4.2.3.1 General

The default S-filter is an areal Gaussian filter. The value of the S-filter nesting index (cut-off) (see ISO/TS 16610-1) in the *x*-direction/*y*-direction is normally chosen from the following series:

...., 0,000 5 mm; 0,000 8 mm; 0,001 mm; 0,002 mm; 0,002 5 mm; 0,005 mm; 0,008 mm; 0,01 mm; ...

4.2.3.2 S-filter relationships for mechanical surfaces

For mechanical surfaces, the maximum values for the sampling distance and sphere radius are calculated from the value of the S-filter nesting index, as given in Table 2.

Table 2 — Relationships between S-filter nesting index value, sampling distance and sphere radius for mechanical surface

S-filter nesting index value mm	Maximum sampling distance mm	Maximum sphere radius mm
...	...	...
0,000 1	0,000 02	0,000 07
0,000 2	0,000 04	0,000 14
0,000 25	0,000 05	0,000 2
0,000 5	0,000 1	0,000 35
0,000 8	0,000 15	0,000 5
0,001	0,000 2	0,000 7
0,002	0,000 4	0,001 4
0,002 5	0,000 5	0,002
0,005	0,001	0,003 5
0,008	0,001 5	0,005
0,01	0,002	0,007
0,02	0,004	0,014
0,025	0,005	0,02
0,050	0,01	0,035
0,08	0,015	0,05
0,1	0,02	0,07
0,2	0,04	0,14
0,25	0,05	0,2
...	...	...

NOTE 1 Starting with the value of the S-filter nesting index, the maximum sampling distance is calculated as a 5:1 ratio; the maximum sphere ratio is calculated as an approximately 1,4:1 ratio with the S-filter nesting index value. These ratios are consistent with those contained in ISO 3274:1996.

NOTE 2 The maximum sampling distances in Table 2 are considered ideal and may not be attainable for a given surface and instrument type combination.

4.2.3.3 S-filter relationships for optical surfaces

For optical surfaces (electromagnetic surfaces), the maximum values for the sampling distance and lateral period limit are related to the value of the S-filter nesting index as given in Table 3.

Table 3 — Relationships between S-filter nesting index value, sampling distance and the lateral period limit for optical surface

S-filter nesting index value [a] mm	Maximum sampling distance mm	Maximum lateral period limit mm
…	…	…
0,000 1	0,000 03	0,000 1
0,000 2	0,000 06	0,000 2
0,000 25	0,000 08	0,000 25
0,000 5	0,000 15	0,000 5
0,000 8	0,000 25	0,000 8
0,001	0,000 3	0,001
0,002	0,000 6	0,002
0,002 5	0,000 8	0,002 5
0,005	0,001 5	0,005
0,008	0,002 5	0,008
0,01	0,003	0,01
0,02	0,006	0,02
0,025	0,008	0,025
0,05	0,015	0,05
0,08	0,025	0,08
0,1	0,03	0,1
0,2	0,06	0,2
0,25	0,08	0,25
…	…	…
[a] Alternatively, the optical method used to probe the surface may provide an inherent filter giving rise to the lateral period limit that approximates a Gaussian filter; in these cases, the lateral period limit may be used to define the short-wavelength nesting index instead of a digital S-filter.		

NOTE 1 Starting with the value of the S-filter nesting index, the maximum sampling distance is calculated as a 3:1 ratio; the maximum lateral period limit is calculated as an approximately 1:1 ratio with the S-filter nesting index value.

NOTE 2 The maximum sampling distances in Table 3 are considered ideal and may not be attainable for a given surface and instrument type combination.

4.3 Association method

When applying an F-operation that requires a method of association, the default method of association is total least squares.

4.4 Filtration

4.4.1 General

The filtration depends on the type of surface (S-L surface or S-F surface) specified.

For an S-L surface, both an L-filter and an F-operation are specified. For an S-F surface, only an F-operation is specified.

4.4.2 F-operation

The form shall be removed using a feature of the same class as the nominal form with the default association method.

NOTE 1 For features of size, the size is variable in the default association operation.

NOTE 2 For non-default form removal, a filtration method according to the ISO 16610 series can also be used. A filtration masterplan of all these filtration methods can be found in ISO/TS 16610-1.

4.4.3 L-filter

The default L-filter is an areal Gaussian filter (see ISO 16610-21). The nesting index in the x-direction/y-direction is a mandatory part of the specification of the S-L surface.

4.5 Definition area

4.5.1 S-L surface

The default definition area for the S-L surface is a square with the same size as the evaluation area.

4.5.2 S-F surface

The default definition area for the S-F surface is a square with the same size as the evaluation area.

5 General information

A decision tree for the complete specification operator is given in Annex A. If not otherwise specified, the *default attribute values* for the parameters defined in ISO 25178-2 that shall be applied are given in Annex B. If not otherwise specified, the *default units* for parameters defined in ISO 25178-2 that shall be used are given in Annex C. The compatibility with surface texture profile parameters is given in Annex D. The relation to the GPS matrix model is given in Annex E.

Annex A
(informative)

Decision tree for complete specification operator

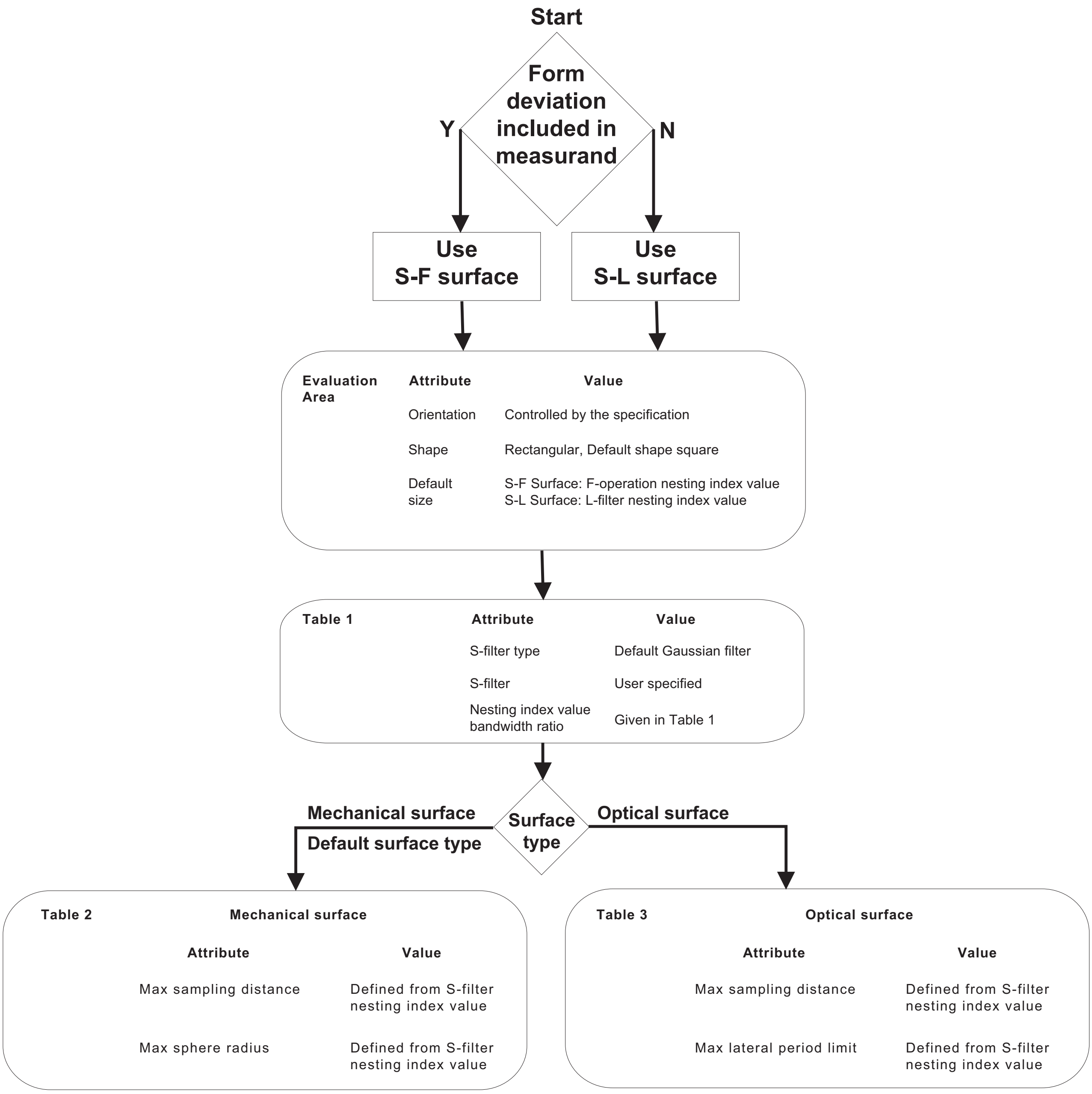

Figure A.1 — Decision tree for a complete specification operator

NOTE The order in which the attribute values for the GPS operations are determined does not reflect the order in which the GPS operations are implemented.

Annex B
(normative)

Default attribute values for parameters from ISO 25178-2

B.1 Field parameters

B.1.1 Spatial parameters

Paragraph in ISO 25178-2: 2012	Parameter (abbreviated term)	Attribute	Default value
4.2.1	Sal	fastest decay to a specified value s, with $0 \leq s < 1$	s is 0,2
4.2.2	Str	fastest and slowest decays to s, with $0 \leq s < 1$	s is 0,2

B.1.2 Functions and related parameters

Paragraph in ISO 25178-2: 2012	Parameter (abbreviated term)	Attribute	Default value
4.4.5.1	Vvv	material ratio p	p is 80 %
4.4.5.2	Vvc	material ratios p and q	p is 10 % q is 80 %
4.4.6.1	Vmp	material ratio p	p is 10 %
4.4.6.2	Vmc	material ratios p and q	p is 10 % q is 80 %
4.4.7	Sxp	material ratios p and q	p is 2,5 % q is 50 %
4.4.9.8	SRC	Threshold, T_h	T_h is 10 %

B.2 Named feature parameters

Paragraph in ISO 25178-2: 2012	Parameter (abbreviated term)	Attribute	Default value
6.8.1	Spd	Wolfprune nesting index X %	X % is 5 %
6.8.2	Spc	Wolfprune nesting index X %	X % is 5 %
6.8.3.1	S5p	Wolfprune nesting index X %	X % is 5 %
6.8.3.2	S5v	Wolfprune nesting index X %	X % is 5 %
6.8.4	Sda(c)	Wolfprune nesting index X %	X % is 5 % The significant feature is *Closed*.
6.8.5	Sha(c)	Wolfprune nesting index X %	X % is 5 % The significant feature is *Closed*.
6.8.6	Sdv(c)	Wolfprune nesting index X %	X % is 5 % The significant feature is *Closed*.
6.8.7	Shv(c)	Wolfprune nesting index X %	X % is 5 % The significant feature is *Closed*.

Annex C
(normative)

Default units for parameters from ISO 25178-2

C.1 Field parameters

C.1.1 Height parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
4.1.1	Sq	µm
4.1.2	Ssk	1
4.1.3	Sku	1
4.1.4	Sp	µm
4.1.5	Sv	µm
4.1.6	Sz	µm
4.1.7	Sa	µm

C.1.2 Spatial parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
4.2.1	Sal	µm
4.2.2	Str	1
4.5.1	*S*td	degrees

C.1.3 Hybrid parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
4.3.1	Sdq	radians
4.3.2	Sdr	%

C.1.4 Functions and related parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
4.4.2	Smr(c)	%
4.4.3	Sdc(mr)	µm
4.4.4	Sk, Spk, Svk	µm
4.4.4	Smr1, Smr2	%
4.4.4	Svq, Spq, Smq	µm
4.4.7	Sxp	µm

C.1.5 Void and material volume parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units[a]
4.4.5	Vv(p)	ml m^{-2}
4.4.5.1	Vvv	ml m^{-2}
4.4.5.2	Vvc	ml m^{-2}
4.4.6	Vm(p)	ml m^{-2}
4.4.6.1	Vmp	ml m^{-2}
4.4.6.2	Vmc	ml m^{-2}

[a] The unit ml m^{-2} is used because oil is usually specified in litres and the amount of oil per square metre for typical applications is of the order of one millilitre.

C.1.6 Other parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
4.4.9.4	Svfc	1
4.4.9.5	Safc	1

C.2 Feature parameters

Paragraph in ISO 25178-2:2012	Parameter (abbreviated term)	Default units
6.8.1	Spd	mm^{-2}
6.8.2	Spc	mm^{-2}
6.8.3	S10z	µm
6.8.3.1	S5p	µm
6.8.3.2	S5v	µm
6.8.4	Sda(c)	$µm^{2}$
6.8.5	Sha(c)	$µm^{2}$
6.8.6	Sdv(c)	$µm^{3}$
6.8.7	Shv(c)	$µm^{3}$

Annex D
(informative)

Relationship with surface texture profile parameters

D.1 General

Surface texture has traditionally been defined from profiles. This reflects the limitations in technology, with only profile measuring instruments being initially available[2)]. Technology has progressed and areal instruments are now widely available. This has resulted in a paradigm shift from profile to areal[3)] and has led to the development of this areal-surface-texture chain of standards.

With the long history and usage of profile parameters, knowledge has been built up and familiarity with profile methods has developed; inevitably, with the introduction of areal parameters, a comparison between surface texture profile and areal parameter values has resulted. This annex presents advice and guidelines on these relationships and on the differences between profile-surface-texture and areal-surface-texture parameters and their values.

D.2 Filtration

The biggest difference between profile and areal methods is in the filtration used. A profile extracted from an S-L surface or an S-F surface is not mathematically the same as a profile measured according to the surface texture profile chain of standards. The latter uses a profile filter (filtration in the traverse direction only, which is orthogonal to the lay) and the former an areal filter (filtration in both the x- and y-directions which may or may not be related to the lay direction), which can produce very different results even with the 'same' filter type and cut-off/nesting index.

In practice, some surfaces can be very similar with profile filters and areal filters, but caution is advised. The user has to have a real understanding of the difference and similarities between the effects from profile filters and areal filters on the particular surface under investigation. Which features are affected by the difference, and at what scales? Do they matter for the particular comparison?

To minimize the differences, it is recommended that

— the orientation of the rectangular portion of the surface, over which the measurement is made, be aligned with the lay of the surface,

— a Gaussian filter be used with a recommended cut-off value given by the default values in the surface texture profile chain of standards, i.e. from the series

...; 0,08 mm; 0,25 mm; 0,8 mm; 2,5 mm; 8,0 mm; ...,

— other default values, where appropriate, given in the surface texture profile chain of standards be used, i.e. the default stylus tip radius, sampling spacing, etc.,

— the length of the "traverse" direction of the rectangular portion of the surface be five times the cut-off length.

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2) See Reference [5] in the Bibliography.

3) See References [6] and [7] in the Bibliography.

D.3 Other considerations

Only those areal parameters that have a direct profile equivalent can be compared. For example, the root mean square height (Sq) can be compared with the roughness parameter (Rq), but the texture aspect ratio (Str) has no profile equivalent and so cannot be compared to any profile parameter.

Surface texture parameters that characterize the extrema of the surface [i.e. maximum peak height (Sp), maximum pit height (Sv), maximum height (Sz), etc.] tend to have larger measured values with areal parameters than with equivalent profile parameters, since the “peaks” and “valleys” shown on a profile nearly always go over the flanks of a peak/valley and not the true extrema.

It is not recommended to use the measured values from an equivalent areal parameter to compare with profile tolerance specifications. Generally, the measured values from equivalent profile and areal parameters are correlated, but are not directly comparable in an absolute sense for the reasons given above.

It should be noted that most surface texture profile instruments are based on the stylus (contact) method and that most surface texture areal instruments are based on non-contact approaches. The difference in probing the surface can also lead to differences between profile and areal measured values.

Annex E
(informative)

Relation to the GPS matrix model

E.1 General

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

The ISO/GPS Masterplan given in ISO/TR 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 specifications made in accordance with this document, unless otherwise indicated.

E.2 Information about this part of ISO 25178 and its use

This part of ISO 25178 specifies the complete specification operator for surface texture (scale limited surfaces) by areal methods.

E.3 Position in the GPS matrix model

This part of ISO 25178 is a general GPS standard, which influences the chain link 3 of the chains of standards on areal surface texture in the general GPS matrix, as illustrated in Figure E.1.

Fundamental GPS standards

Global GPS standards

General GPS standards						
Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
Size						
Distance						
Radius						
Angle						
Form of a line independent of datum						
Form of a line dependent on datum						
Form of a surface independent of datum						
Form of a surface dependent on datum						
Orientation						
Location						
Circular run-out						
Total run-out						
Datums						
Roughness profile						
Waviness profile						
Primary profile						
Surface imperfections						
Edges						
Areal surface textures			X			

Figure E.1 — Position in the GPS matrix model

E.4 Related standards

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

Bibliography

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

[2] ISO 8015*, Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

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

[4] ISO/TR 14638:1995, *Geometrical Product Specifications (GPS) — Masterplan*

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