INTERNATIONAL STANDARD

ISO 12781-1

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Geometrical product specifications (GPS) — Flatness —

Part 1: Vocabulary and parameters of flatness

Spécification géométrique des produits (GPS) — Planéité —

Partie 1: Vocabulaire et paramètres de planéité

Reference number
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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 12781-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 12781-1 cancels and replaces ISO/TS 12781-1:2003, which has been technically revised.

ISO 12781 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Flatness*:

— *Part 1: Vocabulary and parameters of flatness*

— *Part 2: Specification operators*

Introduction

This part of ISO 12781 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 2 of the chain of standards on form of a surface (independent of a datum).

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this part of ISO 12781 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 12781 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 12781, unless otherwise indicated.

For more detailed information on the relationship of this part of ISO 12781 to other standards and the GPS matrix model, see Annex C.

This part of ISO 12781 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for flatness of integral features.

Extracting data always involves applying a certain filtering process. An additional filtering of the extracted data might or might not be applied. This additional filter can be a mean line filter (Gaussian, spline, wavelet, etc.) or a non-linear filter (e.g. morphological filter). The type of filtering influences the definition of flatness and the specification operators and, therefore, needs to be stated unambiguously.

This part of ISO 12781 is not intended to disallow any means of measuring flatness.

Geometrical product specifications (GPS) — Flatness —

Part 1: Vocabulary and parameters of flatness

1 Scope

This part of ISO 12781 defines the terms and concepts related to flatness of individual complete integral features only.

2 Normative references

The following referenced documents are indispensable for the application 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 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO 14660-2:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

ISO 17450-1:— [1], *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 14660-1, ISO 14660-2, ISO 17450-1 and the following apply.

3.1 General terms

3.1.1
flatness
property of a plane

3.1.2
nominal plane
mathematically defined plane as specified by the design

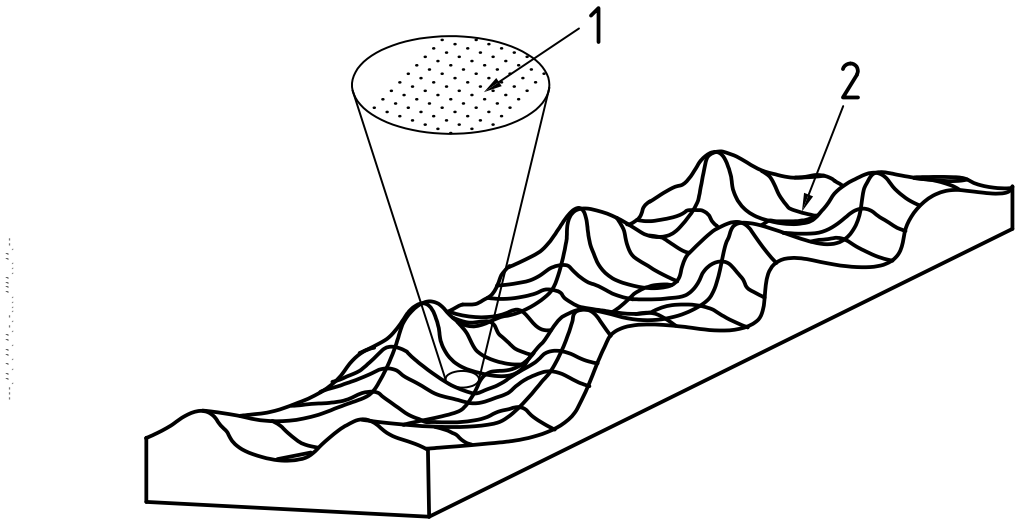
1) To be published. (Revision of ISO/TS 17450-1:2005).

3.2 Terms relating to the surface

3.2.1
extracted surface
〈flatness〉 digital representation of the real surface

See Figure 1.

NOTE The extraction conventions for flatness are given in ISO 12781-2. This extracted surface is an extracted integral feature as defined in ISO 14660-1.



Key
1 extracted surface
2 real surface

Figure 1 — Extracted surface

3.2.2
flatness surface
extracted surface (type plane) intentionally modified by a filter

NOTE 1 This is the surface to which the concepts and parameters of this part of ISO 12781 can be applied.

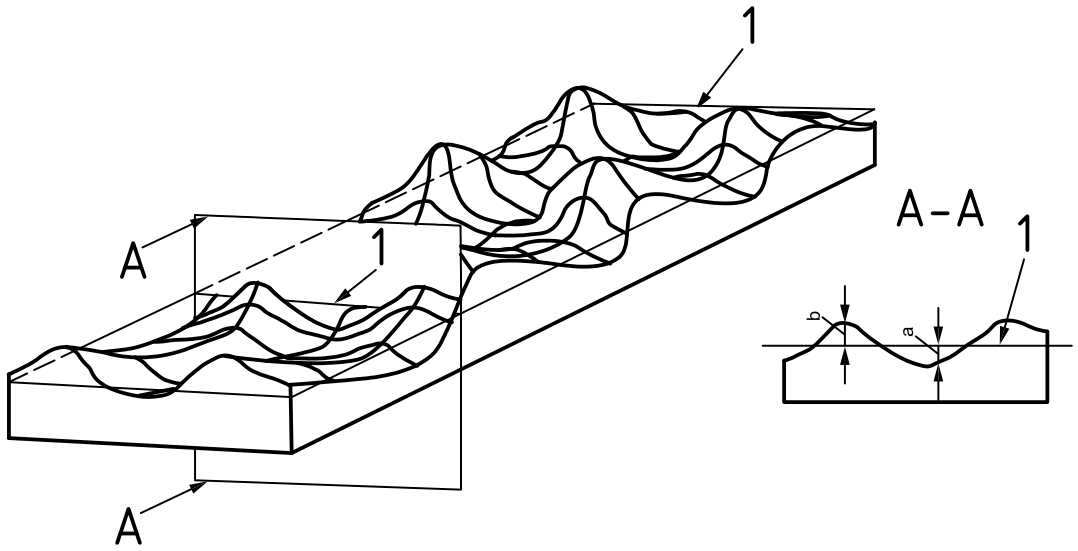
NOTE 2 The areal Gaussian filter is a convolution of two orthogonal profile Gaussian filters.

3.2.3
local flatness deviation
deviation of a point on a flatness surface from a reference plane, the deviation being normal to the reference plane

See Figure 2.

NOTE 1 The deviation is negative if from the reference plane the point lies in the direction of the material.

NOTE 2 For reference plane, see 3.3.1.



Key

1 any reference plane

a Negative local flatness deviation.

b Positive local flatness deviation.

Figure 2 — Local form deviation for flatness

3.3 Terms relating to the reference plane

3.3.1
reference plane
associated plane fitting the flatness surface in accordance with specified conventions, to which the deviations from flatness and the flatness parameters are referred

3.3.1.1
minimum zone reference planes
two parallel planes enclosing the flatness surface and having the least separation

NOTE The abbreviated term MZ is used to refer to minimum zone reference elements.

See Figure 3.

3.3.1.1.1
outer minimum zone reference plane
minimum zone reference plane outside the material

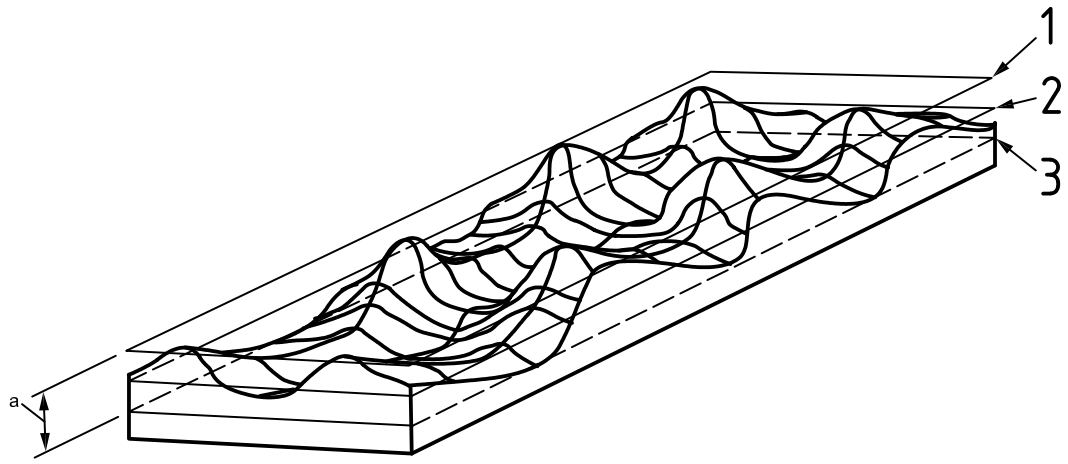
See Figure 3.

3.3.1.1.2
inner minimum zone reference plane
minimum zone reference plane inside the material

See Figure 3.

3.3.1.1.3
mean minimum zone reference plane
arithmetic mean plane of the minimum zone reference planes

See Figure 3.



Key

1 outer minimum zone reference plane

2 mean minimum zone reference plane

3 inner minimum zone reference plane

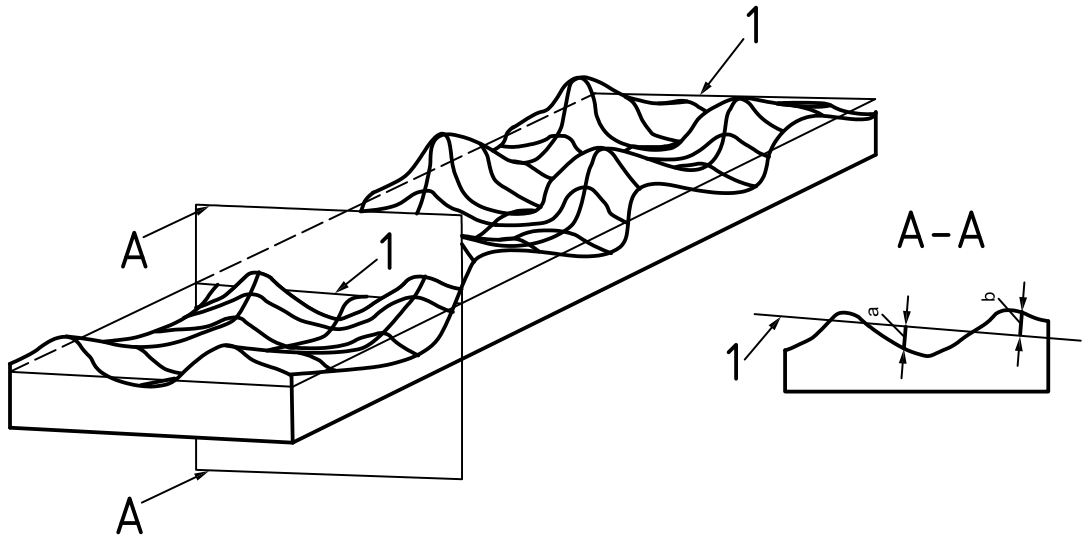
a Least separation.

Figure 3 — Minimum zone reference planes

3.3.1.2
least squares reference plane
plane such that the sum of the squares of the local flatness deviations is a minimum

NOTE The abbreviated term LS is used to refer to least squares reference elements and the abbreviated term G (for Gaussian) is used as a prefix for parameters based on least squares reference elements.

See Figure 4.



Key

1 least squares reference plane

a Negative local flatness deviation.

b Positive local flatness deviation.

Figure 4 — Least squares reference plane

3.4 Parameters

3.4.1
peak-to-valley flatness deviation
value of the largest positive local flatness deviation added to the absolute value of the largest negative local flatness deviation

NOTE 1 The peak-to-valley flatness deviation is defined for all reference planes.

NOTE 2 The peak-to-valley straightness deviation is the only parameter that is defined for minimum zone reference planes.

NOTE 3 The modifier GT is used in specifications to indicate that a form tolerance applies to the peak-to-valley deviation relative to the least squares reference element.

3.4.2
peak-to-reference flatness deviation
value of the largest positive local flatness deviation from the least squares reference plane

NOTE 1 The peak-to-reference flatness deviation is only defined for least squares reference planes.

NOTE 2 The modifier GP is used in specifications to indicate that a form tolerance applies to the peak-to-reference deviation relative to the least squares reference element.

3.4.3
reference-to-valley flatness deviation
absolute value of the largest negative local flatness deviation from the least squares reference plane

NOTE 1 The reference-to-valley flatness deviation is only defined for least squares reference planes.

NOTE 2 The modifier GV is used in specifications to indicate that a form tolerance applies to the reference-to-valley deviation relative to the least squares reference element.

3.4.4
root-mean-square flatness deviation
ΔF_{rms}
square root of the sum of the squares of the local flatness deviations from the least squares reference plane

NOTE 1 The root-mean-square flatness deviation is only defined for least squares reference planes.

NOTE 2 The modifier GQ is used in specifications to indicate that a form tolerance applies to the root-mean-square deviation relative to the least squares reference element.

NOTE 3 The root-mean-square flatness deviation is given by:

$$\Delta F_{\mathrm{rms}} = \sqrt{\frac{1}{A}\int_{A} \Delta F_{\mathrm{l}}{}^{2}\,\mathrm{d}A}$$

where

ΔF_{rms} is the root-mean-square flatness deviation;

ΔF_{l} is the local flatness deviation;

A is the surface area of the flatness feature.

4 Straightness deviations

The deviations of the local straightness profiles of the flatness features are specified in ISO 12780-1.

Annex A
(informative)

Mathematical definition of flatness tolerances of nominal integral features

A flatness tolerance zone (see Figure A.1) of a nominal integral feature consists of a set of points, $\vec{P}_i$, subject to the following conditions:

$\vec{L}, \hat{N}$ — In a coordinate system of arbitrary origin and orientation, a reference plane is defined by a point, $\vec{L}$, and a unit direction, $\hat{N}$.

$d_i = \hat{N} \bullet \left(\vec{P}_i - \vec{L}\right)$ — Points $\vec{P}_i$ are a normal, signed distance, d_i, from the reference plane.

$b \leqslant d_i \leqslant a$
$t = a - b, t > 0$ — Points $\vec{P}_i$ are restricted to being between two planes, each oriented parallel to the reference plane and separated from each other by the flatness tolerance, t.

NOTE These two planes need not be equally disposed about the reference plane.

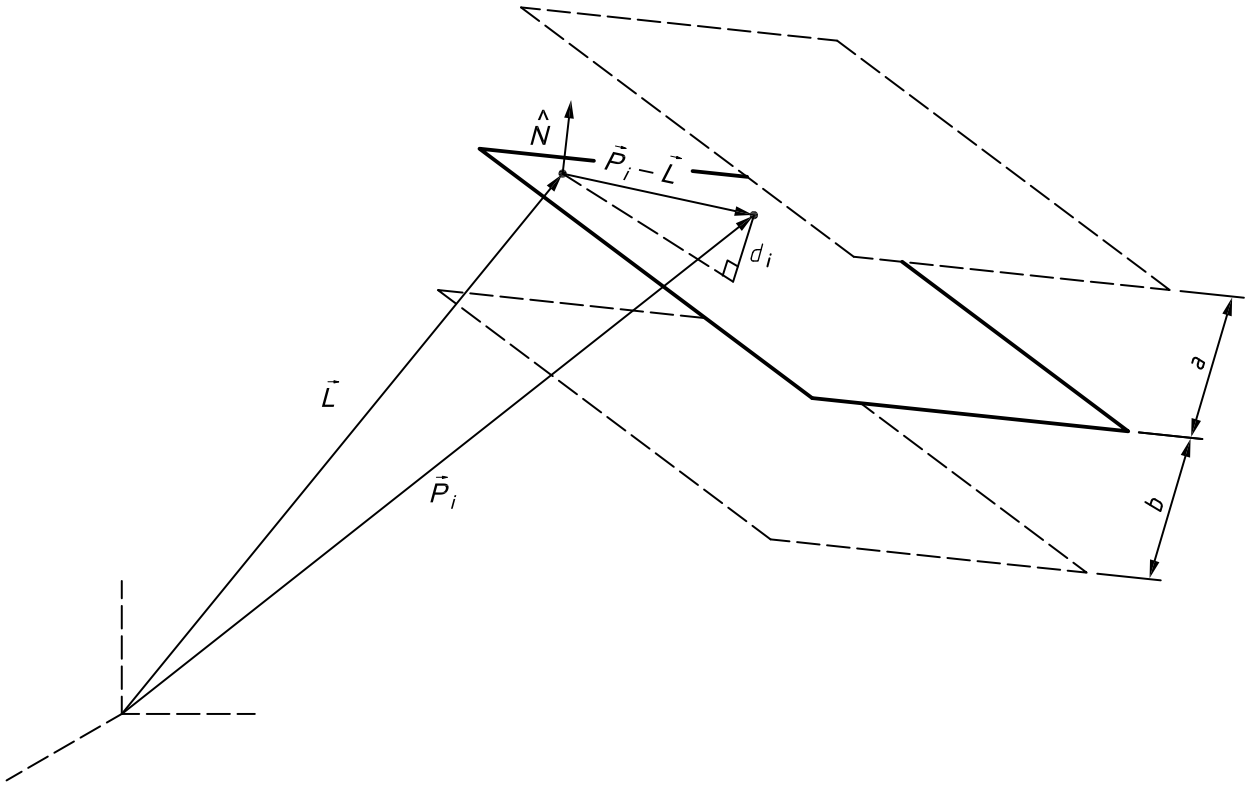


Figure A.1 — Flatness tolerance zone of a nominal integral feature

Annex B
(informative)

Synoptic tables of terms, abbreviations and parameters

The indications of form requirements are based on combinations of symbols and modifiers that uniquely describe the specification operator in a brief form on a drawing. However, there is a need to be able to describe specification and verification operators, e.g. in measurement reports and other technical documentation where it is impractical to rely on drawing symbols. This annex provides textual equivalents for the terms and parameters defined in ISO 12180-1, ISO 12181-1, ISO 12780-1 and this part of 12781, which are recommended for use in those situations.

Table B.1 — Terms and abbreviated terms

Abbreviated term	Term	Defined in
LSCI	Least squares reference circle	ISO 12181-1:2011, 3.3.1.2
LSCY	Least squares reference cylinder	ISO 12180-1:2011, 3.3.1.2
LSLI	Least squares reference line	ISO 12780-1:2011, 3.3.1.2
LSPL	Least squares reference plane	ISO 12781-1:2011, 3.3.1.2
LCD	Local cylindricity deviation	ISO 12180-1:2011, 3.2.3
LFD	Local flatness deviation	ISO 12781-1:2011, 3.2.3
LRD	Local roundness deviation	ISO 12181-1:2011, 3.2.3
LSD	Local straightness deviation	ISO 12780-1:2011, 3.2.3
MICI	Maximum inscribed reference circle	ISO 12181-1:2011, 3.3.1.4
MICY	Maximum inscribed reference cylinder	ISO 12180-1:2011, 3.3.1.4
MCCI	Minimum circumscribed reference circle	ISO 12181-1:2011, 3.3.1.3
MCCY	Minimum circumscribed reference cylinder	ISO 12180-1:2011, 3.3.1.3
MZCI	Minimum zone reference circles	ISO 12181-1:2011, 3.3.1.1
MZCY	Minimum zone reference cylinders	ISO 12180-1:2011, 3.3.1.1
MZLI	Minimum zone reference lines	ISO 12780-1:2011, 3.3.1.1
MZPL	Minimum zone reference planes	ISO 12781-1:2011, 3.3.1.1
UPR	Undulations per revolution	ISO 12181-1:2011, 3.4.1

Table B.2 — Parameters and abbreviated terms

Abbreviated term	Parameter	Defined in
CYLrr	Cylinder radii peak-to-valley	ISO 12180-1:2011, 3.5.2.7
CYLtt	Cylinder taper (LSCY)[a]	ISO 12180-1:2011, 3.5.2.5
CYLat	Cylinder taper angle	ISO 12180-1:2011, 3.5.2.8
STRsg	Generatrix straightness deviation	ISO 12180-1:2011, 3.5.2.3
STRlc	Local generatrix straightness deviation	ISO 12180-1:2011, 3.5.2.2
CYLp	Peak-to-reference cylindricity deviation (LSCY)[a]	ISO 12180-1:2011, 3.5.1.2
FLTp	Peak-to-reference flatness deviation (LSPL)[a]	ISO 12781-1:2011, 3.4.2
RONp	Peak-to-reference roundness deviation (LSCI)[a]	ISO 12181-1:2011, 3.6.1.2
STRp	Peak-to-reference straightness deviation (LSLI)[a]	ISO 12780-1:2011, 3.5.2
CYLt	Peak-to-valley cylindricity deviation (MZCY, LSCY, MICY, MCCY)[a]	ISO 12180-1:2011, 3.5.1.1
FLTt	Peak-to-valley flatness deviation (MZPL), (LSPL)[a]	ISO 12781-1:2011, 3.4.1
RONt	Peak-to-valley roundness deviation (MZCI, LSCI, MCCI, MICI)[a]	ISO 12181-1:2011, 3.6.1.1
STRt	Peak-to-valley straightness deviation (MZLI, LSLI)[a]	ISO 12780-1:2011, 3.5.1
CYLv	Reference-to-valley cylindricity deviation (LSCY)[a]	ISO 12180-1:2011, 3.5.1.3
FLTv	Reference-to-valley flatness deviation (LSPL)[a]	ISO 12781-1:2011, 3.4.3
RONv	Reference-to-valley roundness deviation (LSCI)[a]	ISO 12181-1:2011, 3.6.1.3
STRv	Reference-to-valley straightness deviation (LSLI)[a]	ISO 12780-1:2011, 3.5.3
CYLq	Root-mean-square cylindricity deviation (LSCY)[a]	ISO 12180-1:2011, 3.5.1.4
FLTq	Root-mean-square flatness deviation (LSPL)[a]	ISO 12781-1:2011, 3.4.4
RONq	Root-mean-square roundness deviation (LSCI)[a]	ISO 12181-1:2011, 3.6.1.4
STRq	Root-mean-square straightness deviation (LSLI)[a]	ISO 12780-1:2011, 3.5.4
STRsa	Straightness deviation of the extracted median line	ISO 12180-1:2011, 3.5.2.1

[a] The abbreviated terms given in parentheses after the parameter names indicate the reference elements to which the parameter can be applied.

Annex C
(informative)

Relationship to the GPS matrix model

C.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 part of ISO 12781 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 12781 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 12781, unless otherwise indicated.

C.2 Information about this part of ISO 12781 and its use

This part of ISO 12781 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for flatness of integral features.

C.3 Position in the GPS matrix model

This part of ISO 12781 is a general GPS standard, which influences chain link 2 of the chain of standards on form of surface independent of datum in the general GPS matrix, as graphically illustrated in Figure C.1.

	Global GPS standards						
	General GPS standards						
Fundamental GPS standards	**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						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile						
	Waviness profile						
	Primary profile						
	Surface defects						
	Edges						

Figure C.1 — Position in the GPS matrix model

C.4 Related International Standards

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

Bibliography

[1] ISO 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

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

[3] ISO 11562, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Metrological characteristics of phase correct filters*

[4] ISO 12180-1, *Geometrical product specifications (GPS) — Cylindricity — Part 1: Vocabulary and parameters of cylindrical form*

[5] ISO 12181-1, *Geometrical product specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

[6] ISO 12780-1, *Geometrical product specifications (GPS) — Straightness — Part 1: Vocabulary and parameters of straightness*

[7] ISO 12780-2, *Geometrical product specifications (GPS) — Straightness — Part 2: Specification operators*

[8] ISO 12781-2, *Geometrical product specifications (GPS) — Flatness — Part 2: Specification operators*

[9] 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*

[10] ISO/TR 14638, *Geometrical product specification (GPS) — Masterplan*

[11] ISO 17450-2, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

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