TECHNICAL SPECIFICATION

ISO/TS 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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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

ISO/TS 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/TS 12781 is a geometrical product specification (GPS) Technical Specification 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).

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

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

Extracting data will always involve applying a certain filtering process. An additional filtering of the extracted data may or may 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 will influence the definition of flatness and the specification operators and, therefore, needs to be stated unambiguously.

This part of ISO/TS 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/TS 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/TS 12780-2:2003, *Geometrical Product Specifications (GPS) — Straightness — Part 2: Specification operators*

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/TS 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/TS 17450-1 and the following apply.

3.1 General terms

3.1.1
flatness
property of a plane

3.1.2
nominal plane
the mathematically defined plane as specified by the design

1) To be published.

3.2 Terms relating to the surface

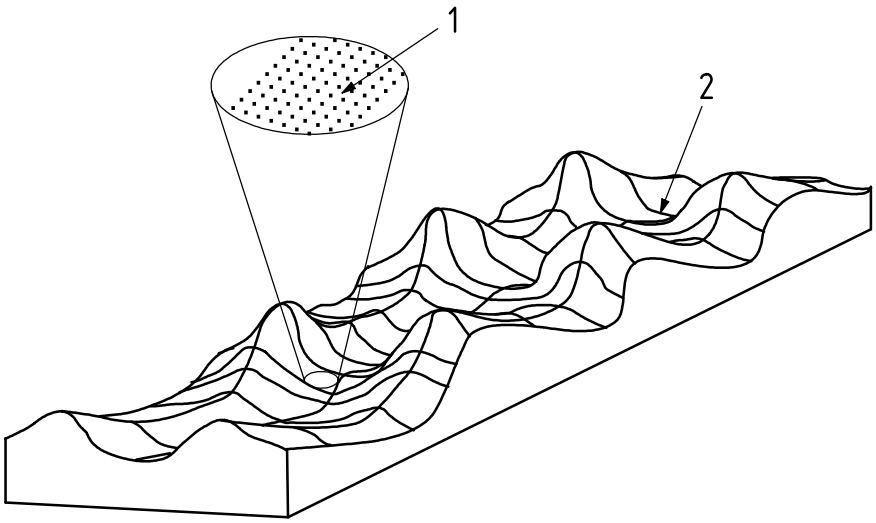
3.2.1
real surface of a workpiece
integral feature part of a real surface of a workpiece limited by the adjacent real (integral) features

[ISO 14660-1:1999, definition 2.4]

3.2.2
extracted surface
⟨flatness⟩ digital representation of the real surface.

See Figure 1.

NOTE The extraction conventions for flatness are given in ISO/TS 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

3.2.3
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/TS 12781 can be applied

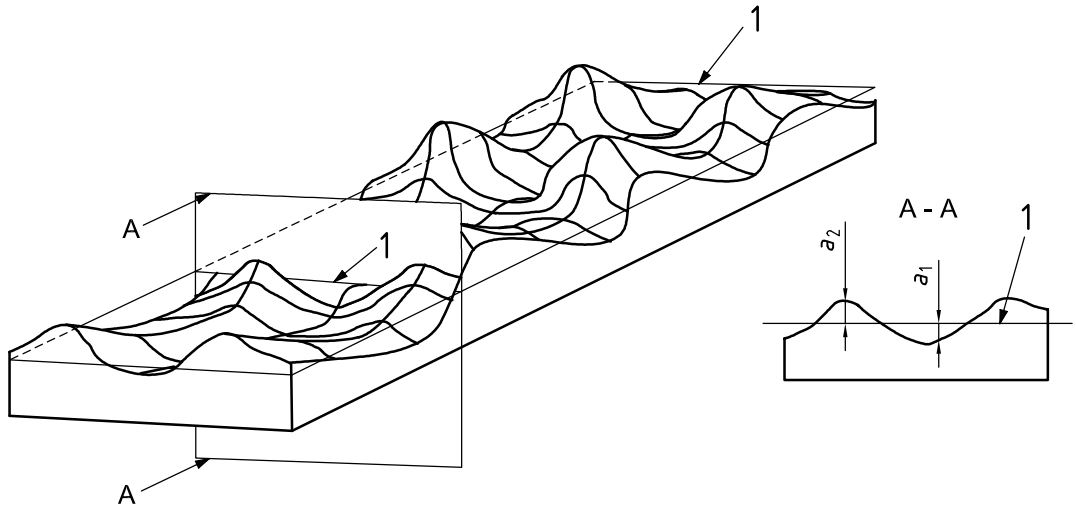
NOTE 2 The areal Gaussian filter is a convolution of two orthogonal profile Gaussian filters.

3.2.4
local flatness deviation
LFD
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 See 3.3.1 for reference plane.



Key

a_1 negative local flatness deviation

a_2 positive local flatness deviation

1 any reference plane

Figure 2 — Local form deviation for flatness

3.2.5
straightness profile
extracted line intentionally modified by a filter

[ISO/TS 12780-1:2003, definition 3.2.3]

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
MZPL
two parallel planes enclosing the flatness surface and having the least separation

See Figure 3.

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

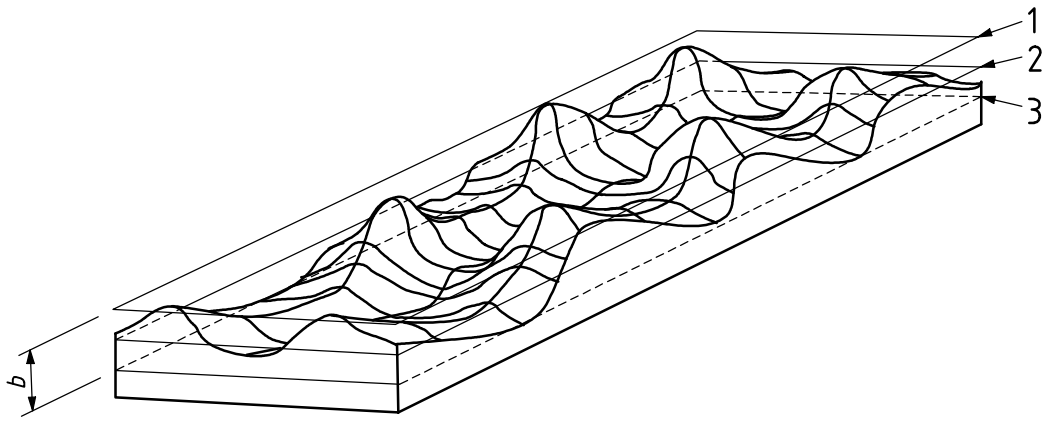
See Figure 3.

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.



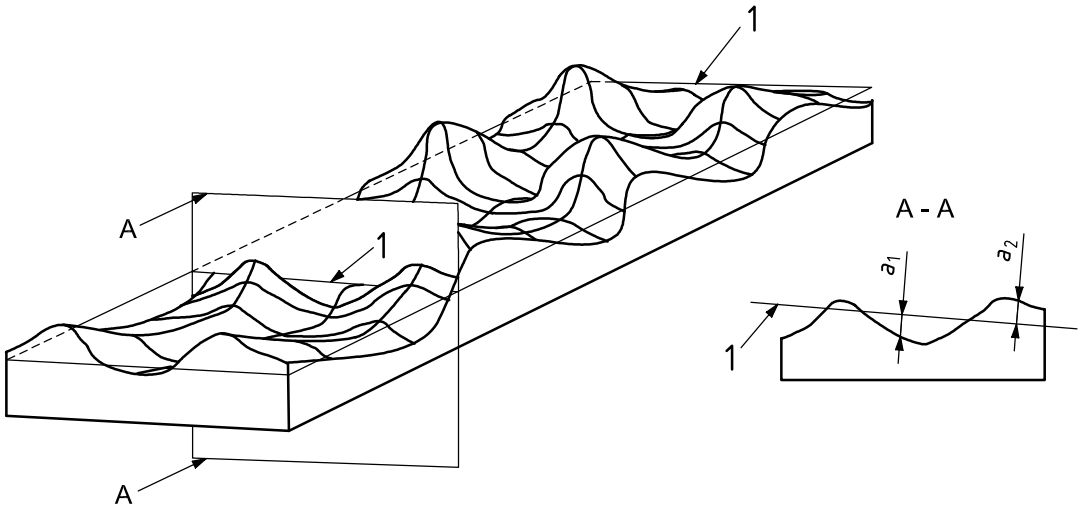
Key

b least separation
1 outer minimum zone reference plane
2 mean minimum zone reference plane
3 inner minimum zone reference plane

Figure 3 — Minimum zone reference planes

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

See Figure 4.



Key

a_1 negative local flatness deviation

a_2 positive local flatness deviation

1 lLeast squares reference plane

Figure 4 — Least squares reference plane

3.4 Terms relating to the filter function

3.4.1 General

If not otherwise specified, the details of the filter characteristics are as specified in ISO/TS 12780-2.

NOTE Only the phase correct mean line filter is currently defined (see ISO 11562:1996, definition 2.2). Consequently, the terms in this clause relate only to this type of filter. Other filter methods are currently being investigated by ISO. It is anticipated that in a future version of this part of ISO/TS 12781, these new filters will be incorporated.

3.4.2
profile filter
filter operating on an open profile, transmitting a range of sinusoidal undulations for which the ratio of output to input amplitude is defined, while attenuating (i.e. reducing) the ratio for undulations lying outside the range at either or both ends

[ISO/TS 12780-1:2003, definition 3.4.2]

NOTE 1 The areal Gaussian filter is a convolution of two orthogonal profile Gaussian filters.

NOTE 2 Other filter methods are currently being investigated by ISO. It is anticipated that in a future version of this part of ISO/TS 12781, these new filters will be incorporated. Some of these new filters are not a convolution of two orthogonal profiler filters and so appropriate areal filter terms will be added where necessary.

3.4.3
transmission characteristic of a filter
characteristic which indicates the amount by which the amplitude of a sinusoidal profile is attenuated as a function of its wavelength

[ISO 11562:1996, definition 2.3]

3.4.4
cut-off wavelength of the phase correct filter
wavelength of a sinusoidal profile of which 50 % of the amplitude is transmitted by the profile filter

NOTE Profile filters are identified by their cut-off wavelength value.

[ISO 11562:1996, definition 2.5]

3.5 Parameters

3.5.1
peak-to-valley flatness deviation (MZPL), (LSPL)
FLTt
value of the largest positive local flatness deviation added to the absolute value of the largest negative local flatness deviation

NOTE The peak-to-valley flatness deviation can be used for reference planes (MZPL), (LSPL).

3.5.2
peak-to-reference flatness deviation (LSPL)
FLTp
value of the largest positive local flatness deviation from the least squares reference plane

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

3.5.3
reference-to-valley flatness deviation (LSPL)
FLTv
absolute value of the largest negative local flatness deviation from the least squares reference plane

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

3.5.4
root mean square flatness deviation (LSPL)
FLTq
square root of the sum of the squares of the local flatness deviations from the least squares reference plane

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

$$FLT\mathrm{q} = \sqrt{\frac{1}{A}\int_{A} \mathrm{LFD}^2 \,\mathrm{d}A}$$

where

LFD 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 covered by ISO/TS 12780.

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 be 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.

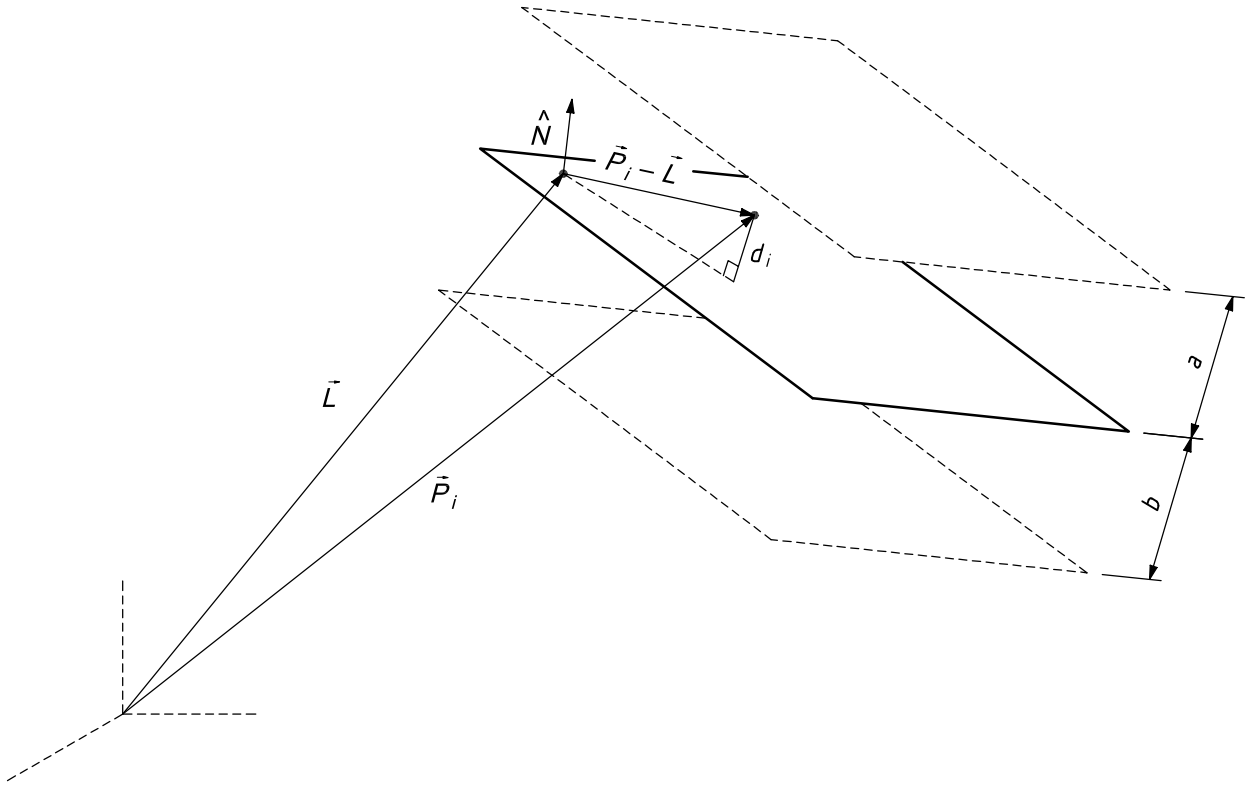


Figure A.1 — Flatness tolerance zone of a nominal integral feature

Annex B
(informative)

Synoptic tables of terms, abbreviations and parameters

Table B.1 — Terms and abbreviations

Abbreviation	Term	Defined in	
		ISO/TC	Subclause
LSCI	Least squares reference circle	12181-1:2003	3.3.1.2
LSCY	Least squares reference cylinder	12180-1:2003	3.3.1.2
LSLI	Least squares reference line	12780-1:2003	3.3.1.2
LSPL	Least squares reference plane	12781-1:2003	3.3.1.2
LCD	Local cylindricity deviation	12180-1:2003	3.2.4
LFD	Local flatness deviation	12781-1:2003	3.2.4
LRD	Local roundness deviation	12181-1:2003	3.2.4
LSD	Local straightness deviation	12780-1:2003	3.2.4
MICI	Maximum inscribed reference circle	12181-1:2003	3.3.1.4
MICY	Maximum inscribed reference cylinder	12180-1:2003	3.3.1.4
MCCI	Minimum circumscribed reference circle	12181-1:2003	3.3.1.3
MCCY	Minimum circumscribed reference cylinder	12180-1:2003	3.3.1.3
MZCI	Minimum zone reference circles	12181-1:2003	3.3.1.1
MZCY	Minimum zone reference cylinders	12180-1:2003	3.3.1.1
MZLI	Minimum zone reference lines	12780-1:2003	3.3.1.1
MZPL	Minimum zone reference planes	12781-1:2003	3.3.1.1
UPR	Undulations per revolution	12181-1:2003	3.4.1

Table B.2 — Terms and parameters

Parameter	Term	Defined in	
		ISO/TC	Subclause
*CYL*rr	Cylinder radii peak-to-valley	12180-1:2003	3.6.2.7
*CYL*tt	Cylinder taper (LSCY)	12180-1:2003	3.6.2.5
*CYL*at	Cylinder taper angle	12180-1:2003	3.6.2.8
*STR*sg	Generatrix straightness deviation	12180-1:2003	3.6.2.3
*STR*lc	Local generatrix straightness deviation	12180-1:2003	3.6.2.2
*CYL*p	Peak-to-reference cylindricity deviation (LSCY)	12180-1:2003	3.6.1.2
*FLT*p	Peak-to-reference flatness deviation (LSPL)	12781-1:2003	3.5.2
*RON*p	Peak-to-reference roundness deviation (LSCI)	12181-1:2003	3.6.1.2
*STR*p	Peak-to-reference straightness deviation (LSLI)	12780-1:2003	3.5.2
*CYL*t	Peak-to-valley cylindricity deviation (MZCY), (LSCY), (MICY), (MCCY)	12180-1:2003	3.6.1.1
*FLT*t	Peak-to-valley flatness deviation (MZPL), (LSPL)	12781-1:2003	3.5.1
*RON*t	Peak-to-valley roundness deviation (MZCI, LSCI, MCCI, MICI)	12181-1:2003	3.6.1.1
*STR*t	Peak-to-valley straightness deviation (MZLI, LSLI)	12780-1:2003	3.5.1
*CYL*v	Reference-to-valley cylindricity deviation (LSCY)	12180-1:2003	3.6.1.3
*FLT*v	Reference-to-valley flatness deviation (LSPL)	12781-1:2003	3.5.3
*RON*v	Reference-to-valley roundness deviation (LSCI)	12181-1:2003	3.6.1.3
*STR*v	Reference-to-valley straightness deviation (LSLI)	12780-1:2003	3.5.3
*CYL*q	Root mean square cylindricity deviation (LSCY)	12180-1:2003	3.6.1.4
*FLT*q	Root mean square flatness deviation (LSPL)	12781-1:2003	3.5.4
*RON*q	Root mean square roundness deviation (LSCI)	12181-1:2003	3.6.1.4
*STR*q	Root mean square straightness deviation (LSLI)	12780-1:2003	3.5.4
*STR*sa	Straightness deviation of the extracted median line	12180-1:2003	3.6.2.1

Annex C
(informative)

Relation to the GPS matrix model

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

C.1 Information about this part of ISO/TS 12781 and its use

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

C.2 Position in the GPS matrix model

This part of ISO/TS 12781 is a general GPS document, 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						
	Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
Fundamental GPS standards	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 imperfections						
	Edges						

Figure C.1

C.3 Related International Standards

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

Bibliography

[1] ISO 1101:—[2)], *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

[2] ISO 11562:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Metrological characterization of phase correct filters*

[3] ISO/TS 12180-1:2003, *Geometrical Product Specifications (GPS) — Cylindricity — Part 1: Vocabulary*

[4] ISO/TS 12181-1:2003, *Geometrical Product Specifications (GPS) — Roundness — Part 1: Vocabulary*

[5] ISO/TS 12780-1:2003, *Geometrical Product Specifications (GPS) — Straightness — Part 1: Vocabulary*

[6] ISO/TS 12781-2:2003, *Geometrical Product Specifications (GPS) — Flatness — Part 2: Specification operators*

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

[8] ISO/TS 17450-2:2002, *Geometrical Product Specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

2) To be published. (Revision of ISO 1101:1983)

ICS 01.040.17; 17.040.01

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