INTERNATIONAL STANDARD

ISO 12780-1

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2011-04-01

Geometrical product specifications (GPS) — Straightness —

Part 1: Vocabulary and parameters of straightness

Spécification géométrique des produits (GPS) — Rectitude —

Partie 1: Vocabulaire et paramètres de rectitude

Reference number
ISO 12780-1:2011(E)

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Contents

Page

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 12780-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 12780-1 cancels and replaces ISO/TS 12780-1:2003, which has been technically revised.

ISO 12780 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Straightness*:

— *Part 1: Vocabulary and parameters of straightness*

— *Part 2: Specification operators*

Introduction

This part of ISO 12780 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 line independent of datum.

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 of the relationship of this part of ISO 12780 to other standards and the GPS matrix model, see Annex C.

This part of ISO 12780 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for straightness 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 straightness and the specification operators and, therefore, needs to be stated unambiguously.

This part of ISO 12780 is not intended to disallow any means of measuring straightness.

Geometrical product specifications (GPS) — Straightness —

Part 1:
Vocabulary and parameters of straightness

1 Scope

This part of ISO 12780 defines the terms and concepts related to straightness of individual integral features and covers complete straightness profiles only.

NOTE Straightness of an extracted derived axis of a cylinder is defined in ISO 12180-1 and ISO 12180-2.

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

ISO 12780-2:2011, *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 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 and ISO 17450-1 and the following apply.

3.1 General terms

3.1.1
straightness
property of a straight line

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

3.1.2
normal of the surface
normal of a feature associated with an integral feature

3.1.3
straightness plane
plane for which the intersection with the associated integral feature is a straight line

See Figure 1.

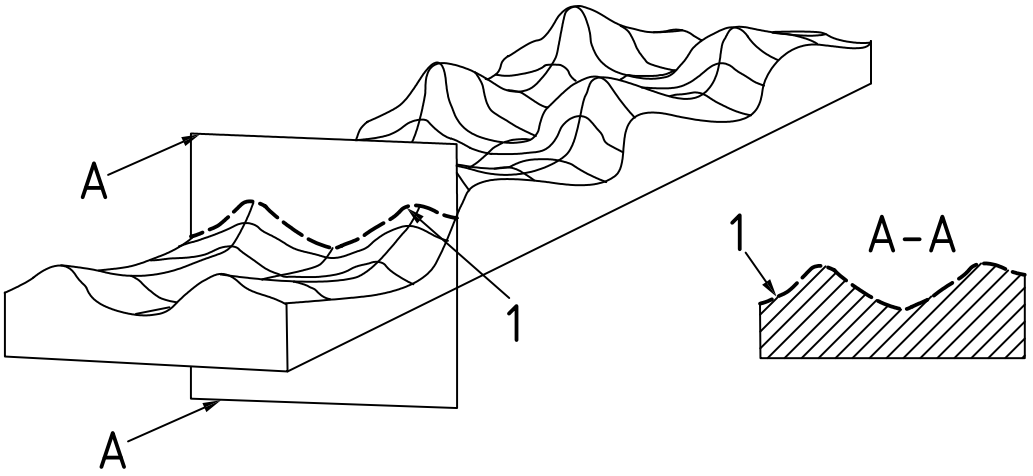
NOTE By default, the straightness plane includes the normal of the surface

3.2 Terms relating to profiles

3.2.1
extracted line
⟨straightness⟩ digital representation of the intersection of the real surface and the straightness plane

See Figure 1.

NOTE The extraction conventions for straightness are given in ISO 12780-2. This extracted line is an extracted integral feature as defined in ISO 14660-1.



Key
A-A straightness plane
1 extracted line

Figure 1 — Straightness plane and extracted line

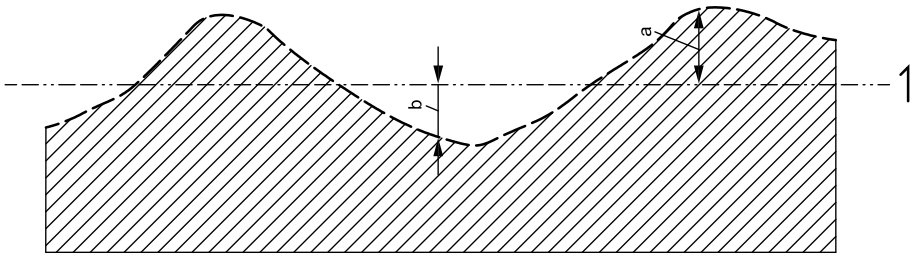
3.2.2
straightness profile
extracted line intentionally modified by a filter

NOTE This is the profile to which the concepts and parameters of this part of ISO 12780 can be applied.

3.2.3
local straightness deviation
ΔS_l
deviation of a point on a straightness profile from the reference line, the deviation being normal to the reference line

See Figure 2.

NOTE 1 The deviation is negative if from the reference line the point lies in the direction of the material.
NOTE 2 For reference line, see 3.3.1.



Key

1 reference line

a Positive local straightness deviation.

b Negative local straightness deviation.

Figure 2 — Local straightness deviation

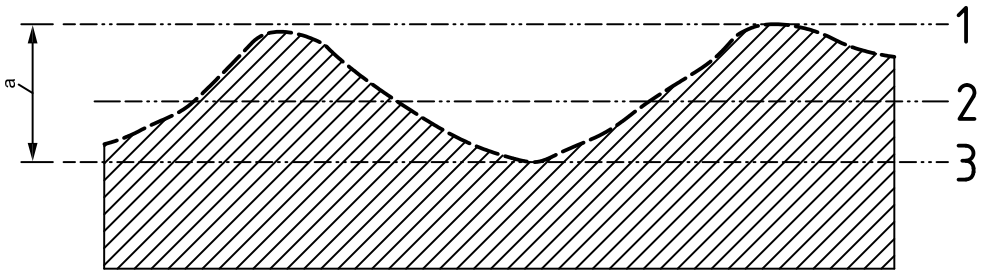
3.3 Terms relating to the reference line

3.3.1
reference line
associated line fitting the straightness profile in accordance with specified conventions, to which the deviations from straightness and the straightness parameters are referred

3.3.1.1
minimum zone reference lines
two parallel lines in the straightness plane enclosing the straightness profile and having the least separation

See Figure 3.

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



Key

1 outer minimum zone reference line

2 mean minimum zone reference line

3 inner minimum zone reference line

a Least separation.

Figure 3 — Minimum zone reference lines

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

See Figure 3.

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

See Figure 3.

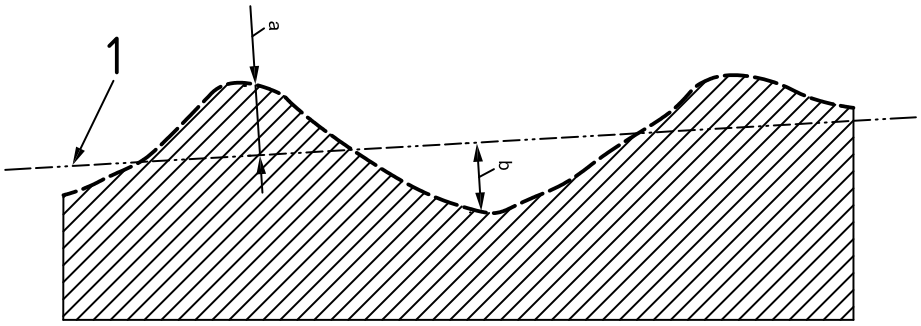
3.3.1.1.3
mean minimum zone reference line
arithmetic mean line of the minimum zone reference lines

See Figure 3.

3.3.1.2
least squares reference line
line such that the sum of the squares of the local straightness deviations is a minimum

See Figure 4.

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



Key

1 least squares reference line

a Positive local straightness deviation.

b Negative local straightness deviation.

Figure 4 — Least squares reference line

3.4 Terms relating to the filter function

NOTE 1 If not otherwise specified, the details of the filter characteristics are as specified in ISO 12780-2.

NOTE 2 Only the phase correct mean line filter is currently defined (see ISO 11562). Consequently, the terms in this subclause relate only to this type of filter. Other filter methods are currently being investigated by ISO. It is intended to incorporate these new filters in a future edition of this part of ISO 12780.

3.4.1
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

3.4.2
cut-off wavelength
cut-off wavelength of the filter applied to the extracted line

3.4.3
transmission band for straightness profiles
band of sinusoidal profile undulations which are transmitted by greater than a specified percentage by the filter, defined by the values of the upper and lower cut-off wavelengths

NOTE The specified percentage is usually 50 %.

3.5 Terms relating to parameters

3.5.1
peak-to-valley straightness deviation
value of the largest positive local straightness deviation added to the absolute value of the largest negative local straightness deviation

NOTE 1 The peak-to-valley straightness deviation is defined for all reference lines.

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

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.

3.5.2
peak-to-reference straightness deviation
value of the largest positive local straightness deviation from the least squares reference line

NOTE 1 The peak-to-reference straightness deviation is only defined for least squares reference lines.

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.

3.5.3
reference-to-valley straightness deviation
absolute value of the largest negative local straightness deviation from the least squares reference line

NOTE 1 The reference-to-valley straightness deviation is defined only for least squares reference lines.

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.

3.5.4
root-mean-square straightness deviation
ΔS_{rms}
square root of the sum of the squares of the local straightness deviations from the least squares reference line

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

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 straightness deviation is given by:

$$\Delta S_{\text{rms}} = \sqrt{\frac{1}{L}\int_0^L \Delta S_{\text{l}}^2 \, \mathrm{d}X}$$

where

ΔS_{rms} is the root-mean-square straightness deviation;

ΔS_{l} is the local straightness deviation;

X is the instantaneous position in the straightness profile;

L is the length of the reference line.

Annex A
(informative)

Mathematical definition of straightness tolerances of nominal integral features

A straightness tolerance zone (see Figure A.1) for a surface line of a nominal integral feature consists of a set of points, P_i, subject to the following conditions.

$\hat{K} \cdot \left(\vec{F} - \vec{P}_i \right) = 0$

In a coordinate system of arbitrary origin and orientation, a straightness plane that contains the surface line is defined by a point, $\vec{F}$, and a unit surface normal, $\hat{K}$.

NOTE For a planar surface, the straightness plane is parallel to the plane of the view in which the straightness tolerance is applied. For a cylindrical or conical surface, the straightness plane contains the axis of the cylinder/cone.

Points, $\vec{P}_i$, are restricted to being on this straightness plane.

$\hat{K} \cdot \left(\vec{F} - \vec{L} \right) = 0$

$\hat{N} \cdot \hat{K} = 0$

A reference line is defined on the straightness plane by a point, $\vec{L}$, and a unit direction, $\hat{N}$.

$d_i = \left(\hat{K} \times \hat{N} \right) \cdot \left(\vec{P}_i - \vec{L} \right)$

Points, $\vec{P}_i$, are a normal, signed distance, d_i, from the reference line.

$b \leqslant d_i \leqslant a$

$t = a - b, t > 0$

Points $\vec{P}_i$ are restricted to being between two lines on the straightness plane, each oriented parallel to the reference line and separated from each other by the straightness tolerance, t.

NOTE These two lines need not be equally disposed about the reference line.

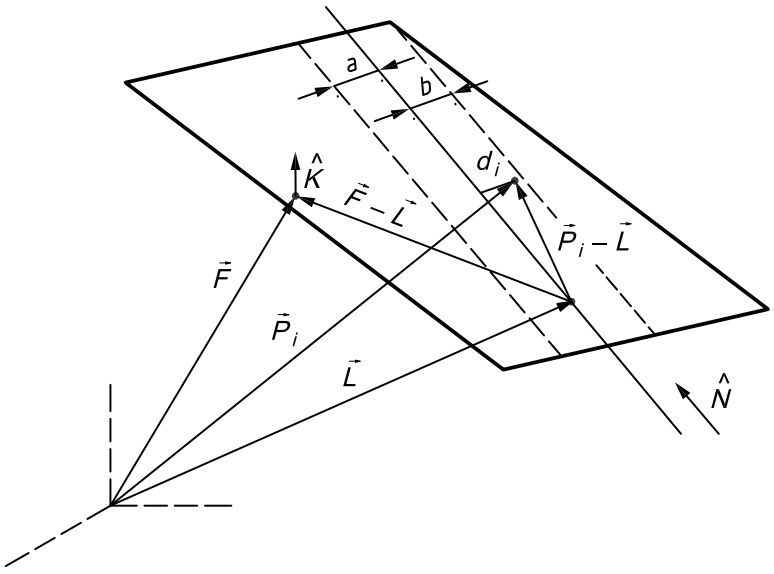


Figure A.1 — Straightness tolerance zone of a nominal integral feature

Annex B
(informative)

Synoptic tables of terms, abbreviated terms 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, this part of ISO 12780 and 12781-1, 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 — Terms and parameters

Abbreviation	Term	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 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.

C.2 Information about this part of ISO 12780 and its use

This part of ISO 12780 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for straightness of integral features.

C.3 Position in the GPS matrix model

This part of ISO 12780 is a general GPS standard, which influences chain link 2 of the chain of standards on form of line independent of datum in the general GPS matrix, as graphically illustrated in Figure C.1.

	Global GPS standards						
Fundamental GPS standards	**General 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 12180-1:2001, *Geometrical product specifications (GPS) — Cylindricity — Part 1: Vocabulary and parameters of cylindrical form*

[4] ISO 12180-2, *Geometrical product specifications (GPS) — Cylindricity — Part 2: Specification operators*

[5] ISO 12181-1:2001, *Geometrical product specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

[6] ISO 12781-1:2001, *Geometrical product specifications (GPS) — Flatness — Part 1: Vocabulary and parameters of flatness*

[7] 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*

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

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

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