INTERNATIONAL STANDARD

ISO 12180-1

First edition
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Geometrical product specifications (GPS) — Cylindricity —

Part 1: Vocabulary and parameters of cylindrical form

Spécification géométrique des produits (GPS) — Cylindricité —

Partie 1: Vocabulaire et paramètres de cylindricité

Reference number
ISO 12180-1:2011(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 12180-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 12180-1 cancels and replaces ISO/TS 12180-1:2003, which has been technically revised.

ISO 12180 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Cylindricity*:

— *Part 1: Vocabulary and parameters of cylindrical form*

— *Part 2: Specification operators*

Introduction

This part of ISO 12180 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 12180 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 12180 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 12180, unless otherwise indicated.

For more detailed information on the relationship of this part of ISO 12180 to other standards and the GPS matrix model, see Annex D.

This part of ISO 12180 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for cylindricity 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 cylindricity and the specification operators and, therefore, needs to be stated unambiguously.

This part of ISO 12180 is not intended to disallow any means of measuring cylindricity.

Geometrical product specifications (GPS) — Cylindricity —

Part 1:
Vocabulary and parameters of cylindrical form

1 Scope

This part of ISO 12180 defines the terms and concepts related to cylindricity 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 11562:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Metrological characteristics of phase correct filters*

ISO 12181-1:2011, *Geometrical product specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

ISO 12780-1:2011, *Geometrical product specifications (GPS) — Straightness — Part 1: Vocabulary and parameters of straightness*

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 11562, ISO 12181-1, ISO 12780-1, ISO 14660-1, ISO 14660-2, ISO 17450-1 and the following apply.

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

3.1 General terms

3.1.1
cylindricity
property of a cylinder

3.1.2
nominal cylinder
mathematically cylindrical form as specified by design intent

NOTE For the purposes of this part of ISO 12180, the term “form of a nominal cylinder” is understood to mean the form of a right circular cylinder (i.e. it has a right angle between the cylinder axis and every circular cross-section).

3.1.3
generatrix plane
half plane through the axis of the associated cylinder

3.2 Terms relating to the surface

3.2.1
extracted surface
⟨cylindricity⟩ digital representation of the real surface

NOTE The extraction conventions for cylindricity are given in ISO 12180-2. This extracted surface is an extracted integral feature as defined in ISO 14660-1.

3.2.2
cylindricity surface
extracted surface (type cylinder) intentionally modified by a filter

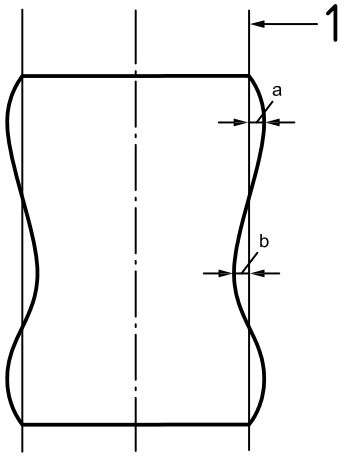
NOTE This is the surface to which the concepts and parameters of this part of ISO 12180 can be applied.

3.2.3
local cylindricity deviation
ΔC_{l}
deviation of a point on a cylindricity surface from the reference cylinder, the deviation being normal to the reference cylinder

See Figures 1 and 2.

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

NOTE 2 For the reference cylinder, see 3.3.1.



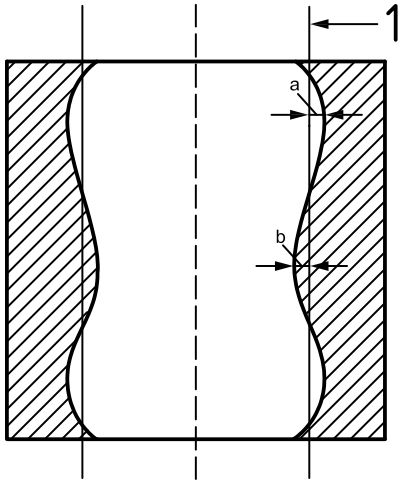
Key

1 reference cylinder

a Positive local deviation.

b Negative local deviation.

Figure 1 — Local form deviation of an external cylindrical feature



Key

1 reference cylinder

a Negative local deviation.

b Positive local deviation.

Figure 2 — Local form deviation of an internal cylindrical feature

3.2.4
extracted generatrix line
digital representation of the line of intersection of the real surface and a generatrix plane

NOTE The extraction conventions for cylindricity are given in ISO 12180-2. This extracted surface is an extracted integral feature as defined in ISO 14660-1.

3.2.5
generatrix profile
extracted generatrix line intentionally modified by a filter

3.2.6
local generatrix deviation
deviation of a point on a generatrix from the reference line, the deviation being normal to the reference line

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

NOTE 2 This definition is similar to ISO 12780-1:2011, definition 3.2.4: local straightness deviation.

3.3 Terms relating to the reference cylinder

3.3.1
reference cylinder
associated cylinder fitting the cylindricity surface in accordance with specified conventions, to which the deviations from cylindrical form and the cylindricity parameters are referred

3.3.1.1
minimum zone reference cylinders
two coaxial cylinders enclosing the cylindricity surface and having the least radial separation

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

3.3.1.1.1
outer minimum zone reference cylinder
outer cylinder of the minimum zone reference cylinders

3.3.1.1.2
inner minimum zone reference cylinder
inner cylinder of the minimum zone reference cylinders

3.3.1.1.3
mean minimum zone reference cylinder
arithmetic mean cylinder of the minimum zone reference cylinders

3.3.1.2
least squares reference cylinder
cylinder for which the sum of the squares of the local cylindricity 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.

3.3.1.3
minimum circumscribed reference cylinder
smallest possible cylinder that can be fitted around the cylindricity surface

NOTE The abbreviated term MC is used to refer to minimum circumscribed reference elements.

3.3.1.4
maximum inscribed reference cylinder
largest possible cylinder that can be fitted within the cylindricity surface

NOTE 1 Cases exist where the maximum inscribed reference cylinder is not unique.

NOTE 2 The abbreviated term MI is used to refer to maximum inscribed reference elements.

3.3.2
associated derived axis of a cylindrical feature
axis of the reference cylinder(s)

3.4 Terms relating to the circumference and the generatrix

3.4.1
generatrix wavelength
length of a generatrix divided by the number of sinusoidal undulations along that generatrix

NOTE The number of sinusoidal undulations is not necessarily an integer.

3.5 Terms relating to parameters

3.5.1 General parameters

3.5.1.1
peak-to-valley cylindricity deviation
value of the largest positive local cylindricity deviation added to the absolute value of the largest negative local cylindricity deviation

NOTE 1 The peak-to-valley cylindricity deviation is defined for all reference cylinders.

NOTE 2 The peak-to-valley cylindricity deviation is the only parameter that is defined for minimum zone, maximum inscribed and minimum circumscribed reference cylinders.

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.

3.5.1.2
peak-to-reference cylindricity deviation
value of the largest positive local cylindricity deviation from the least squares reference cylinder

NOTE 1 The peak-to-reference cylindricity deviation is only defined for least squares reference cylinders.

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.

3.5.1.3
reference-to-valley cylindricity deviation
absolute value of the largest negative local cylindricity deviation from the least squares reference cylinder

NOTE 1 The reference-to-valley cylindricity deviation is only defined for least squares reference cylinders.

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.

3.5.1.4
root-mean-square cylindricity deviation
ΔC_{rms}
square root of the sum of the squares of the local cylindricity deviations from the least squares reference cylinder

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

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 cylindricity deviation is given by:

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

where

ΔC_{rms} is the root-mean-square cylindricity deviation;

ΔC_l is the local cylindricity deviation;

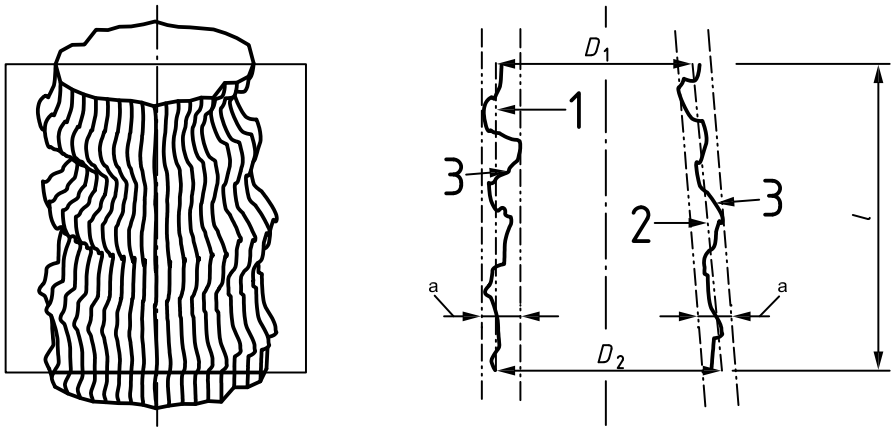
A is the surface area of the cylindrical feature.

3.5.2 Other parameters of the cylindrical feature

3.5.2.1
straightness deviation of the extracted median line
diameter of the minimum circumscribed cylinder that totally encloses the extracted median line

3.5.2.2
local generatrix straightness deviation
straightness deviation value calculated from a generatrix profile obtained from an intersection of a plane through the axis of the least squares reference cylinder and the cylindrical feature within the full extent of the feature

See Figure 3.



Key
1 associated line through left-hand generatrix profile
2 associated line through right-hand generatrix profile
3 generatrix profiles
D_1 local diameter at the top
D_2 local diameter at the bottom
l evaluation length

a Local generatrix straightness deviation (see Table C.2).

NOTE The absolute value $|D_1 - D_2|/2$ is the local cylinder taper value. This parameter is usually evaluated with a length, l, of 100 mm.

Figure 3 — Local cylinder taper

3.5.2.3
generatrix straightness deviation
largest local generatrix straightness value

3.5.2.4
local cylinder taper
half of the absolute difference in local diameter at the top and the local diameter at the bottom of the cylindrical feature of the two associated lines fitted through the two generatrix profiles obtained from an intersection of a plane through the axis of the least squares reference cylinder and the cylindrical feature within the full extent of the feature

See Figure 3.

3.5.2.5
cylinder taper
largest local cylinder taper value

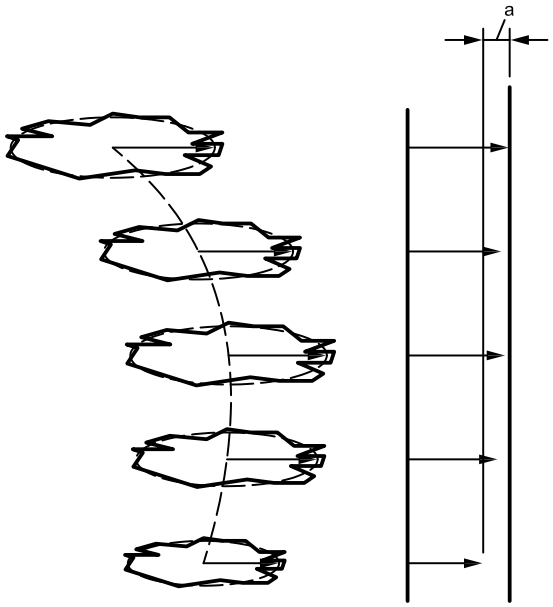
NOTE The cylinder taper is only defined for least squares reference cylinders.

3.5.2.6
local radii
radii of a reference circle associated to an extracted roundness profile whose cross-section is perpendicular to the axis of the least squares cylinder

3.5.2.7
cylinder radii peak-to-valley
largest local radii minus the smallest local radii

See Figure 4.

NOTE The reference circles are fitted to the extracted roundness profiles in accordance with ISO 12181-1.

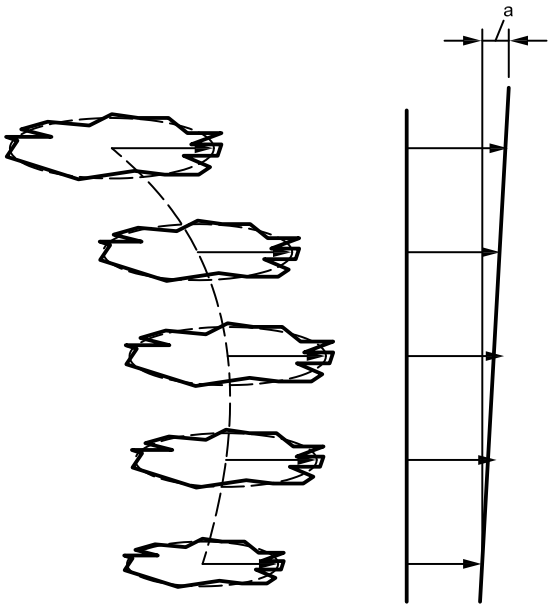


a Cylinder radii peak-to-valley (see Table C.2).

Figure 4 — Cylinder radii peak-to-valley

3.5.2.8
cylinder taper angle
angle obtained from the reference axis to an associated straight line through the local radii

See Figure 5.



a Cylinder taper angle (see Table C.2).

Figure 5 — Cylinder taper angle

4 Radial cross-section deviations

The radial cross-section profiles of the cylindrical feature are roundness profiles, and the radial cross-section form deviations are covered by ISO 12181-1 and ISO 12181-2.

5 Straightness deviations

The straightness deviations of the local generatrix profiles and the extracted median lines of the cylindrical features are covered by ISO 12780-1 and ISO 12780-2.

Annex A
(informative)

Mathematical definition of cylindricity tolerances of nominal integral features

A cylindricity 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, an axis is defined by a point, $\vec{L}$, and a unit direction, $\hat{N}$.

$d_i = \left| \hat{N} \times \left(\vec{P}_i - \vec{L} \right) \right|$ — Points, $\vec{P}_i$, are at a radial distance, d_i, from the axis.

$r_1 \leqslant d_i \leqslant r_2$ — Points, $\vec{P}_i$, are restricted to being between two coaxial cylinders of radius, r_1 and r_2, which are centred on the axis.

$t = r_2 - r_1 , r_2 > r_1$ — The difference in radius between the coaxial cylinders equals the cylindricity tolerance, t.

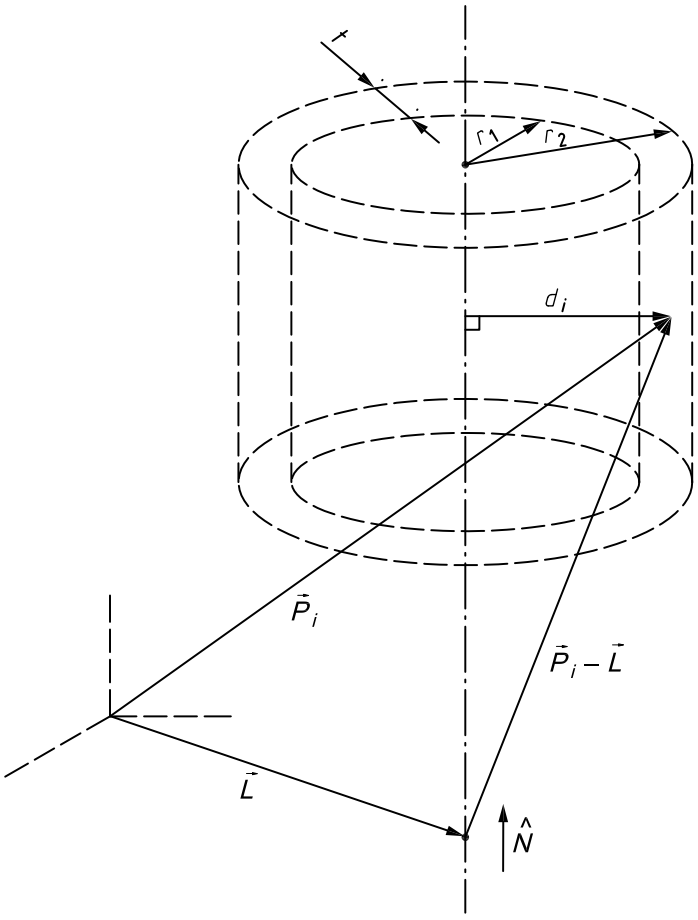


Figure A.1 — Cylindricity tolerance zone of a nominal integral feature

Annex B
(informative)

Consideration in the assessment of deviations from cylindrical form

Error analysis considers the actual deviation from cylindrical form as a combination of simple elements, each of which has a significance that can be related to defects or machining errors. These deviations may be classified in the following ways.

— Median line deviation [see Figure B.1 a)]: the deviation in a nominal cylindrical workpiece having an axis which is curved (in either planar or spatial modes), but whose cross-section is circular and of constant radius.

— Radial deviations, i.e. variations in cross-section dimension [see Figure B.1 b)]: the deviation in a nominal cylindrical workpiece having all the cross-sections circular and concentric to a straight axis, but whose diameters vary along the axis according to simple or complex laws or randomly (typical deviations include conical, barrel or more complex forms).

— Cross-section deviations [see Figure B.1 c)]: the deviation in a nominal cylindrical workpiece having cross-sections of the same size and form, but which are not round (the deviations from roundness of cross-sections arising from linear, rotary or combined translation).

Typical sources of these deviations, either singly or in combination, include

— transmitted errors of machine tool motions,

— distortion resulting from thermal, pressure or stress effects,

— tool wear, and

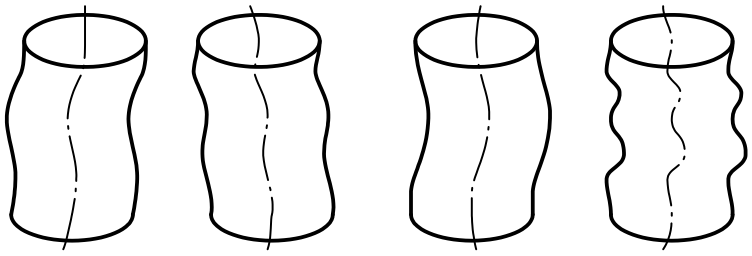
— vibration.

According to ISO 1101:

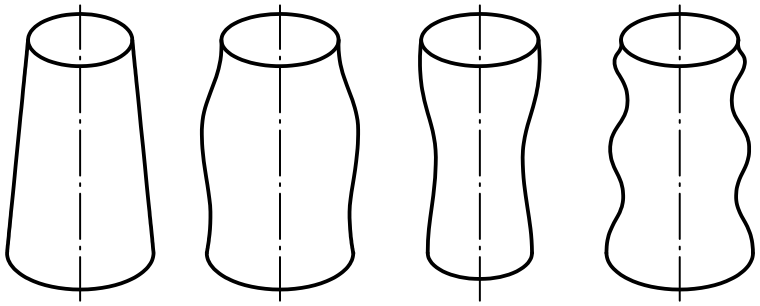
— median line deviation can be specified by the straightness of the median line;

— radial deviation can be specified by the parallelism of the generatrix profile relative to the cylinder axis as a datum line;

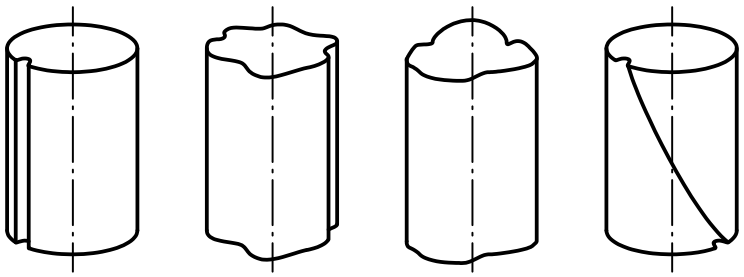
— cross-section deviations can be specified by roundness of the cross-sections.



a) Median line deviations



b) Radial deviations



c) Cross-section deviations

Figure B.1 — Deviations from cylindrical form

Annex C
(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 this part of ISO 12180, ISO 12181-1, ISO 12780-1 and 12781-1, which are recommended for use in those situations.

Table C.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 C.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 D
(informative)

Relationship to the GPS matrix model

D.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 12180 is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this part of ISO 12180 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 12180, unless otherwise indicated.

D.2 Information about this part of ISO 12180 and its use

This part of ISO 12180 defines terms and concepts necessary for defining the specification operators according to ISO 17450-2 for cylindricity of integral features.

D.3 Position in the GPS matrix model

This part of ISO 12180 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 D.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 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						
	Roughness profile						
	Datums						
	Roughness profile						
	Waviness profile						
	Primary profile						
	Surface defects						
	Edges						

Figure D.1 — Position in the GPS matrix model

D.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Figure D.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 12180-2, *Geometrical product specifications (GPS) — Cylindricity — Part 2: Specification operators*

[4] ISO 12181-2, *Geometrical product specifications (GPS) — Roundness — Part 2: Specification operators*

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

[6] ISO 12781-1:2011, *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*

ICS 01.040.17; 17.040.20

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