INTERNATIONAL STANDARD

ISO 1101

Third edition
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Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out

Spécification géométrique des produits (GPS) — Tolérancement géométrique — Tolérancement de forme, orientation, position et battement

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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 1101 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This third edition cancels and replaces the second edition (ISO 1101:2004) and ISO 10578:1992. Representations of specifications in the form of a 3D model have been added.

Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain links 1, 2 and 3 of the chain of standards on form, orientation, location and run out, and chain link 1 of the chain of standards on datums.

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. The default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise stated.

For more detailed information on the relation of this International Standard to the GPS matrix model, see Annex D.

This International Standard represents the initial basis and describes the required fundamentals for geometrical tolerancing. Nevertheless, it is advisable to consult the separate standards referenced in Clause 2 and in Table 2 for more detailed information.

For the presentation of lettering (proportions and dimensions), see ISO 3098-2.

All figures in this International Standard for the 2D drawing indications have been drawn in first-angle projection with dimensions and tolerances in millimetres. It should be understood that third-angle projection and other units of measurement could have been used equally well without prejudice to the principles established. For all figures giving tolerancing examples in 3D, the dimensions and tolerances are the same as for the similar figures shown in 2D.

The figures in this International Standard illustrate the text and are not intended to reflect an actual application. Consequently, the figures are not fully dimensioned and toleranced, showing only the relevant general principles. Neither are the figures intended to imply a particular display requirement in terms of whether hidden detail, tangent lines or other annotations are shown or not shown. Many figures have lines or details removed for clarity, or added or extended to assist with the illustration of the text.

For a definitive presentation (proportions and dimensions) of the symbolization for geometrical tolerancing, see ISO 7083.

Annex A of this International Standard has been provided for information only. It presents previous drawing indications that have been omitted here and are no longer used.

It needs to be noted that the former use of the term “circularity” has been changed to the term “roundness” for reasons of consistency with other standards.

Definitions of features are taken from ISO 14660-1 and ISO 14660-2, which provide new terms different from those used in previous edition of this International Standard. The former terms are indicated in the text following the new terms, between parentheses.

For the purposes of this International Standard, the terms “axis” and “median plane” are used for derived features of perfect form, and the terms “median line” and “median surface” for derived features of imperfect form. Furthermore, the following line types have been used in the explanatory illustrations, i.e. those representing non-technical drawings for which the rules of ISO 128 (all parts) apply.

Feature level	Feature type	Details	Line type	
			Visible	Behind plane/surface
Nominal feature (ideal feature)	integral feature	point line/axis surface/plane	wide continuous	narrow dashed
	derived feature	point line/axis face/plane	narrow long dashed dotted	narrow dashed dotted
Real feature	integral feature	surface	wide freehand continuous	narrow freehand dashed
Extracted feature	integral surface	point line surface	wide short dashed	narrow short dashed
	derived feature	point line face	wide dotted	narrow dotted
Associated feature	integral feature	point straight line ideal feature	wide doubled-dashed double-dotted	narrow double-dashed double-dotted
	derived feature	point straight line plane	narrow long dashed double-dotted	wide dashed double-dotted
	datum	point line surface/plane	wide long dashed double-short dashed	narrow long dashed double-short dashed
Tolerance zone limits, tolerances planes		line surface	continuous narrow	narrow dashed
Section, illustration plane, drawing plane, aid plane		line surface	narrow long dashed short dashed	narrow dashed short dashed
Extension, dimension, leader and reference lines		line	continuous narrow	narrow dashed

Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out

IMPORTANT — The illustrations included in this International Standard are intended to illustrate the text and/or to provide examples of the related technical drawing specification; these illustrations are not fully dimensioned and toleranced, showing only the relevant general principles.

As a consequence, the illustrations are not a representation of a complete workpiece, and are not of a quality that is required for use in industry (in terms of full conformity with the standards prepared by ISO/TC 10 and ISO/TC 213), and as such are not suitable for projection for teaching purposes.

1 Scope

This International Standard contains basic information and gives requirements for the geometrical tolerancing of workpieces.

It represents the initial basis and defines the fundamentals for geometrical tolerancing.

NOTE Other International Standards referenced in Clause 2 and in Table 2 provide more detailed information on geometrical tolerancing.

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 128-24:1999, *Technical drawings — General principles of presentation — Part 24: Lines on mechanical engineering drawings*

ISO 1660:1987, *Technical drawings — Dimensioning and tolerancing of profiles*

ISO 2692:2006, *Geometrical product specifications (GPS) — Geometrical tolerancing — Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)*

ISO 5458:1998, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Positional tolerancing*

ISO 5459:2011, *Geometrical product specifications (GPS) — Geometrical tolerancing — Datums and datum systems*

ISO 8015:2011, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

ISO 10579:2010, *Geometrical product specifications (GPS) — Dimensioning and tolerancing — Non-rigid parts*

ISO 12180-1:2011, *Geometrical product specifications (GPS) — Cylindricity — Part 1: Vocabulary and parameters of cylindrical form*

ISO 12180-2:2011, *Geometrical product specifications (GPS) — Cylindricity — Part 2: Specification operators*

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

ISO 12181-2:2011, *Geometrical product specifications (GPS) — Roundness — Part 2: Specification operators*

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

ISO 12780-2:2011, *Geometrical product specifications (GPS) — Straightness — Part 2: Specification operators*

ISO 12781-1:2011, *Geometrical product specifications (GPS) — Flatness — Part 1: Vocabulary and parameters of flatness*

ISO 12781-2:2011, *Geometrical product specifications (GPS) — Flatness — 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 17450-2:—[1], *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14660-1 and ISO 14660-2 and the following apply.

3.1
tolerance zone
space limited by one or several geometrically perfect lines or surfaces, and characterized by a linear dimension, called a tolerance

NOTE See also 4.4.

3.2
intersection plane
plane, established from an extracted feature of the workpiece, identifying a line on an extracted surface (integral or median) or a point on an extracted line

NOTE The use of intersection planes makes it possible to define toleranced features independent of the view.

3.3
orientation plane
plane, established from an extracted feature of the workpiece, identifying the orientation of the tolerance zone

NOTE 1 For a derived feature, the use of an orientation plane makes it possible to define the direction of the width of the tolerance zone independent of the TEDs (case of location) or of the datum (case of orientation).

NOTE 2 The orientation plane is only used when the toleranced feature is a median feature (centre point, median straight line) and the tolerance zone is defined by two parallel straight lines or two parallel planes.

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1 To be published. (Revision of ISO/TS 17450-2:2002)

3.4
direction feature
feature, established from an extracted feature of the workpiece, identifying the direction of the width of the tolerance zone

NOTE 1 The direction feature can be a plane, a cylinder or a cone.

NOTE 2 For a line in a surface, the use of a direction feature makes it possible to change the direction of the width of the tolerance zone.

NOTE 3 The direction feature is used on a complex surface or a complex profile when the direction of the tolerance value is not normal to the specified geometry.

NOTE 4 By default, the direction feature is a cone, a cylinder or a plane constructed from the datum or datum system indicated in the second compartment of the direction feature indicator. The geometry of the direction feature depends on the geometry of the toleranced feature.

3.5
compound contiguous feature
feature composed of several single features joined together without gaps

NOTE 1 A compound contiguous feature can be closed or not.

NOTE 2 A non-closed compound contiguous feature can be defined by the way of using the “between” symbol (see 10.1.4).

NOTE 3 A closed compound contiguous feature can be defined by the way of using the “all around” symbol (see 10.1.2). In this case, it is a set of single features whose intersection with any plane parallel to a collection plane is a line or a point.

3.6
collection plane
plane, established from a nominal feature on the workpiece, defining a closed compound contiguous feature

NOTE The collection plane may be required when the “all around” symbol is applied.

3.7
theoretically exact dimension
TED
dimension indicated on technical product documentation, which is not affected by an individual or general tolerance

NOTE 1 For the purpose of this International Standard, the term “theoretically exact dimension” has been abbreviated TED.

NOTE 2 A theoretically exact dimension is a dimension used in operations (e.g. association, partition, collection, …).

NOTE 3 A theoretically exact dimension can be a linear dimension or an angular dimension.

NOTE 4 A TED can define

— the extension or the relative location of a portion of one feature,

— the length of the projection of a feature,

— the theoretical orientation or location from one or more features, or

— the nominal shape of a feature.

NOTE 5 A TED is indicated by a rectangular frame including a value.

4 Basic concepts

4.1 Geometrical tolerances shall be specified in accordance with functional requirements. Manufacturing and inspection requirements can also influence geometrical tolerancing.

NOTE Indicating geometrical tolerances does not necessarily imply the use of any particular method of production, measurement or gauging.

4.2 A geometrical tolerance applied to a feature defines the tolerance zone within which that feature shall be contained.

4.3 A feature is a specific portion of the workpiece, such as a point, a line or a surface; these features can be integral features (e.g. the external surface of a cylinder) or derived (e.g. a median line or median surface). See ISO 14660-1.

4.4 According to the characteristic to be toleranced and the manner in which it is dimensioned, the tolerance zone is one of the following:

— the space within a circle;

— the space between two concentric circles;

— the space between two equidistant lines or two parallel straight lines;

— the space within a cylinder;

— the space between two coaxial cylinders;

— the space between two equidistant surfaces or two parallel planes;

— the space within a sphere.

4.5 Unless a more restrictive indication is required, for example by an explanatory note (see Figure 8), the toleranced feature may be of any form or orientation within this tolerance zone.

4.6 The tolerance applies to the whole extent of the considered feature unless otherwise specified as in Clauses 12 and 13.

4.7 Geometrical tolerances which are assigned to features related to a datum do not limit the form deviations of the datum feature itself. It may be necessary to specify tolerances of form for the datum feature(s).

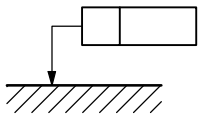
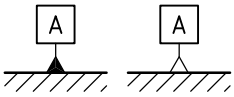
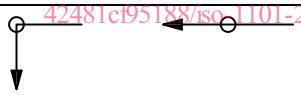
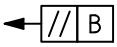
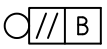
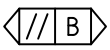
5 Symbols

See Tables 1 and 2.

Table 1 — Symbols for geometrical characteristics

Tolerances	Characteristics	Symbol	Datum needed	Subclause
Form	Straightness	—	no	18.1
	Flatness	▱	no	18.2
	Roundness	○	no	18.3
	Cylindricity	⌭	no	18.4
	Profile any line	⌒	no	18.5
	Profile any surface	⌓	no	18.7
Orientation	Parallelism	//	yes	18.9
	Perpendicularity	⊥	yes	18.10
	Angularity	∠	yes	18.11
	Profile any line	⌒	yes	
	Profile any surface	⌓	yes	
Location	Position	⌖	yes or no	18.12
	Concentricity (for centre points)	◎	yes	18.13
	Coaxiality (for axes)	◎	yes	18.13
	Symmetry	⌯	yes	18.14
	Profile any line	⌒	yes	18.6
	Profile any surface	⌓	yes	18.8
Run-out	Circular run-out	↗	yes	18.15
	Total run-out	⌰	yes	18.16

Table 2 — Additional symbols

Description	Symbol	Reference
Toleranced feature indication		Clause 7
Datum feature indication		Clause 9 and ISO 5459
Datum target indication		ISO 5459
Theoretically exact dimension	50	Clause 11
Median feature	Ⓐ	Clause 7
Unequally disposed tolerance zone	UZ	Subclause 10.2
Between	◄►	Subclause 10.1.4
From … to	→	Subclause 10.1.4
Projected tolerance zone	Ⓟ	Clause 13
Maximum material requirement	Ⓜ	Clause 14 and ISO 2692
Least material requirement	Ⓛ	Clause 15 and ISO 2692
Free state condition (non-rigid parts)	Ⓕ	Clause 16 and ISO 10579
All around (profile)		Subclause 10.1
Envelope requirement	Ⓔ	ISO 8015
Common zone	CZ	Subclause 8.5
Minor diameter	LD	Subclause 10.2
Major diameter	MD	Subclause 10.2
Pitch diameter	PD	Subclause 10.2
Line element	LE	Subclause 18.9.4
Not convex	NC	Subclause 6.3
Any cross-section	ACS	Subclause 18.13.1
Direction feature		Subclause 8.1
Collection plane		Subclause 10.1.2
Intersection plane		Clause 16
Orientation plane		Clause 17

6 Tolerance frame

6.1 The requirements are shown in a rectangular frame which is divided into two or more compartments. These compartments contain, from left to right, in the following order (see the examples in Figures 1, 2, 3, 4 and 5):

— first compartment: the symbol for the geometrical characteristic;

— second compartment: the width of the tolerance zone in the unit used for linear dimensions and complementary requirements (see Clauses 7, 8, 10, and 12 to 16). If the tolerance zone is circular or cylindrical, the value is preceded by the symbol "⌀". If the tolerance zone is spherical, the value is preceded by "S⌀";

— third and subsequent compartment, if applicable: the letter or letters identifying the datum or common datum or datum system (see the examples in Figures 2, 3, 4 and 5).

Figure 1

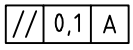


Figure 2

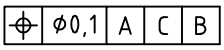


Figure 3

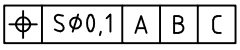


Figure 4

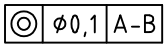


Figure 5

6.2 When a tolerance applies to more than one feature this shall be indicated above the tolerance frame by the number of features followed by the symbol "×" (see the examples in Figures 6 and 7).

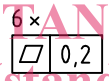


Figure 6

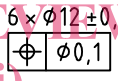


Figure 7

6.3 If required, indications qualifying the form of the feature within the tolerance zone shall be written near the tolerance frame (see the example in Figure 8).

NOTE See also Table 2.

Figure 8

6.4 If it is necessary to specify more than one geometrical characteristic for a feature, the requirements may be given in tolerance frames one under the other for convenience (see the example in Figure 9).

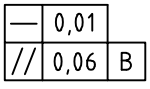


Figure 9

6.5 If required, indications qualifying the direction of the tolerance zone or the extracted (actual) line or both shall be written after the tolerance frame, e.g. use of intersection plane to indicate the direction of the toleranced feature (see Clause 7), use of the orientation plane to indicate the orientation of the tolerance zone, use of the direction feature to indicate the direction of the width of the tolerance zone (see Clause 8).

7 Toleranced features

A geometrical specification applies to a single complete feature, unless an appropriate modifier is indicated. When the toleranced feature is not a single complete feature, see Clause 10.

When the geometrical specification **refers to the feature itself** (integral feature), the tolerance frame shall be connected to the toleranced feature by a leader line starting from either end of the frame and terminating in one of the following ways:

— In *2D annotation*, on the outline of the feature or an extension of the outline (but clearly separated from the dimension line) (see Figures 10 and 11). The termination of the leader line is

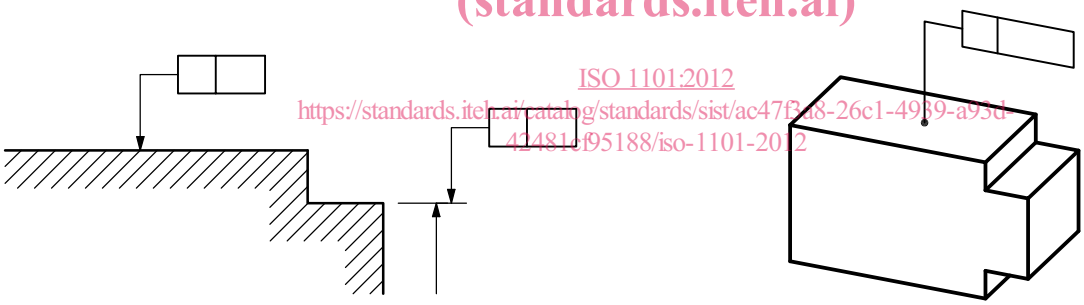
  — an arrow if it terminates on a drawn line, or

  — a dot (filled or unfilled) when the indicated feature is an integral feature and the leader line terminates within the bounds of the feature.

The arrowhead may be placed on a reference line using a leader line to point to the surface (see Figure 12).

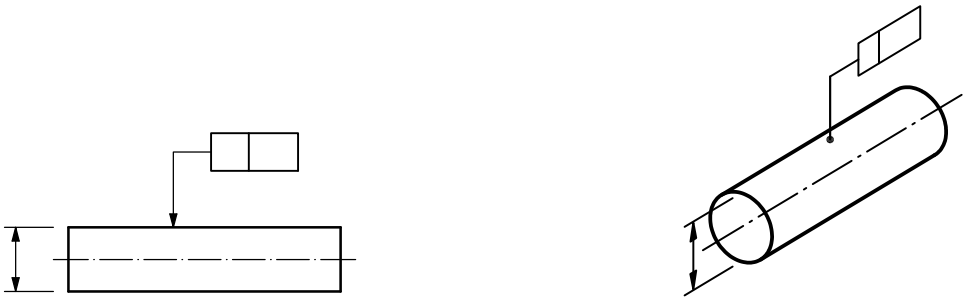
— In *3D annotation*, on the feature itself [see Figures 10 b) and 11 b)]. The termination of the leader line is a dot. When the surface is visible, the dot is filled out; when the surface is hidden the dot is not filled out and the leader line is a dashed line.

  The termination of the leader line may be an arrow placed on a reference line using a leader line to point to the surface [see Figure 12 b)]. The above rules for the dot terminating the leader line also apply in this case.



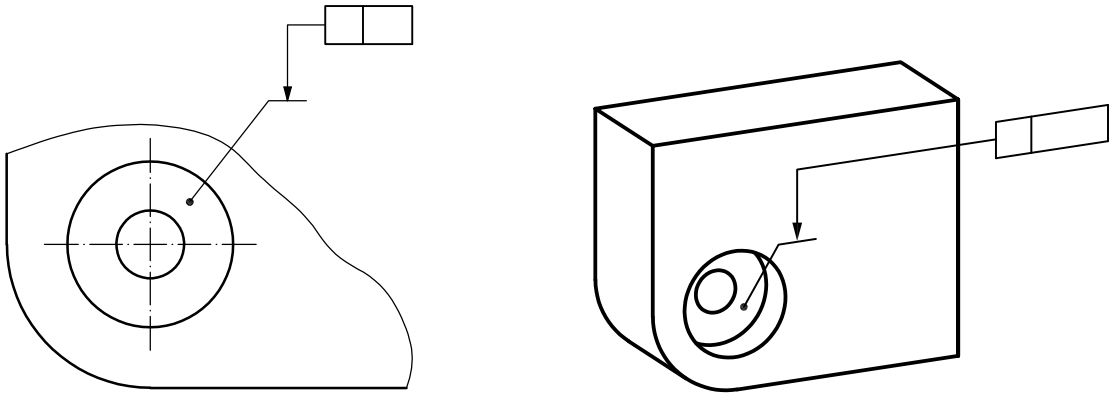
a) 2D **b) 3D**

Figure 10



a) 2D **b) 3D**

Figure 11



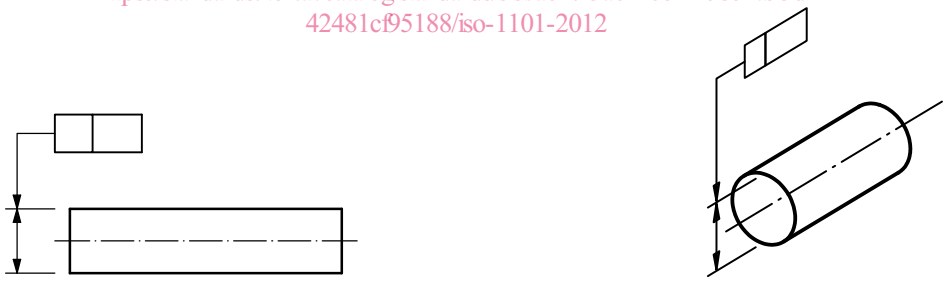
a) 2D b) 3D

Figure 12

When the tolerance refers to a median line, a median surface, or a median point (derived feature), it is indicated either

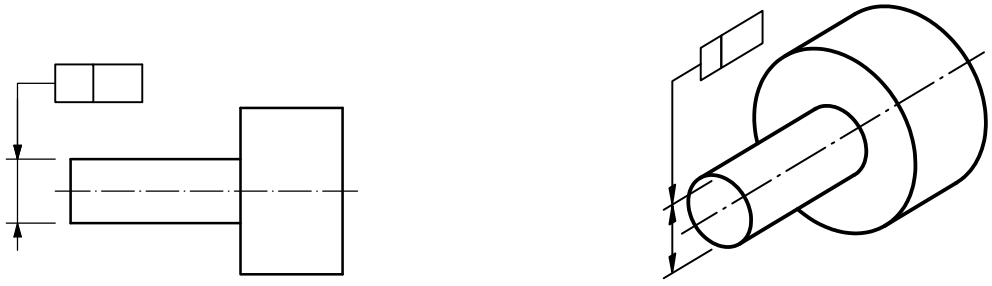
— by the leader line starting from either end of the tolerance frame terminated by an arrow on the extension of the dimension line of a feature of size [see the examples in Figures 13 a), 13 b), 14 a), 14 b), 15 a) and 15 b)], or

— by a modifier Ⓐ (median feature) placed at the rightmost end of the second compartment of the tolerance frame from the left. In this case, the leader line starting from either end of the tolerance frame does not have to terminate on the dimension line, but can terminate with an arrow on the outline of the feature [see Figures 16 a) and 16 b)].



a) 2D b) 3D

Figure 13



a) 2D b) 3D

Figure 14