INTERNATIONAL STANDARD

ISO 1101

Second edition
2004-12-15

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

Reference number
ISO 1101:2004(E)

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Printed in Switzerland

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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 second edition cancels and replaces the first edition (ISO 1101:1983), which has been technically revised.

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 and 2 of the chain of standards on form, orientation, location and run out, and chain link 1 of the chain of standards on datums.

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

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.

In the interest of uniformity, all figures in this International Standard 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.

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.

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.

This and future editions of ISO 1101 will be revised to include improved illustrations whenever new amendments for ISO 1101 have reached the stage of publication.

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:—[1)], *Geometrical Product Specification (GPS) — Geometrical tolerancing — Maximum material requirement (MMR) and least material requirement (LMR)*

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

ISO 5459:1981, *Technical drawings — Geometrical tolerancing — Datums and datum-systems for geometrical tolerances*

1) To be published. (Revision of ISO 2692:1988)

ISO 8015:1985, *Technical drawings — Fundamental tolerancing principle*

ISO 10578:1992, *Technical drawings — Tolerancing of orientation and location — Projected tolerance zone*

ISO 10579:1993, *Technical drawings — Dimensioning and tolerancing — Non-rigid parts*

ISO/TS 12180-1:2003, *Geometrical Product Specifications (GPS) — Cylindricity — Part 1: Vocabulary and parameters of cylindrical form*

ISO/TS 12180-2:2003, *Geometrical Product Specifications (GPS) — Cylindricity — Part 2: Specification operators*

ISO/TS 12181-1:2003, *Geometrical Product Specifications (GPS) — Roundness — Part 1: Vocabulary and parameters of roundness*

ISO/TS 12181-2:2003, *Geometrical Product Specifications (GPS) — Roundness — Part 2: Specification operators*

ISO/TS 12780-1:2003, *Geometrical Product Specifications (GPS) — Straightness — Part 1: Vocabulary and parameters of straightness*

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

ISO/TS 12781-1:2003, *Geometrical Product Specifications (GPS) — Flatness — Part 1: Vocabulary and parameters of flatness*

ISO/TS 12781-2:2003, *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/TS 17450-2:2002, *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.

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 on a drawing 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).

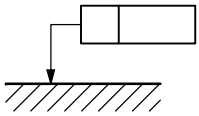
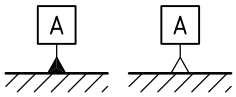
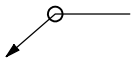
5 Symbols

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	18.6
	Profile any surface	⌓	yes	18.8
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		Clause 11
Projected tolerance zone	Ⓟ	Clause 13 and ISO 10578
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

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 examples of Figures 1, 2, 3, 4 and 5):

— the symbol for the geometrical characteristic;

— the tolerance value in the unit used for linear dimensions. This value is preceded by the symbol "⌀" if the tolerance zone is circular or cylindrical; or by "S⌀" if the tolerance zone is spherical;

— if applicable, the letter or letters identifying the datum or common datum or datum system (see examples of Figures 2, 3, 4 and 5).

Figure 1

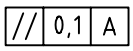


Figure 2

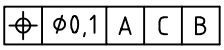


Figure 3

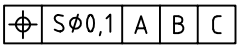


Figure 4

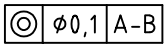


Figure 5

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 examples of Figures 6 and 7).

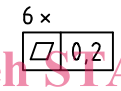


Figure 6

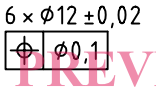


Figure 7

6.3 If required, indications qualifying the form of the feature within the tolerance zone shall be written near the tolerance frame (see example of 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 example of Figure 9).

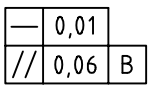


Figure 9

7 Toleranced features

The tolerance frame shall be connected to the toleranced feature by a leader line starting from either side of the frame and terminating with an arrowhead in one of the following ways:

— on the outline of the feature or an extension of the outline (but clearly separated from the dimension line) when the tolerance refers to the line or surface itself (see examples of Figures 10 and 11); the arrowhead may be placed on a reference line using a leader line to point to the surface (see example of Figure 12);

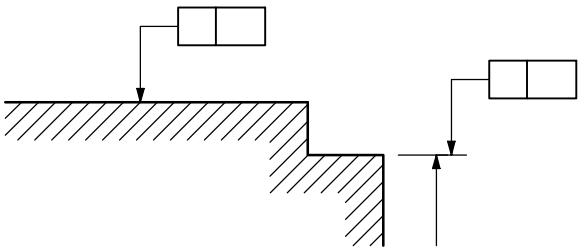


Figure 10

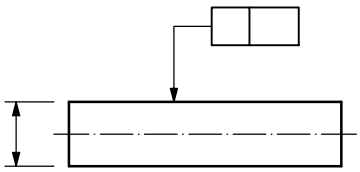


Figure 11

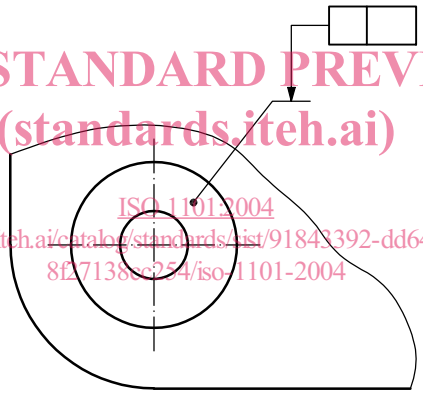


Figure 12

— as an extension of the dimension line when the tolerance refers to the median line or median surface or a point defined by the feature so dimensioned (see examples of Figures 13, 14 and 15).

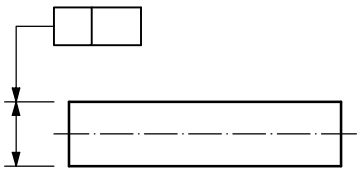


Figure 13

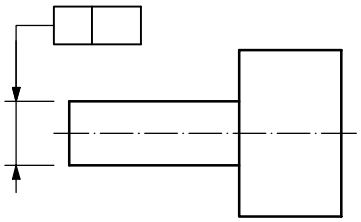


Figure 14

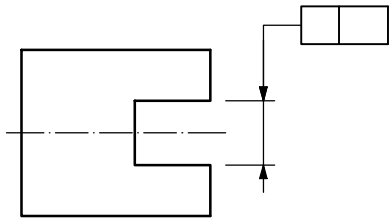


Figure 15

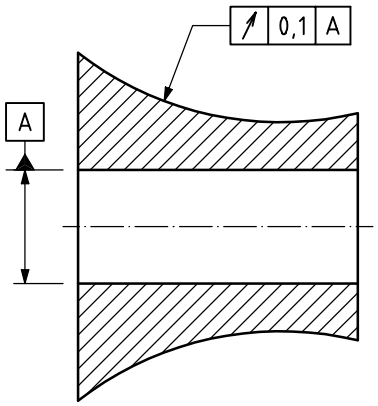
If needed, an indication specifying the form of the feature (line instead of a surface) shall be written near the tolerance frame (see Figures 88 and 89).

NOTE When the toleranced feature is a line, a further indication might be needed to control the orientation, see Figure 89.

8 Tolerance zones

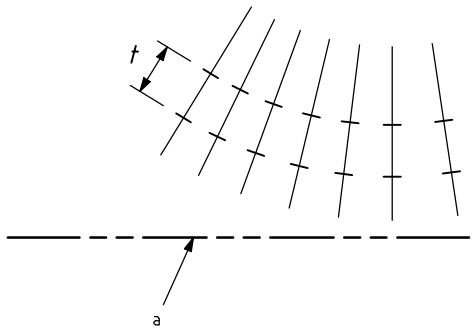
8.1 The width of the tolerance zone applies normal to the specified geometry (see examples of Figures 16 and 17) unless otherwise indicated (see examples of Figures 18 and 19).

NOTE The orientation alone of the leader line does not influence the definition of the tolerance.



Drawning indication

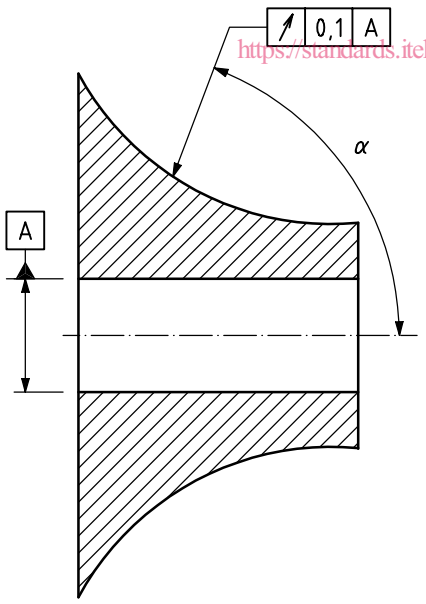
Figure 16



a Datum A.

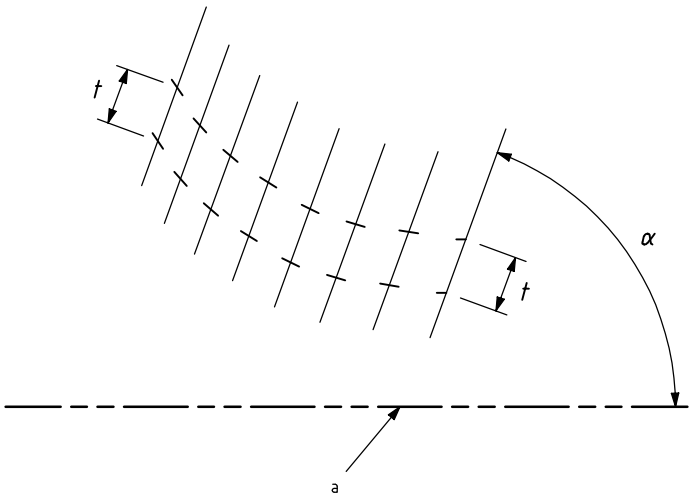
Interpretation

Figure 17



Drawning indication

Figure 18



a Datum A.

Interpretation

Figure 19

The angle α shown in Figure 18 shall be indicated, even if it is equal to 90°.

In the case of roundness, the width of the tolerance zone always applies in a plane perpendicular to the nominal axis.

8.2 In the case of a centre point or median line or median surface toleranced in one direction:

— the orientation of the width of a positional tolerance zone is based on the pattern of the theoretically exact dimensions (TED) and is at 0° or 90° as indicated by the direction of the arrowhead of the leader line unless otherwise indicated (see example of Figure 20);

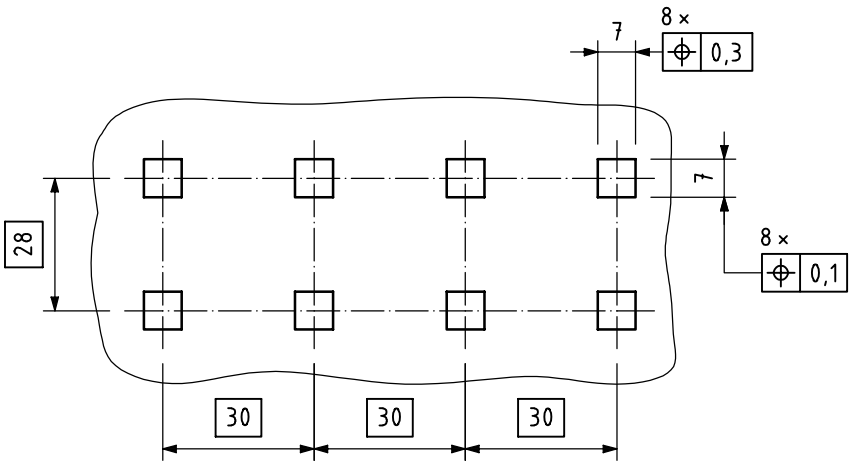
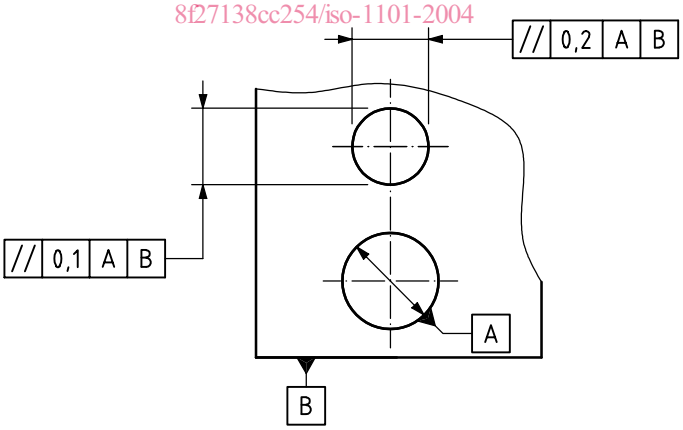


Figure 20

— the orientation of the width of an orientation tolerance zone is at 0° or 90° relative to the datum as indicated by the direction of the arrowhead of the leader line unless otherwise indicated (see examples of Figures 21 and 22);

— when two tolerances are stated, they shall be perpendicular to each other unless otherwise specified (see examples of Figures 21 and 22).



Drawning indication

Figure 21