INTERNATIONAL STANDARD

ISO 1101

Second 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

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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).

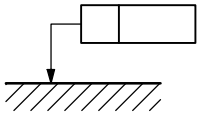
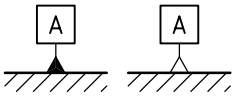
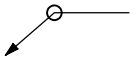
5 Symbols

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	50	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

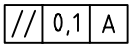


Figure 2

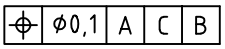


Figure 3

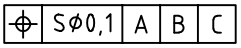


Figure 4

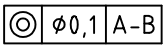


Figure 5

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).

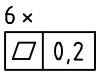


Figure 6

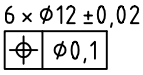


Figure 7

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).

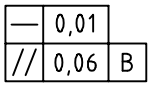


Figure 9

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);

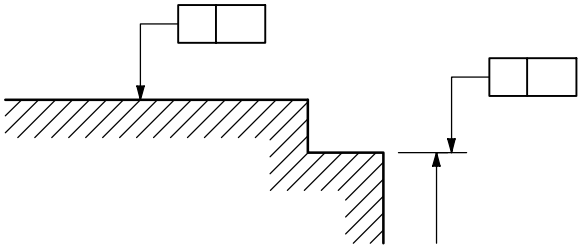


Figure 10

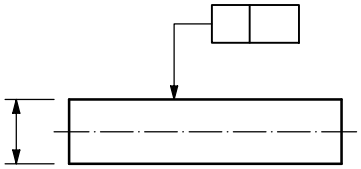


Figure 11

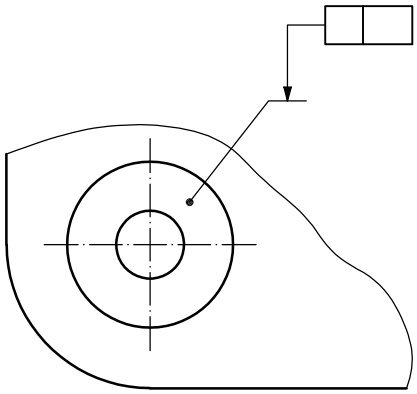


Figure 12

— 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).

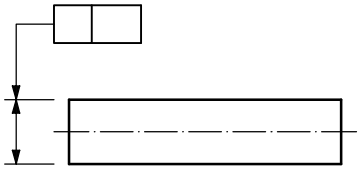


Figure 13

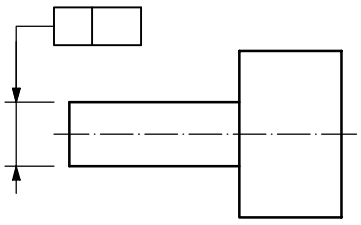


Figure 14

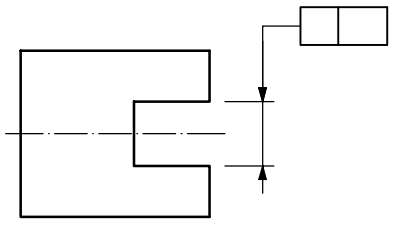


Figure 15

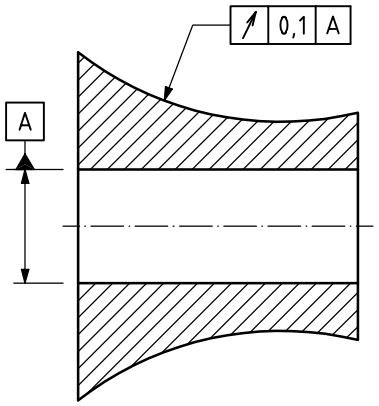
If needed, an indication specifying the form of the feature (line instead of a surface) shall be written near the tolerance frame (see Figures 88 and 89).

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

8 Tolerance zones

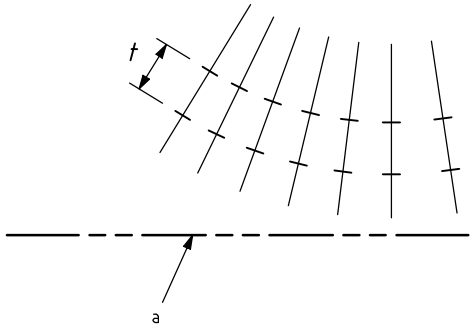
8.1 The width of the tolerance zone applies normal to the specified geometry (see examples of Figures 16 and 17) unless otherwise indicated (see examples of Figures 18 and 19).

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



Drawning indication

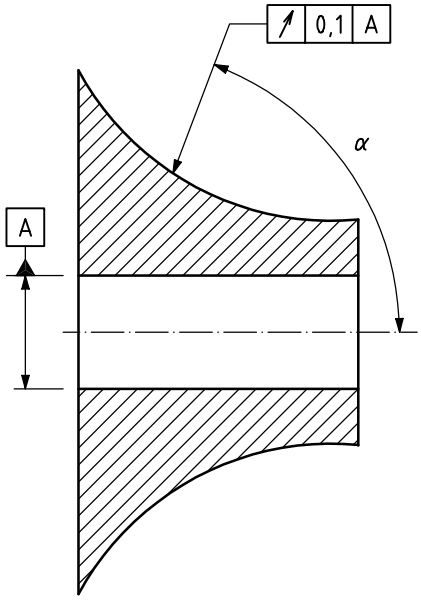
Figure 16



a Datum A.

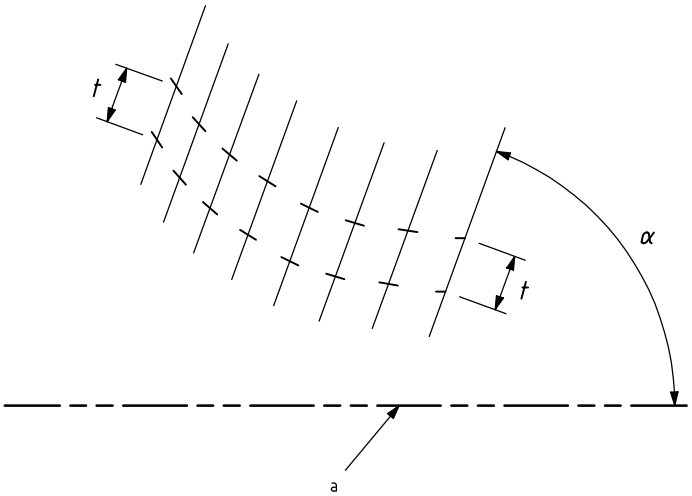
Interpretation

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);

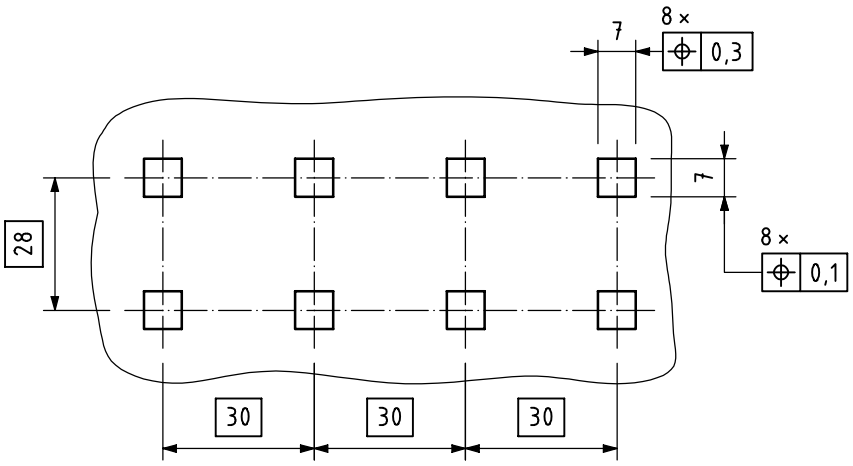
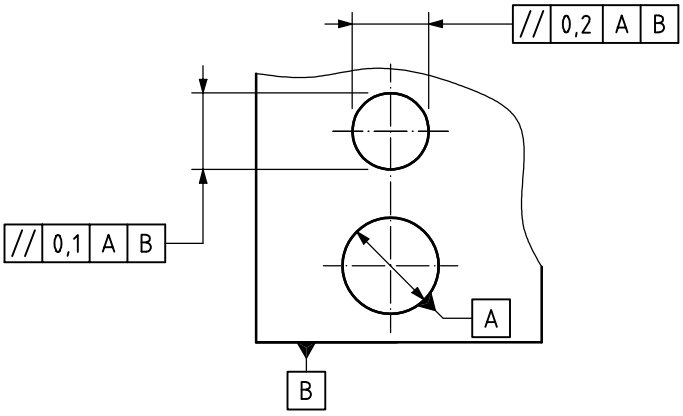


Figure 20

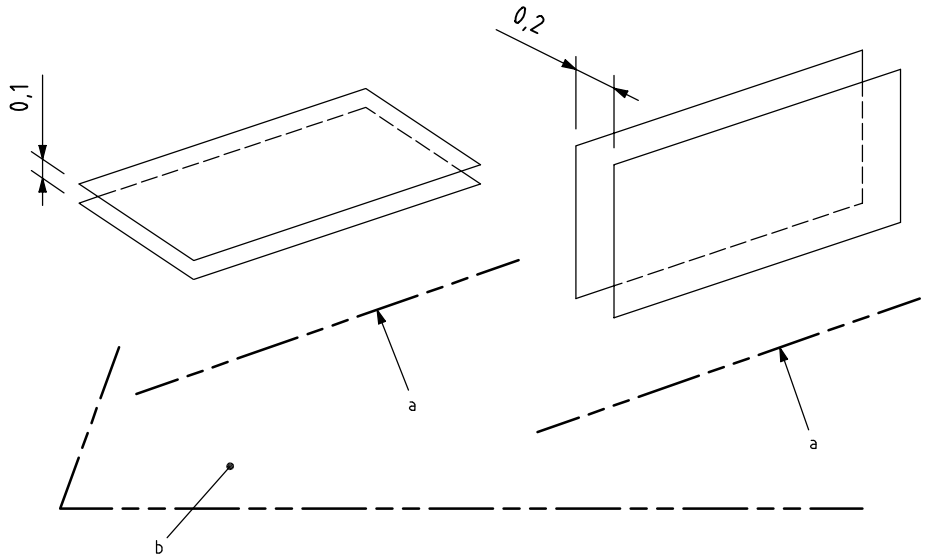
— the orientation of the width of an orientation tolerance zone is at 0° or 90° relative to the datum as indicated by the direction of the arrowhead of the leader line unless otherwise indicated (see examples of Figures 21 and 22);

— 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



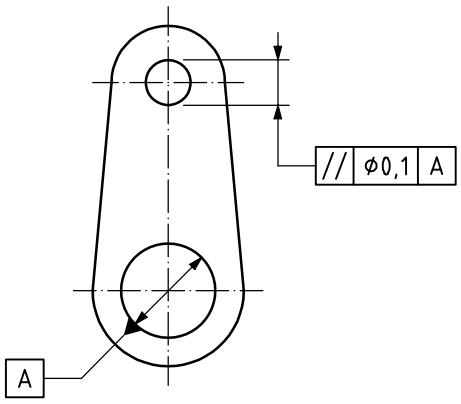
a) Tolerance 0,1 b) Tolerance 0,2

[a] Datum A
[b] Datum B

Interpretation

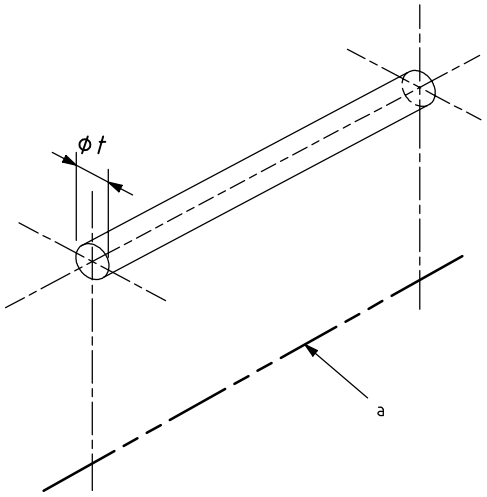
Figure 22

8.3 The tolerance zone is cylindrical (see examples of Figures 23 and 24) or circular if the tolerance value is preceded by the symbol "⌀" or spherical if it is preceded by the symbol "S⌀".



Drawning indication

Figure 23



[a] Datum A.

Interpretation

Figure 24

8.4 Individual tolerance zones of the same value applied to several separate features may be specified (see example of Figure 25).

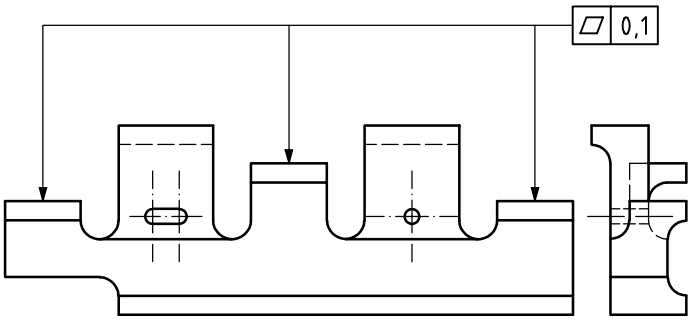


Figure 25

8.5 Where a single tolerance zone is applied to several separate features, the requirement shall be indicated by the symbol “CZ” for common zone following the tolerance in the tolerance frame (see example of Figure 26).

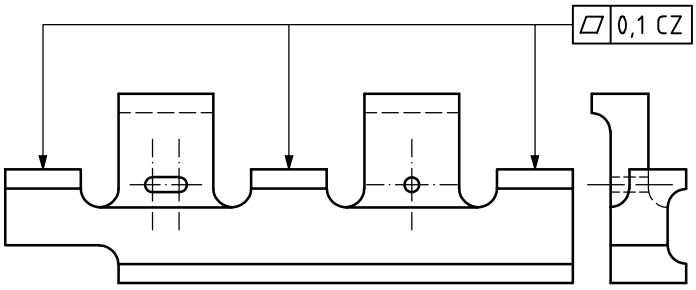


Figure 26

9 Datums

9.1 Datums shall be indicated as given in the examples in 9.2 to 9.5. For additional information see ISO 5459.

NOTE At the next revision of this International Standard, this clause will be moved to ISO 5459.

9.2 A datum related to a toleranced feature shall be designated by a datum letter. A capital letter shall be enclosed in a datum frame and connected to a filled or open datum triangle to identify the datum (see examples of Figures 27 and 28); the same letter which defines the datum shall also be indicated in the tolerance frame. There is no difference in the meaning between a filled and an open datum triangle.

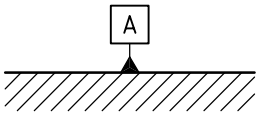


Figure 27

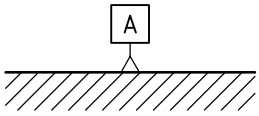


Figure 28

9.3 The datum triangle with the datum letter shall be placed:

— on the outline of the feature or an extension of the outline (but clearly separated from the dimension line), when the datum is the line or surface shown (see example of Figure 29); the datum triangle may be placed on a reference line using a leader line to point to the surface (see example of Figure 30);

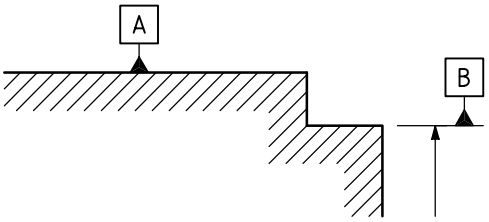


Figure 29

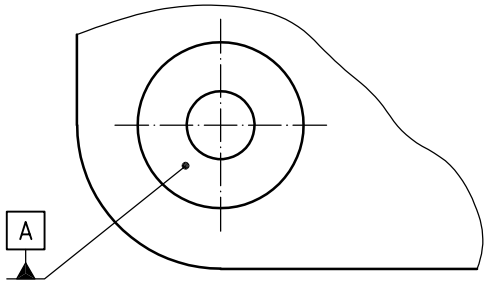


Figure 30

— as an extension of the dimension line when the datum is the axis or median plane or a point defined by the feature so dimensioned (see examples of Figures 31 to 33). If there is insufficient space for two arrowheads, one of them may be replaced by the datum triangle (see examples of Figures 32 and 33).

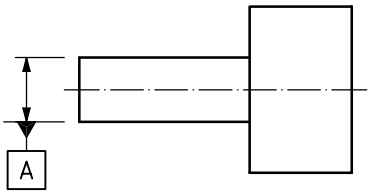


Figure 31

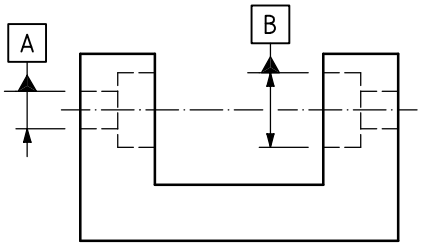


Figure 32

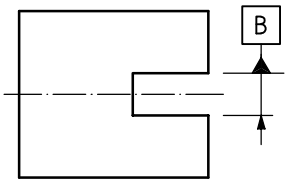


Figure 33

9.4 If a datum is applied to a restricted part of a feature only, this restriction shall be shown as a wide, long dashed-dotted line and dimensioned (see example of Figure 34). See ISO 128-24:1999, Table 2, 04.2.

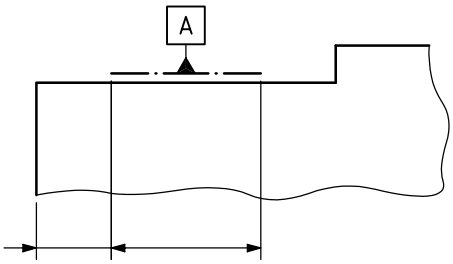


Figure 34

9.5 A datum established by a single feature is identified by a capital letter (see Figure 35).

A common datum established by two features is identified by two capital letters separated by a hyphen (see example of Figure 36).

Where a datum system is established by two or three features, i.e. multiple datums, the capital letters for identifying the datums are indicated in an order of priority, from left to right, in separate compartments (see example of Figure 37).

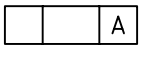


Figure 35

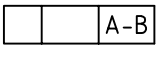


Figure 36

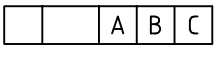


Figure 37

10 Supplementary indications

10.1 If a profile characteristic is applied to the entire outline of the cross-sections or if it is applied to the entire surface represented by the outline it shall be indicated using the symbol “all around” (see examples of Figures 38 and 39). The all-around symbol does not involve the entire workpiece, but only the surfaces represented by the outline and identified by the tolerance indication (see examples of Figures 38 and 39).

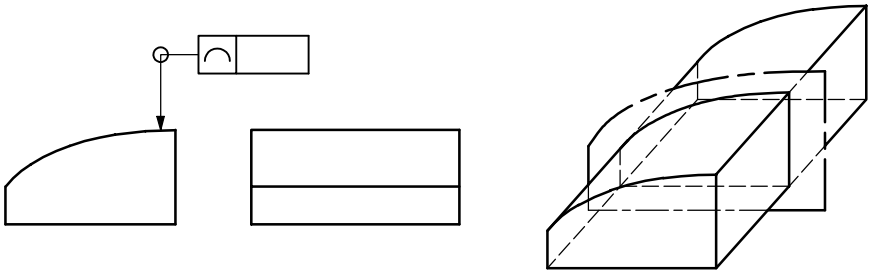
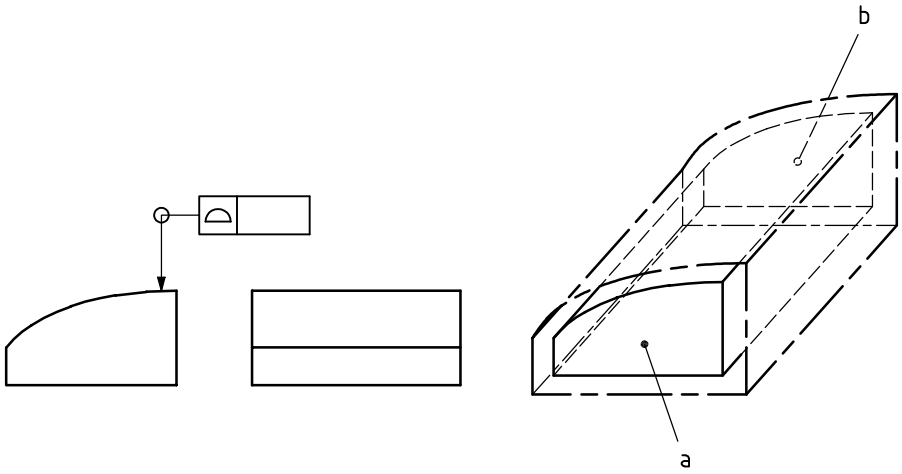


Figure 38



NOTE The long dashed short dashed line indicates the considered features. Surfaces a and b are not considered in the specification.

Figure 39

10.2 Tolerances and datums specified for screw threads apply to the axis derived from the pitch cylinder, unless otherwise specified, e.g. “MD” for major diameter and “LD” for minor diameter (see examples of Figures 40 and 41). Tolerances and datums specified for gears and splines shall designate the specific feature to which they apply, i.e. “PD” for pitch diameter, “MD” for major diameter or “LD” for minor diameter.

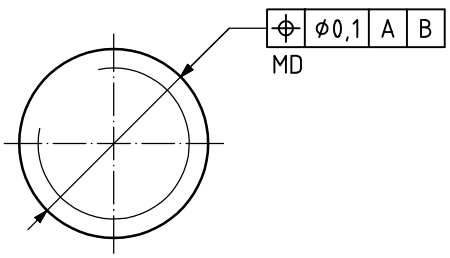


Figure 40

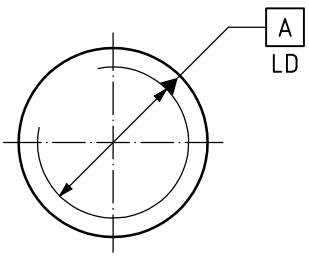


Figure 41

11 Theoretically exact dimensions (TED)

If tolerances of location, orientation or profile are prescribed for a feature or a group of features, the dimensions determining the theoretically exact location, orientation or profile respectively are called theoretically exact dimensions (TED).

TED also apply to the dimensions determining the relative orientation of the datums of a system.

TED shall not be toleranced. They are to be enclosed in a frame (see examples of Figures 42 and 43).

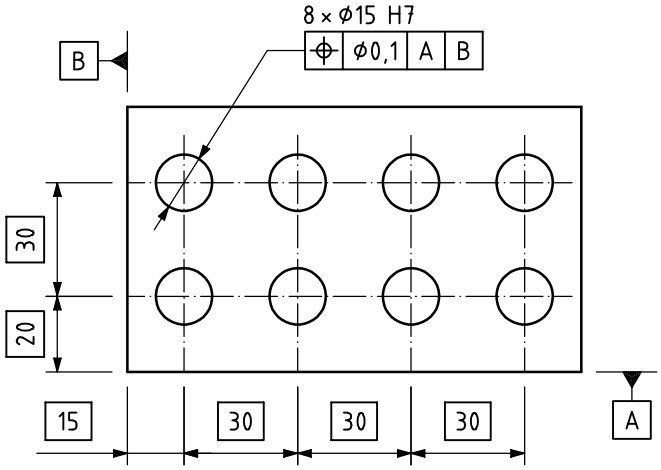


Figure 42

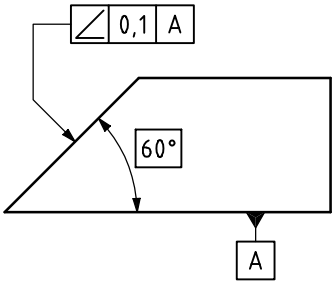


Figure 43

12 Restrictive specifications

12.1 If a tolerance of the same characteristic is applied to a restricted length, lying anywhere within the total extent of the feature, the value of the restricted length shall be added after the tolerance value and separated from it by an oblique stroke [see example of Figure 44 a)]. If two or more tolerances of the same characteristic are to be indicated, they may be combined as shown in Figure 44 b).

a) b)

Figure 44

12.2 If a tolerance is applied to a restricted part of a feature only, this restriction shall be shown as a wide, long dashed-dotted line and dimensioned (see examples of Figures 45 and 46).See ISO 128-24:1999, Table 2, 04.2.

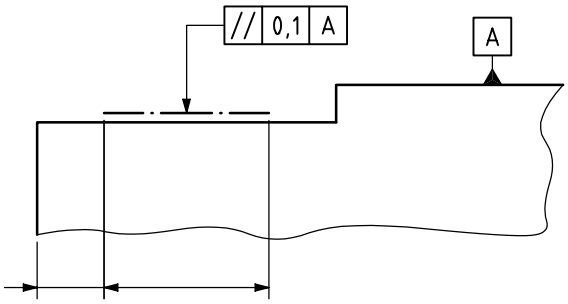


Figure 45

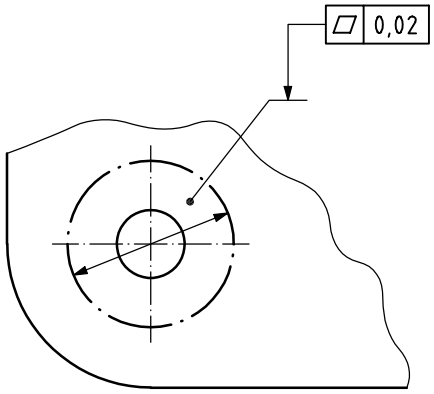


Figure 46

12.3 Restricted part of a datum (see 9.4).

12.4 Restrictions to the form of a feature within the tolerance zone are given in 6.3 and Clause 7.

13 Projected tolerance zone

Projected tolerance zones shall be indicated by the specification modifier symbol Ⓟ (see example of Figure 47). See ISO 10578 for additional information.

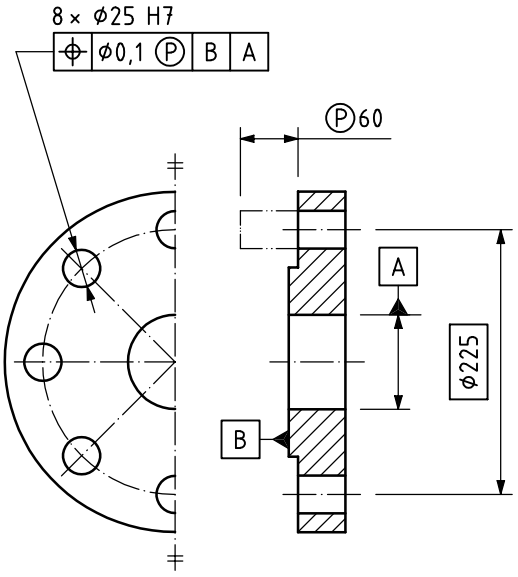


Figure 47

14 Maximum material requirement

The maximum material requirement shall be indicated by the specification modifier symbol Ⓜ. The symbol is placed after the specified tolerance value, datum letter or both as appropriate (see examples of Figures 48, 49 and 50). See ISO 2692 for detailed rules.

NOTE At the next revision of this International Standard, this clause will be moved to ISO 2692.

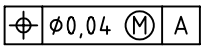


Figure 48

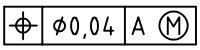


Figure 49

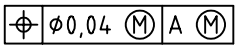


Figure 50

15 Least material requirement

The least material requirement shall be indicated by the specification modifier symbol Ⓛ. The symbol shall be placed after the specified tolerance value, datum letter or both as appropriate (see examples of Figures 51, 52 and 53). See ISO 2692 for additional information.

NOTE At the next revision of this International Standard, this clause will be moved to ISO 2692.

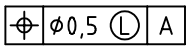


Figure 51

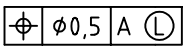


Figure 52

Figure 53

16 Free state condition

The free state condition for non-rigid parts shall be indicated by the specification modifier symbol Ⓕ placed after the specified tolerance value (see examples of Figures 54 and 55). See ISO 10579 for additional information.

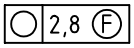


Figure 54

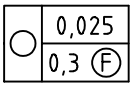


Figure 55

Several specification modifiers, Ⓟ, Ⓜ, Ⓛ, Ⓕ and CZ, may be used simultaneously in the same tolerance frame (see example of Figure 56).

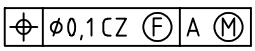


Figure 56

17 Interrelationship of geometrical tolerances

For functional reasons, one or more characteristics can be toleranced to define the geometrical deviations of a feature. Certain types of tolerances, which limit the geometrical deviations of a feature, can also limit other types of deviations for the same feature.

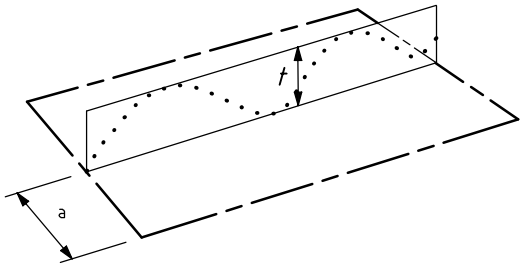
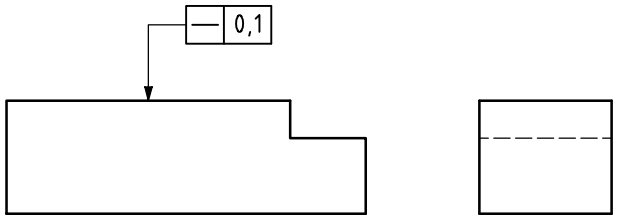
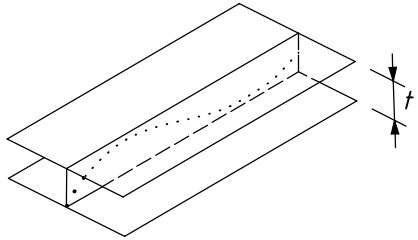
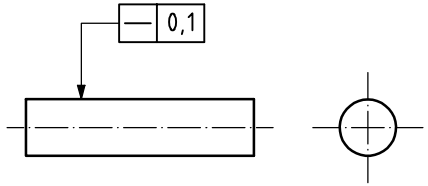
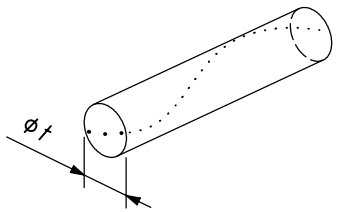
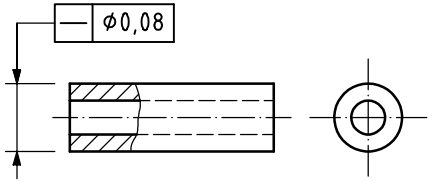
Location tolerances of a feature control location deviation, orientation deviation and form deviation of this feature, and not vice-versa.

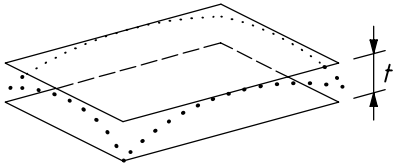
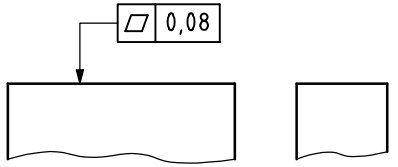
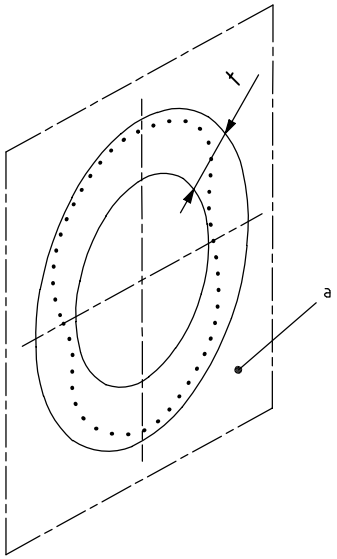
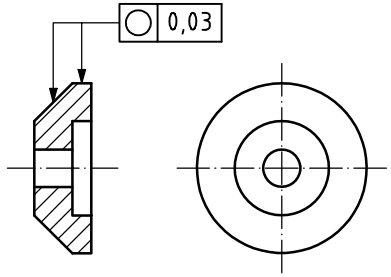
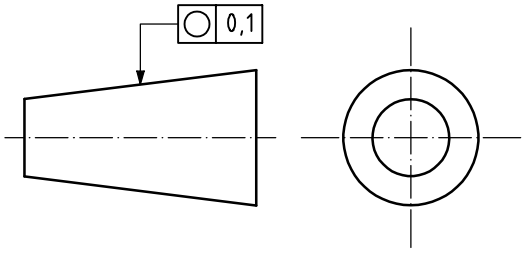
Orientation tolerances of a feature control orientation and form deviations of this feature and not vice-versa.

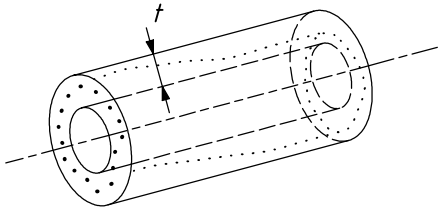
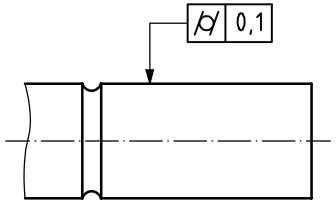
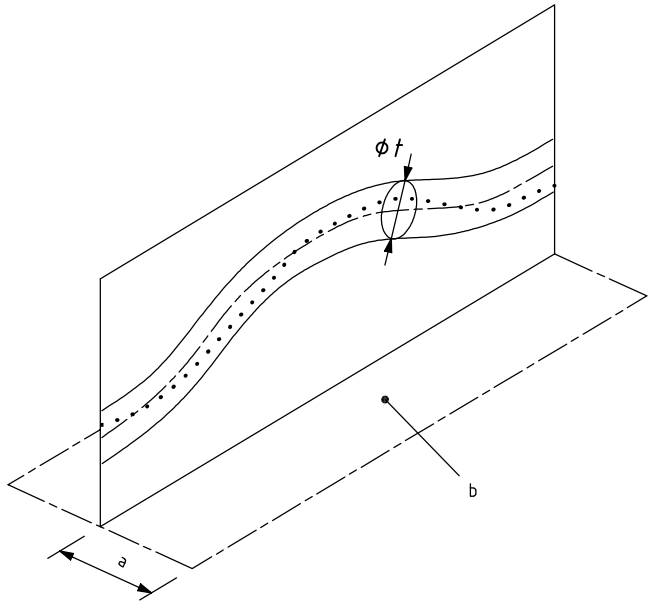
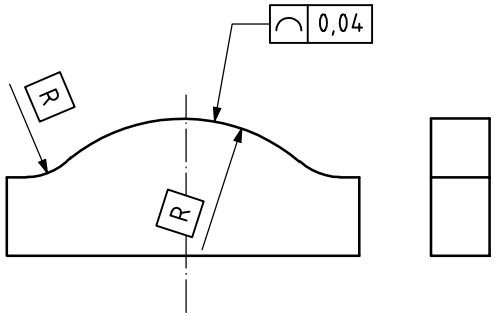
Form tolerances of a feature control only form deviations of this feature.

18 Definitions of geometrical tolerances

An explanation based on examples of the various geometrical tolerances and their tolerance zones are provided in this clause. The illustrations accompanying the definitions only show those deviations which relate to the specific definition.

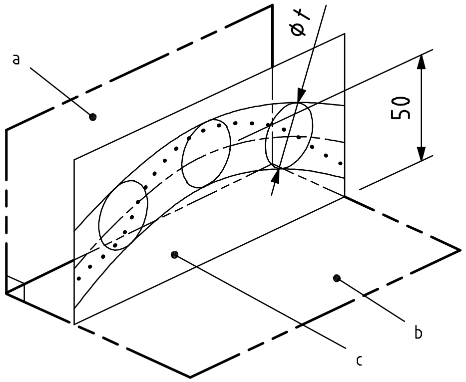
Symbol	Definition of the tolerance zone	Indication and explanation
	18.1 Straightness tolerance (see ISO/TS 12780-1 and ISO/TS 12780-2)	
	The tolerance zone, in the considered plane, is limited by two parallel straight lines a distance t apart and in the specified direction only.  [a] Any distance. **Figure 57**	Any extracted (actual) line on the upper surface, parallel to the plane of projection in which the indication is shown, shall be contained between two parallel straight lines 0,1 apart.  **Figure 58**
—	The tolerance zone is limited by two parallel planes a distance t apart.  **Figure 59**	Any extracted (actual) generating line on the cylindrical surface shall be contained between two parallel planes 0,1 apart. NOTE The definition for an extracted generating line has not been standardized.  **Figure 60**
	The tolerance zone is limited by a cylinder of diameter t, if the tolerance value is preceded by the symbol ϕ.  **Figure 61**	The extracted (actual) median line of the cylinder to which the tolerance applies shall be contained within a cylindrical zone of diameter 0,08.  **Figure 62**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.2 Flatness tolerance (see ISO/TS 12781-1 and ISO/TS 12781-2)	
▱	The tolerance zone is limited by two parallel planes a distance t apart.  **Figure 63**	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart.  **Figure 64**
	18.3 Roundness tolerance (see ISO/TS 12181-1 and ISO/TS 12181-2)	
○	The tolerance zone, in the considered cross-section, is limited by two concentric circles with a difference in radii of t.  [a] Any cross-section. **Figure 65**	The extracted (actual) circumferential line, in any cross-section of the cylindrical and conical surfaces, shall be contained between two co-planar concentric circles, with a difference in radii of 0,03.  **Figure 66** The extracted (actual) circumferential line, in any cross-section of the conical surface, shall be contained between two co-planar concentric circles with a difference in radii of 0,1. NOTE The definition of an extracted circumferential line has not been standardized.  **Figure 67**

Symbol	Definition of the tolerance zone	Indication and explanation
⌭	**18.4 Cylindricity tolerance** (see ISO/TS 12780-1and ISO/TS 12780-2)	
	The tolerance zone is limited by two coaxial cylinders with a difference in radii of t.  **Figure 68**	The extracted (actual) cylindrical surface shall be contained between two coaxial cylinders with a difference in radii of 0,1.  **Figure 69**
⌒	**18.5 Profile tolerance of a line not related to a datum** (See ISO 1660)	
	The tolerance zone is limited by two lines enveloping circles of diameter t, the centres of which are situated on a line having the theoretically exact geometrical form.  a Any distance. b Plane perpendicular to the drawing plane in Figure 71. **Figure 70**	In each section, parallel to the plane of projection in which the indication is shown, the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0,04, the centres of which are situated on a line having the theoretically exact geometrical form.  **Figure 71**

Dimensions in millimetres

<table>
<tr><th>Symbol</th><th>Definition of the tolerance zone</th><th>Indication and explanation</th></tr>
<tr><td rowspan="2">⌒</td><td colspan="2">18.6 Profile tolerance of a line related to a datum system (See ISO 1660)</td></tr>
<tr><td>The tolerance zone is limited by two lines enveloping circles of diameter t, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B.



a Datum A.
b Datum B.
c Plane parallel to datum A.

Figure 72</td><td>In each section, parallel to the plane of projection in which the indication is shown, the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0,04, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B.

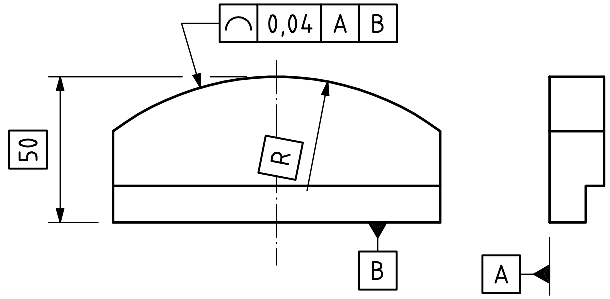


Figure 73</td></tr>
<tr><td rowspan="2">⌓</td><td colspan="2">18.7 Profile tolerance of a surface not related to a datum (See ISO 1660)</td></tr>
<tr><td>The tolerance zone is limited by two surfaces enveloping spheres of diameter t, the centres of which are situated on a surface having the theoretically exact geometrical form.

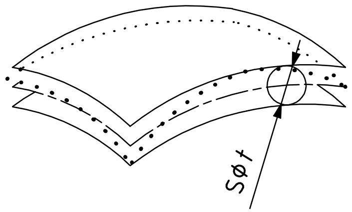


Figure 74</td><td>The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of diameter 0,02, the centres of which are situated on a surface having the theoretically exact geometrical form.

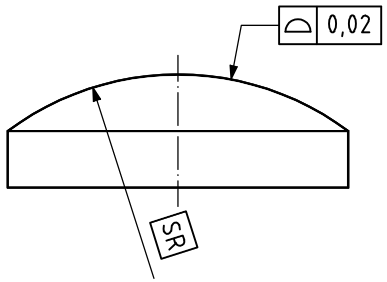
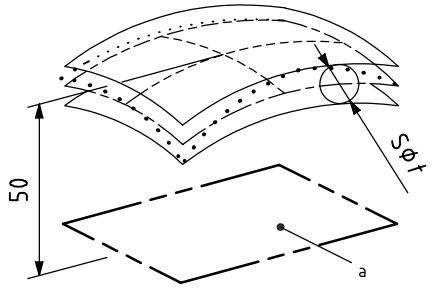


Figure 75</td></tr>
</table>

<table>
<tr><th>Symbol</th><th>Definition of the tolerance zone</th><th>Indication and explanation</th></tr>
<tr><td rowspan="2">⌓</td><td colspan="2">18.8 Profile tolerance of a surface related to a datum (See ISO 1660)</td></tr>
<tr><td>The tolerance zone is limited by two surfaces enveloping spheres of diameter t, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A.
 

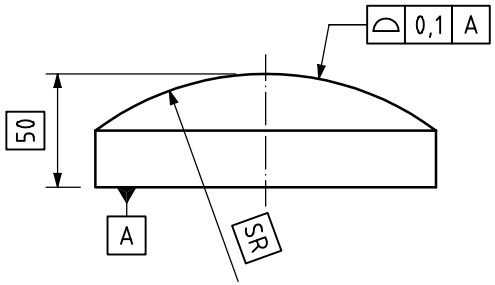
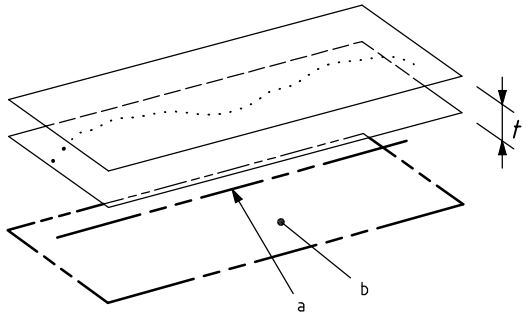
a Datum A.
Figure 76</td><td>The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of diameter 0,1, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A.
 

Figure 77</td></tr>
<tr><td rowspan="3">//</td><td colspan="2">18.9 Parallelism tolerance</td></tr>
<tr><td colspan="2">18.9.1 Parallelism tolerance of a line related to a datum system</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart. The planes are parallel to the datums and in the direction specified.
 

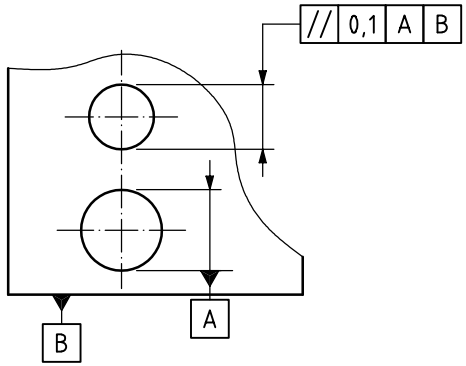
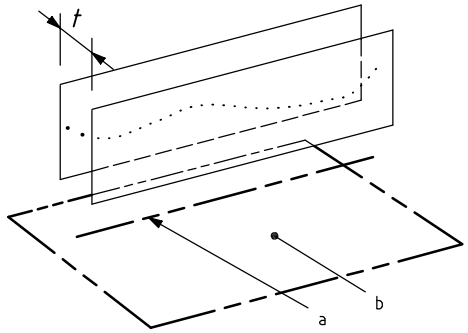
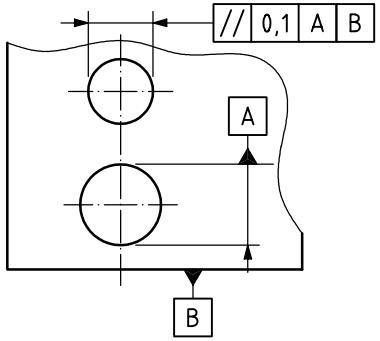
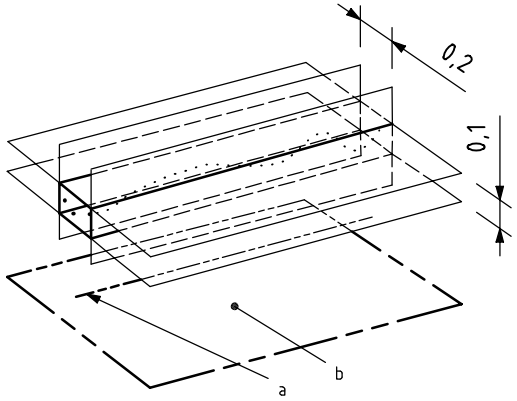
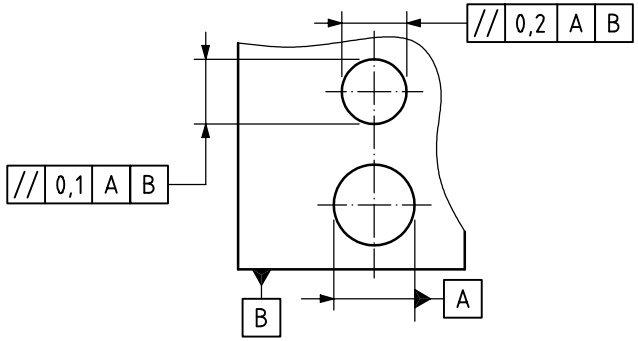
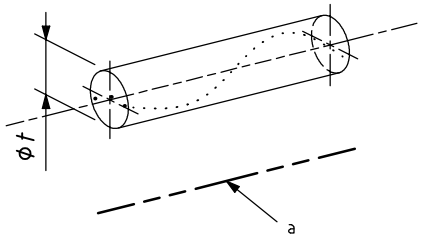
a Datum A.
b Datum B.
Figure 78</td><td>The extracted (actual) median line shall be contained between two parallel planes 0,1 apart which are parallel to the datum axis A, orientated with respect to datum plane B and in the direction specified.
 

Figure 79</td></tr>
</table>

Symbol	Definition of the tolerance zone	Indication and explanation
	18.9.1 Parallelism tolerance of a line related to a datum system (*continued*)	
	 a Datum A. b Datum B. **Figure 80**	The extracted (actual) median line shall be contained between two parallel planes 0,1 apart, which are parallel to the datum axis A, orientated with respect to datum plane B and in the direction specified.  **Figure 81**
//	The tolerance zone is limited by two pairs of parallel planes a distance 0,1 and 0,2 respectively apart and perpendicular to each other. The planes are parallel to the datum axis A (a) and datum plane B (b).  a Datum A. b Datum B. **Figure 82**	The extracted (actual) median line shall be contained between two pairs of parallel planes 0,1 and 0,2 respectively apart, be parallel to the datum axis A, and in the direction specified with respect to datum plane B, and perpendicular to each other.  **Figure 83**

<table>
<tr><th>Symbol</th><th>Definition of the tolerance zone</th><th>Indication and explanation</th></tr>
<tr><td rowspan="4">//</td><td colspan="2">18.9.2 Parallelism tolerance of a line related to a datum line</td></tr>
<tr><td>The tolerance zone is limited by a cylinder of diameter t, parallel to the datum, if the tolerance value is preceded by the symbol ϕ.
 

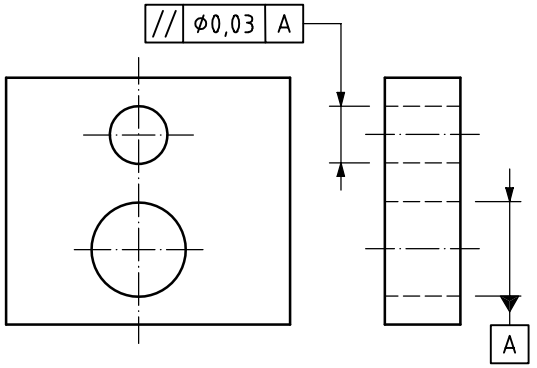
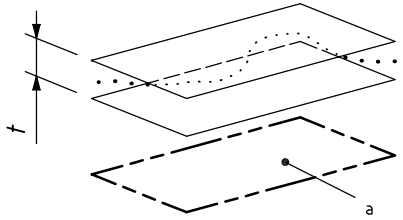
[a] Datum A.
Figure 84</td><td>The extracted (actual) median line shall be within a cylindrical zone of diameter 0,03 parallel to the datum axis A.
 

Figure 85</td></tr>
<tr><td colspan="2">18.9.3 Parallelism tolerance of a line related to a datum surface</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum.
 

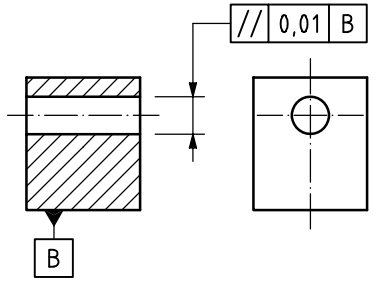
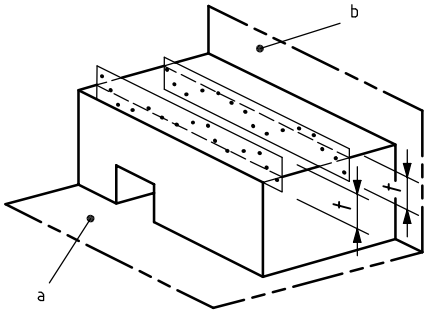
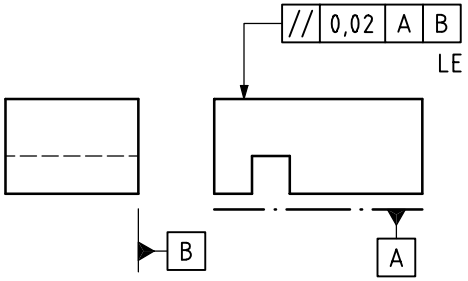
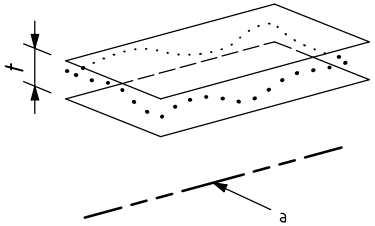
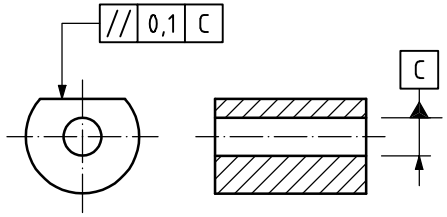
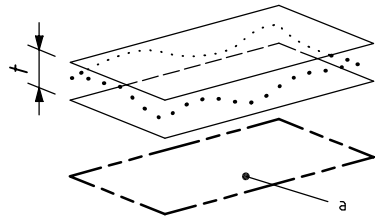
[a] Datum B.
Figure 86</td><td>The extracted (actual) median line shall be contained between two parallel planes 0,01 apart which are parallel to the datum plane B.
 

Figure 87</td></tr>
</table>

Symbol	Definition of the tolerance zone	Indication and explanation
	18.9.4 Parallelism tolerance of a line related to a datum system	
//	The tolerance zone is limited by two parallel lines a distance t apart and oriented parallel to datum plane A, the lines lying in a plane parallel to datum plane B.  a Datum A. b Datum B. **Figure 88**	Each extracted (actual) line shall be contained between two parallel lines 0,02 apart parallel to datum A and lying in a plane parallel to datum B.  **Figure 89**
	18.9.5 Parallelism tolerance of a surface related to a datum line	
	The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum.  a Datum C. **Figure 90**	The extracted (actual) surface shall be contained between two parallel planes 0,1 apart which are parallel to the datum axis C.  **Figure 91**

<table>
<tr><th>Symbol</th><th>Definition of the tolerance zone</th><th>Indication and explanation</th></tr>
<tr><td rowspan="2">//</td><td colspan="2">18.9.6 Parallelism tolerance of a surface related to a datum surface</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum plane.
 

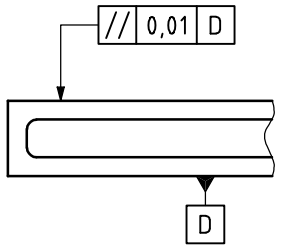
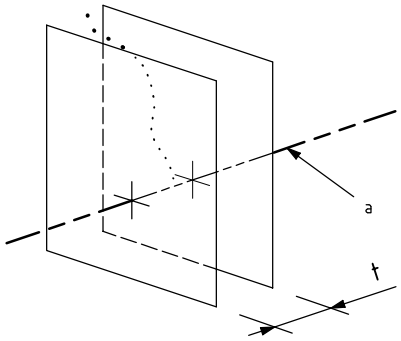
[a] Datum D.
Figure 92</td><td>The extracted (actual) surface shall be contained between two parallel planes 0,01 apart which are parallel to datum plane D.
 

Figure 93</td></tr>
<tr><td rowspan="3">⊥</td><td colspan="2">18.10 Perperpendicularity tolerance</td></tr>
<tr><td colspan="2">18.10.1 Perpendicularity tolerance of a line related to a datum line</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.
 

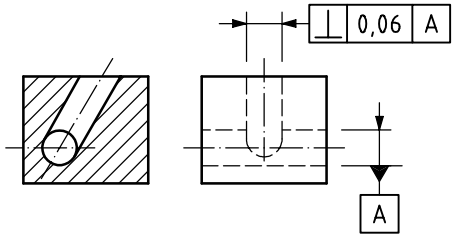
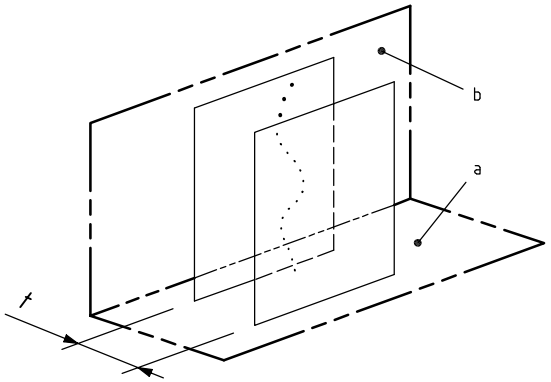
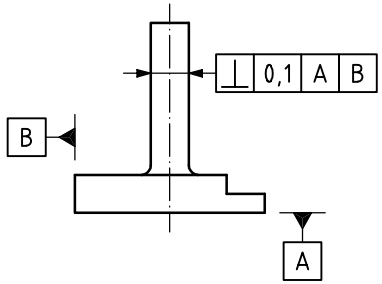
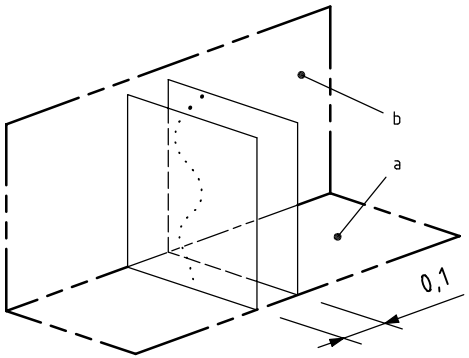
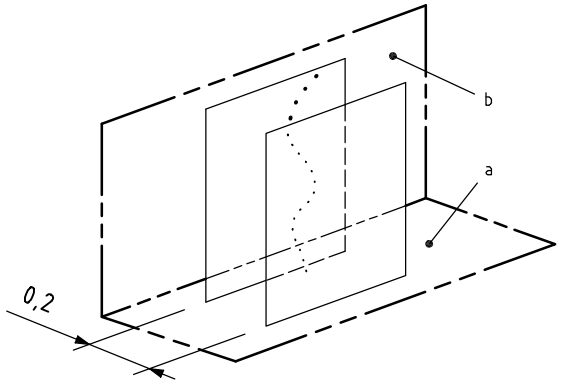
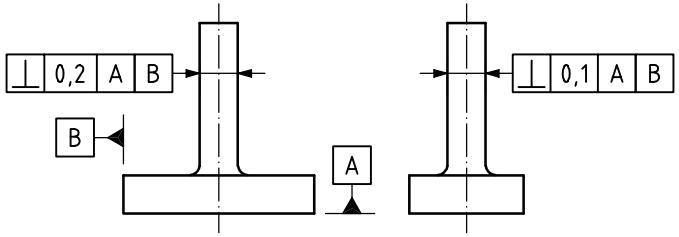
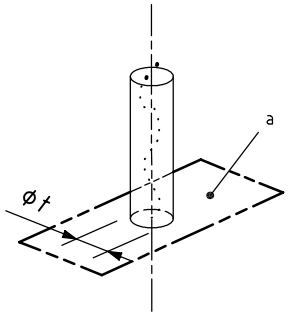
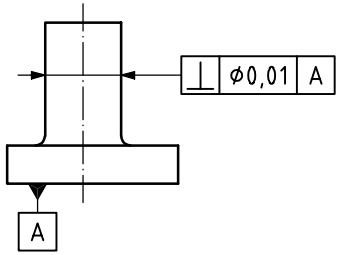
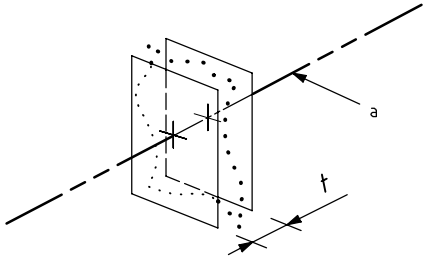
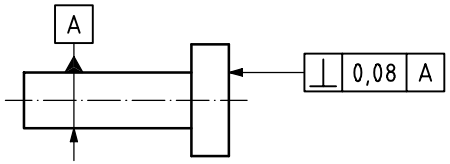
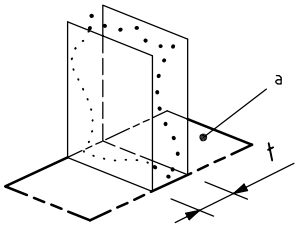
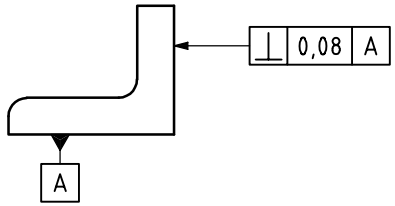
[a] Datum A.
Figure 94</td><td>The extracted (actual) median line shall be contained between two parallel planes 0,06 apart that are perpendicular to datum axis A.
 

Figure 95</td></tr>
</table>

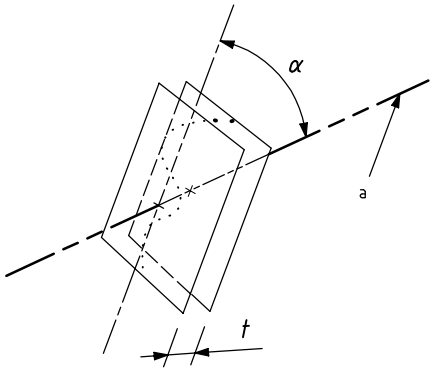
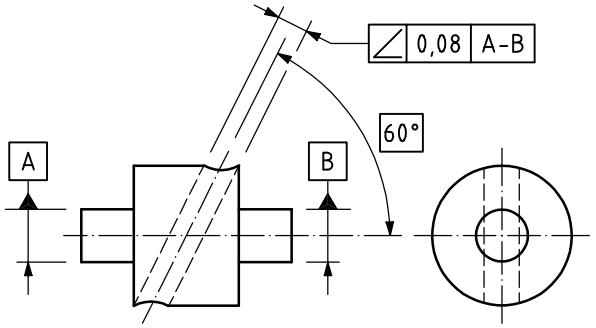
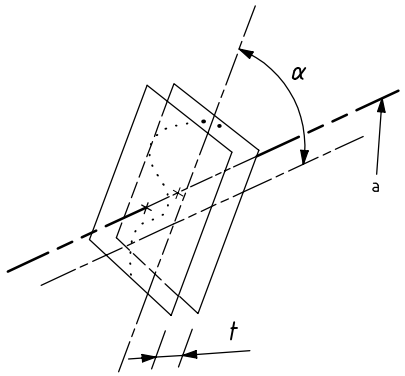
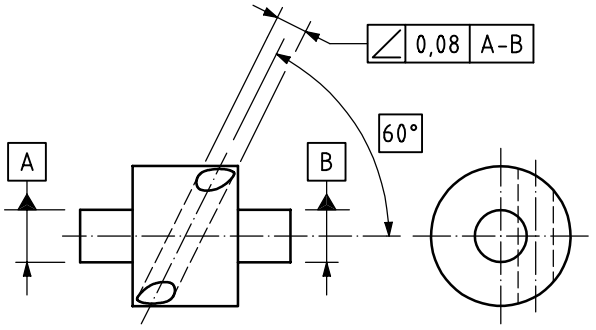
Symbol	Definition of the tolerance zone	Indication and explanation
	18.10.2 Perpendicularity tolerance of a line related to a datum system	
⊥	The tolerance zone is limited by two parallel planes a distance t apart. The planes are perpendicular to the datum A and parallel to datum B.  a Datum A. b Datum B. **Figure 96**	The extracted (actual) median line of the cylinder shall be contained between two parallel planes 0,1 apart that are perpendicular to datum plane A and in the direction specified with respect to datum plane B.  **Figure 97**

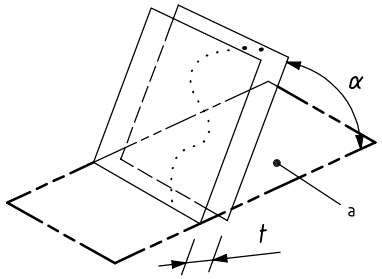
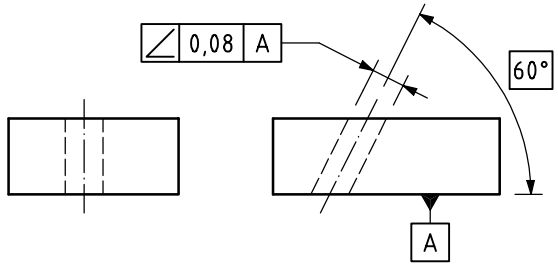
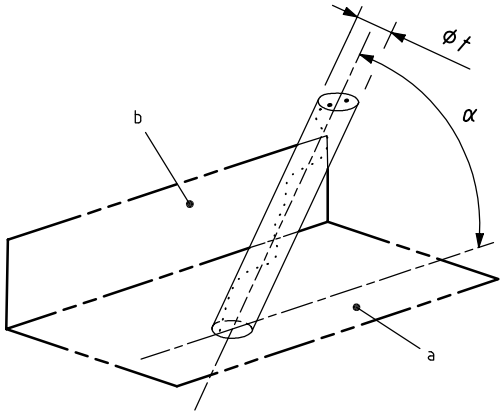
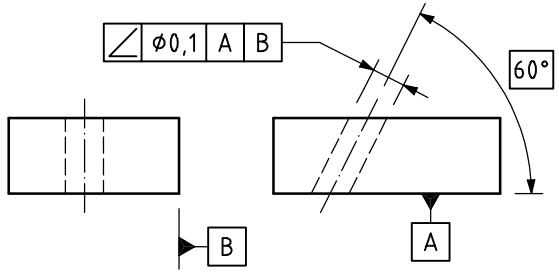
Symbol	Definition of the tolerance zone	Indication and explanation
	18.10.2 Perpendicularity tolerance of a line related to a datum system (*continued*)	
⊥	The tolerance zone is limited by two pairs of parallel planes a distance 0,1 and 0,2 apart and perpendicular to each other. Both planes are perpendicular to the datum A, one pair of planes being parallel to datum B (see Figure 99), the other pair being perpendicular to datum B (see Figure 98).  a Datum A. b Datum B. **Figure 98**  a Datum A. b Datum B. **Figure 99**	The extracted (actual) median line of the cylinder shall be contained between two pairs of parallel planes 0,1 and 0,2 apart, in the direction specified with respect to datum plane B, and perpendicular to each other. Both pairs of parallel planes shall be perpendicular to datum plane A.  **Figure 100**

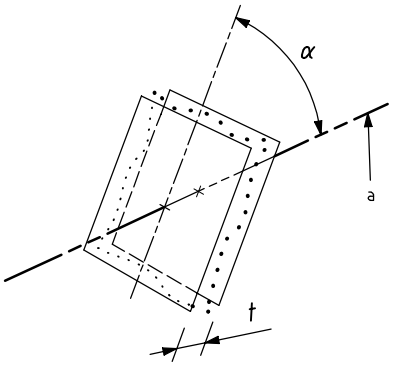
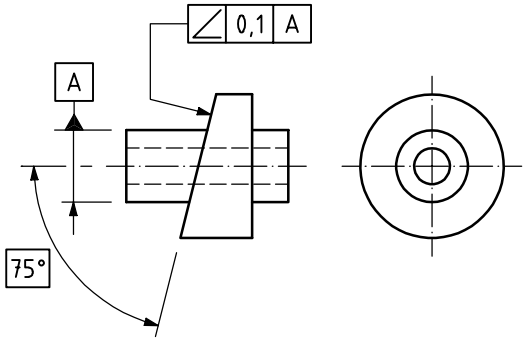
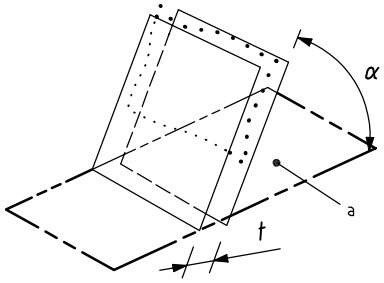
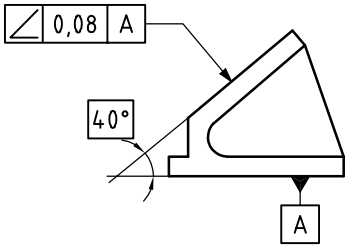
Symbol	Definition of the tolerance zone	Indication and explanation
	18.10.3 Perpendicularity tolerance of a line related to a datum surface	
⊥	The tolerance zone is limited by a cylinder of diameter t perpendicular to the datum if the tolerance value is preceded by the symbol ϕ.  [a] Datum A. **Figure 101**	The extracted (actual) median line of the cylinder shall be within a cylindrical zone of diameter 0,01 perpendicular to datum plane A.  **Figure 102**
	18.10.4 Perpendicularity tolerance of a surface related to a datum line	
	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.  [a] Datum A. **Figure 103**	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart that are perpendicular to datum axis A.  **Figure 104**

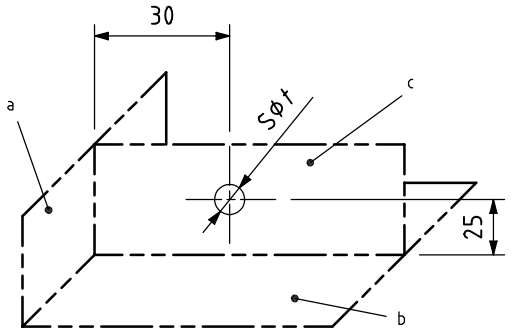
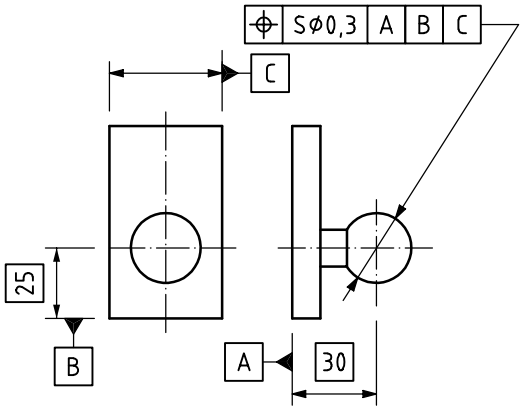
Symbol	Definition of the tolerance zone	Indication and explanation
	18.10.5 Perpendicularity tolerance of a surface related to a datum surface	
⊥	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.  [a] Datum A. **Figure 105**	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart that are perpendicular to datum plane A.  **Figure 106**

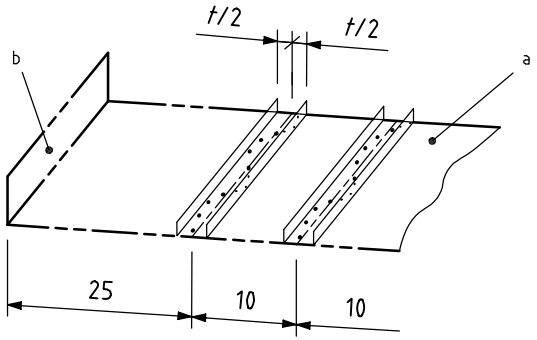
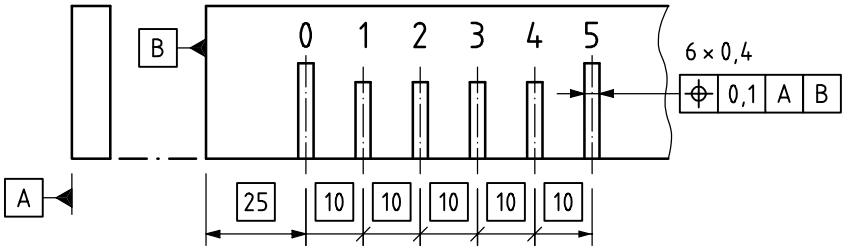
Dimensions in millimetres

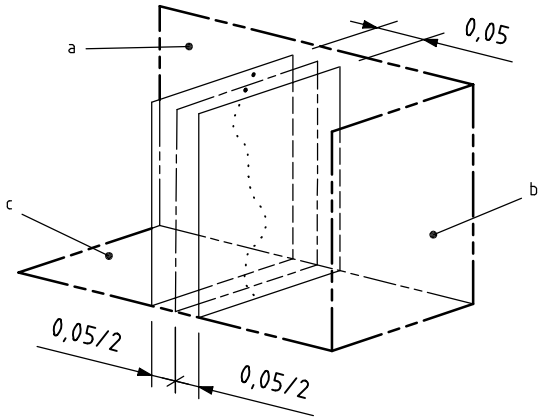
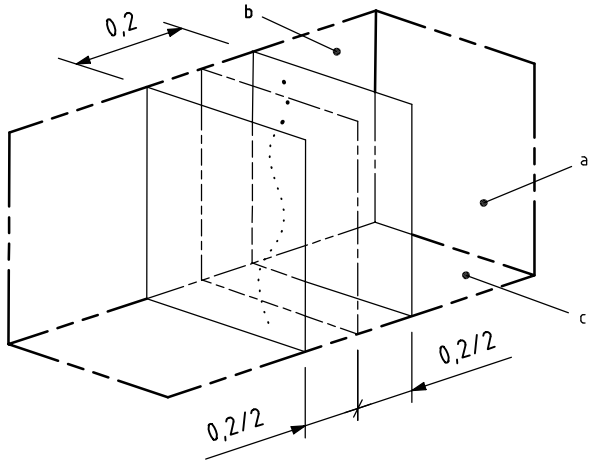
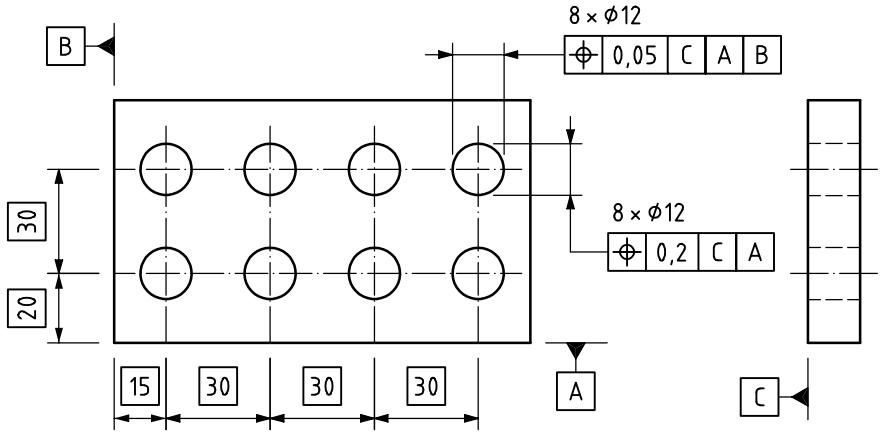
Symbol	Definition of the tolerance zone	Indication and explanation
	18.11 Angularity tolerance	
	18.11.1 Angularity tolerance of a line related to a datum line	
∠	a) Line and datum line in the same plane: The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.  [a] Datum A-B. **Figure 107**	The extracted (actual) median line shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 60° to the common datum straight line A-B.  **Figure 108**
	b) The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum. The considered line and the datum line are not in the same plane.  [a] Datum A-B. **Figure 109**	The extracted (actual) median line shall be contained between two parallel planes 0,08 apart that are inclined at theoretically exact 60° to the common datum straight line A-B.  **Figure 110**

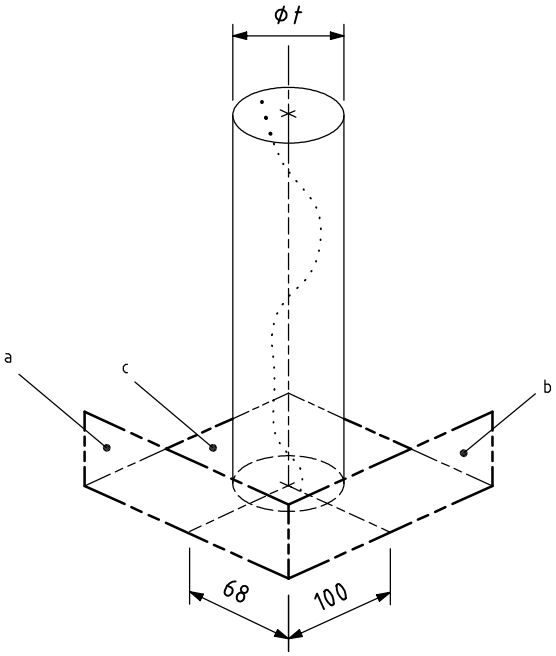
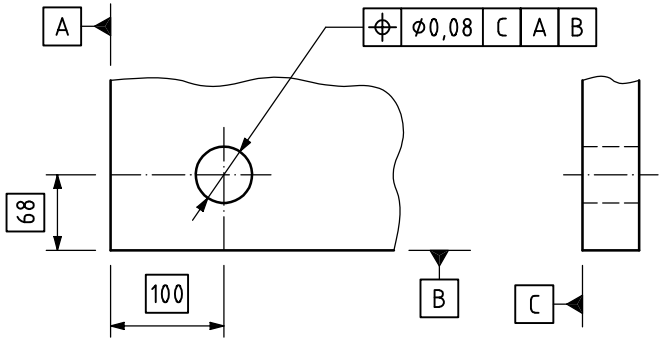
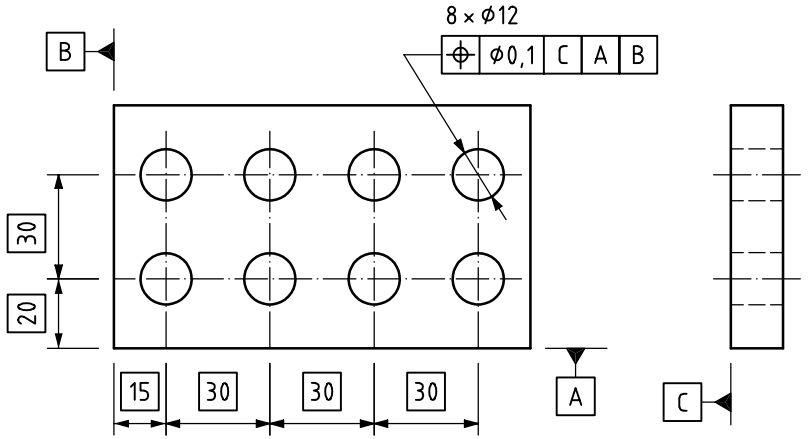
Symbol	Definition of the tolerance zone	Indication and explanation
	18.11.2 Angularity tolerance of a line related to a datum surface	
	The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.  a Datum A. **Figure 111**	The extracted (actual) median line shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 60° to datum plane A.  **Figure 112**
∠	The tolerance zone is limited by a cylinder of diameter t if the tolerance value is preceded by the symbol ⌀. The cylindrical tolerance zone is parallel to a datum plane B and inclined at the specified angle to the datum plane A.  a Datum A. b Datum B. **Figure 113**	The extracted (actual) median line shall be within a cylindrical tolerance zone of diameter 0,1 that is parallel to datum plane B and inclined at a theoretically exact angle of 60° to datum plane A.  **Figure 114**

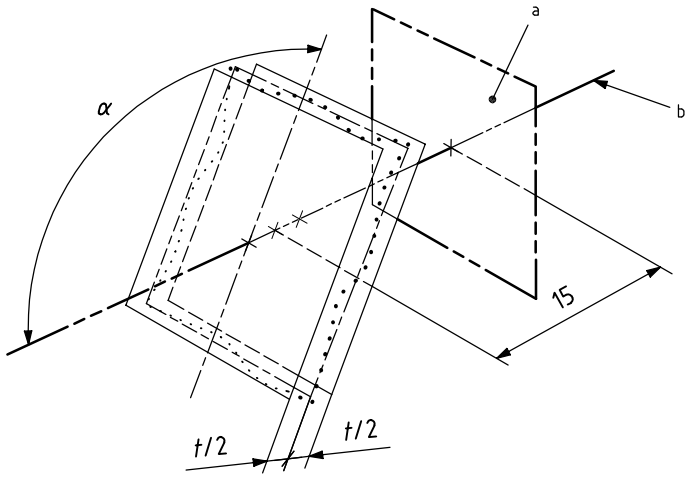
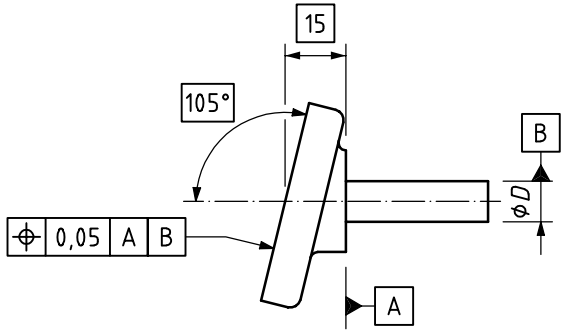
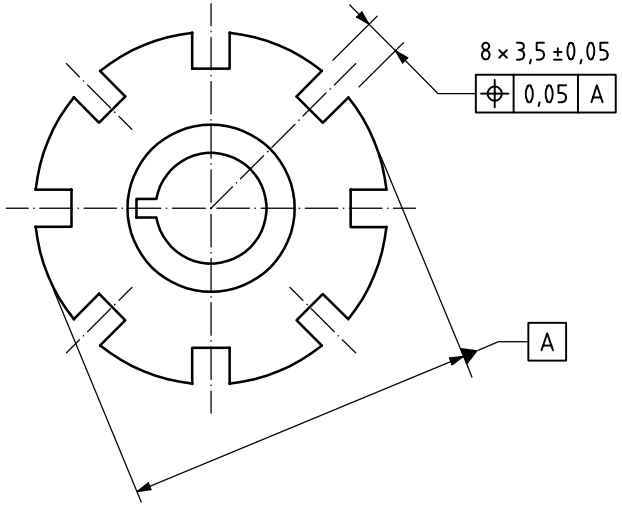
Symbol	Definition of the tolerance zone	Indication and explanation
	18.11.3 Angularity tolerance of a surface related to a datum line	
∠	The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.  [a] Datum A. **Figure 115**	The extracted (actual) surface shall be contained between two parallel planes 0,1 apart that are inclined at a theoretically exact angle of 75° to datum axis A.  **Figure 116**
	18.11.4 Angularity tolerance of a surface related to a datum surface	
	The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.  [a] Datum A. **Figure 117**	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 40° to datum plane A.  **Figure 118**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.12 Position tolerance (see ISO 5458)	
	18.12.1 Position tolerance of a point	
⌖	The tolerance zone is limited by a sphere of diameter t if the tolerance value is preceded by the symbol S⌀. The centre of the spherical tolerance zone is fixed by theoretically exact dimensions with respect to the datums A, B and C.  a Datum A. b Datum B. c Datum C. **Figure 119**	The extracted (actual) centre of the sphere shall be within a spherical zone of diameter 0,3, the centre of which coincides with the theoretically exact position of the sphere, with respect to datum planes A and B and to datum median plane C. NOTE The definition of extracted (actual) centre of a sphere has not been standardized.  **Figure 120**

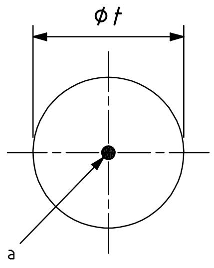
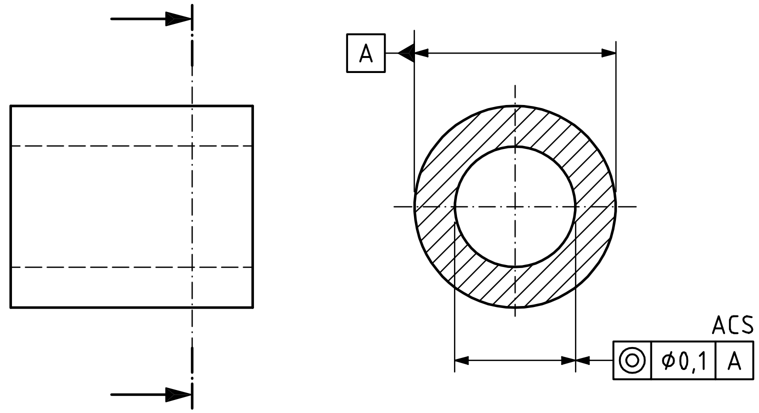
Symbol	Definition of the tolerance zone	Indication and explanation
	18.12.2 Position tolerance of a line	
⌖	The tolerance zone is limited by two parallel planes a distance t apart and symmetrically disposed about the centre line. The centre line is fixed by theoretically exact dimensions with respect to datums A and B. The tolerance is specified in one direction only.  a Datum A. b Datum B. **Figure 121**	The extracted (actual) centre line of each of the scribe lines shall be contained between two parallel planes 0,1 apart that are symmetrically disposed about the theoretically exact position of the considered line, with respect to datum planes A and B.  **Figure 122**

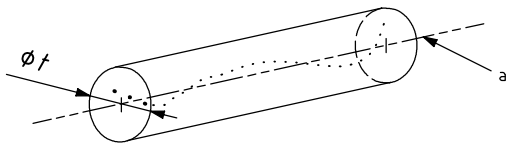
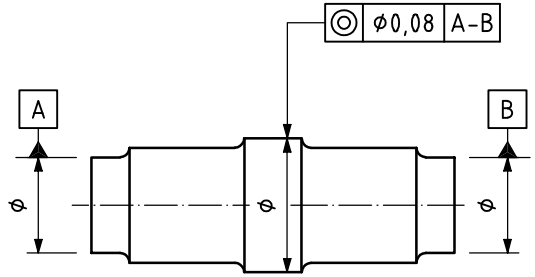
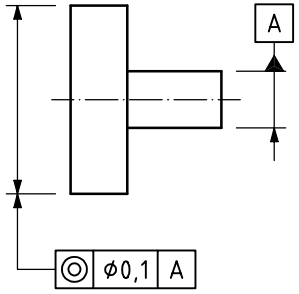
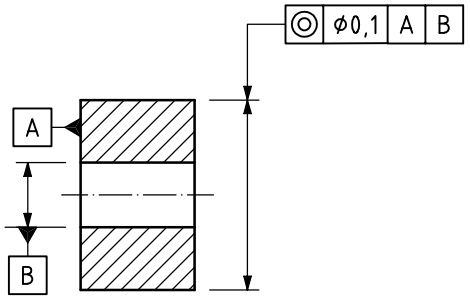
Symbol	Definition of the tolerance zone	Indication and explanation
	18.12.2 Position tolerance of a line (*continued*)	
⌖	The tolerance zone is limited by two pairs of parallel planes a distance 0,05 and 0,2 apart respectively and symmetrically disposed about the theoretically exact position. The theoretically exact position is fixed by theoretically exact dimensions with respect to the datums C, A and B. The tolerance is specified in two directions with respect to the datums.  a Datum A. b Datum B. c Datum C. **Figure 123**  a Datum A. b Datum B. c Datum C. **Figure 124**	The extracted (actual) median line of each hole shall be contained between two pairs of parallel planes 0,05 and 0,2 apart respectively, in the direction specified, and perpendicular to each other. Each pair of parallel planes is orientated with respect to the datum system and symmetrically disposed about the theoretically exact position of the considered hole, with respect to datum planes C, A and B.  **Figure 125**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.12.2 Position tolerance of a line (*continued*)	
⌖	The tolerance zone is limited by a cylinder of diameter t if the tolerance value is preceded by the symbol ⌀. The axis of the tolerance cylinder is fixed by theoretically exact dimensions with respect to the datums C, A and B.  a Datum A. b Datum B. c Datum C. **Figure 126**	The extracted (actual) median line shall be within a cylindrical zone of diameter 0,08, the axis of which coincides with the theoretically exact position of the considered hole, with respect to datum planes C, A and B.  **Figure 127** The extracted (actual) median line of each hole shall be within a cylindrical zone of diameter 0,1, the axis of which coincides with the theoretically exact position of the considered hole, with respect to datum planes C, A, and B.  **Figure 128**

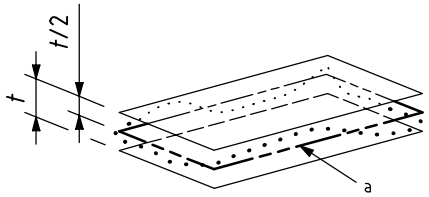
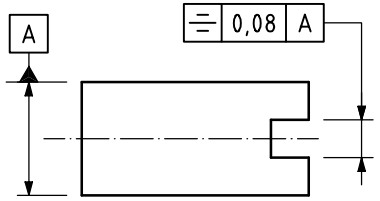
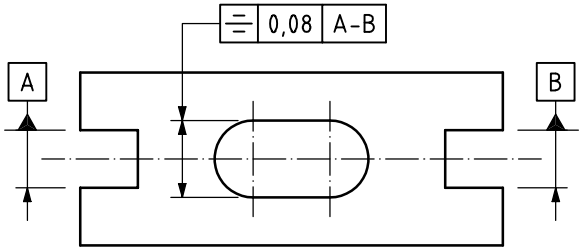
Symbol	Definition of the tolerance zone	Indication and explanation
	18.12.3 Position tolerance of a flat surface or a median plane	
⌖	The tolerance zone is limited by two parallel planes a distance t apart and symmetrically disposed about the theoretically exact position fixed by theoretically exact dimensions with respect to the datums A and B.  a Datum A. b Datum B. **Figure 129**	The extracted (actual) surface shall be contained between two parallel planes 0,05 apart that are symmetrically disposed about the theoretically exact position of the surface, with respect to datum plane A and datum axis B.  **Figure 130** The extracted (actual) median surface shall be contained between two parallel planes 0,05 apart which are symmetrically disposed about the theoretically exact position of the median plane, with respect to datum axis A.  NOTE The theoretically exact angle between the eight keyways is implicitly given (see 4.4 of ISO 5458:1998). **Figure 131**

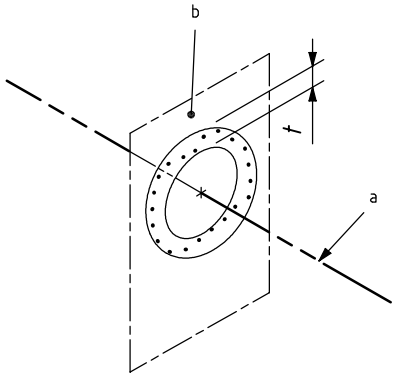
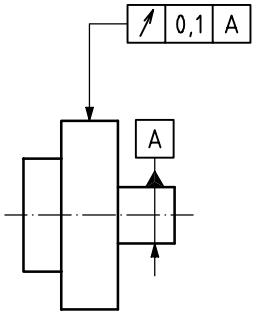
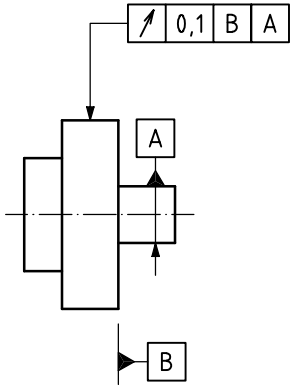
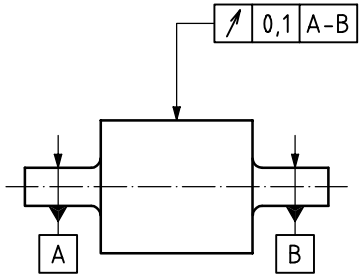
Dimensions in millimetres

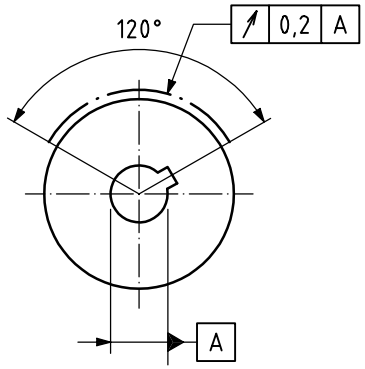
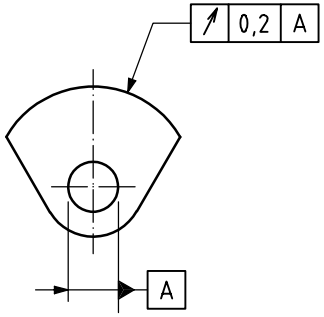
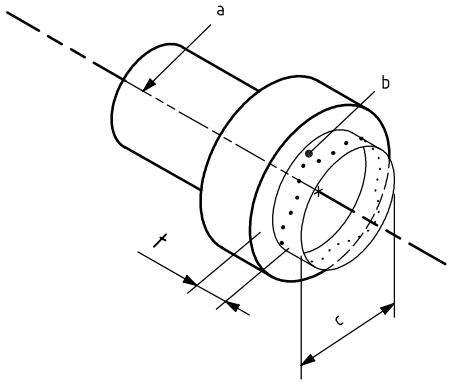
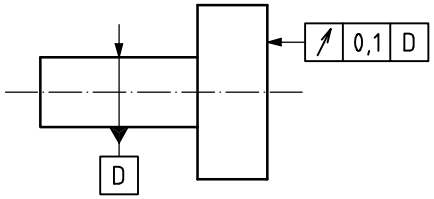
Symbol	Definition of the tolerance zone	Indication and explanation
	18.13 Concentricity and coaxiality tolerance	
	18.13.1 Concentricity tolerance of a point	
◎	The tolerance zone is limited by a circle of diameter t; the tolerance value shall be preceded by the symbol ϕ. The centre of the circular tolerance zone coincides with the datum point.  [a] Datum point A. **Figure 132**	The extracted (actual) centre of the inner circle shall be within a circle of diameter 0,1 concentric with datum point A in the cross-section.  **Figure 133**

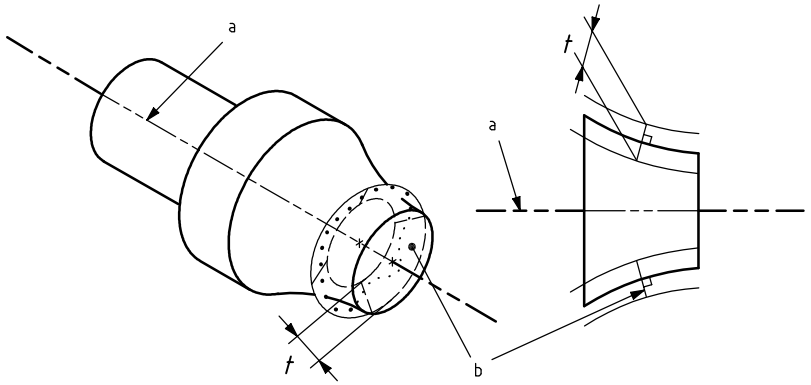
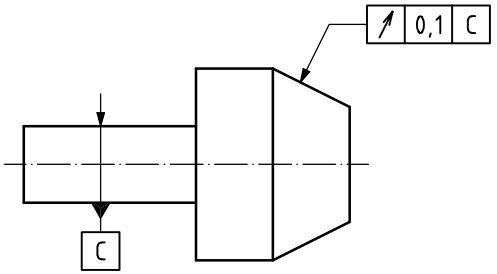
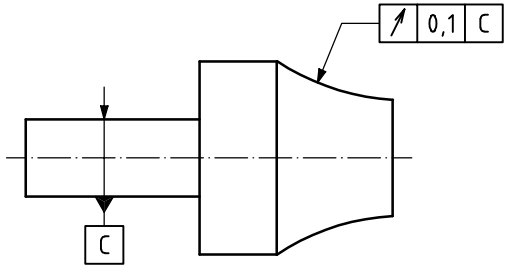
Symbol	Definition of the tolerance zone	Indication and explanation
	18.13.2 Coaxiality tolerance of an axis	
◎	The tolerance zone is limited by a cylinder of diameter t; the tolerance value shall be preceded by the symbol ϕ. The axis of the cylindrical tolerance zone coincides with the datum.  [a] Datum A-B. **Figure 134**	The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0,08 the axis of which is the common datum straight line A-B.  **Figure 135** The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0,1 the median line of which is the datum axis A (see Figure 136). The extracted (actual) axis of the large cylinder shall be within a cylindrical zone of diameter 0,1, the axis of which is datum axis B perpendicular to datum plane A (see Figure 137).  **Figure 136**  **Figure 137**

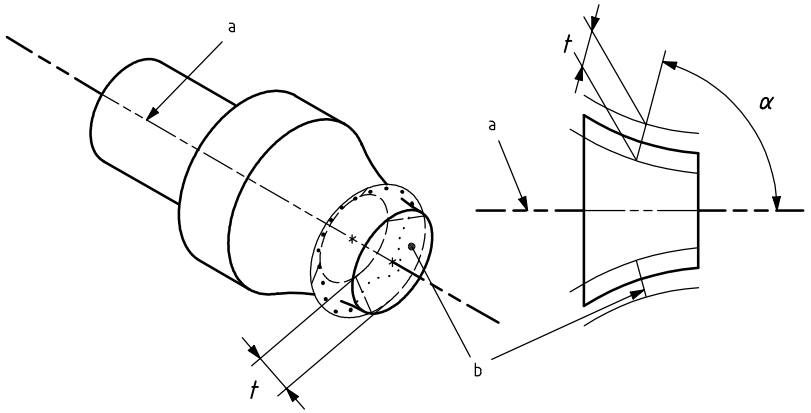
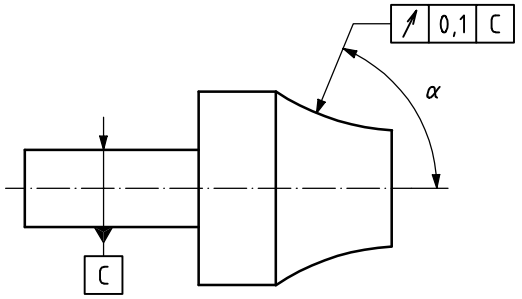
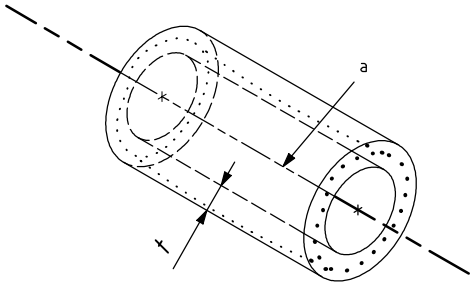
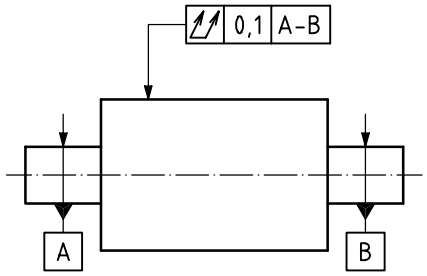
Dimensions in millimetres

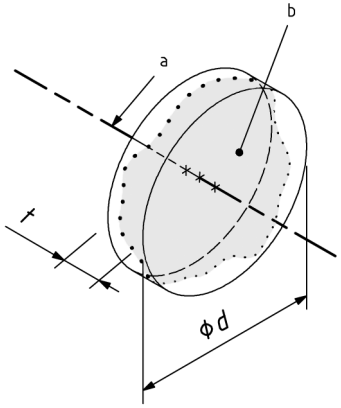
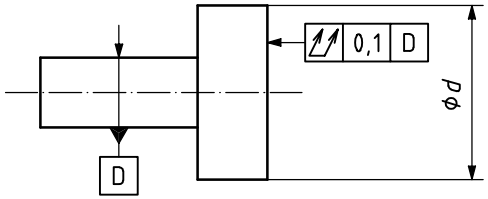
Symbol	Definition of the tolerance zone	Indication and explanation
	18.14 Symmetry tolerance	
	18.14.1 Symmetry tolerance of a median plane	
⌯	The tolerance zone is limited by two parallel planes a distance t apart, symmetrically disposed about the median plane, with respect to the datum.  [a] Datum. **Figure 138**	The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart which are symmetrically disposed about the datum median plane A.  **Figure 139** The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart and symmetrically disposed about the common datum plane A-B.  **Figure 140**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.15 Circular run-out tolerance	
	18.15.1 Circular run-out tolerance — radial	
↗	The tolerance zone is limited within any cross-section perpendicular to the datum axis by two concentric circles with a difference in radii of t, the centres of which coincide with the datum.  a Datum. b Cross-section plane. **Figure 141**	The extracted (actual) line in any cross-section plane perpendicular to datum axis A shall be contained between two coplanar concentric circles with a difference in radii of 0,1 (see Figure 142). The extracted (actual) line in any cross-section plane parallel to datum plane B, shall be contained between two coplanar concentric circles concentric to datum axis A with a difference in radii of 0,1 (see Figure 143).  **Figure 142**  **Figure 143** The extracted (actual) line in any cross-section plane perpendicular to common datum straight line A-B shall be contained between two coplanar concentric circles with a difference in radii of 0,1.  **Figure 144**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.15.1 Circular run-out tolerance — radial (*continued*)	
	Run-out usually applies to complete features, but could be applied to a restricted part of a feature (see Figure 145).	The extracted (actual) line in any cross-section plane perpendicular to datum axis A shall be contained between two coplanar concentric circles with a difference in radii of 0,2.  **Figure 145**  **Figure 146**
↗	**18.15.2 Circular run-out tolerance — axial**	
	The tolerance zone is limited to any cylindrical section by two circles with a distance t apart lying in the cylindrical section, the axis of which coincides with the datum.  a Datum A. b Tolerance zone. c Any diameter. **Figure 147**	The extracted (actual) line, in any cylindrical section, the axis of which coincides with datum axis D, shall be contained between two circles with a distance of 0,1.  **Figure 148**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.15.3 Circular run-out tolerance in any direction	
	The tolerance zone is limited within any conical section by two circles a distance t apart, the axes of which coincide with the datum. The width of the tolerance zone is normal to the specified geometry unless otherwise indicated.  a Datum C. b Tolerance zone. **Figure 149**	The extracted (actual) line in any conical section, the axis of which coincides with datum axis C, shall be contained between two circles within the conical section with a distance of 0,1.  **Figure 150** When the generator line for the toleranced feature is not straight, the apex angle of the conical section will change depending on the actual position [see Figure 149 (right) and Figure 151].  **Figure 151**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.15.4 Circular run-out tolerance in a specified direction	
↗	The tolerance zone is limited within any conical section of the specified angle by two circles a distance t apart, the axes of which coincide with the datum.  a Datum C. b Tolerance zone. **Figure 152**	The extracted (actual) line in any conical section (angle α), the axis of which coincides with datum axis C, shall be contained between two circles at a distance 0,1 apart within the conical section.  **Figure 153**
	18.16 Total run-out tolerance	
⌰	**18.16.1 Total radial run-out tolerance**	
	The tolerance zone is limited by two coaxial cylinders with a difference in radii of t, the axes of which coincide with the datum.  a Datum A-B. **Figure 154**	The extracted (actual) surface shall be contained between two coaxial cylinders with a difference in radii of 0,1 and the axes coincident with the common datum straight line A-B.  **Figure 155**

Symbol	Definition of the tolerance zone	Indication and explanation
	18.16.2 Total axial run-out tolerance	
	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.  a Datum D. b Extracted surface. **Figure 156**	The extracted (actual) surface shall be contained between two parallel planes 0,1 apart which are perpendicular to datum axis D.  **Figure 157**

Annex A
(informative)

Former practices

A.1 This annex describes former practices that have been omitted and are no longer used. Therefore, it is not an integral part of this International Standard, but should be used for information only.

The following drawing indications were described in ISO 1101:1983. Their use in practice has shown that their interpretation was ambiguous. Therefore, these drawing indications should no longer be used.

A.2 It was former practice to connect the tolerance frame by a leader line terminating with an arrow directly to the axis or median plane (see Figure A.1) or common axis or median plane (see Figures A.2 and A.3) when the tolerance referred to such feature(s). This was used as an alternate method to the indications shown in Figures 13, 14 and 15.

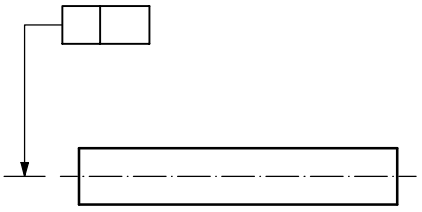


Figure A.1

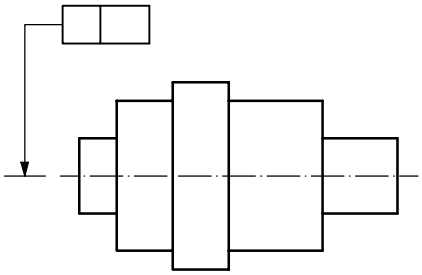


Figure A.2

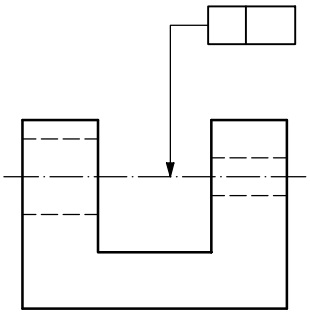


Figure A.3

A.3 It was former practice to connect the datum triangle and the datum letter directly to the axis or median plane or common axis or median plane (see Figure A.4) when the datum referred to such feature(s). This was used as an alternate method to the indication shown in Figure 33.

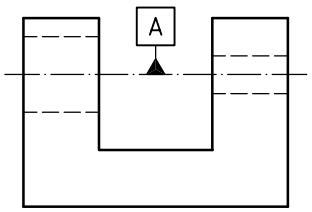


Figure A.4

A.4 It was former practice to indicate datum letters without giving them an order of precedence (see Figure A.5). Therefore, it was not possible to clearly distinguish between the primary and secondary datum. This was used as an option to the indication shown in Figure 37.

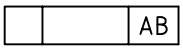


Figure A.5

A.5 It was former practice to connect the tolerance frame directly to the datum feature by a leader line (see Figures A.6 and A.7). This was used as an alternate method to the method described in 9.3.

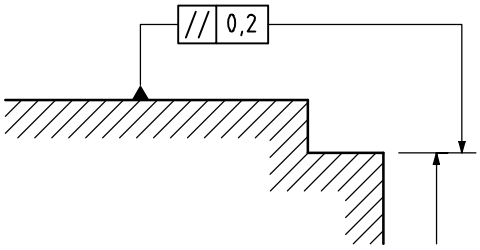


Figure A.6

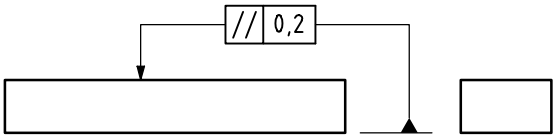


Figure A.7

A.6 It was former practice to indicate individual tolerance zones of the same value applied to several separate features as shown in Figures A.8 and A.10. This was used as an alternate method to the method described in 8.4.

A.7 It was former practice to indicate the requirement for common zone by placing the label “common zone” near the tolerance frame (see Figures A.9 and A.10). This was used as an alternate method to the method described in 8.5.

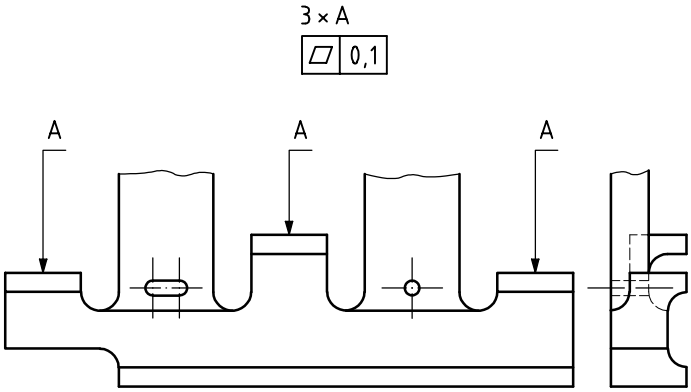


Figure A.8

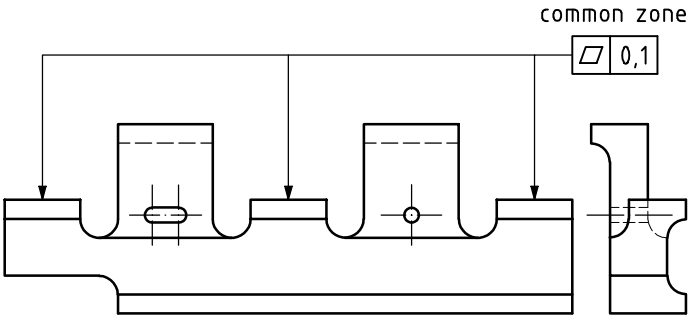


Figure A.9

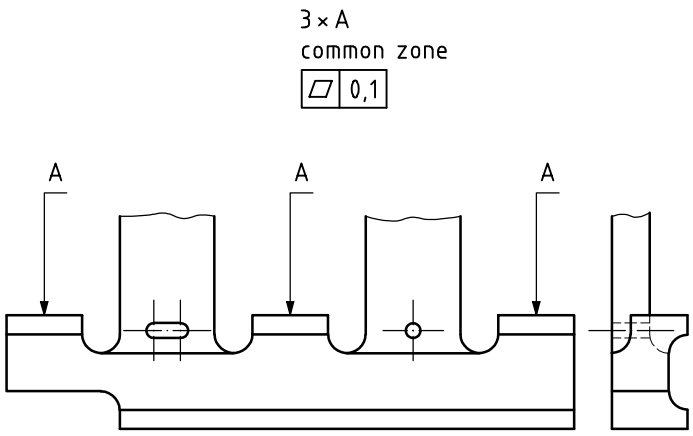


Figure A.10

Annex B
(normative)

Assessment of geometrical deviations

B.1 General

International documents concerning the assessment of geometrical deviations for cylindricity, roundness, flatness and straightness have been developed (see ISO/TS 12180-1, ISO/TS 12180-2, ISO/TS 12181-2, ISO/TS 12181-2, ISO/TS 12780-1, ISO/TS 12780-2, ISO/TS 12781-1 and ISO/TS 12781-2).

However, at the time of publication of this International Standard, it has not been possible to reach a consensus on complete defaults for filter UPR (undulations per revolution), probe tip radius and method of association for cylindricity, roundness, flatness and straightness (i.e. the conditions for the reference cylinder, reference circle, reference plane and reference line, respectively).

This means that specifications for cylindricity, roundness, flatness and straightness should explicitly state which values are to be used for these specification operations (according to ISO/TS 17450-2) in order for it to be unique.

NOTE It is intended that the indication of special specification operator be given in a forthcoming amendment to this International Standard.

Since no complete default has been established, a selection of definitions for tolerance zones that are based on geometrically ideal features is given hereunder for consideration. These examples are given to show how to assess form deviations of extracted (actual) features and to compare them to tolerance zones. It shall be noted that the selection of definitions for tolerance zones does not describe the complete setup for the required specification operations and, consequently, only constitutes incomplete defaults and are to be used only if no further indication is given (see also above note).

To ensure compatibility with previous practice, this annex reproduces and enhances elements of ISO 1101:1983 not otherwise covered in this edition.

A selection of definitions for tolerance zones that are based on geometrically ideal features is given for consideration. Examples are given to show how to assess form deviations of extracted (actual) features and to compare them to tolerance zones.

B.2 Straightness

The straightness of a single toleranced feature is deemed to be correct when the feature is confined between two straight lines, and the distance between both is equal to or less than the value of the specified tolerance. The orientation of the straight lines shall be chosen so that the maximum distance between them is the least possible value.

An example for a particular cross-section is given as follows:

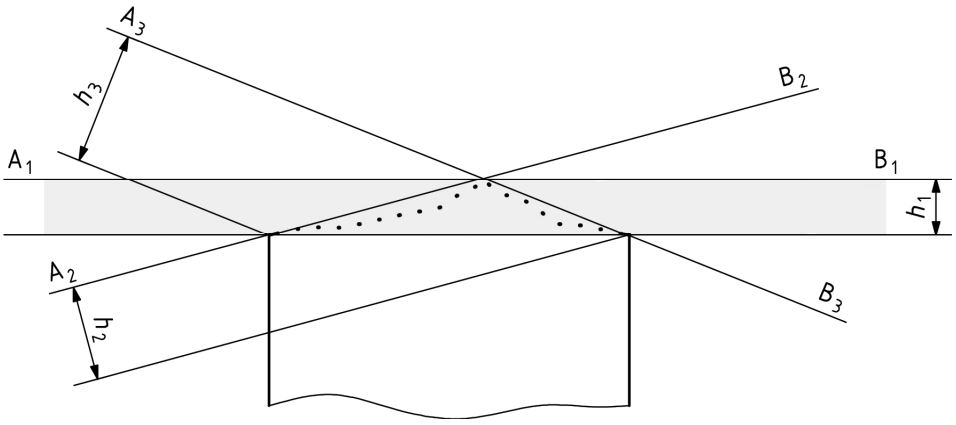


Figure B.1

Possible orientations of the straight lines:	A_1-B_1		A_2-B_2		A_3-B_3
Corresponding distances:	h_1		h_2		h_3
In the case of Figure B.1:	h_1	$<$	h_2	$<$	h_3

Therefore the correct orientation of the straight lines is A_1-B_1. The distance h_1 is to be equal to or less than the specified tolerance.

B.3 Flatness

The flatness of a single toleranced feature is deemed to be correct when the feature is confined between both planes, and the distance between them is equal to or less than the value of the specified tolerance. The orientation of the planes shall be chosen so that the maximum distance between them is the least possible value.

An example is given as follows:

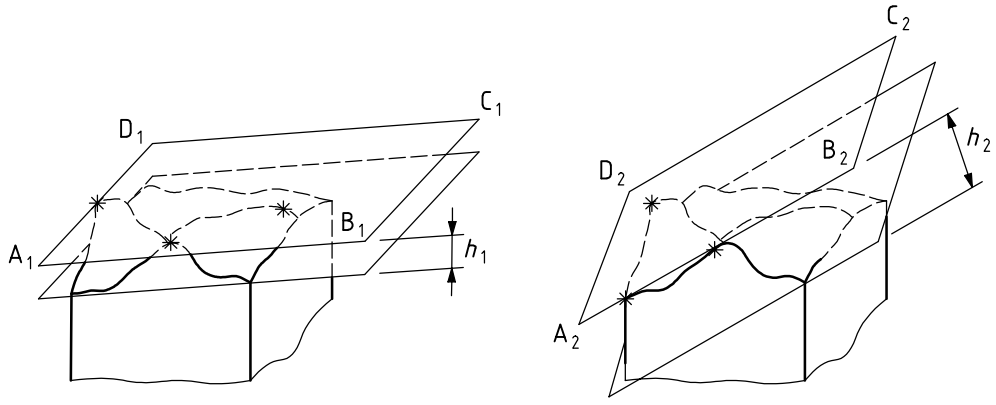


Figure B.2

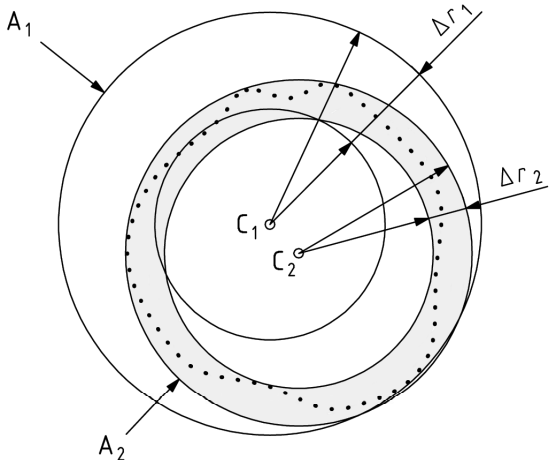
Possible orientations of the planes:	A_1-B_1-C_1-D_1		A_2-B_2-C_2-D_2
Corresponding distances:	h_1		h_2
In the case of Figure B.2:	h_1	$<$	h_2

Therefore the correct orientation of the planes is A_1-B_1-C_1-D_1. The distance h_1 is to be equal to or less than the specified tolerance.

B.4 Roundness

The roundness of a single toleranced feature is deemed to be correct when the feature is confined between two concentric circles such that the difference in radii is equal to or less than the value of the specified tolerance. The location of the centres of these circles and the value of their radii shall be chosen so that the difference in radii between the two concentric circles is the least possible value.

An example for a particular cross-section is given as follows:



$\Delta r_2 < \Delta r_1$

Figure B.3

Possible locations of the centres of the two concentric circles and their minimal difference in radii.

Centre (C_1) of A_1 locates two concentric circles with difference in radii, Δr_1.

Centre (C_2) of A_2 locates two concentric circles with difference in radii, Δr_2.

In the case of Figure B.3: $\Delta r_2 < \Delta r_1$

Therefore the correct locations of the two concentric circles is the one designated A_2. The difference in radii Δr_2 should then be equal to or less than the specified tolerance.

B.5 Cylindricity

The cylindricity of a single toleranced feature is deemed to be correct when the feature is confined between two coaxial cylinders such that the difference in radii is equal to or less than the value of the specified tolerance. The location of the axes of these cylinders and the value of their radii shall be chosen so that the difference in radii between the two coaxial cylinders is the least possible value.

An example is given as follows:

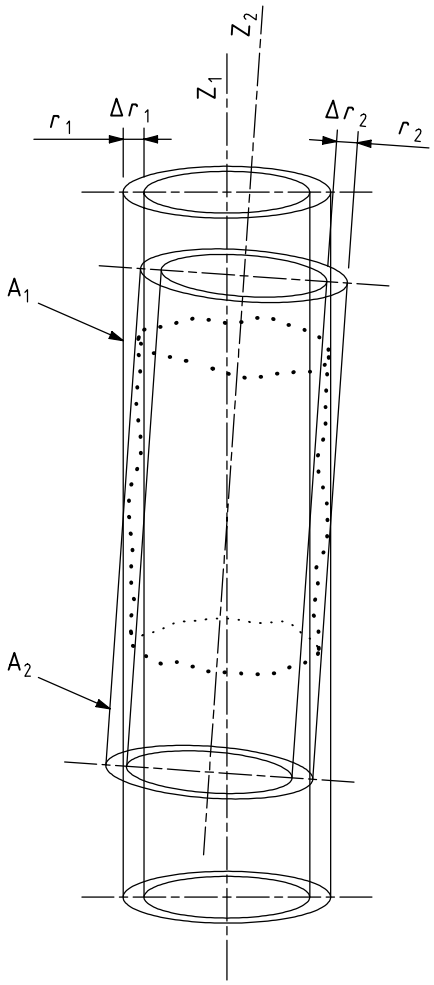


Figure B.4

Possible locations of the axes of the two coaxial cylinders and their minimal difference in radii.

Axis (Z_1) of A_1 locates two coaxial cylinders with difference in radii, Δr_1.

Axis (Z_2) of A_2 locates two coaxial cylinders with difference in radii, Δr_2.

In the case of Figure B.4: $\Delta r_2 < \Delta r_1$

Therefore the correct location of the two coaxial cylinders is the one designated A_2. The difference in radii Δr_2 should then be equal to or less than the specified tolerance.

Annex C
(normative)

Relation to the GPS matrix model

C.1 General

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

C.2 Information about the standard and its use

This International Standard contains basic information for the geometrical tolerancing of workpieces. It represents the initial basis and describes the fundamentals for geometrical tolerancing.

C.3 Position in the GPS matrix model

This International Standard is a general GPS standard, which influences the chain link 1 and 2 of the chains of standards on form, orientation, location and run out and chain link 1 of the chain of standards on datums 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 of datum						
	Form of surface independent of datum						
	Form of surface dependent of datum						
	Orientation						
	Location						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile						
	Primary profile						
	Waviness profile						
	Surface imperfections						
	Edges						

Figure C.1

C.4 Related standards

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

Bibliography

[1] ISO 128 (all parts), *Technical drawings — General principles of presentation*

[2] ISO 129 (all parts), *Technical drawings — Indication of dimensions and tolerances*

[3] ISO 3040:1990, *Technical drawings — Dimensioning and tolerancing — Cones*

[4] ISO 3098-0, *Technical product documentation — Lettering — Part 0: General requirements*

[5] ISO 3098-2:2000, *Technical product documentation — Lettering — Part 2: Latin alphabet, numerals and marks*

[6] ISO/TR 5460:1985, *Technical drawings — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out — Verification principles and methods — Guidelines*

[7] ISO 7083:1983, *Technical drawings — Symbols for geometrical tolerancing — Proportions and dimensions*

[8] ISO/TR 14638:1995, *Geometrical product specification (GPS) — Masterplan*

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