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

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





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Foreword

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

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

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

Introduction

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

The ISO GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO GPS system of which this document is a part. The fundamental rules of ISO GPS given in ISO 8015 apply to this document. The default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise stated.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1 Scope

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

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

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

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

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

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

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

ISO 1101:2012(E)

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

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

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

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

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

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

ISO 12781-2:2011, *Geometrical product specifications (GPS) — Flatness — Part 2: Specification operators*

ISO 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO 14660-2:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

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

3 Terms and definitions

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

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

NOTE See also 4.4.

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

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

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

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

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

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

3.4**direction feature**

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

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

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

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

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

3.5**compound contiguous feature**

feature composed of several single features joined together without gaps

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

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

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

3.6**collection plane**

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

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

3.7**theoretically exact dimension****TED**

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

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

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

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

NOTE 4 A TED can define

- the extension or the relative location of a portion of one feature,
- the length of the projection of a feature,
- the theoretical orientation or location from one or more features, or
- the nominal shape of a feature.

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

4 Basic concepts

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

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

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

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

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

- the space within a circle;
- the space between two concentric circles;
- the space between two equidistant lines or two parallel straight lines;
- the space within a cylinder;
- the space between two coaxial cylinders
- the space between two equidistant surfaces or two parallel planes;
- the space within a sphere.

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

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

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

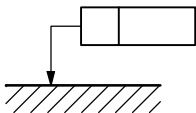
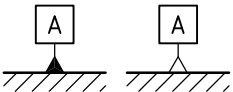











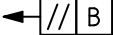


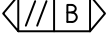
5 Symbols

See Tables 1 and 2.

Table 1 — Symbols for geometrical characteristics

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

Table 2 — Additional symbols

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

6 Tolerance frame

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

- first compartment: the symbol for the geometrical characteristic;
- second compartment: the width of the tolerance zone in the unit used for linear dimensions and complementary requirements (see Clauses 7, 8, 10, and 12 to 16). If the tolerance zone is circular or cylindrical, the value is preceded by the symbol “ ϕ ”. If the tolerance zone is spherical, the value is preceded by “ $S\phi$ ”;
- third and subsequent compartment, if applicable: the letter or letters identifying the datum or common datum or datum system (see the examples in Figures 2, 3, 4 and 5).



Figure 1

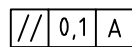


Figure 2

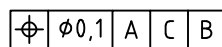


Figure 3

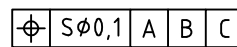


Figure 4

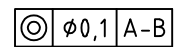


Figure 5

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



Figure 6

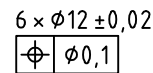


Figure 7

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



NOTE See also Table 2.

Figure 8

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

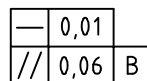


Figure 9

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

7 Toleranced features

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

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

- In *2D annotation*, on the outline of the feature or an extension of the outline (but clearly separated from the dimension line) (see Figures 10 and 11). The termination of the leader line is
 - an arrow if it terminates on a drawn line, or
 - a dot (filled or unfilled) when the indicated feature is an integral feature and the leader line terminates within the bounds of the feature.

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

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

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

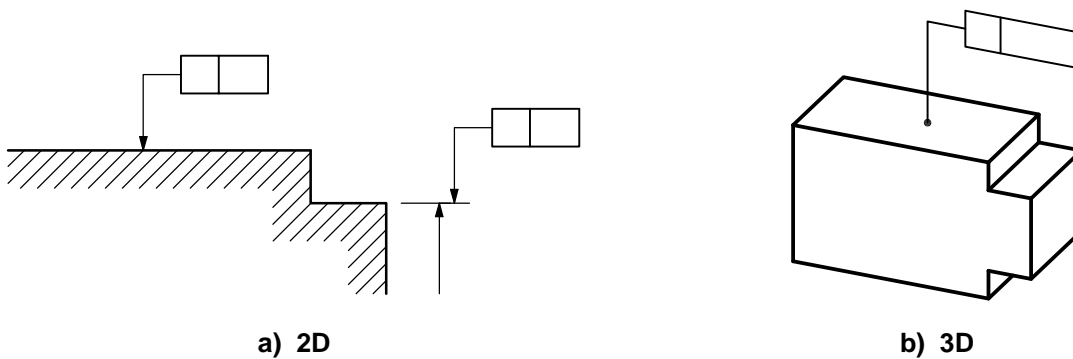


Figure 10

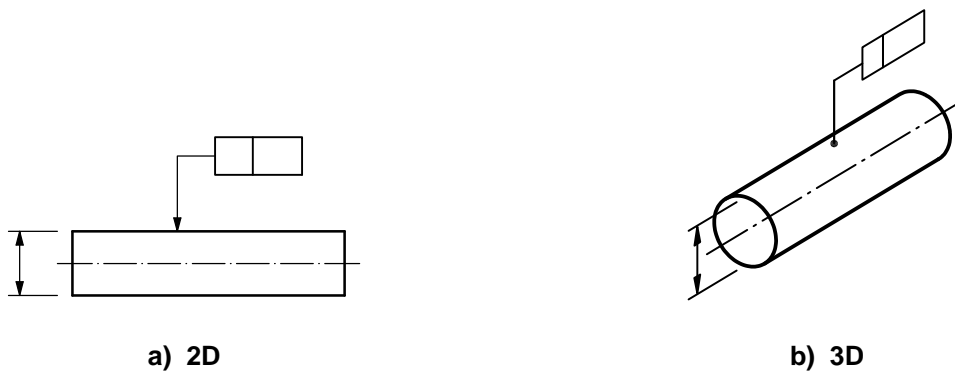


Figure 11

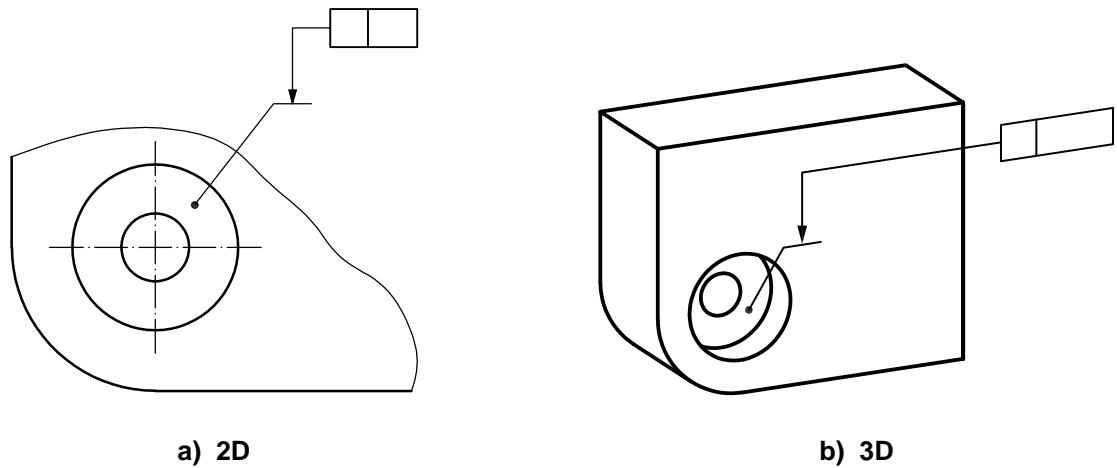


Figure 12

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

- by the leader line starting from either end of the tolerance frame terminated by an arrow on the extension of the dimension line of a feature of size [see the examples in Figures 13 a), 13 b), 14 a), 14 b), 15 a) and 15 b)], or
- by a modifier \textcircled{A} (median feature) placed at the rightmost end of the second compartment of the tolerance frame from the left. In this case, the leader line starting from either end of the tolerance frame does not have to terminate on the dimension line, but can terminate with an arrow on the outline of the feature [see Figures 16 a) and 16 b)].

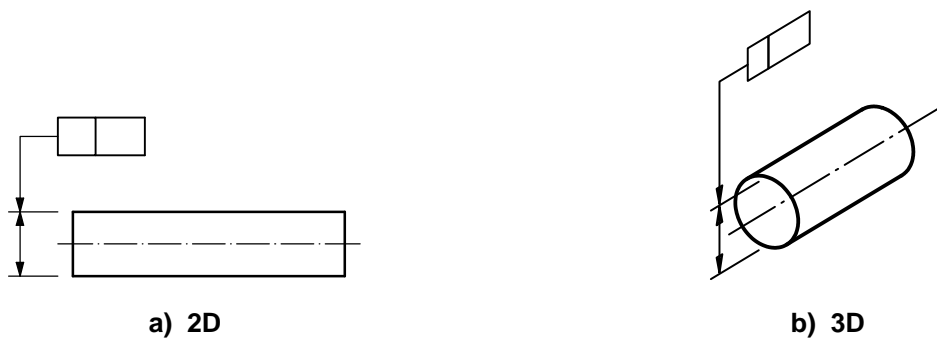


Figure 13

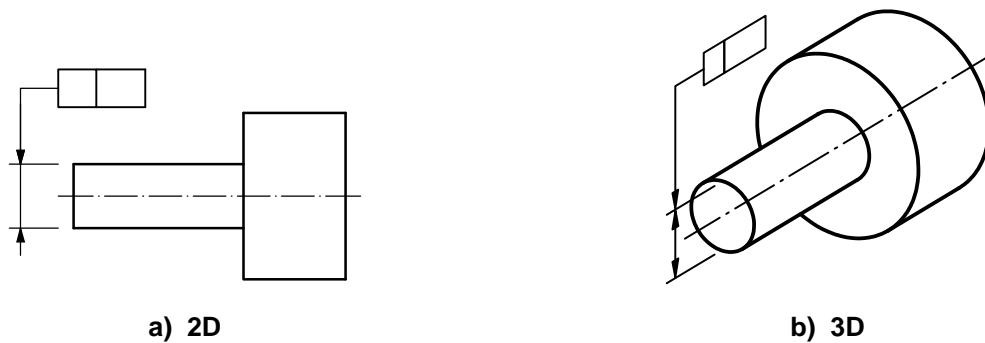


Figure 14

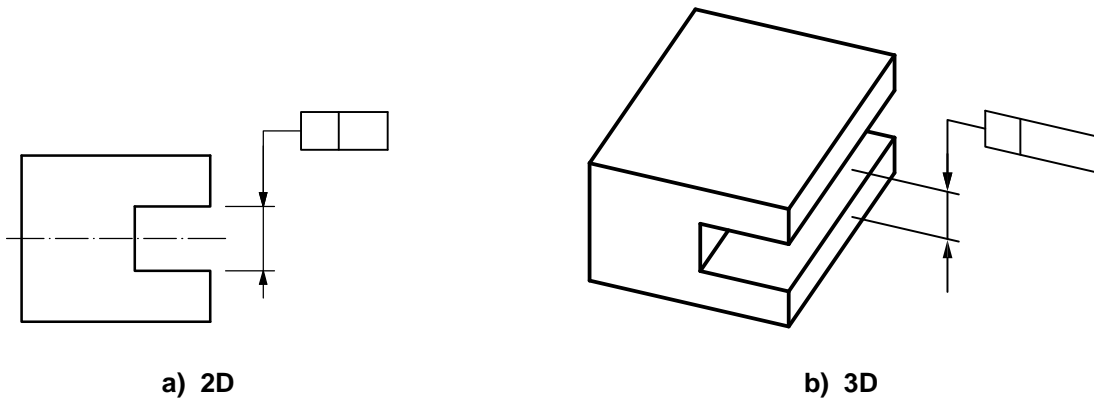


Figure 15

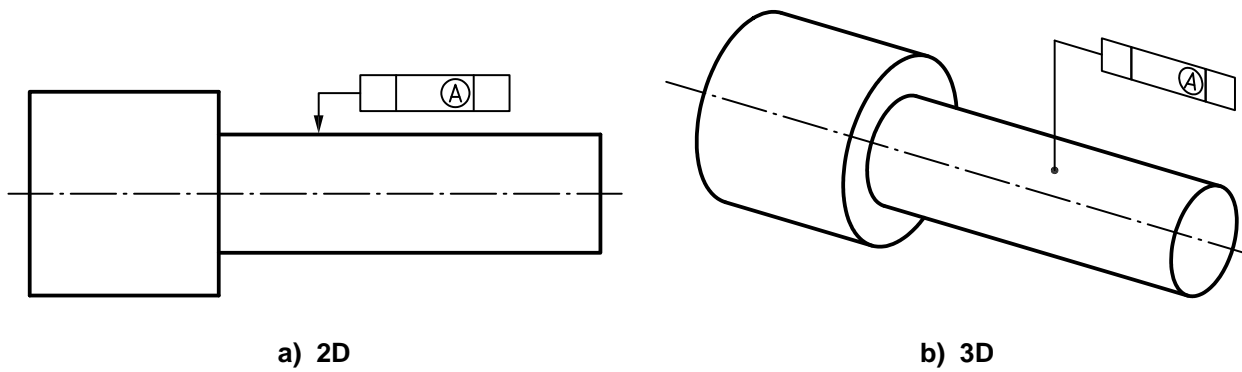


Figure 16

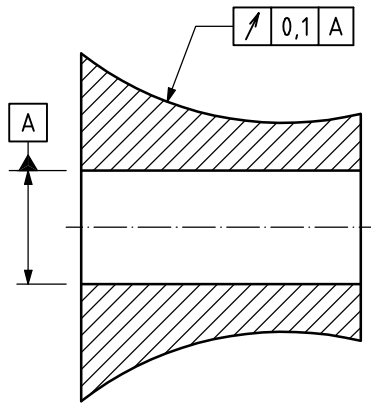
If needed, an indication specifying the type of feature (line instead of a surface) shall be written near the tolerance frame (see Figures 103 and 104).

NOTE When the toleranced feature is a line, a further indication may be needed to control the orientation of the toleranced feature, see Figure 97 for the case of a median line and Figure 103 for the case of an integral line.

8 Tolerance zones

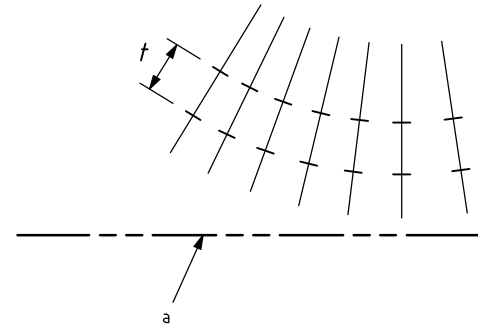
8.1 The tolerance zone is positioned symmetrically from an ideal feature unless otherwise indicated (see 10.2). The tolerance value defines the width of the tolerance zone. This width applies normal to the specified geometry (see Figures 17 and 18) unless otherwise indicated (see Figures 19 and 20).

NOTE The orientation alone of the leader line does not influence the definition of the tolerance zone, except in the case where the orientation of the leader line and therefore the direction of the width of the tolerance zone is indicated by a TED [see Figures 19 a) and 19 b), and 8.2].



Drawing indication

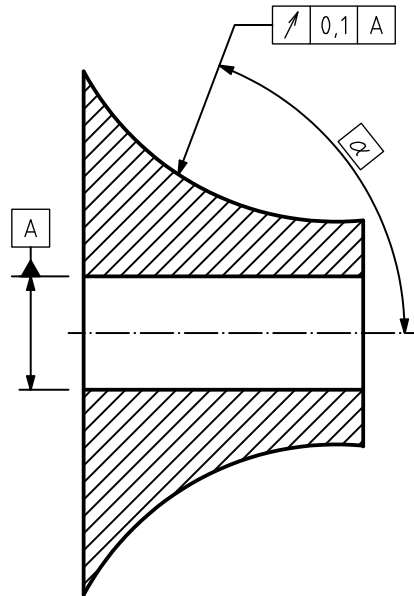
Figure 17



a Datum A.

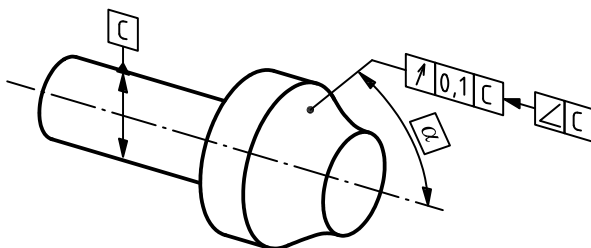
Interpretation

Figure 18

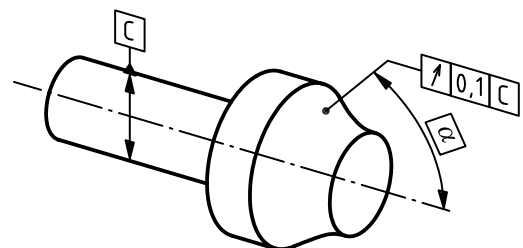


Drawing indication

a) 2D



b) 3D



c) 3D

Figure 19

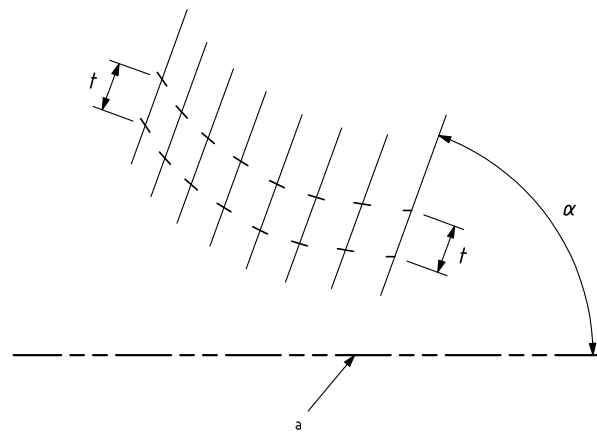
ISO 1101:2012(E)

NOTE 1 When the datum feature identified by the tolerance frame is the same as the feature establishing the direction feature, then the direction feature can be omitted.

NOTE 2 In Figure 19, the theoretical shape of each tolerated feature is a circle. The straight segments are inclined by the angle alpha. This generates a set of tolerance zones which are conical sections with a fixed angle along the surface.

When a direction feature is indicated as shown in Figure 19, the width of the tolerance zone is defined by an infinite set of straight segments, inclined in the direction indicated by the direction feature indicator. Each of these segments has a length equal to the tolerance value and has its midpoint located on the theoretical shape of the tolerance zone by default.

The tolerance value is constant along the length of the considered feature, unless otherwise indicated by a graphical indication, defining a proportional variation from one value to another, between two specified locations on the considered feature, identified as given in 10.1.4. The letters identifying the locations are separated by an arrow (see Figure 21 for restricted parts of a feature). The values are related to the specified locations on the considered feature by the letters indicated over the tolerance frame (e.g. in Figure 21, the value of the tolerance is 0,1 for location J and 0,2 for location K). By default, the proportional variation follows the curvilinear distance, i.e. the distance along the curve connecting the two specified locations.



a Datum A.

Interpretation

Figure 20

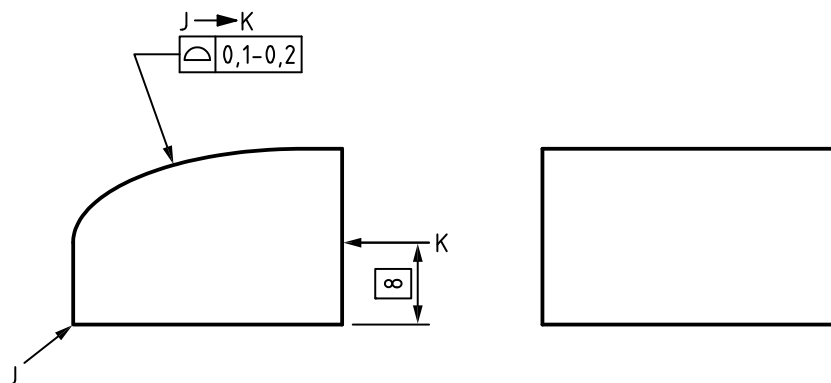


Figure 21

The angle α shown in Figure 19 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 median feature (centre point, median line, median surface) tolerated in one direction:

- In 2D view, when the direction of the width of a tolerance zone is at 0° or 90° relative to the datum or relative to the pattern of the theoretically exact dimensions without using an orientation plane, the arrow of the leader line gives this direction (Figures 22, 23 and 24). In other cases, an orientation plane shall be used.

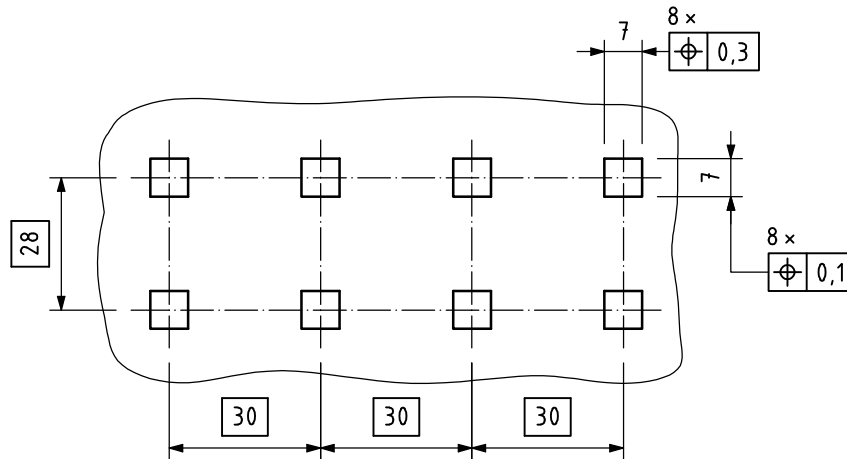
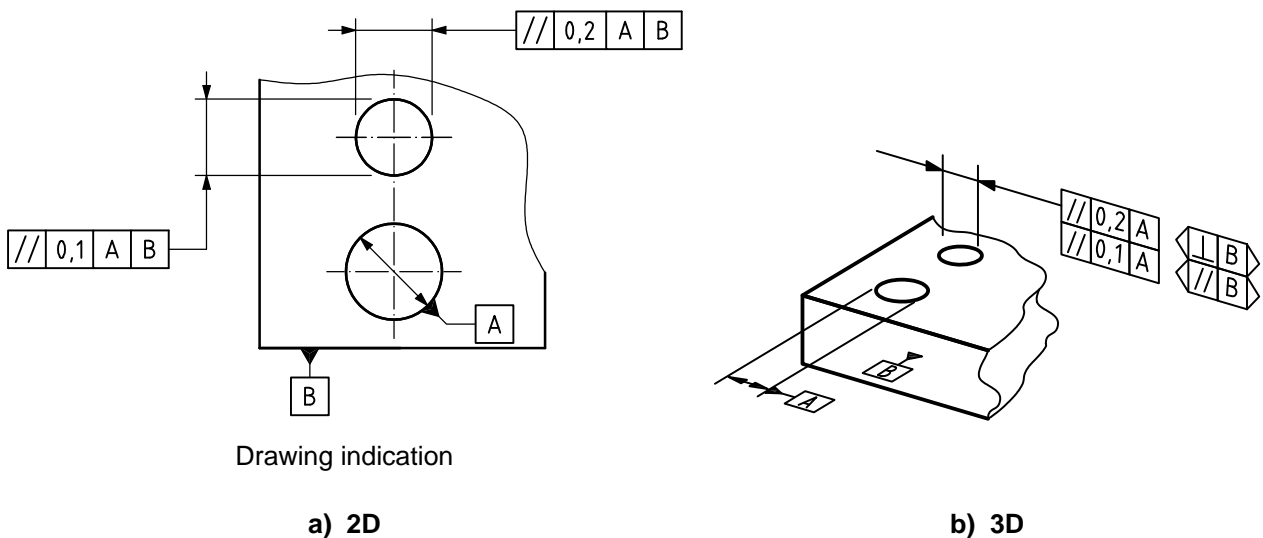


Figure 22

- In 3D view, when the direction of the width of a tolerance zone is to be specified relative to the datum or relative to the pattern of the theoretically exact dimensions, an orientation plane shall be indicated to determine this direction [see Figure 23 b)].
- when two tolerances are stated, they shall be perpendicular to each other unless otherwise specified (see the examples in Figures 23 and 24).

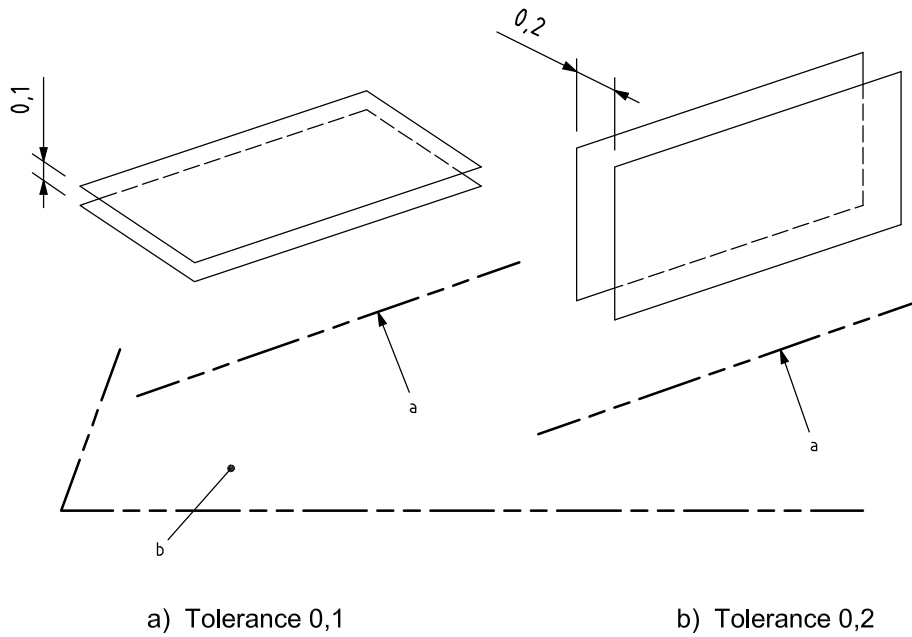


Drawing indication

a) 2D

b) 3D

Figure 23

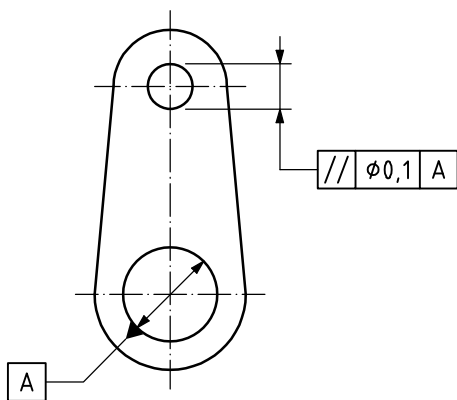


- a Datum A.
- b Datum B.

Interpretation

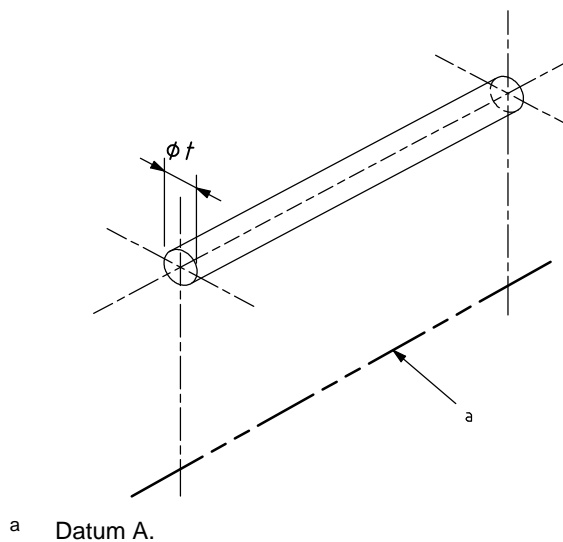
Figure 24

8.3 The tolerance zone is cylindrical (see the examples in Figures 25 and 26) or circular if the tolerance value is preceded by the symbol “ ϕ ” or spherical if it is preceded by the symbol “S ϕ ”.



Drawing indication

Figure 25



Interpretation

Figure 26

8.4 Individual tolerance zones of the same value applied to several separate features may be specified (see the example in Figure 27).

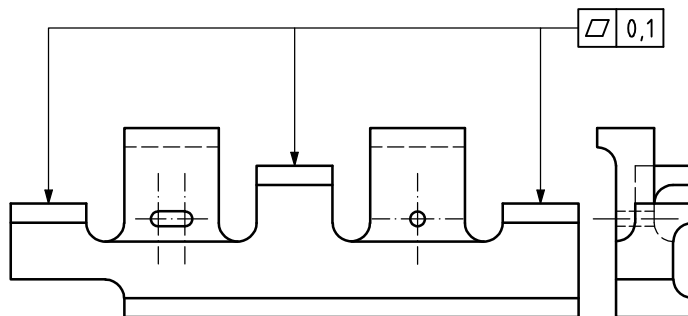


Figure 27

8.5 Where a common tolerance zone is applied to several separate features, this common requirement shall be indicated by the symbol “CZ” for common zone following the tolerance in the tolerance frame [see the examples in Figure 28 a)].

Where several tolerance zones (controlled by the same tolerance frame) are applied simultaneously to several separate features (not independently), to create a combined zone, the requirement shall be indicated by the symbol “CZ” for common zone following the tolerance in the tolerance frame [see the example in Figure 28 b)] and an indication that the specification applies to several features [e.g. using “3 x” over the tolerance frame (see 6.2), or using three leader lines attached to the tolerance frame (see 8.4)].

Where CZ is indicated in the tolerance frame, all the related individual tolerance zones shall be constrained in location and in orientation amongst themselves using either implicit (0 mm, 0°, 90°, etc.) or explicit theoretically exact dimensions (TED).

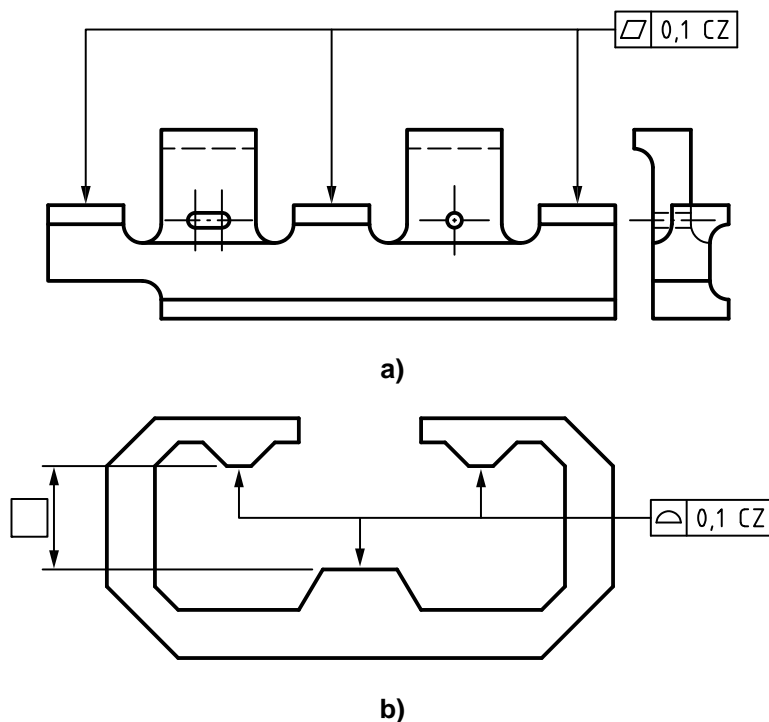


Figure 28

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 tolerated 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 the examples in Figures 29 a), 29 b), Figures 30 a) and 30 b)]; 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 29



Figure 30

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

- in 2D annotation, 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 the example in Figure 31); the datum triangle may be placed on a reference line using a leader line to point to the surface (see the example in Figure 32);

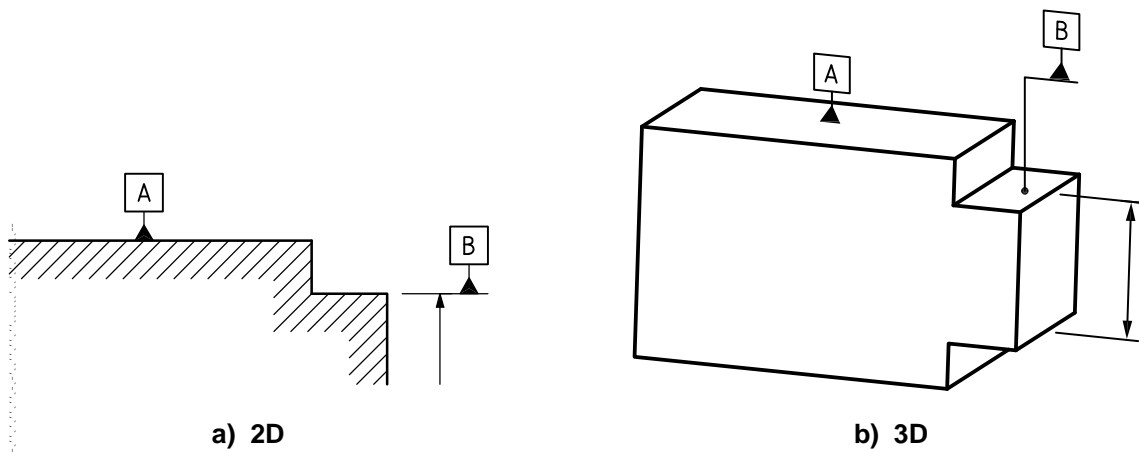


Figure 31

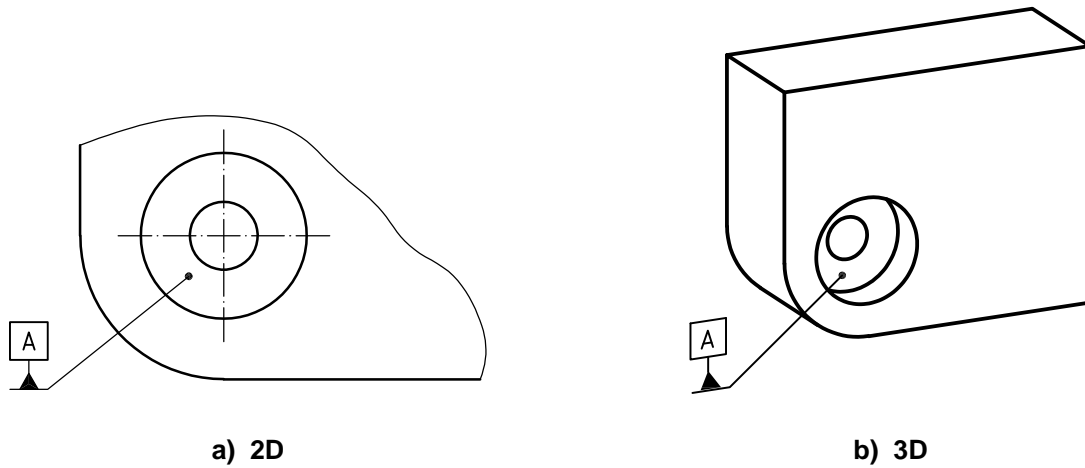


Figure 32

- in 3D annotation, when the datum is established from a datum feature which is not a feature of size, the datum feature indicators shall not be in extension of a dimension line [see Figure 31 b) and Figure 32 b)], and shall be indicated in one of the following ways:
 - For a visible feature:
 - on the feature itself, or
 - on a reference line using a leader line terminated by a filled dot to point to the feature;
 - For a non-visible feature:
 - on a reference line using a dashed leader line terminated by an unfilled dot to point to the feature, or
 - on an extension line tangential to the feature and perpendicular to an outline of the feature, which is clearly separated from the borders of the feature.
- 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 the examples in Figures 33 a) to 35 a) for 2D annotation and Figures 33 b) to 35 b) for 3D annotation], if there is insufficient space for two arrowheads, one of them may be replaced by the datum triangle [see the examples in Figures 34 a) and 35 a) for 2D annotation and Figures 34 b) and 35 b) for 3D annotation].

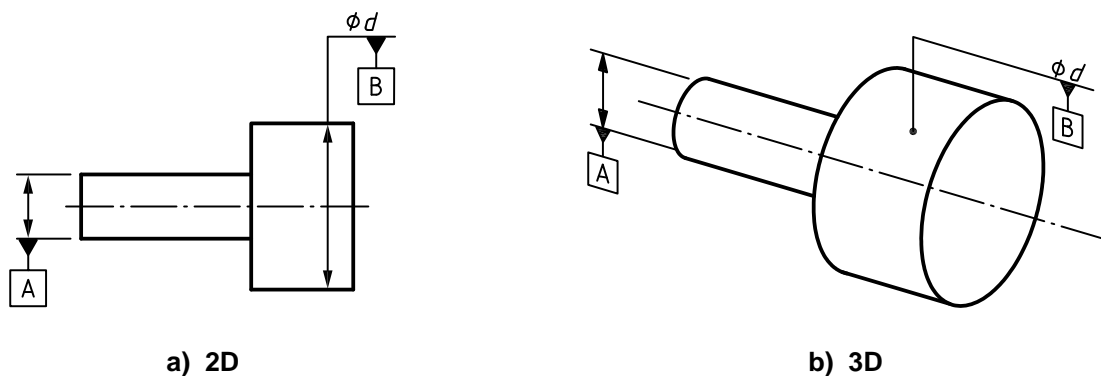


Figure 33

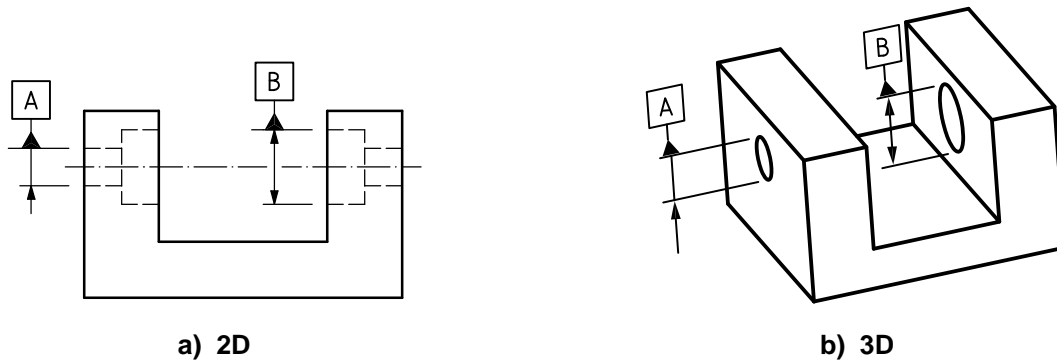


Figure 34

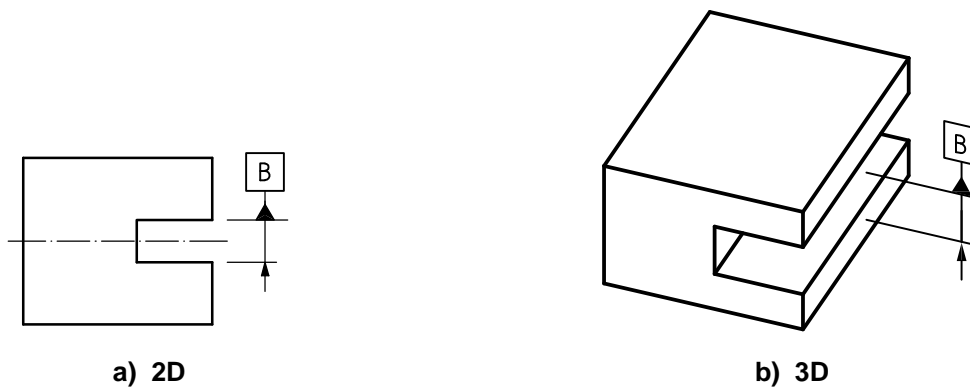


Figure 35

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 the example in Figure 36). See ISO 128-24:1999, Table 2, 04.2.

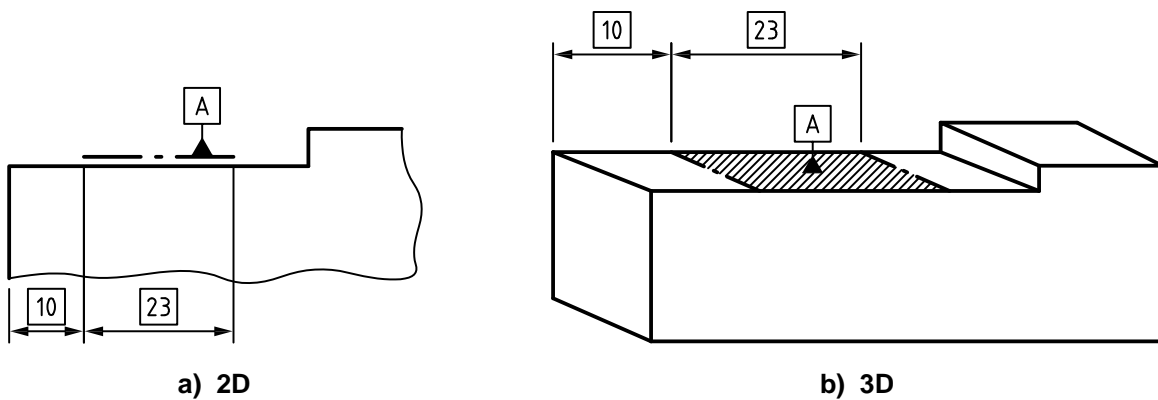


Figure 36

9.5 A datum established by a single feature is identified by a capital letter (see Figure 37).

A common datum established by two features is identified by two capital letters separated by a hyphen (see the example in Figure 38).

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 the example in Figure 39).

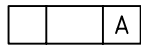


Figure 37

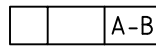


Figure 38

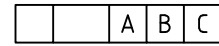


Figure 39

10 Supplementary indications

10.1 Indications of a compound or restricted toleranced feature

10.1.1 General

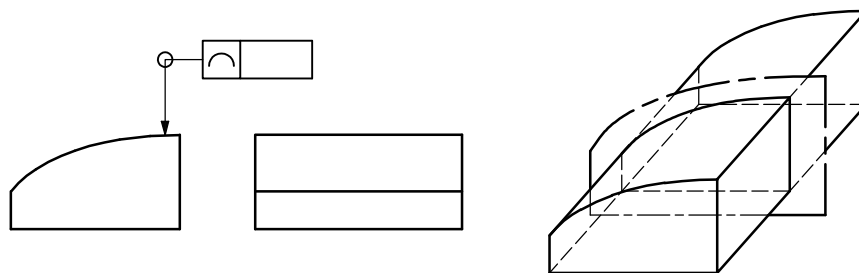
When the toleranced feature is a portion of a single feature, or a compound contiguous feature, then it shall be indicated either as

- a contiguous, closed feature (single or compound), see 10.1.2,
- a restricted area of a single surface, 10.1.3, or
- a contiguous, non-closed feature (single or compound), see 10.1.4.

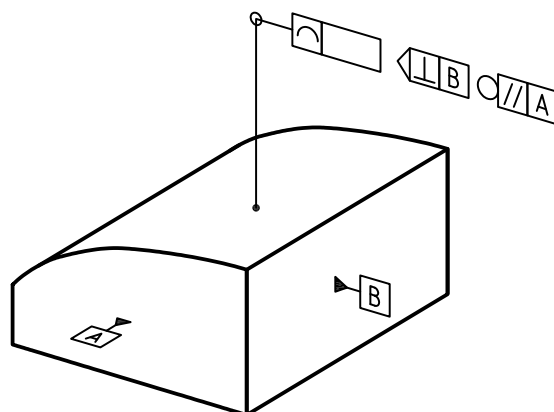
10.1.2 All around — Contiguous, closed toleranced feature

If a requirement applies to a closed compound contiguous surface defined by a collection plane, the “all around” modifier (“O”) shall be placed on the intersection of the leader line and the reference line of the tolerance frame. In 3D annotation, a collection plane indicator identifying the collection plane shall be placed after the tolerance frame [see Figures 40 b) and 41 b)]. In 2D annotation, the collection plane can be implicit parallel to the projection plane in which the specification is indicated. An all-around requirement applies only to the surfaces represented by the outline, not to the entire workpiece (see Figure 41).

If a requirement applies to the set of line elements on the closed compound contiguous surface (defined by a collection plane), an intersection plane indicator identifying the intersection plane shall also be placed between the tolerance frame and the collection plane indicator in 3D annotation [see Figure 40 b)].



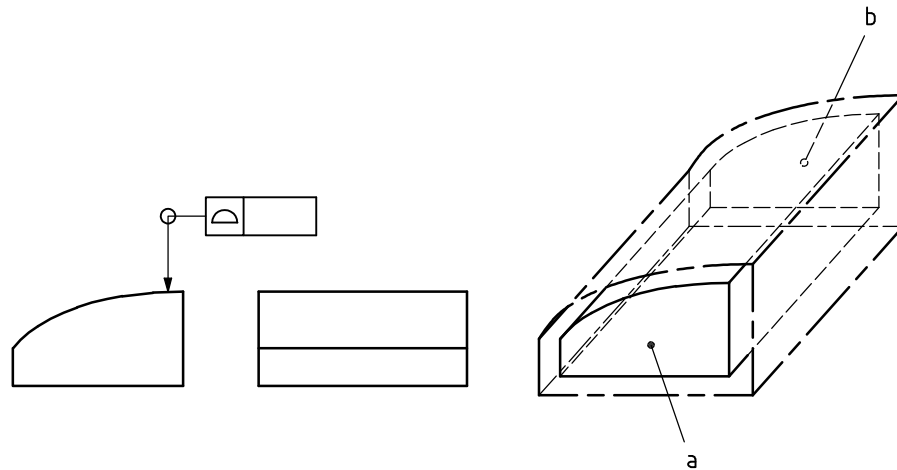
a) 2D



b) 3D

NOTE When using the symbol of profile of any line, if the intersection plane and the collection plane are the same, the collection plane symbol can be omitted.

Figure 40



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

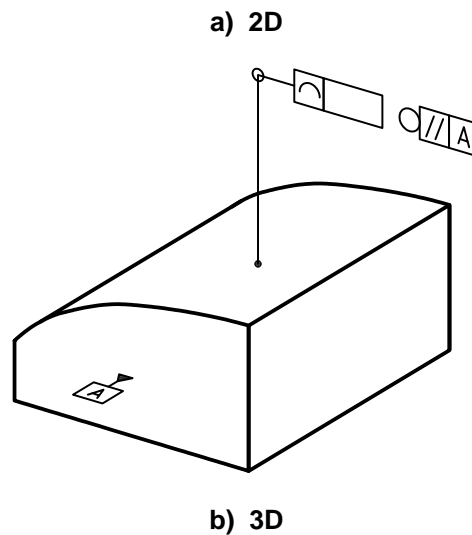


Figure 41

10.1.3 Restricted area tolerated feature

In 2D annotation, the surface portions involved shall be outlined by a long-dashed dotted wide line (in accordance with ISO 128-24) (see Figures 53 and 54).

In 3D annotation, the leader line starting from either end of the tolerance frame shall terminate on a hatched area, indicating the surface portions involved whose location and dimensions shall be defined by TEDs (see Figure 42).

The restricted area is defined either

- by its border indicated as a long-dashed dotted wide line (in accordance with ISO 128-24 type 04.2),
- by its corner points, indicated as crosses on the integral feature (the location of the points being defined by TEDs), identified by capital letters and leader lines terminated by an arrow. The letters are indicated above the tolerance frame with a “between” symbol between the last two, see Figure 42 b). The border is formed by connecting the corner points with straight segments,
- by two straight border lines identified by capital letters and leader lines terminated by an arrow (the location of the border lines being defined by TEDs).

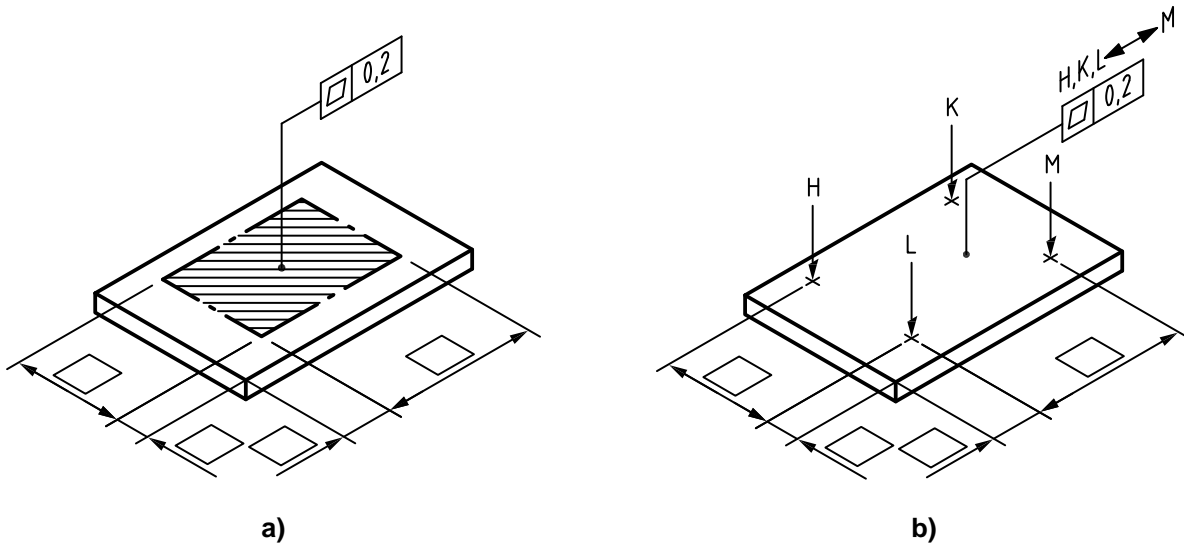


Figure 42

The tolerance requirement applies to each surface or line element independently, unless otherwise specified (e.g. by using a CZ symbol).

10.1.4 Contiguous, non-closed toleranced feature

If a tolerance applies to one identified restricted part of a feature or to contiguous restricted parts of contiguous features, but does not apply to the entire outline of the cross-sections (or entire surface represented by the outline), this restriction shall be indicated using the symbol “ \longleftrightarrow ” (called “between”) and by identifying the start and the end of the toleranced feature.

The points or lines that identify the start and end of the toleranced feature are each identified by a capital letter connected to it by a leader line terminating with an arrowhead. If the point or line is not at the boundary of an integral feature, its location shall be indicated by TEDs.

The between symbol “ \longleftrightarrow ” is used between two capital letters that identify the start and the end of the toleranced feature. This feature (compound toleranced feature) consists of all segments or areas between the start and the end of the identified features or parts of features.

In order to clearly identify the toleranced feature, the tolerance frame shall be connected to the compound toleranced feature by a leader line starting from either end of the frame and terminating with an arrowhead on the outline of the compound toleranced feature (see the example in Figure 43). The arrowhead may also be placed on a reference line using a leader line to point to the surface.

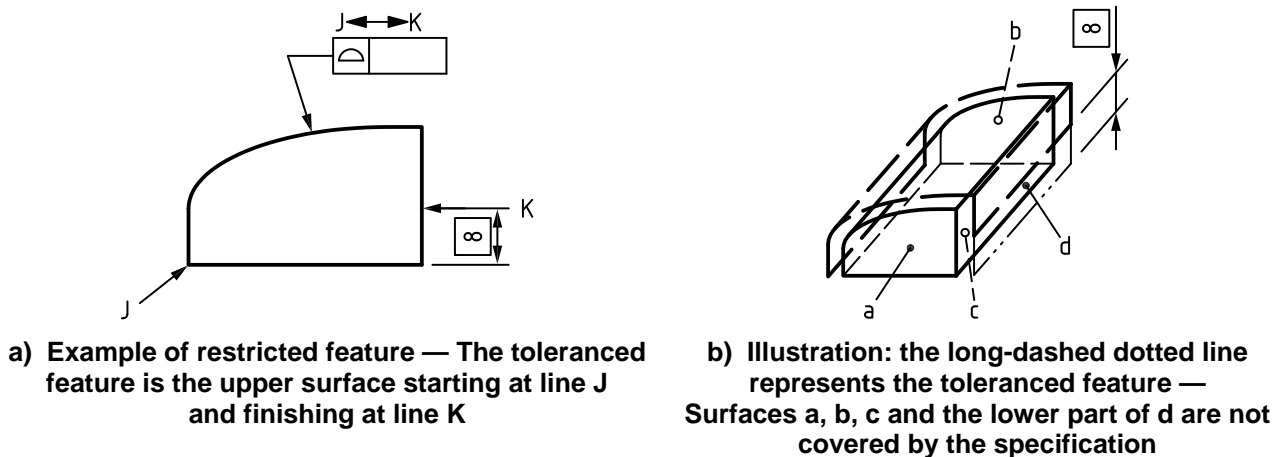


Figure 43

To avoid problems of interpretation regarding the considered nominal feature (see Figure 44), the start and end of the feature shall be indicated as shown in Figure 44.

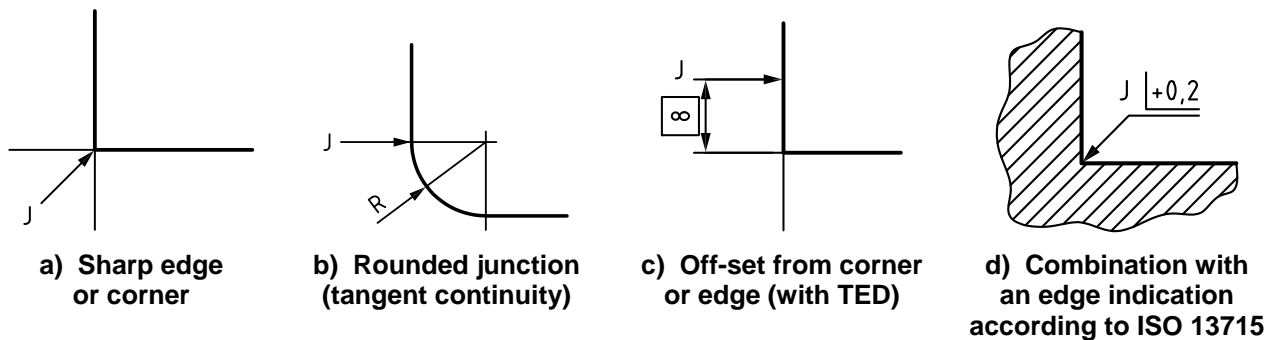


Figure 44

If the tolerance value is variable along the considered compound tolerated feature, the symbol “→” (called “from ... to”) shall be used instead of “between” (see 8.1).

If the same specification is applicable to a set of compound tolerated features, this set can be indicated above the tolerance frame, placing one element above the other (see the example in Figure 45).

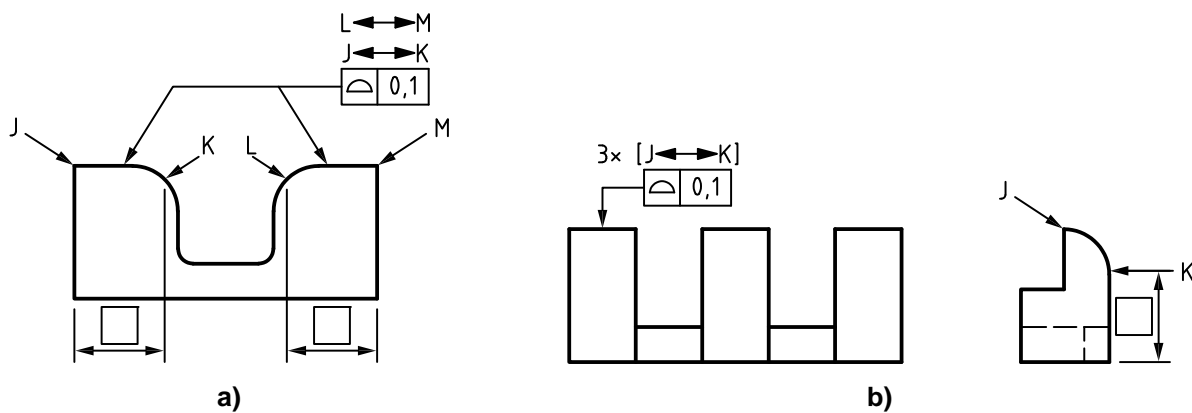


Figure 45

If all the compound toleranced features in the set are defined identically, it is possible to simplify the indication of this set, using the “n x” indication (see 6.2). In this case, the indication of the letters identifying the start and end shall be placed in square brackets.

The rule defined in Clause 8 regarding the common zone indication also applies to defining a common compound tolerance zone (see the example in Figure 46).

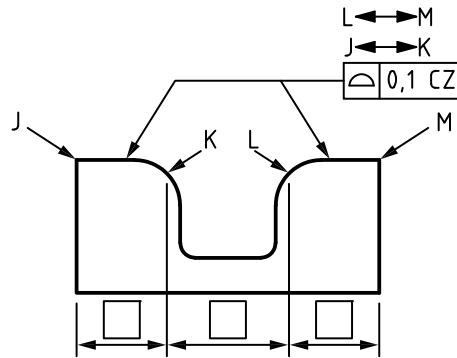
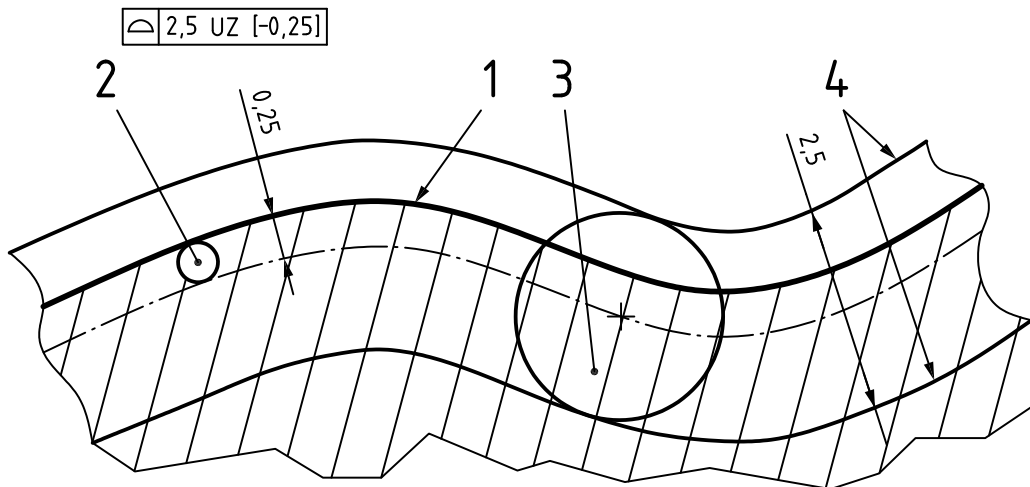


Figure 46

10.2 Indication of an unequally disposed tolerance zone

If the tolerance zone is not centred on the theoretically exact geometrical form, then this unequally disposed tolerance zone shall be indicated using the UZ modifier as shown in Figure 47.



Key

- 1 theoretical profile in this example, the material is below the profile
- 2 sphere to define the offset theoretical profile
- 3 sphere to define the tolerance zone
- 4 limits of the tolerance zone

Figure 47 — Unequally disposed tolerance zone indication

The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of defined diameter equal to the tolerance value, the centres of which are situated on a surface corresponding to the envelope of a sphere in contact with the theoretically exact geometrical form and whose diameter is equal to the absolute value given after UZ with the direction of the offset indicated by the sign, the “+” sign indicating “out of the material” and the “-” sign “into the material”.

10.3 Indications for screw threads, multiple splines and gears

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 the examples in Figures 48 and 49). Tolerances and datums specified for multiple splines and gears shall designate the specific feature to which they apply, i.e. “PD” for pitch diameter, “MD” for major diameter or “LD” for minor diameter.

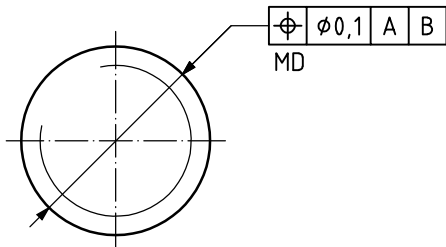


Figure 48

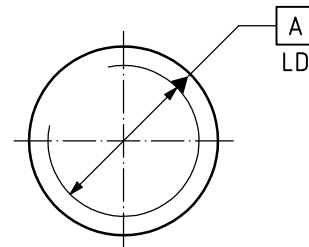


Figure 49

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 can be explicit or implicit.

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

TED shall not be tolerated. They are to be enclosed in a frame (see the examples in Figures 50 and 51).

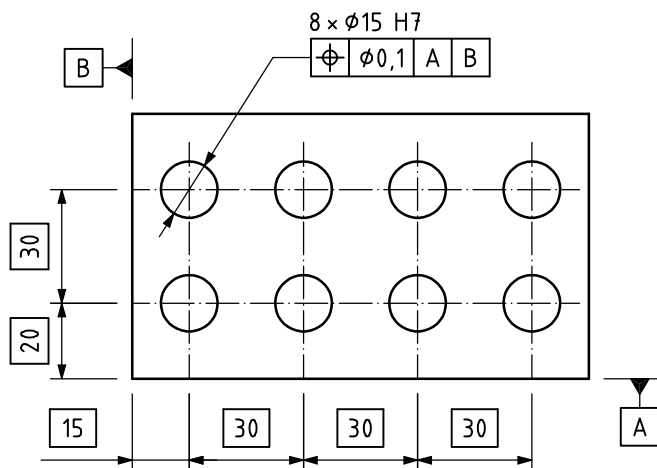


Figure 50

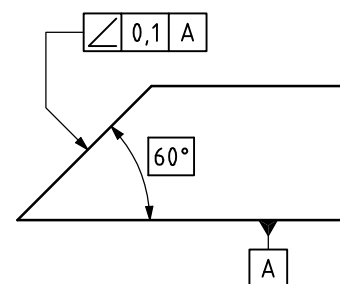


Figure 51

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 the example in Figure 52 a)]. If two or more tolerances of the same characteristic are to be indicated, they may be combined as shown in Figure 52 b).



Figure 52

12.2 If a tolerance is applied to a restricted part of a feature only, this restriction shall be shown as a long-dashed dotted wide line and dimensioned using theoretically exact dimensions [see the examples in Figures 53 a), 53 b), 54 and 55]. If this restriction is shown as a surface, it shall also be hatched [see the examples in Figures 53 b), 54 and 55].

NOTE See ISO 128-24:1999, Table 2, 04.2, for the definition of the long-dashed dotted wide line.

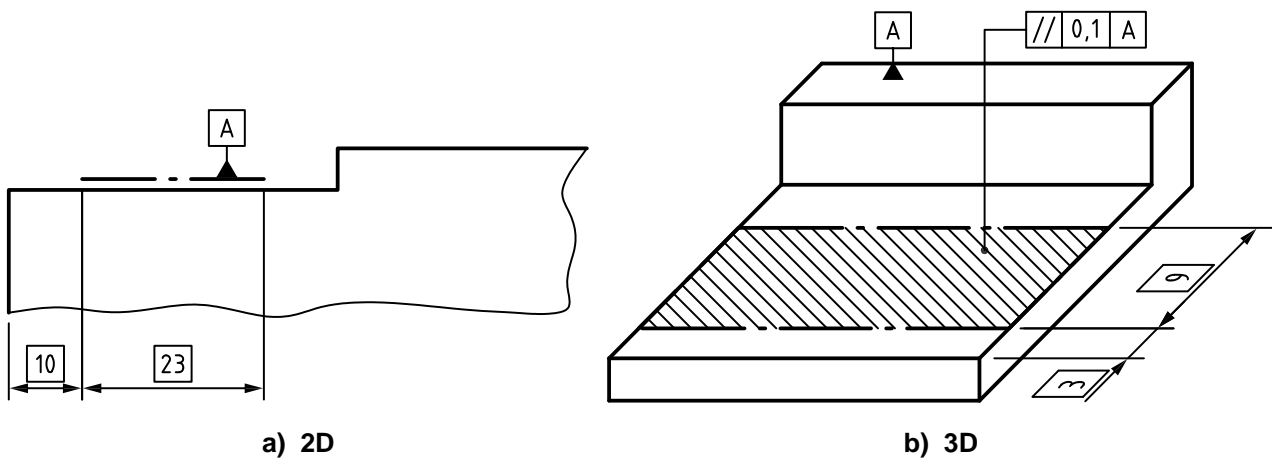


Figure 53

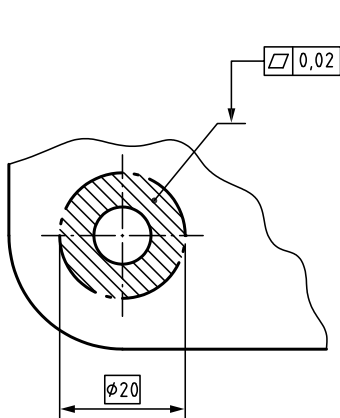


Figure 54

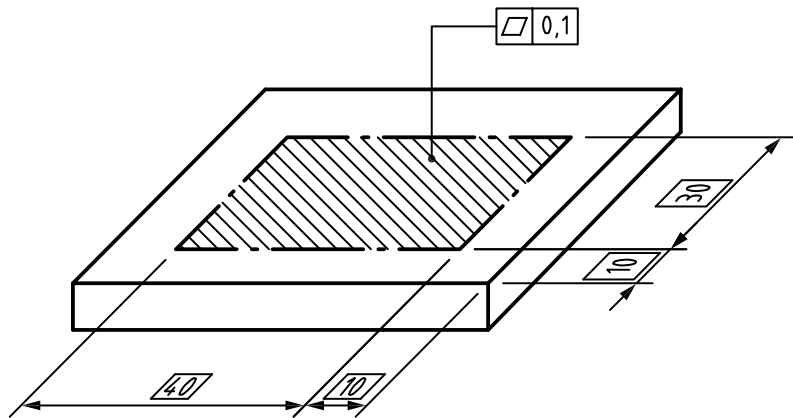


Figure 55

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

The symbol \textcircled{P} after the tolerance value in the second compartment of the tolerance frame indicates a projected tolerance; see Figures 56 a) and b). In this case, the toleranced feature is either a portion of the extended feature or its derived feature (see Table 3 and Clause 7).

The extended feature is an associated feature constructed from the real feature. The default association criterion for the extended feature is a minimized maximum distance between the indicated real feature and the associated feature with the additional constraint of external contact of material.

Table 3 — Feature toleranced with the projected tolerance modifier

The leader line from the tolerance frame points	Toleranced feature
On a cylinder (but not in extension of a dimension line)	Portion of the associated cylinder
In extension of a dimension line of a cylinder	Portion of the axis of the associated cylinder
On a plane (but not in extension of a dimension line)	Portion of the associated plane
In extension of a dimension line of two opposite parallel planes	Portion of the median plane of two associated parallel planes

The limits of the relevant portion of this extended feature shall be clearly defined and shall be indicated either directly or indirectly, as follows.

When indicating the projected tolerance length directly on the drawing by a “virtual” integral feature representing the portion of the extended feature to be considered, this virtual feature shall be indicated by use of a long-dashed double-dotted narrow line, and the length of the extension shall be indicated with the symbol \textcircled{P} prior to the Theoretically Exact Dimension (TED) value. See Figure 56 a).

When indicating the length of the projected toleranced feature indirectly in the tolerance frame, the value shall be indicated after the symbol \textcircled{P} . See Figure 56 b). In this case the representation of the extended feature with a long-dashed double-dotted narrow line shall be omitted. This indirect indication concerns only blind holes.

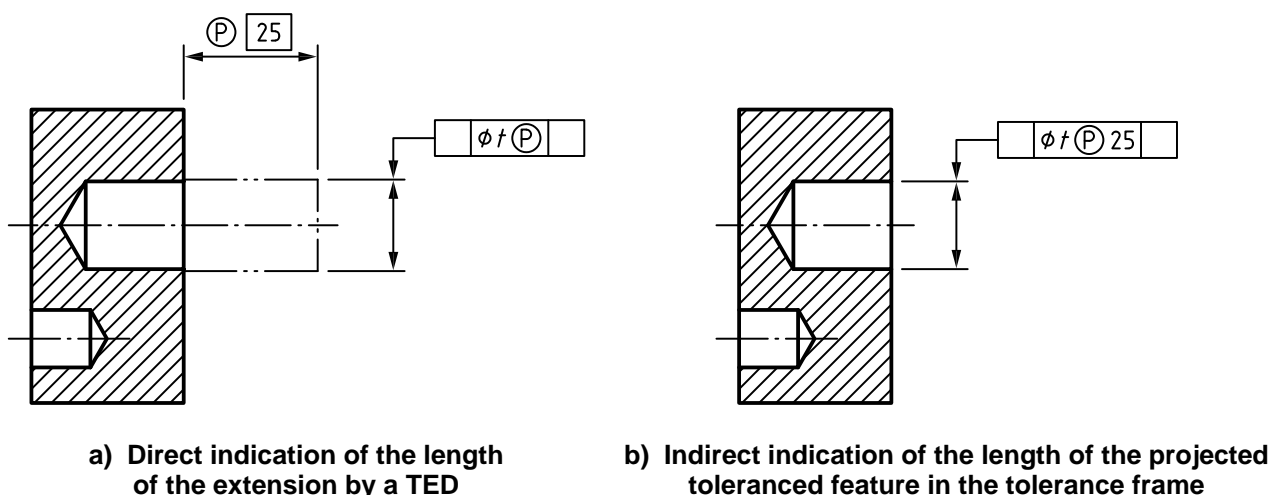
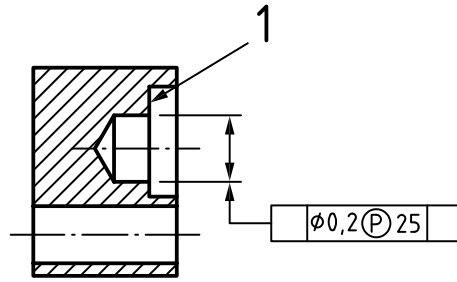


Figure 56 — Two ways of indicating a geometrical specification with projected tolerance modifier

The origin of the projected feature is constructed from the reference plane. To define the reference plane, it is necessary to look for the first plane intersecting the considered feature. See Figure 57. This real feature shall be considered to define the reference plane. The reference plane is an associated plane to this real feature constrained to be perpendicular to the extended feature. See Figure 59.



Key

- 1 reference surface defining the start of the tolerated feature

Figure 57 — Reference surface of the projected feature

By default, the origin of the projected feature corresponds to the location of the reference plane, and the end corresponds to the shift of the projected feature's length from its origin in the outside materials direction.

If the origin of the projected feature is displaced from the reference surface by an offset, this shall be indicated as follows.

- When directly indicated, the offset shall be specified by a theoretically exact dimension (TED); see Figure 58.
- When indirectly indicated, the first value after the modifier indicates the distance to the farthest limit of the extended feature and the second value (offset value), which is preceded by a minus sign, indicates the distance to the nearest limit of the extended feature (the length of the extended feature is the difference between these two values), e.g. $\phi t \text{ (P) } 32-7$; see Figure 59. An offset value of zero shall not be indicated and the minus sign shall be omitted in this case; see Figure 56.

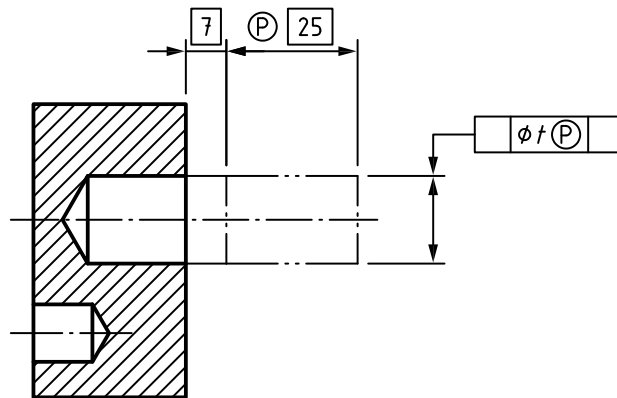
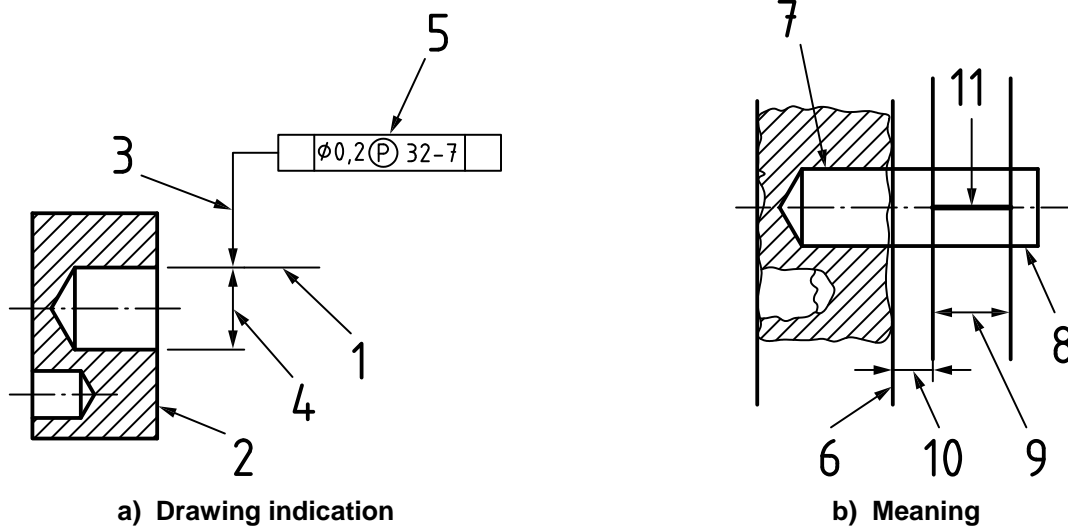


Figure 58 — Example of direct indication of a projected tolerance with an offset

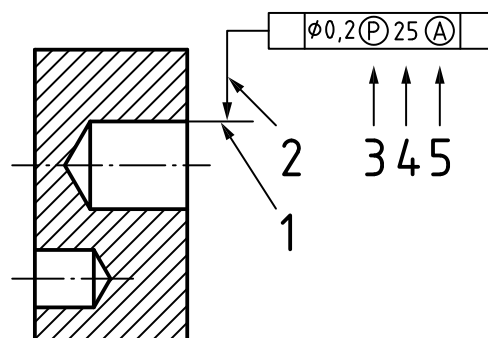


Key

- 1 extension line
- 2 reference surface
- 3 leader line connected to the tolerance frame
- 4 indication defining that the type of the tolerated feature is a median feature (equivalent to the modifier (A))
- 5 modifier defining that the tolerance applies to a portion of an extended feature and is limited by the information (9 and 10)
- 6 associated reference surface
- 7 integral surface
- 8 associated feature
- 9 length of the projected tolerated feature, in this case 25 mm (= 32 – 7)
- 10 offset of the projected tolerated feature from the reference surface, in this case 7 mm
- 11 projected tolerated feature

Figure 59 — Example of indirect indication of a projected tolerance with an offset

The modifier (P) may be used with other types of specification modifiers as appropriate; see Figure 60.



Key

- 1 extension line
- 2 leader line connected to the tolerance frame
- 3 modifier defining that the tolerance applies to a portion of an extended feature and is limited by the subsequent information (4)
- 4 length of projected tolerated feature, in this case 25 mm
- 5 modifier defining that the type of the tolerated feature is a median feature

Figure 60 — Example of use of a projected tolerance zone together with a median modifier

14 Free state condition

The free state condition for non-rigid parts shall be indicated by the specification modifier symbol \textcircled{F} placed after the specified tolerance value (see the examples in Figures 61 and 62). See ISO 10579 for additional information.

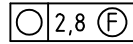


Figure 61



Figure 62

Several specification modifiers, \textcircled{P} , \textcircled{M} , \textcircled{L} , \textcircled{F} and CZ, may be used simultaneously in the same tolerance frame (see the example in Figure 63).

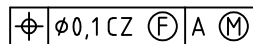


Figure 63

15 Interrelationship of geometrical tolerances

For functional reasons, one or more characteristics can be tolerated 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 the feature, and not vice-versa.

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

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

16 Intersection planes

16.1 Role of intersection planes

Intersection planes shall be used in 3D annotation when the projection plane is involved in the meaning of the specification in 2D annotation, e.g. straightness of a line in a plane, profile of any line, orientation of a line element of a feature (LE), "all around" specification for lines or surfaces. Intersection planes may also be used for convenience in 2D annotation.

16.2 Features to be used for establishing a family of intersection planes

Only surfaces belonging to one of the following invariance classes shall be used to establish a family of intersection planes (see ISO 17450-1):

- revolute (e.g. a cone or a torus);
- cylindrical (i.e. a cylinder);
- planar (i.e. a plane).

16.3 Graphical language

The intersection plane is specified through an intersection plane indicator placed as an extension to the tolerance frame (see Figure 64):

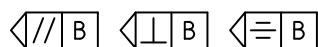


Figure 64 — Intersection plane indicator

The symbol defining how the intersection plane is derived from the datum is placed in the first compartment of the intersection plane indicator. The symbols stand for:

- // parallel;
- ⊥ perpendicular;
- ≡ including.

The letter identifying the datum used to establish the intersection plane is placed in the second compartment of the intersection plane indicator.

16.4 Rules

For geometrical specifications that include intersection plane indicators, the following applies.

When the tolerated feature is a line on an integral feature, an intersection plane shall be indicated in 3D annotation to avoid misinterpretation of the tolerated feature, except in the case of generatrix straightness or circularity of a cylinder or a cone.

The intersection plane is established parallel to, perpendicular to, or including the datum given in the intersection plane indicator, without additional orientation constraints, when the tolerance frame does not indicate datums.

When the tolerance frame indicates one or more datums, then the intersection plane is established parallel to, perpendicular to, or including the datum indicated in the intersection plane indicator with constraints (0° , 90° or an explicitly stated angle) from the datum(s) of the tolerance frame. The datums in the tolerance frame are applied in the specified order before the datum given in the intersection plane indicator is established.

The possible intersection planes are given in Table 4. They depend on the datum used to establish the intersection plane and how the plane is derived from this datum (as defined by the symbol indicated).

Table 4 — Application cases of intersection plane

Indicated datum	Intersection plane		
	Parallel to	Perpendicular to	Including
Axis of revolute surface (cylinder or cone)	Not applicable	OK ^b	OK ^d
Plane (integral or median)	OK ^a	OK ^c	Not applicable
Other type	Not applicable	Not applicable	Not applicable
^a See Figure 65. ^b See Figure 66. ^c See Figure 67. ^d See Figure 68.			

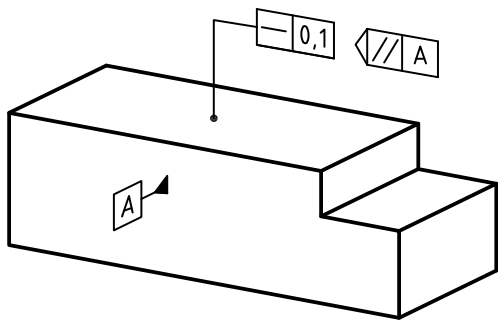


Figure 65

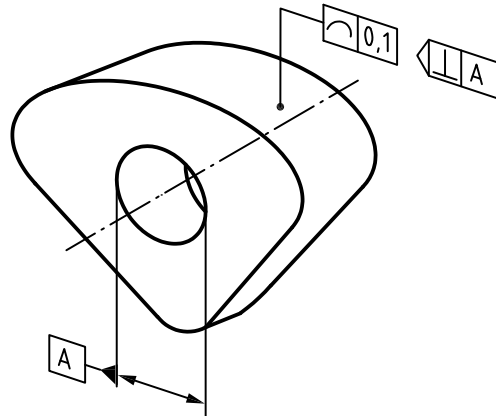


Figure 66

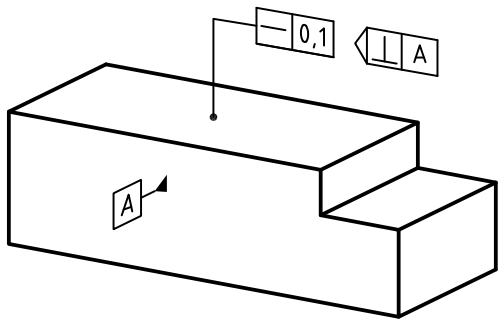


Figure 67

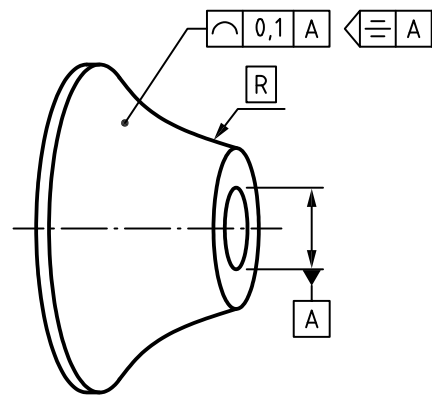
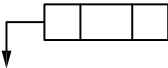




Figure 68

A datum feature indicator and an intersection plane indicator located to the right of the tolerance frame shall be used to indicate an intersection plane, as shown in Table 5.

Table 5 — Indication relative to a geometrical specification using an intersection plane

Tolerance frame	Intersection plane indicator	Datum feature indicator
 a)	 b)	 c)
<p>The intersection plane indicator (b) shall be placed to the right of the tolerance frame (a). The intersection plane indicator shall indicate a datum letter in the second compartment. In the first compartment, a symbol is placed (parallel, perpendicular or symmetrical) and indicates how the intersection plane is related to the datum.</p> <p>The datum corresponding to the datum letter allows the intersection plane to be built in accordance with the specified symbol.</p> <p>The datum is defined from the datum feature identified by the datum feature indicator (c).</p>		

17 Orientation planes

17.1 Role of orientation planes

Orientation planes shall be used in 3D annotation when

- the toleranced feature is a median line or a median point, and
- the width of the tolerance zone is limited by two parallel planes, and
- the tolerance zone is oriented from another feature, established from an extracted feature of the workpiece, identifying the orientation of the tolerance zone.

Orientation planes may also be used for convenience in 2D annotation.

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

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

17.2 Features to be used for establishing orientation planes

Only surfaces belonging to one of the following invariance classes shall be used to establish orientation planes (see ISO 17450-1):

- revolute (e.g. a cone or a torus);
- cylindrical (i.e. a cylinder);
- planar (i.e. a plane).

17.3 Graphical language

The orientation plane is specified through an orientation plane indicator placed as an extension to the tolerance frame (see Figure 69):

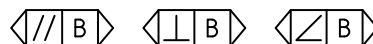


Figure 69 — Orientation plane indicator

The orientation symbol for parallelism, perpendicularity or angularity is placed in the first compartment of the orientation plane indicator.

The letter identifying the datum used to establish the orientation plane is placed in the second compartment of the orientation plane indicator.

17.4 Rules

An orientation plane shall be indicated in 3D annotation when

- the width of the tolerance zone is not normal to the specified geometry, or
- the toleranced feature is a point, or a median line toleranced in one Cartesian direction.

For geometrical specifications that include orientation plane indicators, the following applies.

The orientation plane is established parallel to, perpendicular to, or at a defined angle from the datum indicated in the orientation plane indicator as follows:

- when the orientation plane is defined with an angle different from 0° or 90°, the angularity symbol shall be used and an explicit theoretical angle shall be defined between the orientation plane and the datum of the orientation plane indicator;
- when the orientation plane is defined with an angle equal to 0° or 90°, the parallelism symbol or perpendicularity symbol shall be used respectively.

When the tolerance frame indicates one or more datums, then the orientation plane is established parallel to, perpendicular to, or at a defined angle from a plane defined by the orientation plane indicator with constraints (an implicit angle of 0° or 90° or an explicit stated angle defined by a TED) from the datum(s) of the tolerance frame. The datums in the tolerance frame are applied in the specified order before the plane given in the orientation plane indicator is established.

The possible orientation planes are given in Table 6. They depend on the datum used to establish the orientation plane and how the plane is derived from this datum (as defined by the symbol indicated).

Table 6 — Application cases of orientation plane

Indicated datum	Orientation plane		
	Parallel to	Perpendicular to	Inclined to
Axis of revolute surface (cylinder or cone)	Not applicable	OK	OK
Plane (integral or median)	OK	OK	OK
Other type	Not applicable	Not applicable	Not applicable

Examples are given in Figures 70 and 71.

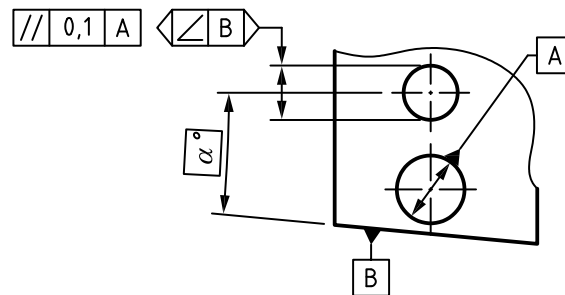
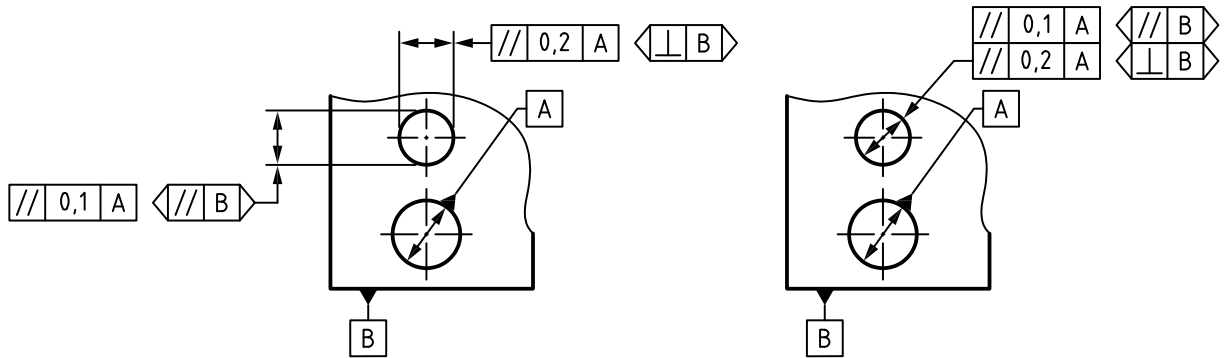


Figure 70



NOTE The above example is in 2D and the orientation plane indicators can be omitted, but in 3D annotation, they are necessary.

Figure 71

A datum feature indicator and an orientation plane indicator located to the right of the tolerance frame shall be used to indicate an orientation plane, as shown in Table 7.

Table 7 — Indication of an orientation plane

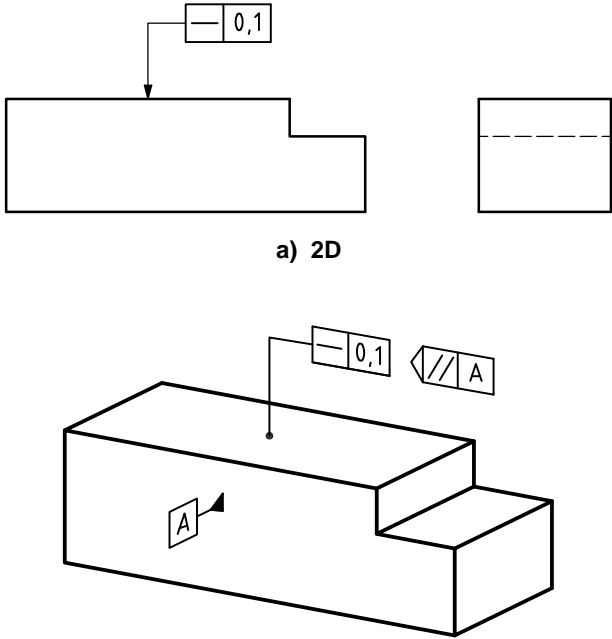
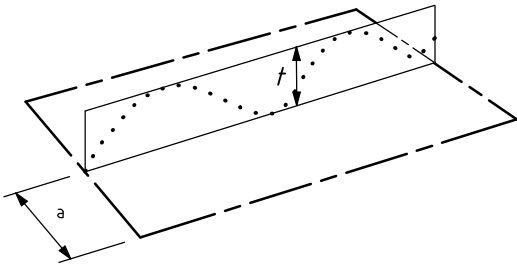
Datum feature indicator	Orientation plane indicator	Indication of geometrical specification using an orientation plane
	<p>The orientation plane indicator shall indicate the datum from which the orientation plane will be built, by a datum letter in its second compartment, and how the orientation of the tolerance zone relates to the datum (parallel, perpendicular or inclined) by a symbol placed in its first compartment. In the case of an angle different from 0° or 90°, the angularity symbol shall be used and an explicit theoretical angle shall be defined between the orientation plane and the datum.</p>	<p>The orientation plane indicator shall be placed to the right of the tolerance frame</p>

18 Definitions of geometrical tolerances

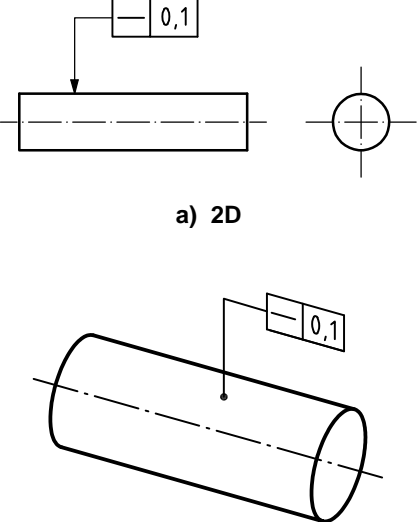
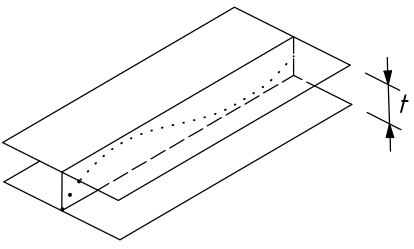
An explanation based on examples of the various geometrical tolerances and their tolerance zones are provided in this clause. The illustrations accompanying the definitions only show those deviations which relate to the specific definition.

18.1 Straightness tolerance (see ISO 12780-1 and ISO 12780-2)

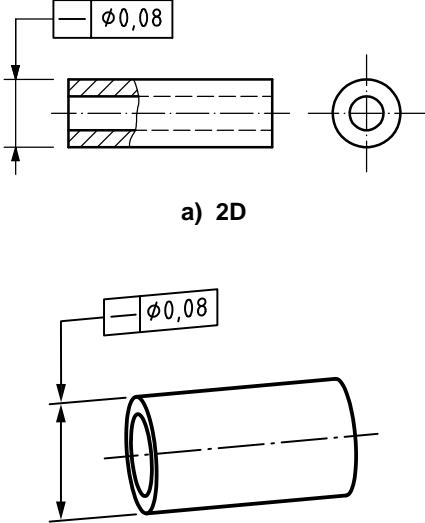
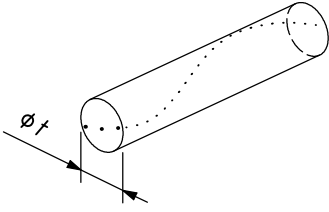
Dimensions in millimetres

Symbol	Indication and explanation
	<p>Any extracted (actual) line on the upper surface, parallel to the plane of projection (2D) or datum plane A, as specified by the intersection plane indicator (3D), shall be contained between two parallel straight lines 0,1 apart.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 72</p>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>The tolerance zone, in the considered plane, is limited by two parallel straight lines a distance t apart and in the specified direction only.</p> <div style="text-align: center;">  </div> <p>a Any distance.</p> <p style="text-align: center;">Figure 73</p>

Dimensions in millimetres


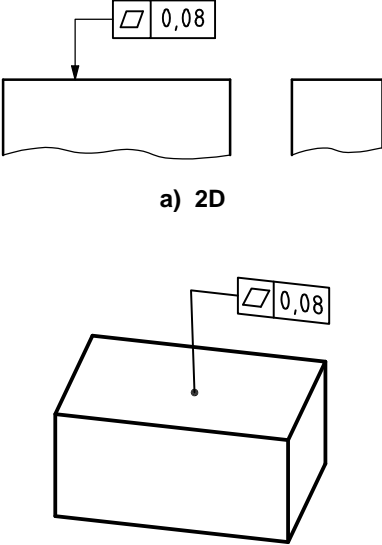
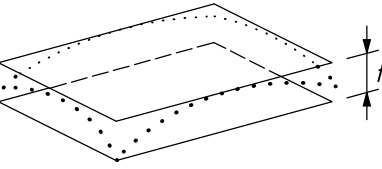
Symbol	Indication and explanation
<p>—</p>	<p>Any extracted (actual) generating line on the cylindrical surface shall be contained between two parallel planes 0,1 apart.</p> <p>NOTE The definition for an extracted generating line has not been standardized.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 74</p> </div>
<p>Definition of the tolerance zone</p>	
<p>The tolerance zone is limited by two parallel planes a distance t apart.</p> <div style="text-align: center;">  <p>Figure 75</p> </div>	

http://www.iso.org/iso/home/technical_info/technical_information_publications/standards_info.htm

Symbol	Indication and explanation
<p>—</p>	<p>The extracted (actual) median line of the cylinder to which the tolerance applies shall be contained within a cylindrical zone of diameter 0,08.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 76</p> </div>
<p>Definition of the tolerance zone</p>	
<p>The tolerance zone is limited by a cylinder of diameter t, if the tolerance value is preceded by the symbol ϕ.</p> <div style="text-align: center;">  <p>Figure 77</p> </div>	

18.2 Flatness tolerance (see ISO 12781-1 and ISO 12781-2)

Dimensions in millimetres


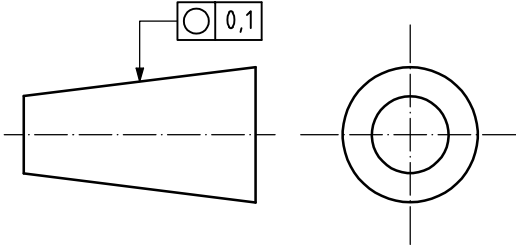
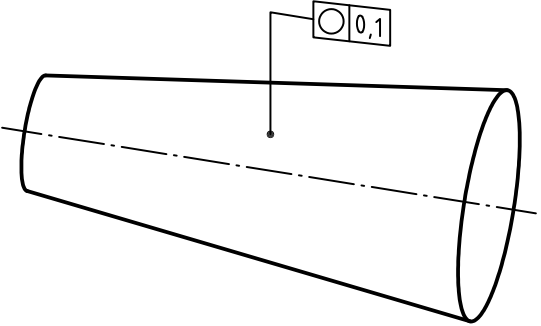
Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,08 apart.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 78</p> </div>
<p>Definition of the tolerance zone</p>	
<p>The tolerance zone is limited by two parallel planes a distance t apart.</p> <div style="text-align: center;">  <p>Figure 79</p> </div>	

18.3 Roundness tolerance (see ISO 12781-1 and ISO 12781-2)

Dimensions in millimetres

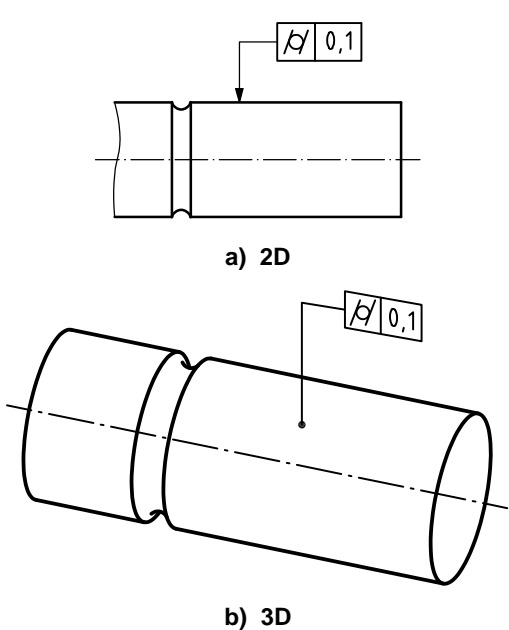
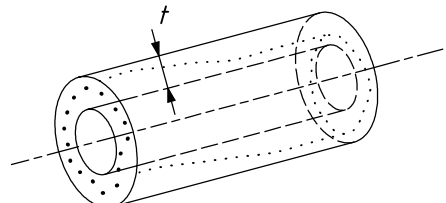
Symbol	Indication and explanation
	<p data-bbox="233 389 1394 450">For the cylindrical surface, the extracted (actual) circumferential line, in any cross-section of the cylindrical, shall be contained between two coplanar concentric circles, with a difference in radii of 0,03.</p> <div data-bbox="327 465 1273 981"> <p data-bbox="486 945 555 974">a) 2D</p> <p data-bbox="1075 945 1144 974">b) 3D</p> </div> <p data-bbox="756 1012 874 1041" style="text-align: center;">Figure 80</p>

Definition of the tolerance zone	
<p data-bbox="150 1128 177 1158">○</p>	<p data-bbox="233 1128 1394 1182">The tolerance zone, in the considered cross-section, is limited by two concentric circles with a difference in radii of t.</p> <div data-bbox="651 1205 981 1758"> </div> <p data-bbox="233 1783 454 1812">a Any cross-section.</p> <p data-bbox="756 1845 874 1874" style="text-align: center;">Figure 81</p>

Symbol	Indication and explanation
	<p>Any extracted (actual) circumferential line, resulting in the intersection of the (actual) revolute surface and a section cone (having as axis, the axis of the associated revolute surface and its generatrix normal to the revolute surface) shall be contained in a conical zone (of the section cone) limited by two circles 0,1 apart (this distance is taken on the generatrix).</p> <p>NOTE The definition of an extracted circumferential line has not been standardized.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>a) 2D</p> </div> <div style="text-align: center;">  <p>b) 3D</p> </div> </div> <p style="text-align: center;">Figure 82</p>

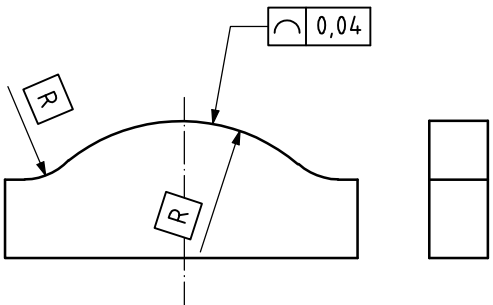
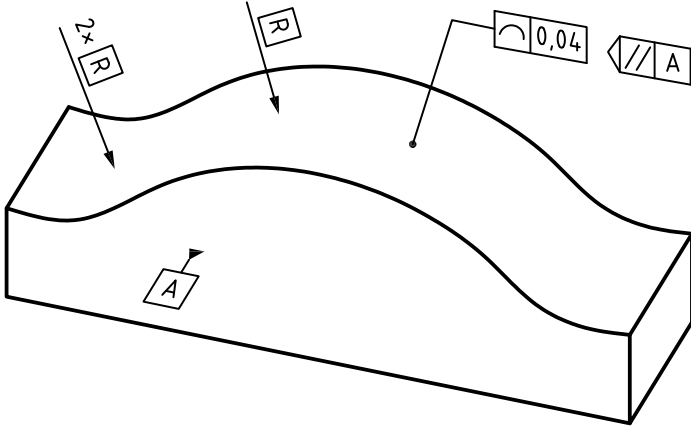
18.4 Cylindricity tolerance (see ISO 12781-1 and ISO 12781-2)


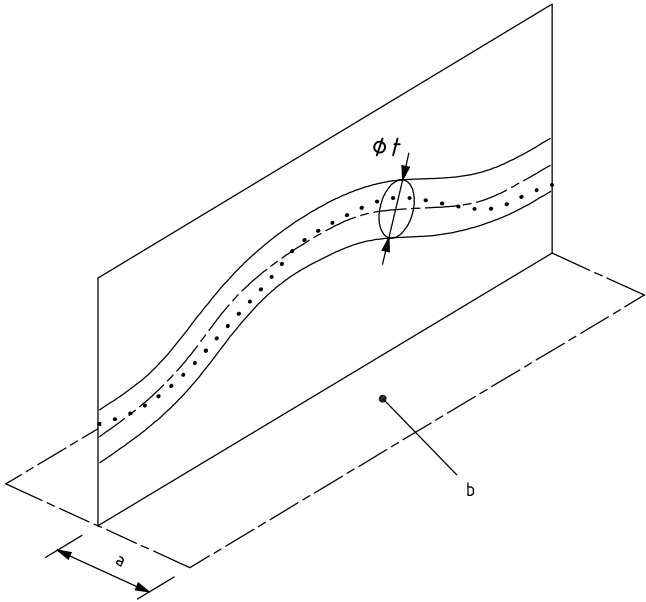
Dimensions in millimetres

Symbol	Indication and explanation
⌀	<p>The extracted (actual) cylindrical surface shall be contained between two coaxial cylinders with a difference in radii of 0,1.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 83</p> </div>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two coaxial cylinders with a difference in radii of t.</p> <div style="text-align: center;">  <p>Figure 84</p> </div>	

18.5 Profile tolerance of a line not related to a datum (see ISO 1660)

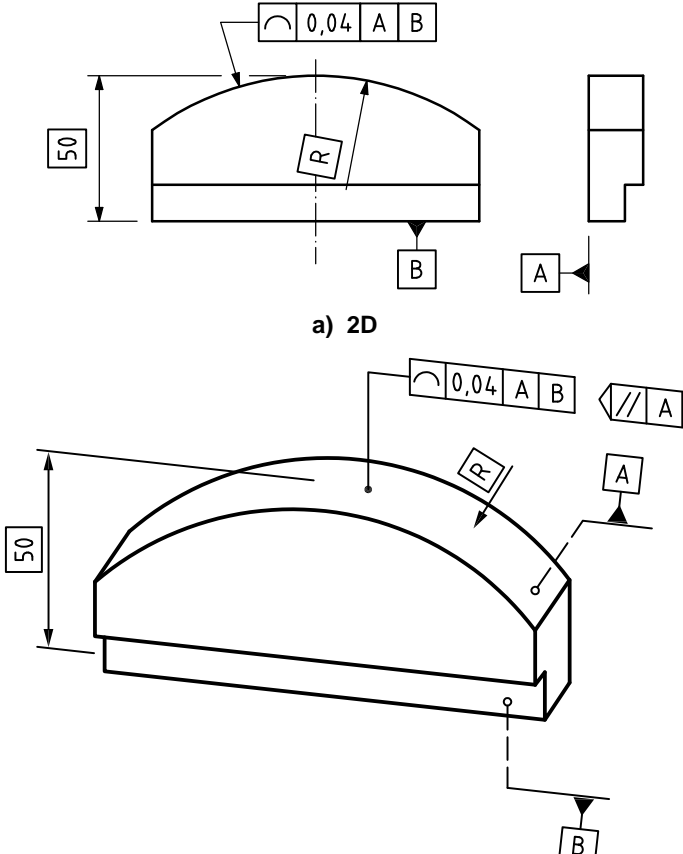
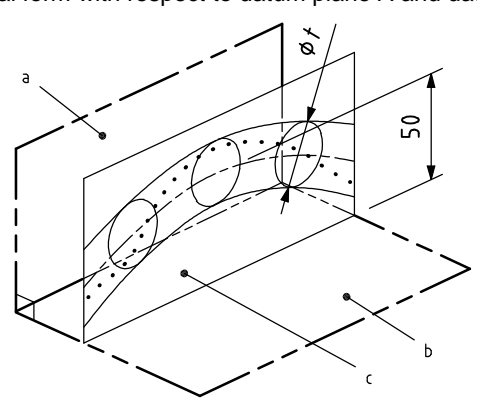
Dimensions in millimetres

Symbol	Indication and explanation
	<p>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.</p>  <p style="text-align: center;">a) 2D</p> <p>In each section, parallel to datum plane A, as specified by the intersection plane indicator, 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.</p>  <p style="text-align: center;">b) 3D</p> <p style="text-align: center;">Figure 85</p>

Symbol	Definition of the tolerance zone
	<p>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.</p>  <p>a Any distance.</p> <p>b Plane perpendicular to the drawing plane in Figure 85.</p> <p style="text-align: center;">Figure 86</p>

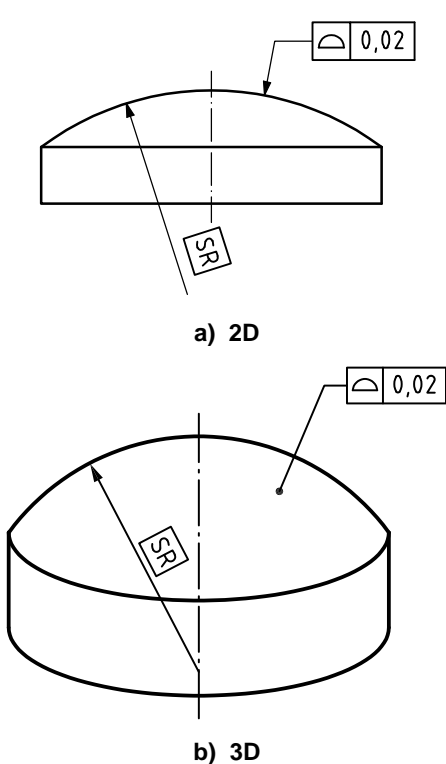
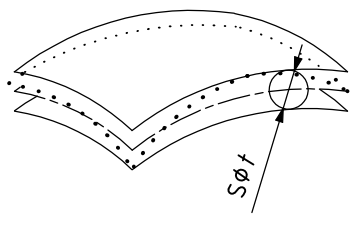
18.6 Profile tolerance of a line related to a datum system (see ISO 1660)

Dimensions in millimetres

Symbol	Indication and explanation
	<p>In each section, parallel to the plane of projection (2D) or datum plane A, as specified by the intersection plane indicator (3D), 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.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 87</p>
	<p>Definition of the tolerance zone</p> <p>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.</p>  <p>a Datum A. b Datum B. c Plane parallel to datum A.</p> <p>Figure 88</p>

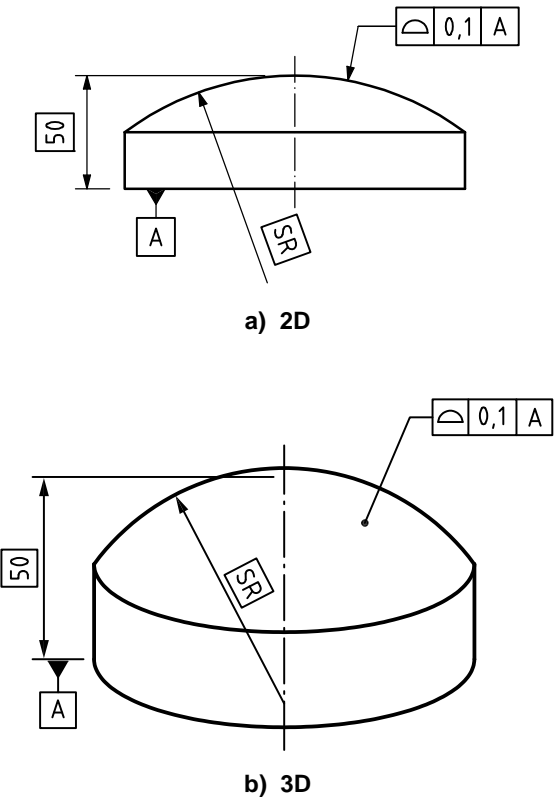
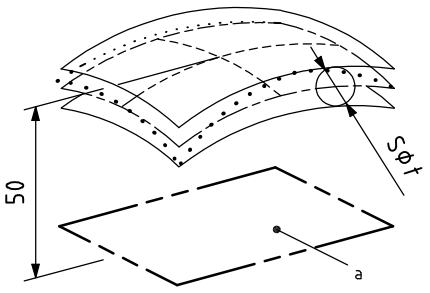
18.7 Profile tolerance of a surface not related to a datum (see ISO 1660)

Dimensions in millimetres

Symbol	Indication and explanation
<p>D</p>	<p>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.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 89</p>
<p>Definition of the tolerance zone</p>	
<p>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.</p>  <p>Figure 90</p>	

18.8 Profile tolerance of a surface related to a datum (see ISO 1660)

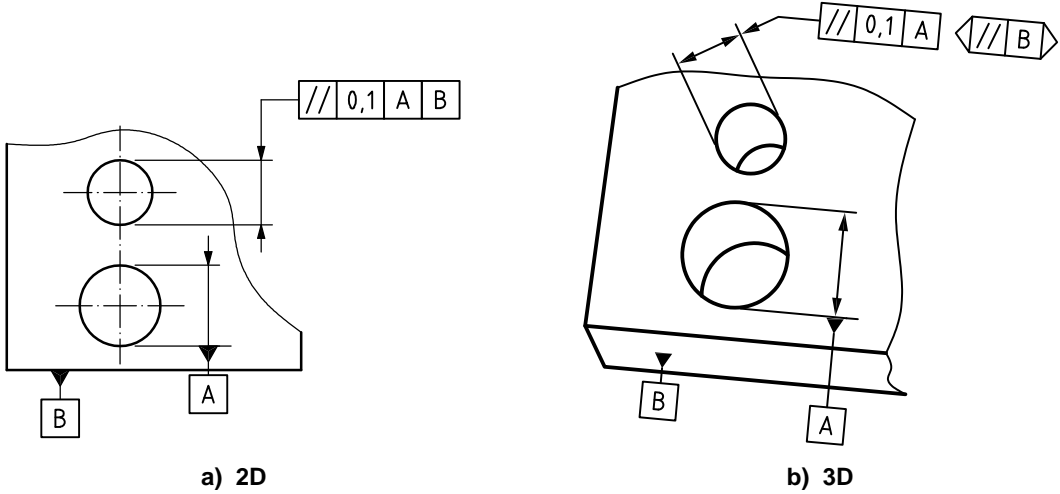
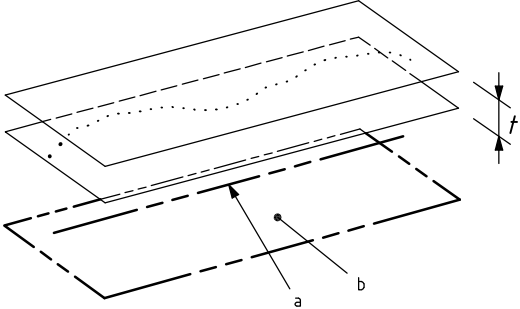
Dimensions in millimetres

Symbol	Indication and explanation
D	<p>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.</p>  <p style="text-align: center;">a) 2D</p> <p style="text-align: center;">b) 3D</p> <p style="text-align: center;">Figure 91</p>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>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.</p>  <p>a Datum A.</p> <p style="text-align: center;">Figure 92</p>

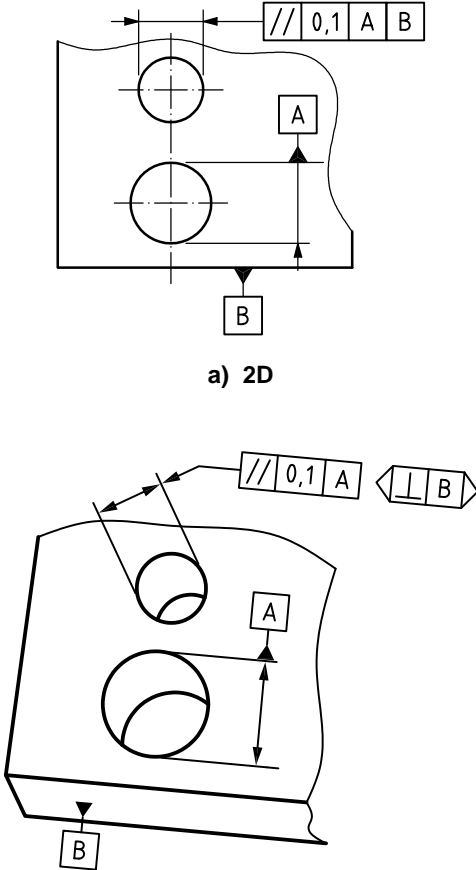
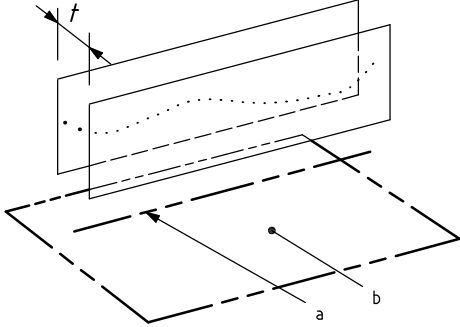
18.9 Parallelism tolerance

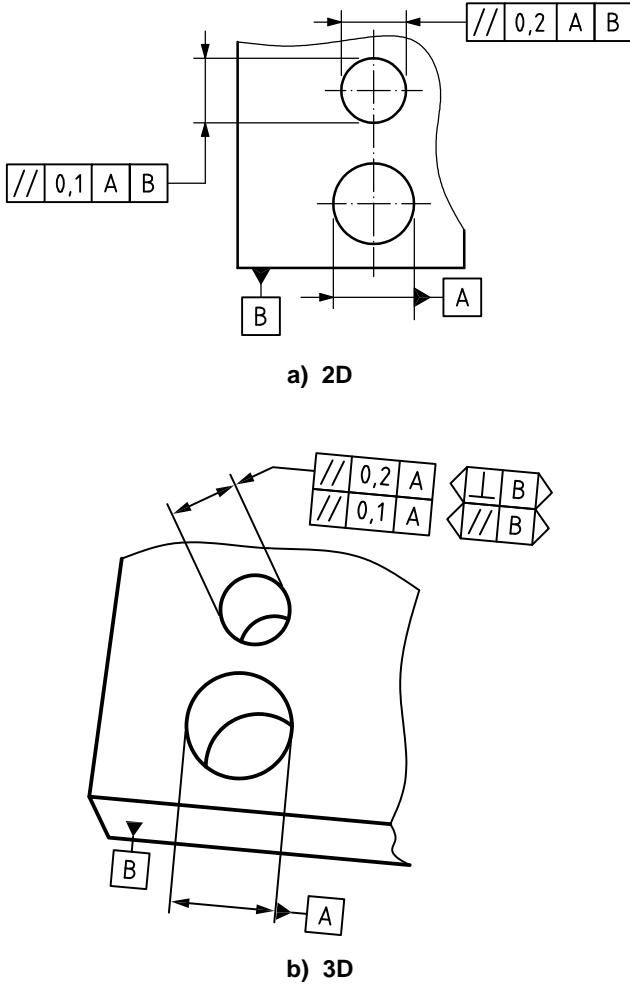
18.9.1 Parallelism tolerance of a line related to a datum system

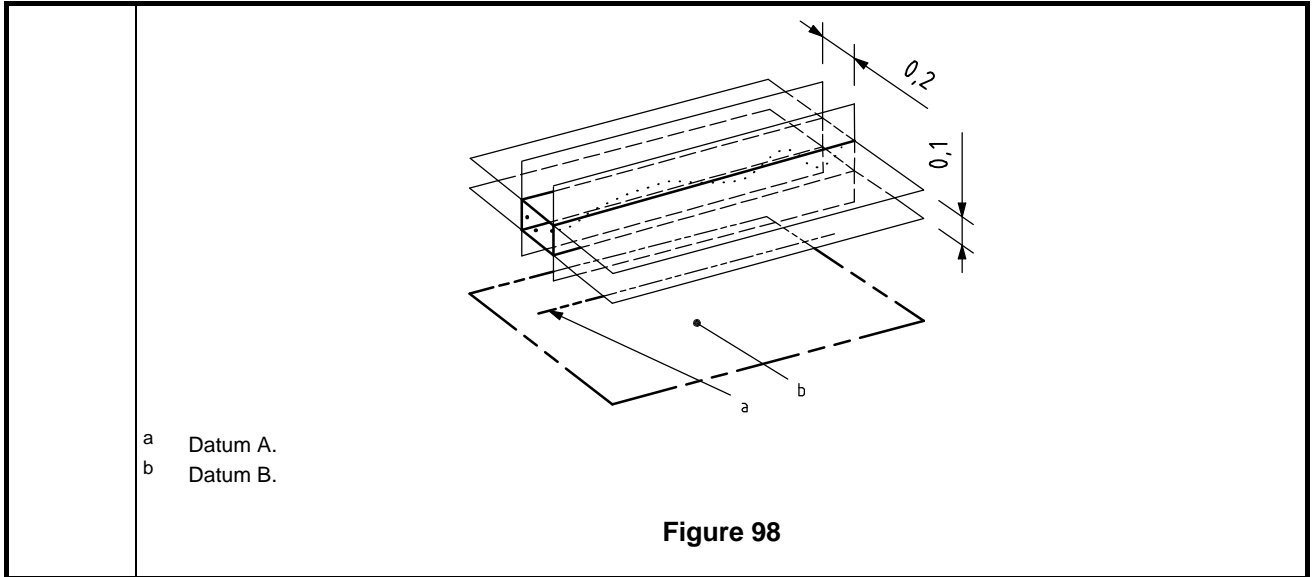
Dimensions in millimetres

Symbol	Indication and explanation
<p>//</p>	<p>The extracted (actual) median line shall be contained between two parallel planes 0,1 apart which are parallel to datum axis A. The planes limiting the tolerance zone are parallel to datum plane B as specified by the direction of the leader line and the secondary datum (2D) or orientation plane indicator (3D) (the direction of the width of the tolerance zone is perpendicular to datum plane B).</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 93</p>
Definition of the tolerance zone	
<p>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.</p>  <p>a Datum A. b Datum B.</p> <p>Figure 94</p>	

Dimensions in millimetres

Symbol	Indication and explanation
//	<p>The extracted (actual) median line shall be contained between two parallel planes 0,1 apart, which are parallel to datum axis A. The planes limiting the tolerance zone are perpendicular to datum plane B as specified by the direction of the leader line and the secondary datum (2D) or the orientation plane indicator (3D) (the direction of the width of the tolerance zone is parallel to datum plane B).</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 95</p> </div>
Definition of the tolerance zone	
<div style="text-align: center;">  </div> <p>a Datum A. b Datum B.</p> <p style="text-align: center;">Figure 96</p>	

Symbol	Indication and explanation
<p>//</p>	<p>The extracted (actual) median line shall be contained between two pairs of parallel planes, which are parallel to datum axis A, and positioned 0,1 and 0,2 apart respectively. The direction of the width of the tolerance zones is specified with respect to datum plane B by the direction of the leader lines and the secondary datum (2D) or the orientation plane indicators (3D).</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 97</p> <p>Definition of the tolerance zone</p> <p>The extracted (actual) median line shall be contained between two pairs of parallel planes, which are parallel to the datum axis A, and positioned 0,1 and 0,2 apart respectively. The orientations of the tolerance zones specified with respect to datum plane B by the orientation plane indicators:</p> <ul style="list-style-type: none"> — the planes limiting the tolerance zone of 0,2 mm are perpendicular to the orientation plane B as specified by the orientation plane indicator; — the planes limiting the tolerance zone of 0,1 mm are parallel to the orientation plane B as specified by the orientation plane indicator.



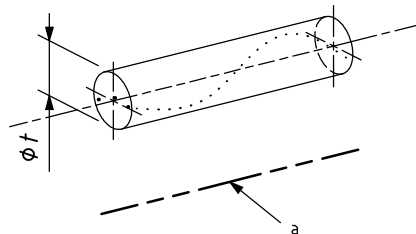
18.9.2 Parallelism tolerance of a line related to a datum line

Dimensions in millimetres

Symbol	Indication and explanation
//	<p>The extracted (actual) median line shall be within a cylindrical zone of diameter 0,03, parallel to datum axis A.</p> <div style="text-align: center;"> <p>a) 2D</p> <p>b) 3D</p> </div> <p>Figure 99</p>

Definition of the tolerance zone

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 100

18.9.3 Parallelism tolerance of a line related to a datum plane

Dimensions in millimetres

Symbol	Indication and explanation
//	<p>The extracted (actual) median line shall be contained between two parallel planes 0,01 apart, which are parallel to datum plane B.</p> <div style="text-align: center;"> <p>a) 2D</p> <p>b) 3D</p> </div> <p>Figure 101</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum.</p> <div style="text-align: center;"> </div> <p>a Datum B.</p> <p>Figure 102</p>	

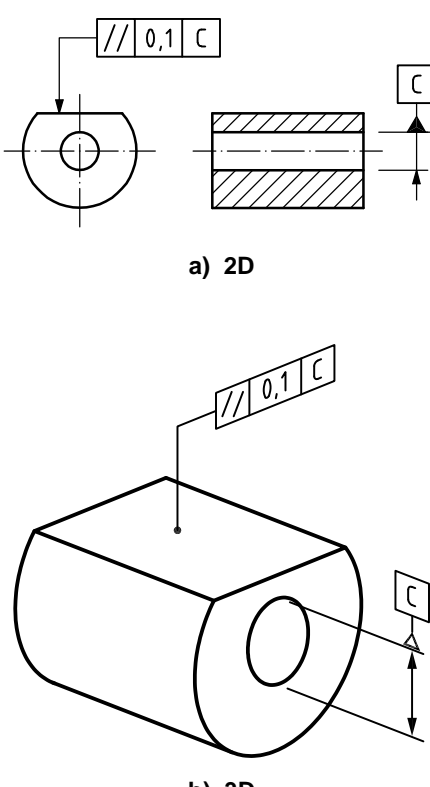
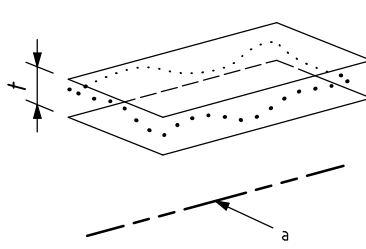
18.9.4 Parallelism tolerance of a surface related to a datum plane

Dimensions in millimetres

Symbol	Indication and explanation
//	<p>Each extracted (actual) line, parallel to datum plane B as specified by the intersection plane indicator, shall be contained between two parallel lines 0,02 apart, which are parallel to datum plane A.</p> <p>a) 2D using a secondary datum b) 2D using an intersection plane indicator</p> <p>c) 3D</p> <p>Figure 103</p>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>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.</p> <p>a Datum A. b Datum B.</p> <p style="text-align: center;">Figure 104</p>

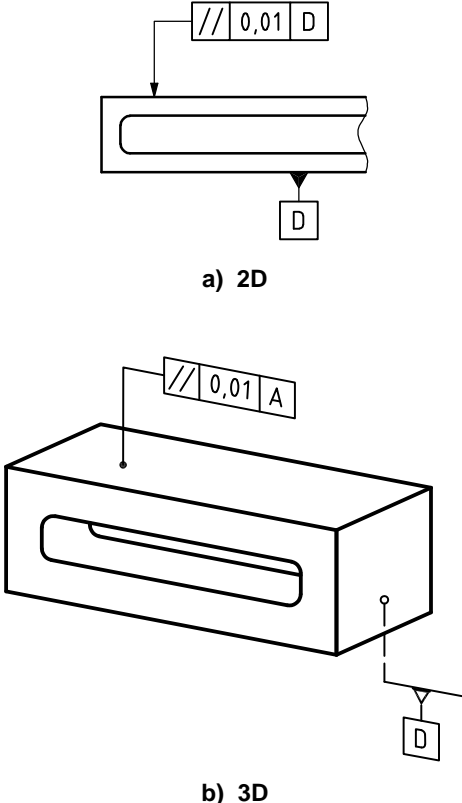
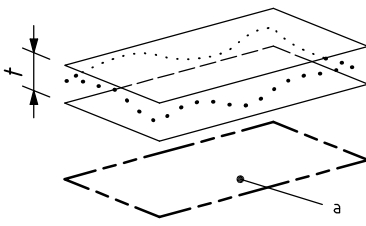
18.9.5 Parallelism tolerance of a surface related to a datum line

Dimensions in millimetres

Symbol	Indication and explanation
//	<p>The extracted (actual) surface shall be contained between two parallel planes 0,1 apart, which are parallel to datum axis C.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 105</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum C.</p> <p style="text-align: center;">Figure 106</p>	

18.9.6 Parallelism tolerance of a surface related to a datum plane


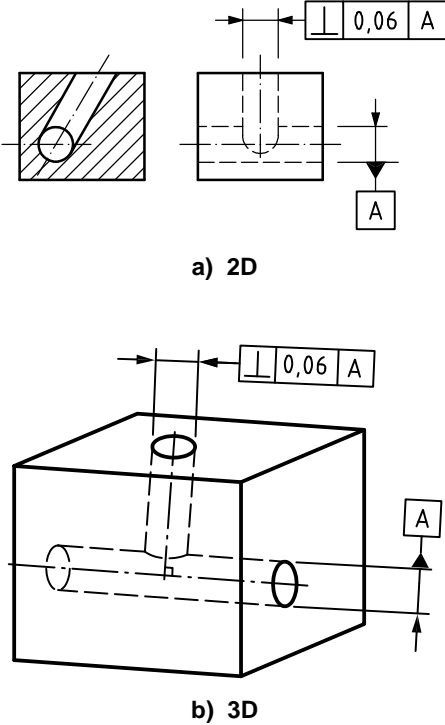
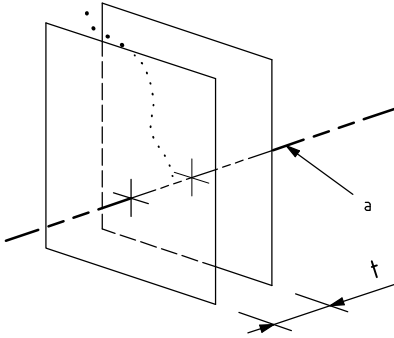
Dimensions in millimetres

Symbol	Indication and explanation
//	<p>The extracted (actual) surface shall be contained between two parallel planes 0,01 apart, which are parallel to datum plane D.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p>Figure 107</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum plane.</p> <div style="text-align: center;">  </div> <p>a Datum D.</p> <p>Figure 108</p>	

18.10 Perpendicularity tolerance


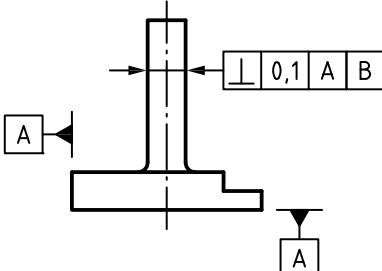
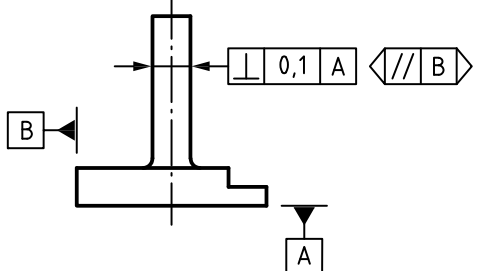
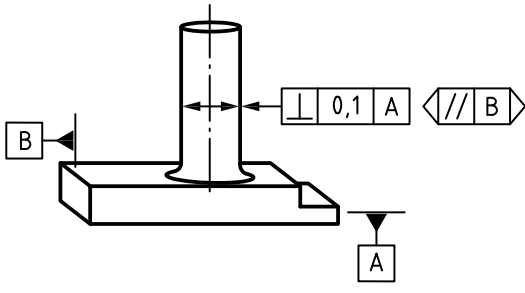
18.10.1 Perpendicularity tolerance of a line related to a datum line

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) median line shall be contained between two parallel planes 0,06 apart, which are perpendicular to datum axis A.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 109</p> </div>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A.</p> <p style="text-align: center;">Figure 110</p>	

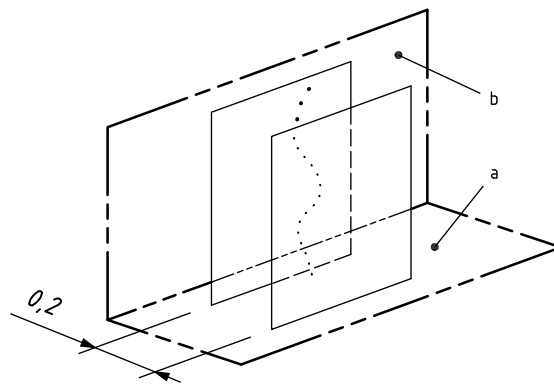
18.10.2 Perpendicularity tolerance of a line related to a datum system

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) median line of the cylinder shall be contained between two parallel planes 0,1 apart, which are perpendicular to datum plane A and in the orientation specified with respect to datum plane B.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>a) 2D using Datum B as a secondary datum</p> </div> <div style="text-align: center;">  <p>b) 2D using an orientation plane indicator</p> </div> </div> <div style="text-align: center; margin-top: 20px;">  <p>c) 3D</p> </div> <p style="text-align: center;">Figure 111</p>

Definition of the tolerance zone

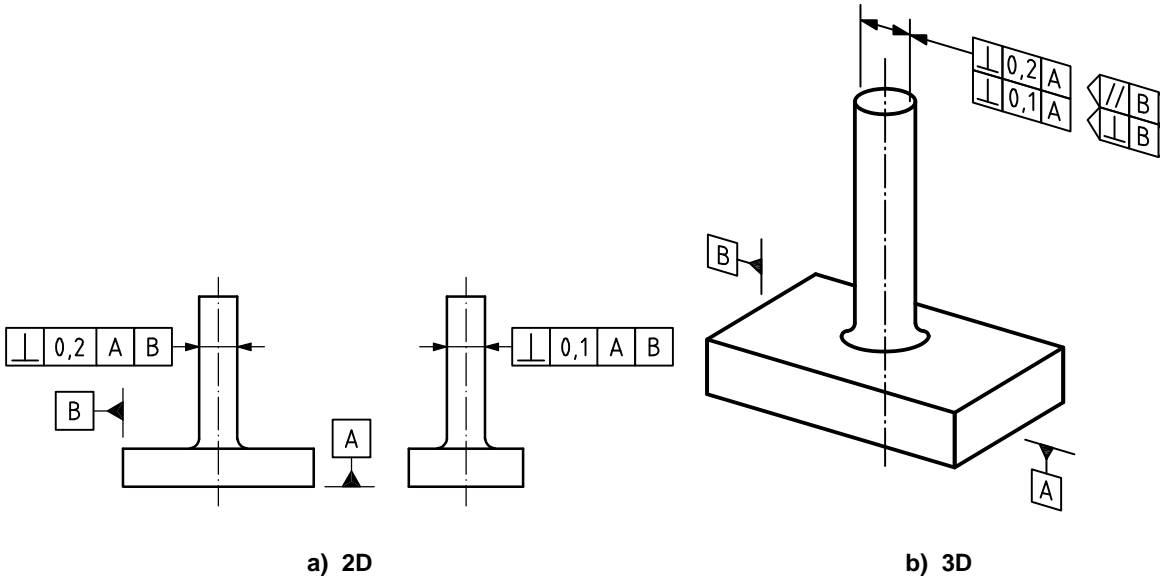
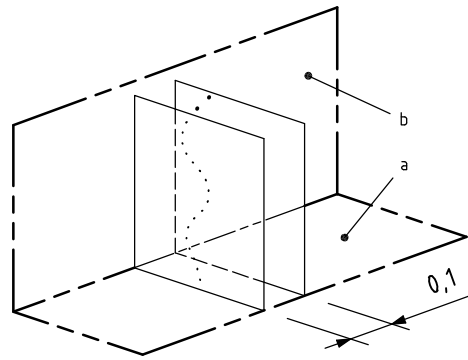
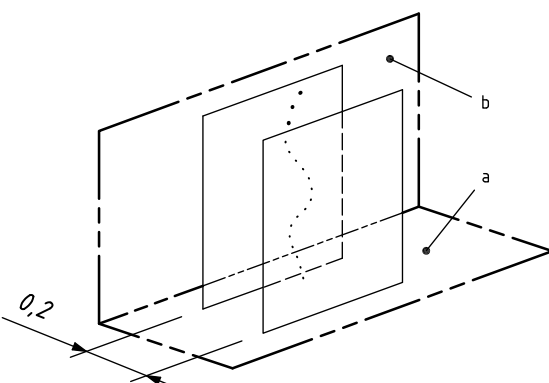
The tolerance zone is limited by two parallel planes a distance t apart. The planes are perpendicular to datum A and parallel to datum B.



- a Datum A.
- b Datum B.


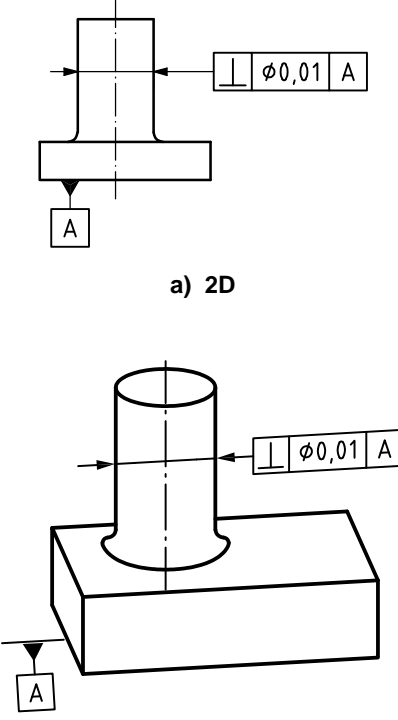
Figure 112

Dimensions in millimetres

Symbol	Indication and explanation
<p style="text-align: center;">⊥</p>	<p>The extracted (actual) median line of the cylinder shall be contained between two pairs of parallel planes, perpendicular to datum plane A, and positioned 0,1 and 0,2 apart respectively. The direction of the width of the tolerance zones is specified with respect to datum plane B by the plane of projection (2D) or the orientation plane indicators (3D).</p>  <p style="text-align: center;">Figure 113</p>
Definition of the tolerance zone	
<p>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 115), the other pair being perpendicular to datum B (see Figure 114).</p>	
 <p>a Datum A. b Datum B.</p> <p style="text-align: center;">Figure 114</p>	 <p style="text-align: center;">Figure 115</p>

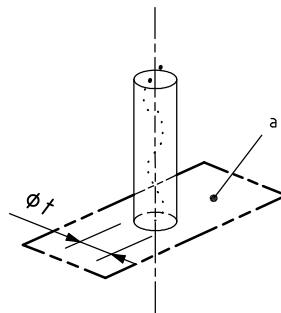
18.10.3 Perpendicularity tolerance of a line related to a datum plane

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) median line of the cylinder shall be within a cylindrical zone of diameter 0,01, which is perpendicular to datum plane A.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p>Figure 116</p>

Definition of the tolerance zone

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 .


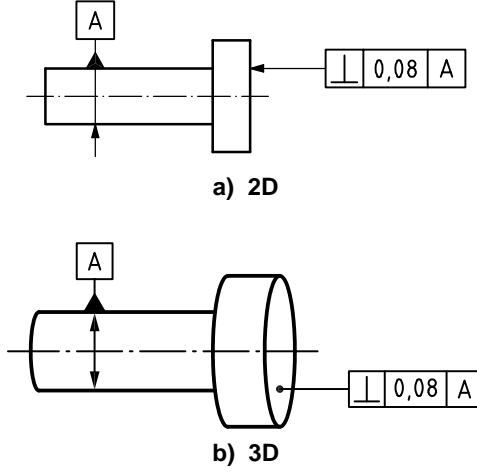
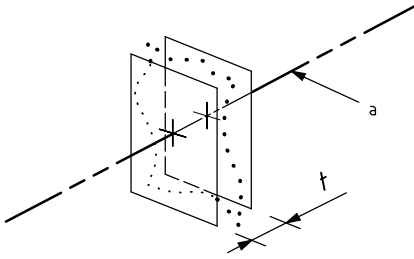


a Datum A.

Figure 117


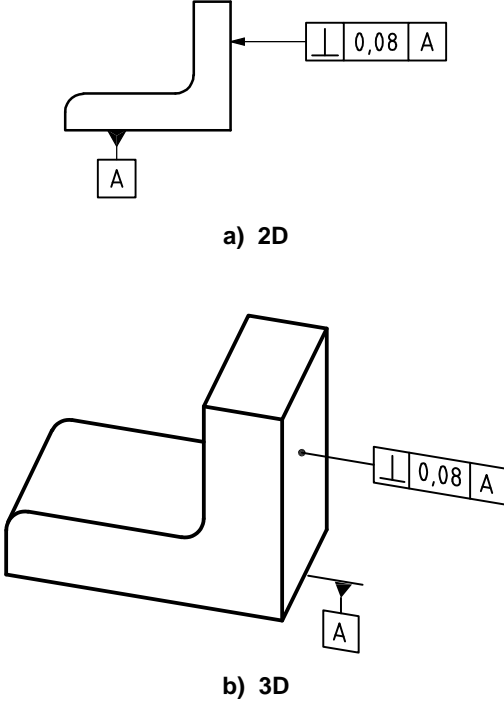
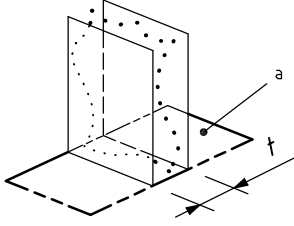
18.10.4 Perpendicularity tolerance of a surface related to a datum line

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,08 apart which are perpendicular to datum axis A.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 118</p>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A.</p> <p style="text-align: center;">Figure 119</p>

18.10.5 Perpendicularity tolerance of a surface related to a datum plane


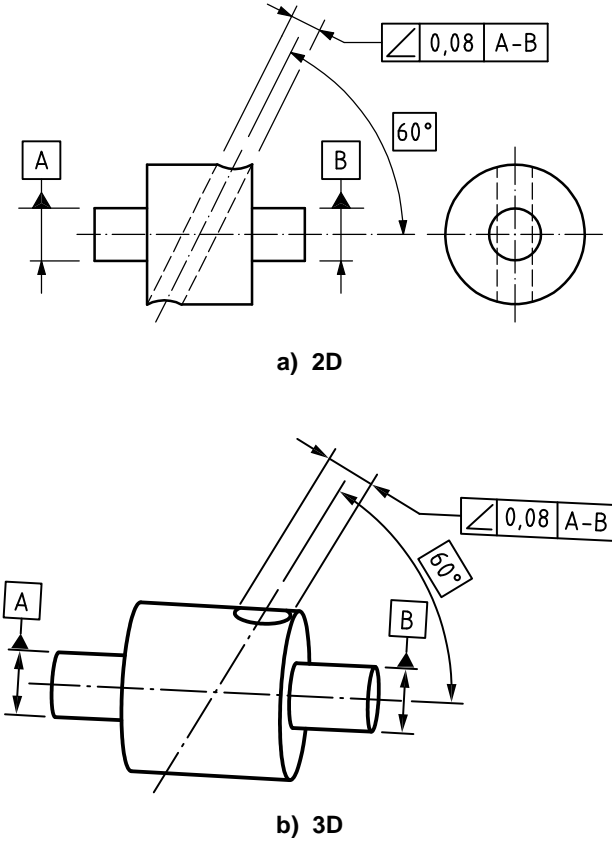
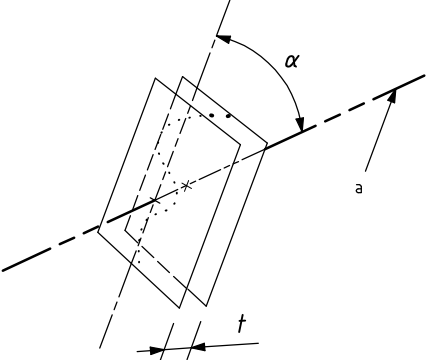
Dimensions in millimetres

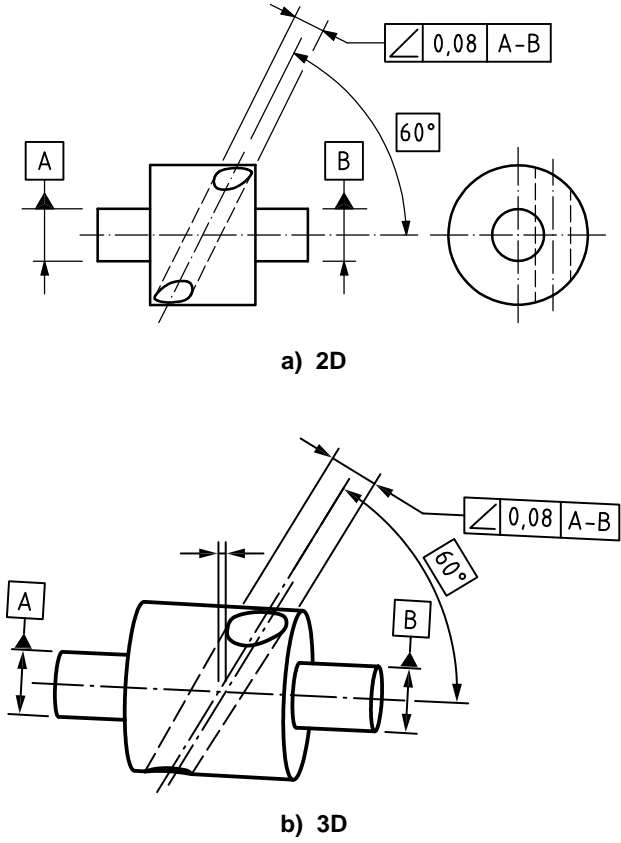
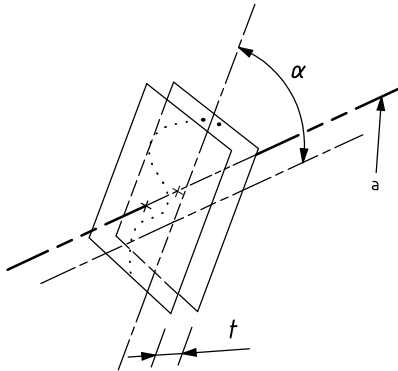
Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,08 apart, which are perpendicular to datum plane A.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 120</p> </div>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A.</p> <p style="text-align: center;">Figure 121</p>

18.11 Angularity tolerance

18.11.1 Angularity tolerance of a line related to a datum line


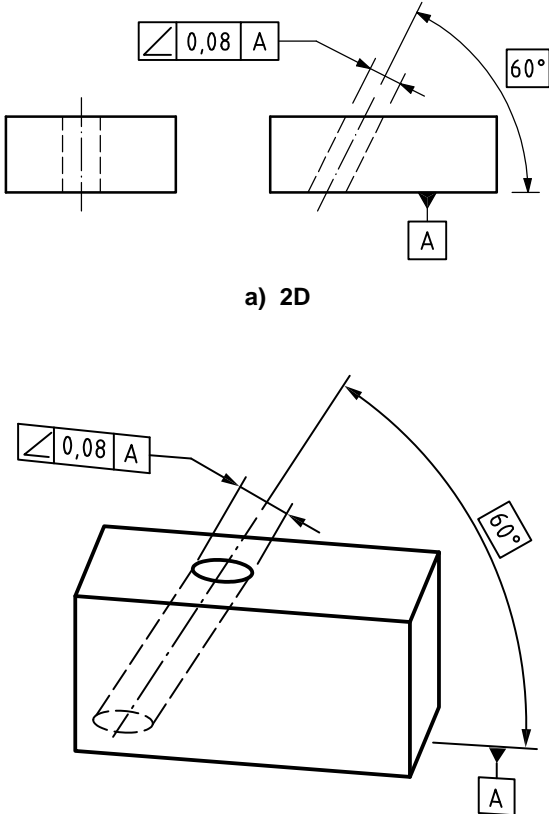
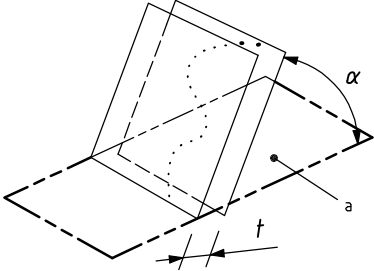
Dimensions in millimetres

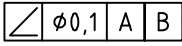
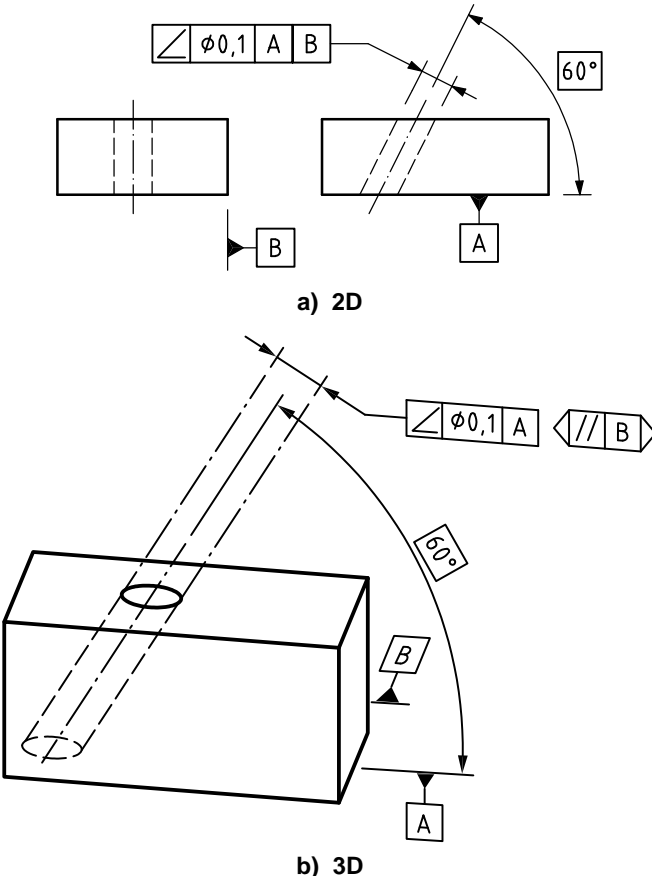
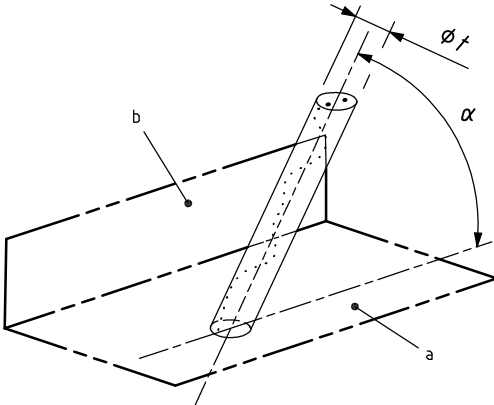
Symbol	Indication and explanation
	<p>The extracted (actual) median line shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 60° to the common datum straight line A-B.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p>Figure 122</p>
Definition of the tolerance zone	
<p>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.</p> <div style="text-align: center;">  </div> <p>a Datum A-B.</p> <p>Figure 123</p>	

Symbol	Indication and explanation
<p>∠</p>	<p>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.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 124</p>
	<p>Definition of the tolerance zone</p> <p>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.</p>  <p>a Datum A-B.</p> <p>Figure 125</p>

18.11.2 Angularity tolerance of a line related to a datum plane


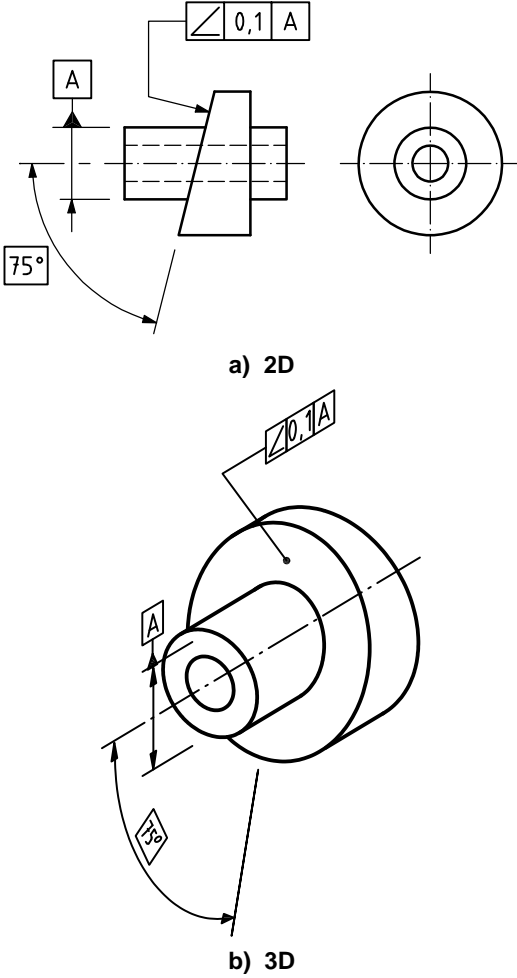
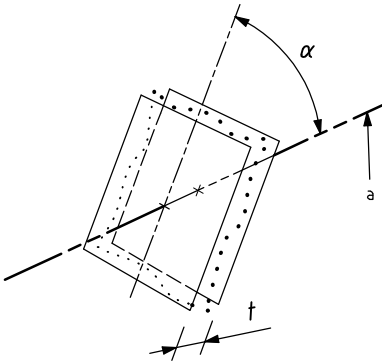
Dimensions in millimetres

Symbol	Indication and explanation
	<p>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.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 126</p> </div>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A.</p> <p style="text-align: center;">Figure 127</p>	

Symbol	Indication and explanation
	<p>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.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 128</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by a cylinder of diameter t if the tolerance value is preceded by the symbol ϕ. The cylindrical tolerance zone is parallel to a datum plane B and inclined at the specified angle to datum plane A.</p>  <p>a Datum A. b Datum B.</p> <p>Figure 129</p>	


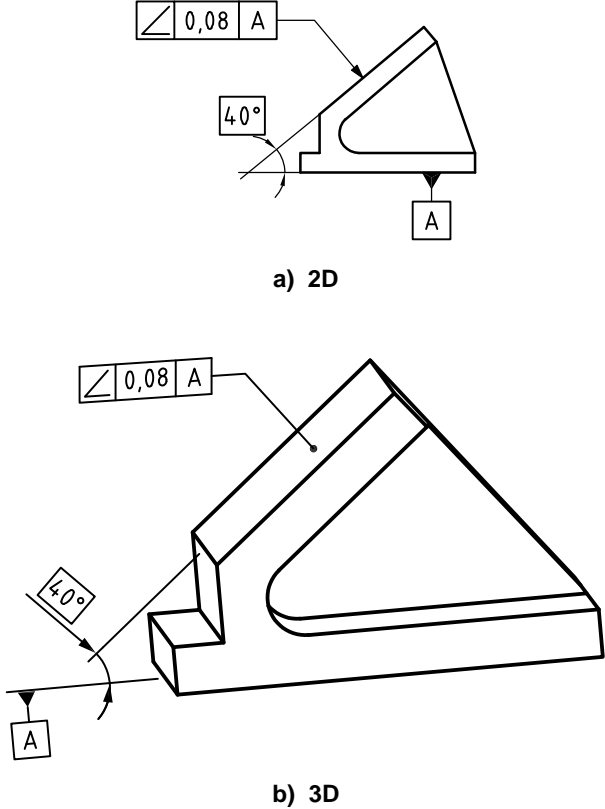
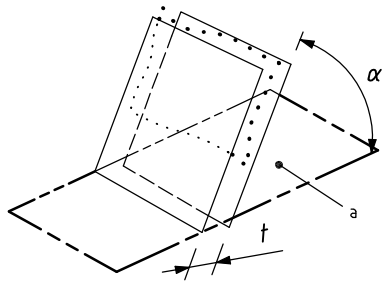
18.11.3 Angularity tolerance of a surface related to a datum line

Dimensions in millimetres

Symbol	Indication and explanation
	<p>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.</p>  <p style="text-align: center;">a) 2D</p> <p style="text-align: center;">b) 3D</p> <p style="text-align: center;">Figure 130</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.</p>  <p style="text-align: center;">Figure 131</p>	

18.11.4 Angularity tolerance of a surface related to a datum plane


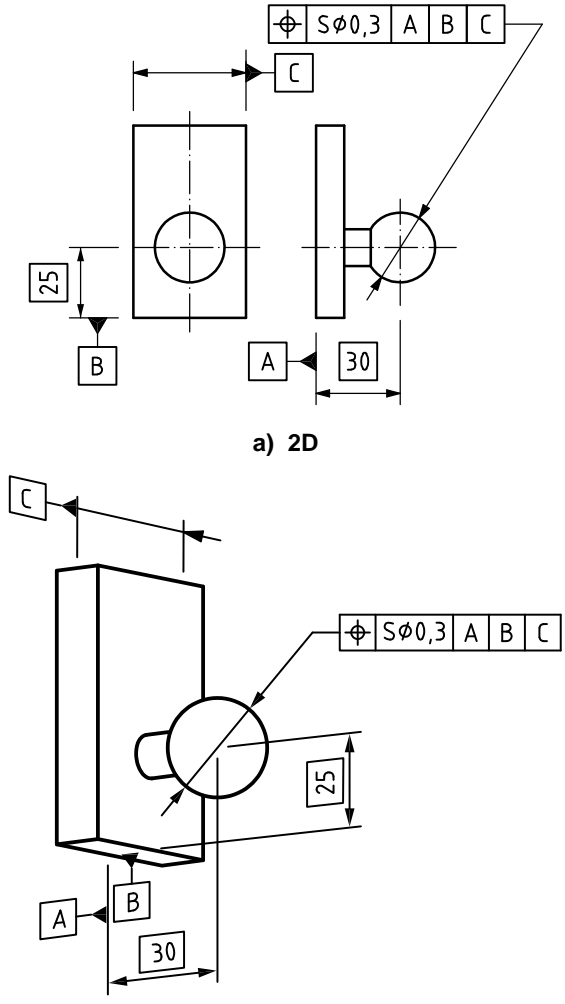
Dimensions in millimetres

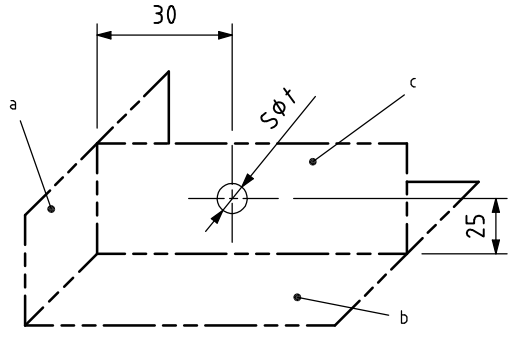
Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 40° to datum plane A.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 132</p>
Definition of the tolerance zone	
<p>The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A.</p> <p style="text-align: center;">Figure 133</p>	

18.12 Position tolerance (see ISO 5458)

18.12.1 Position tolerance of a point


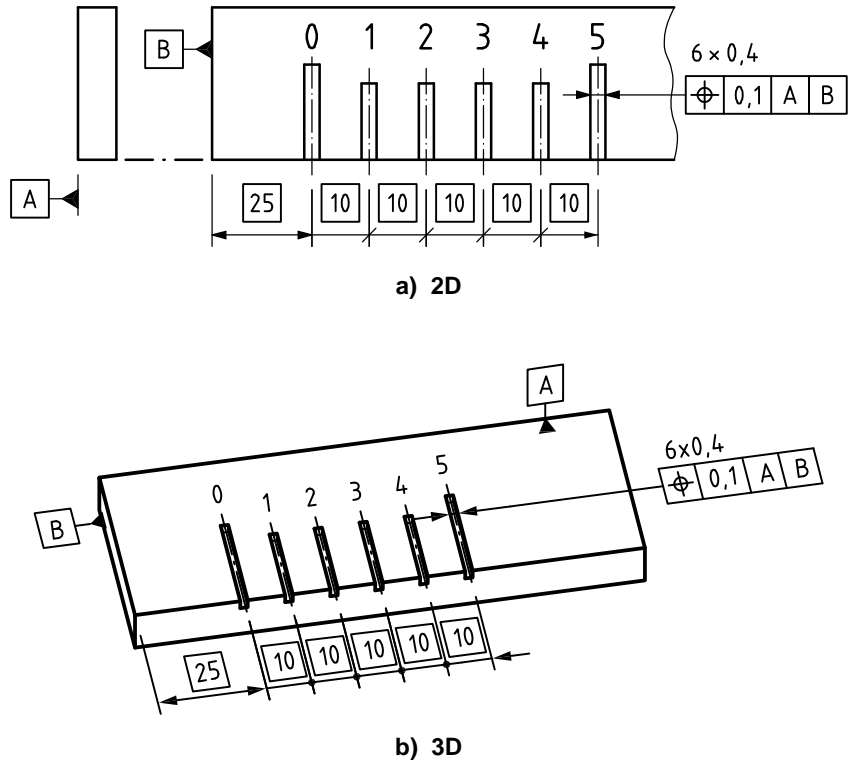
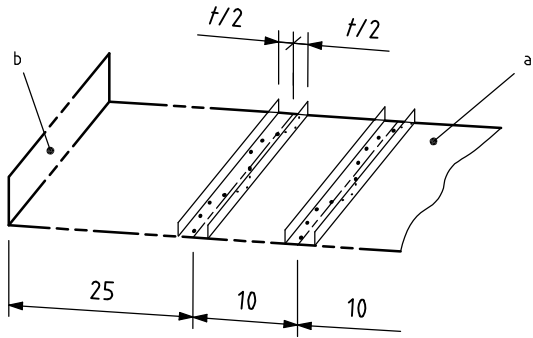
Dimensions in millimetres

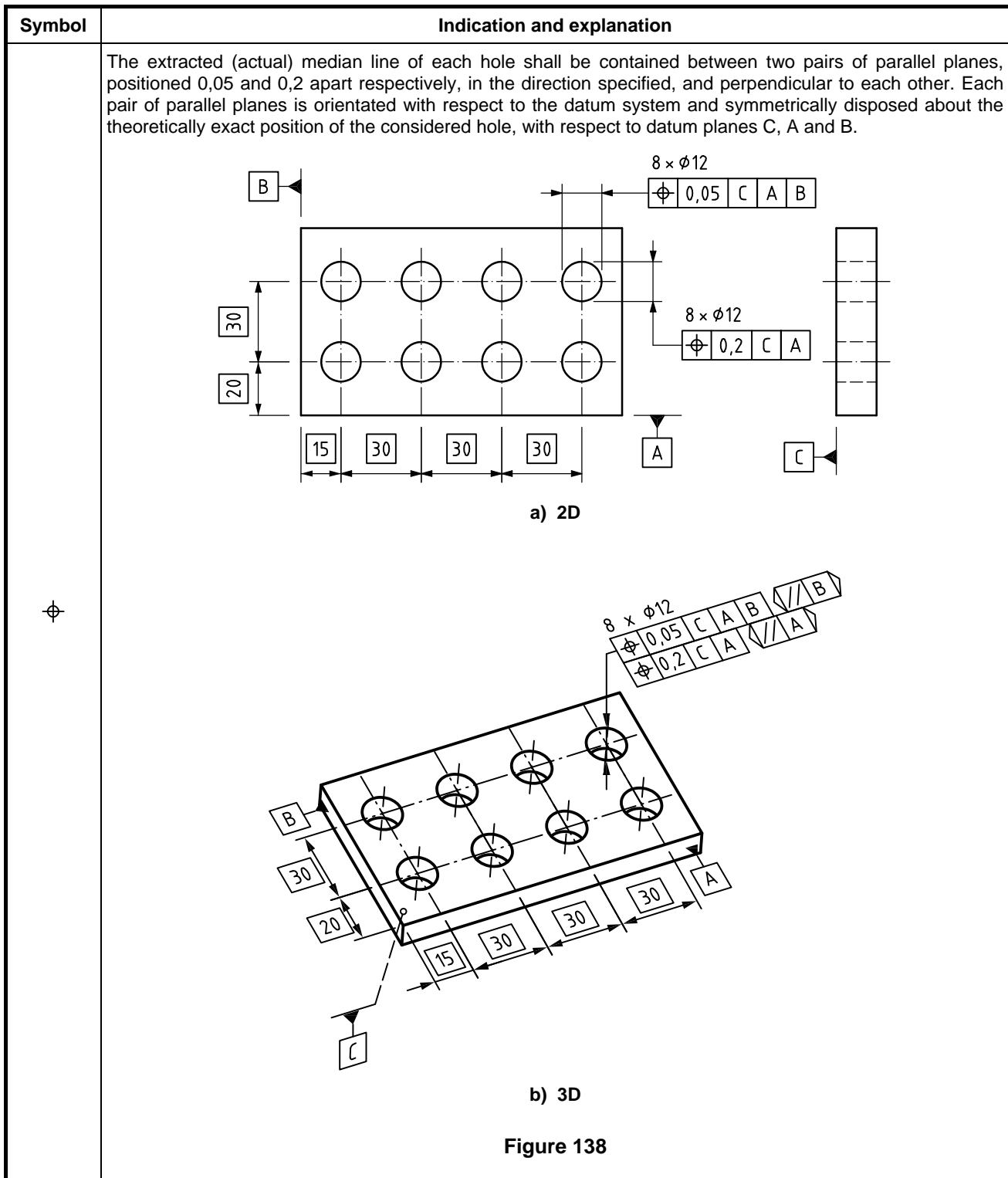
Symbol	Indication and explanation
	<p>The extracted (actual) centre of the sphere shall be within a spherical zone of diameter 0,3, the centre of which coincides with the theoretically exact position of the sphere, with respect to datum planes A and B and to datum median plane C.</p> <p>NOTE The definition of extracted (actual) centre of a sphere has not been standardized.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 134</p>


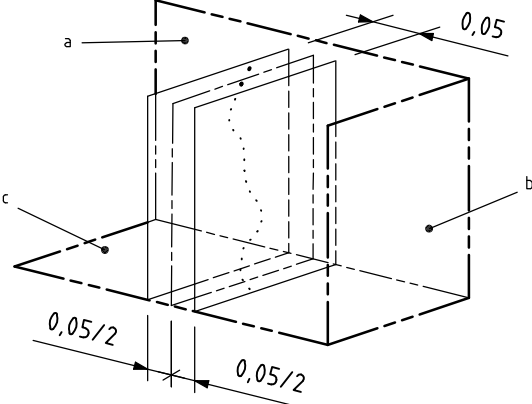
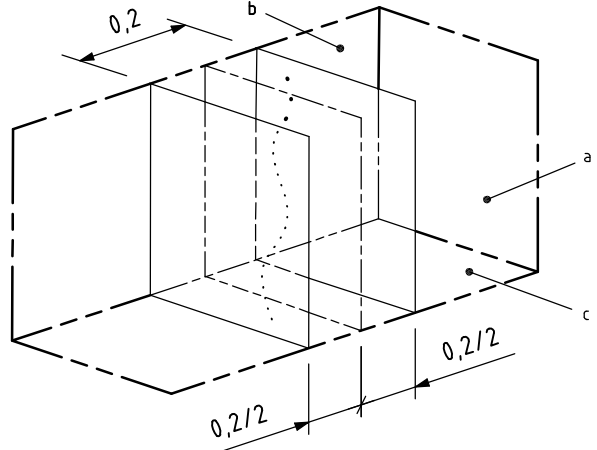
Symbol	Definition of the tolerance zone
\oplus	<p>The tolerance zone is limited by a sphere of diameter t if the tolerance value is preceded by the symbol $S\phi$. The centre of the spherical tolerance zone is fixed by theoretically exact dimensions with respect to datums A, B and C.</p>  <p>a Datum A. b Datum B. c Datum C.</p> <p style="text-align: center;">Figure 135</p>

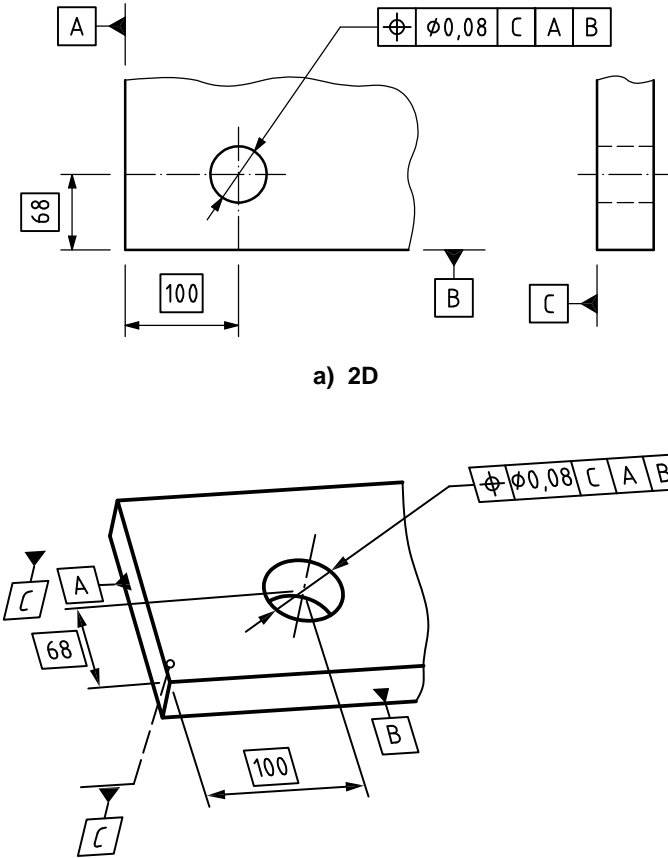
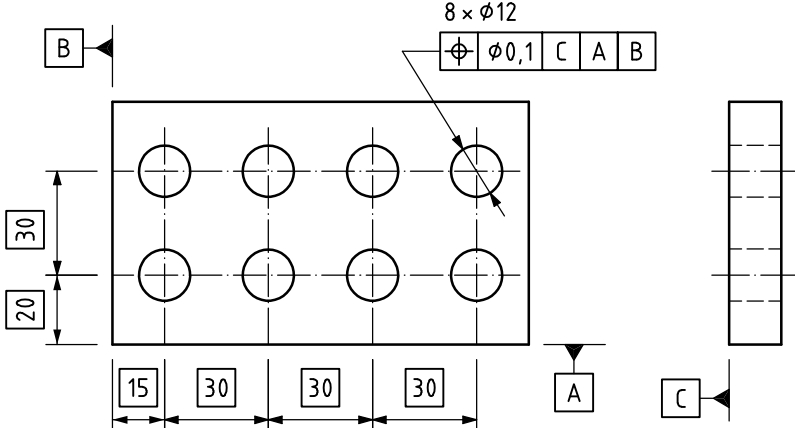
18.12.2 Position tolerance of a line

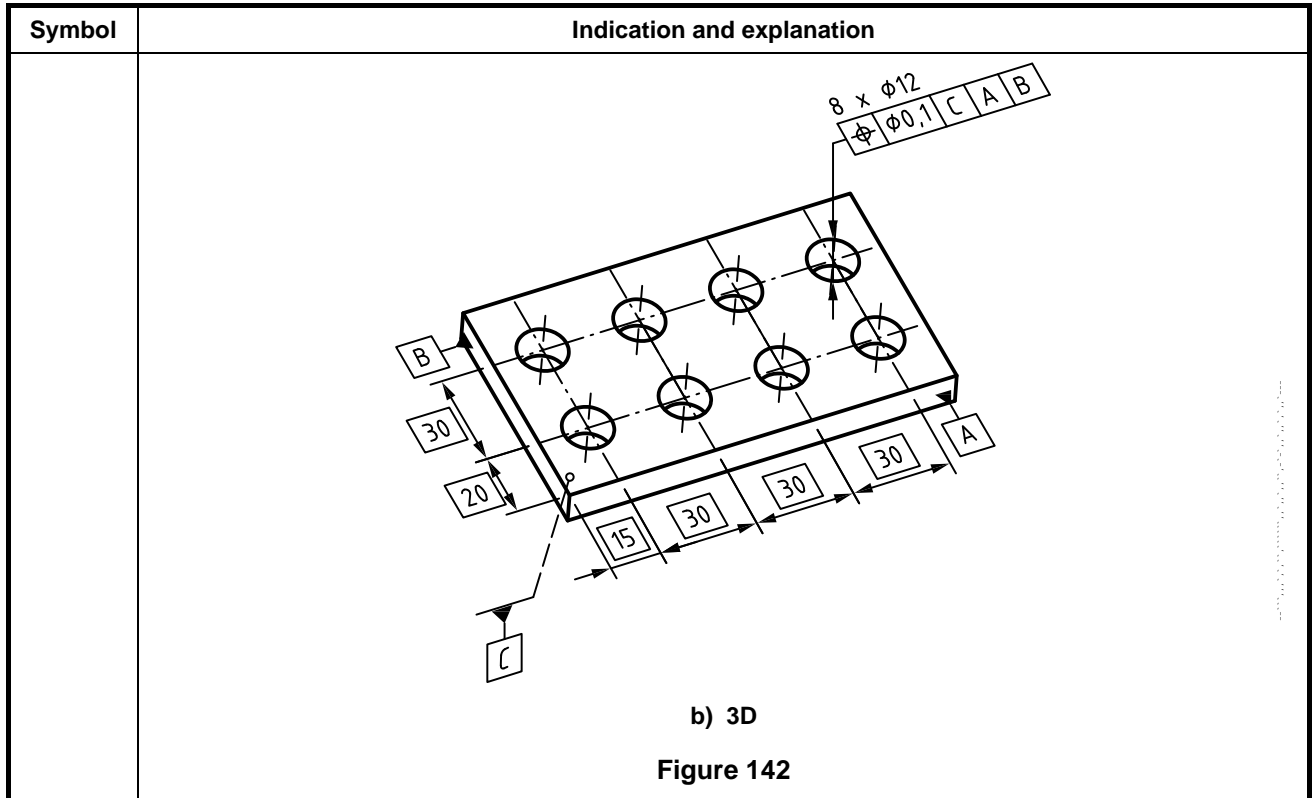
Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) centre line of each of the scribe lines shall be contained between two parallel planes 0,1 apart, which are symmetrically disposed about the theoretically exact position of the considered line, with respect to datum planes A and B.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 136</p> </div>
Definition of the tolerance zone	
<p>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.</p> <div style="text-align: center;">  </div> <p>a Datum A. b Datum B.</p> <p style="text-align: center;">Figure 137</p>	



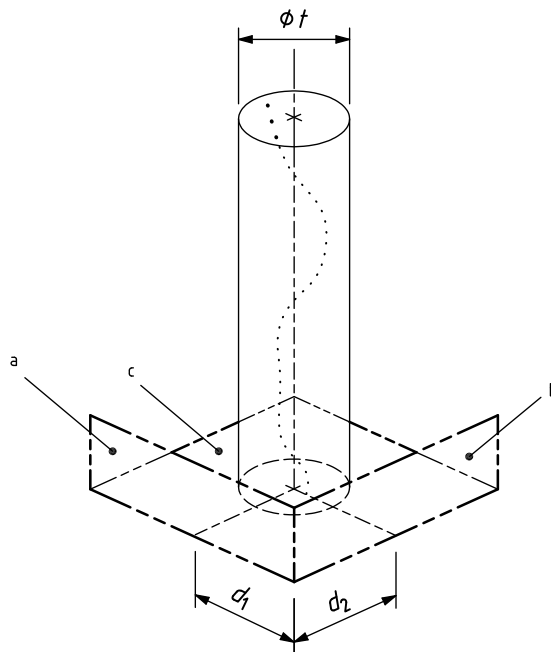
Symbol	Definition of the tolerance zone
	<p>The tolerance zone is limited by two pairs of parallel planes a distance 0,05 and 0,2 apart respectively and symmetrically disposed about the theoretically exact position. The theoretically exact position is fixed by theoretically exact dimensions with respect to datums C, A and B. The tolerance is specified in two directions with respect to the datums.</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>a Datum A. b Datum B. c Datum C.</p> <p>Figure 139</p> </div> <div style="text-align: center;">  <p>a Datum A. b Datum B. c Datum C.</p> <p>Figure 140</p> </div> </div>

Symbol	Indication and explanation
<p style="text-align: center;">⊕</p>	<p>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.</p>  <p style="text-align: center;">a) 2D</p> <p style="text-align: center;">b) 3D</p> <p style="text-align: center;">Figure 141</p>
	<p>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.</p>  <p style="text-align: center;">a) 2D</p>



Definition of the tolerance zone

ϕ The tolerance zone is limited by a cylinder of diameter t if the tolerance value is preceded by the symbol ϕ . The axis of the tolerance cylinder is fixed by theoretically exact dimensions with respect to datums C, A and B.


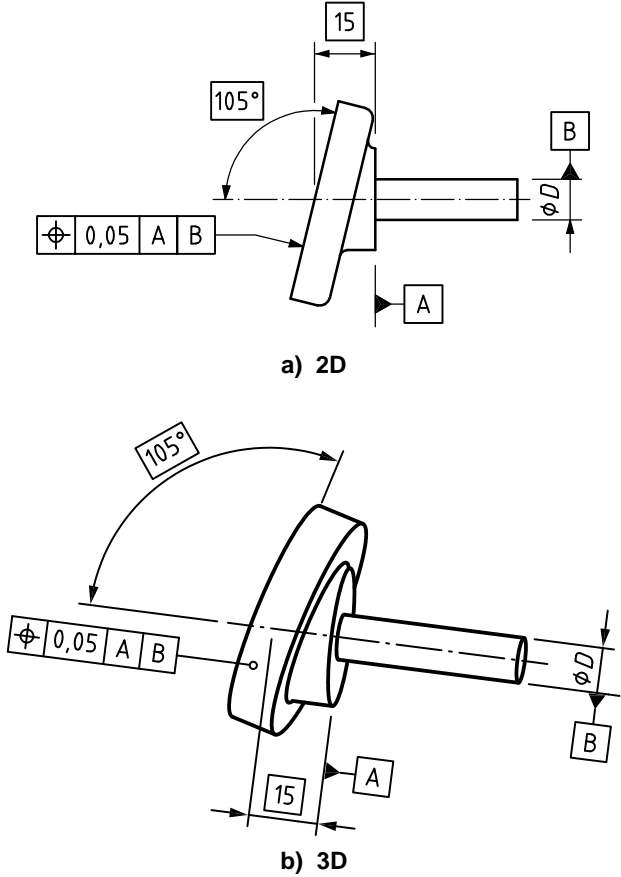


- a Datum A.
- b Datum B.
- c Datum C.

Figure 143

18.12.3 Position tolerance of a flat surface or a median plane


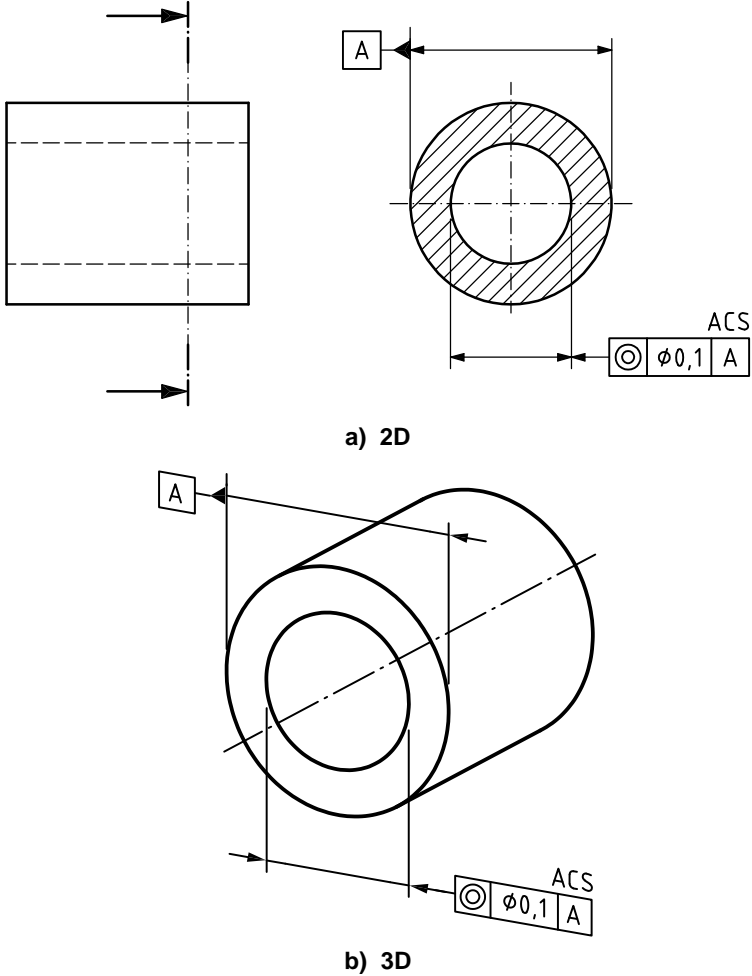
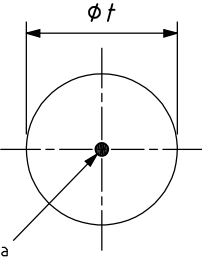
Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,05 apart, which are symmetrically disposed about the theoretically exact position of the surface, with respect to datum plane A and datum axis B.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 144</p>

18.13 Concentricity and coaxiality tolerance


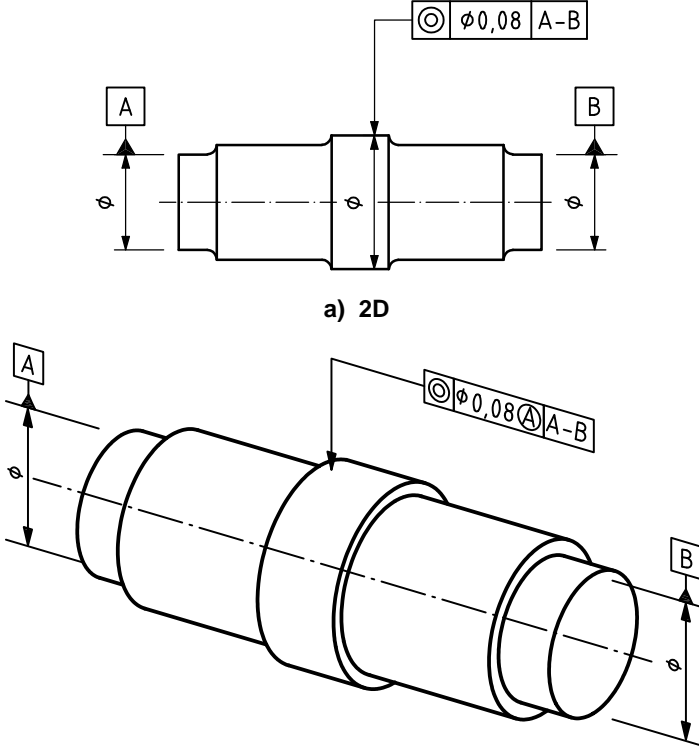

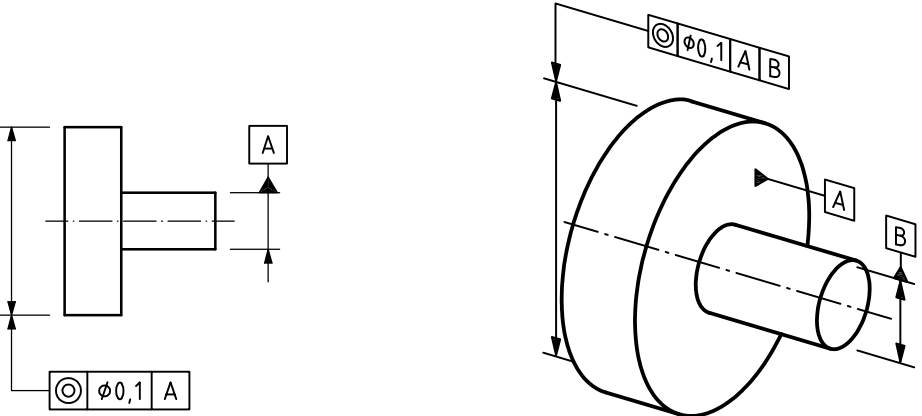
18.13.1 Concentricity tolerance of a point

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) centre of the inner circle in any cross-section shall be within a circle of diameter 0,1, concentric with datum point A defined in the same cross-section.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 147</p> </div> <p style="text-align: center;">Definition of the tolerance zone</p> <p>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.</p> <div style="text-align: center;">  <p>a Datum point A.</p> <p>Figure 148</p> </div>

18.13.2 Coaxiality tolerance of an axis

Dimensions in millimetres

Symbol	Indication and explanation
	<p data-bbox="323 383 1489 439">The extracted (actual) median line of the tolerated cylinder shall be within a cylindrical zone of diameter 0,08, the axis of which is the common datum straight line A-B.</p> <div style="text-align: center;">  <p data-bbox="869 750 933 779">a) 2D</p> <p data-bbox="869 1220 933 1249">b) 3D</p> <p data-bbox="837 1288 965 1317">Figure 149</p> </div>
Symbol	Indication and explanation
	<p data-bbox="323 1406 1489 1462">The extracted (actual) median line of the tolerated cylinder shall be within a cylindrical zone of diameter 0,1, the axis of which is datum axis A [see Figures 150 a) and 150 b)].</p> <div style="text-align: center;">  <p data-bbox="574 1915 638 1944">a) 2D</p> <p data-bbox="1165 1915 1228 1944">b) 3D</p> <p data-bbox="837 1982 965 2011">Figure 150</p> </div>

The extracted (actual) median line of the tolerated cylinder shall be within a cylindrical zone of diameter 0,1, the axis of which is datum axis B which is perpendicular to datum plane A [see Figures 151 a) and 151 b)].

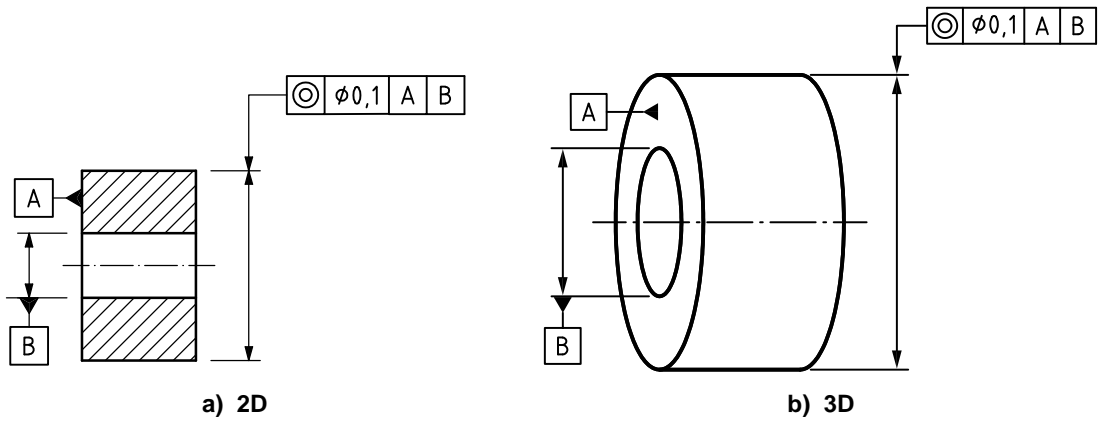
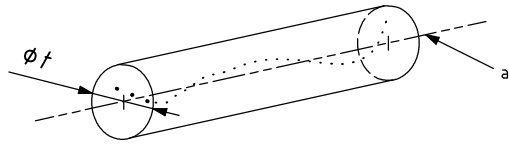


Figure 151

Definition of the tolerance zone

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 150).

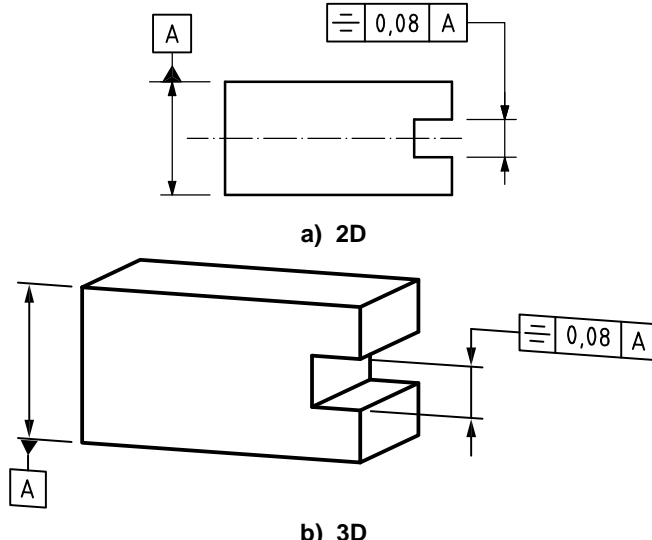
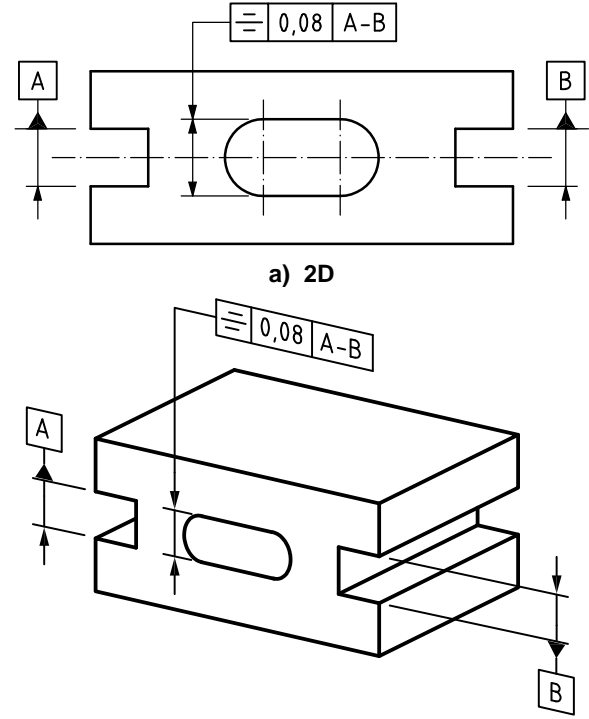
Secondary datum B perpendicular to primary datum A (not shown) (Figure 151).


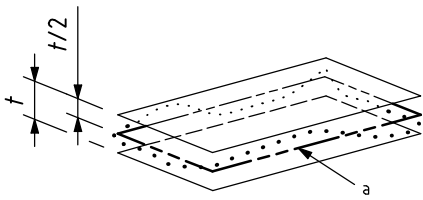
Figure 152

18.14 Symmetry tolerance

18.14.1 Symmetry tolerance of a median plane

Dimensions in millimetres


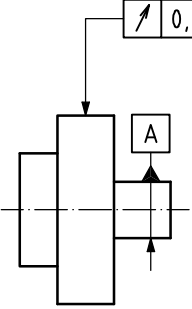
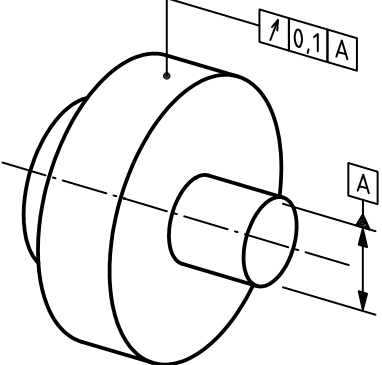
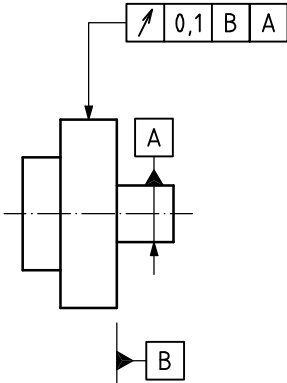
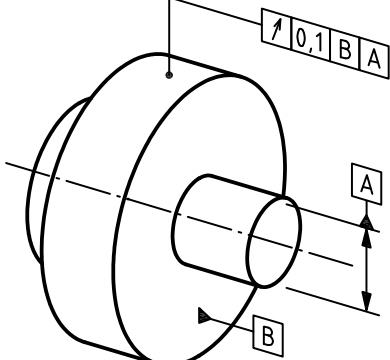
Symbol	Indication and explanation
	<p>The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart, which are symmetrically disposed about datum plane A.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 153</p>
<p>≡</p>	<p>The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart, which are symmetrically disposed about the common datum plane A-B.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 154</p>

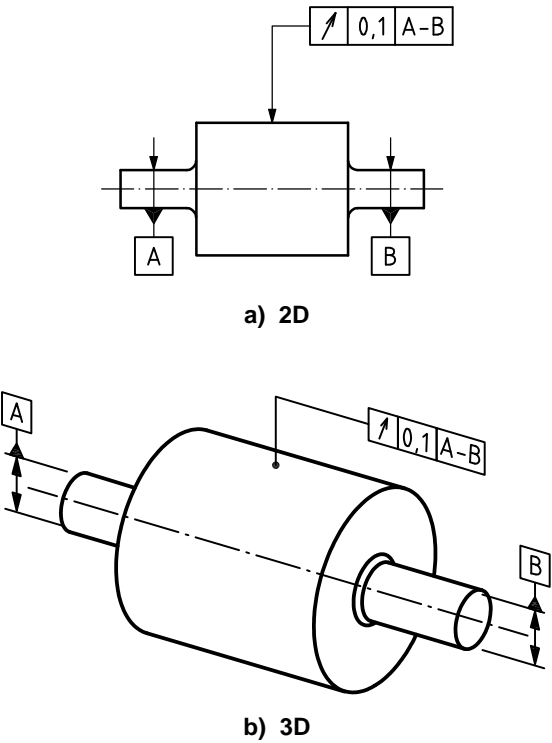
Symbol	Definition of the tolerance zone
	<p>The tolerance zone is limited by two parallel planes a distance t apart, symmetrically disposed about the median plane, with respect to the datum.</p>  <p>a Datum.</p> <p style="text-align: center;">Figure 155</p>

18.15 Circular run-out tolerance

18.15.1 Circular run-out tolerance — Radial

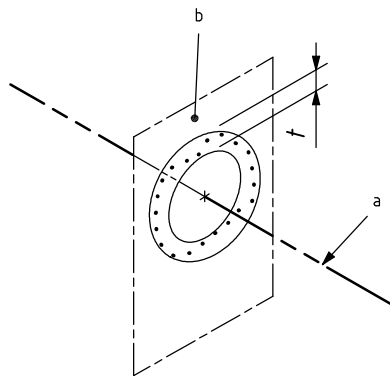
Dimensions in millimetres

Symbol	Indication and explanation
	<p>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 156).</p> <p>The extracted (actual) line in any cross-section plane parallel to datum plane B shall be contained between two coplanar circles that are concentric to datum axis A, with a difference in radii of 0,1 (see Figure 157).</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>a) 2D</p> </div> <div style="text-align: center;">  <p>b) 3D</p> </div> </div> <p style="text-align: center;">Figure 156</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>a) 2D</p> </div> <div style="text-align: center;">  <p>b) 3D</p> </div> </div> <p style="text-align: center;">Figure 157</p>

Symbol	Indication and explanation
	<p>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.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 158</p>

Definition of the tolerance zone


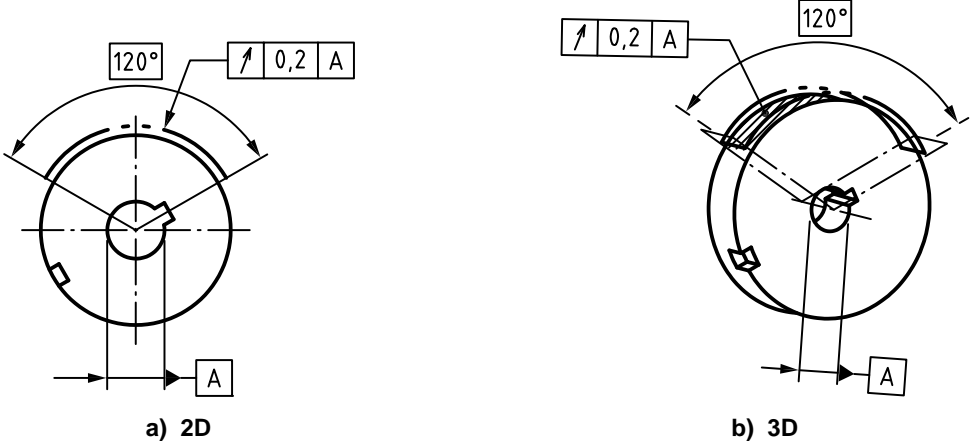
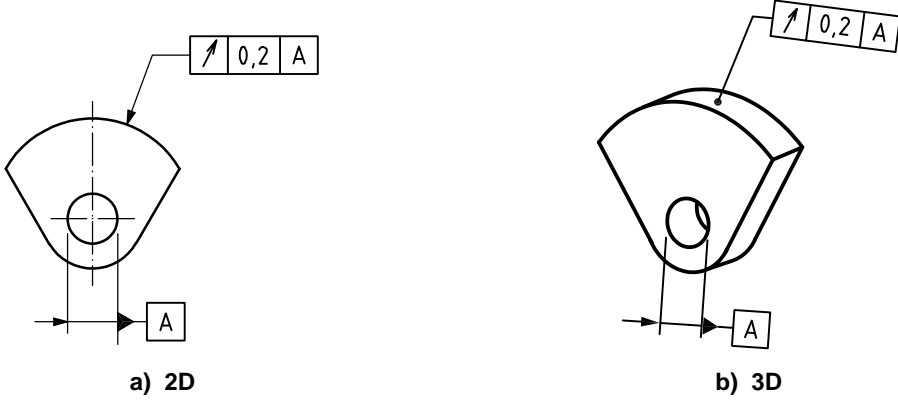
The tolerance zone is limited within any cross-section perpendicular to the datum axis by two concentric circles with a difference in radii of t , the centres of which coincide with the datum.



- a Datum.
- b Cross-section plane.

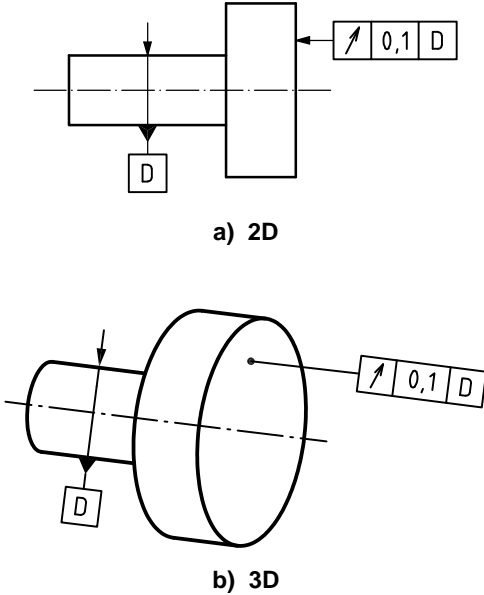
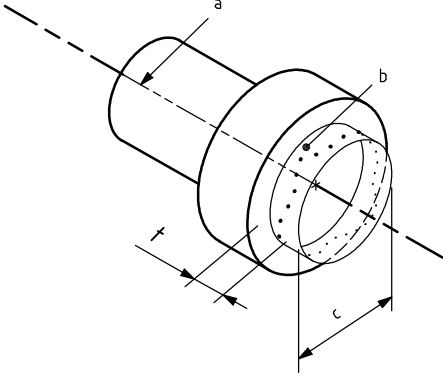
Figure 159

Dimensions in millimetres

Symbol	Indication and explanation
	<p data-bbox="323 320 1490 376">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.</p> <div data-bbox="435 394 1409 837">  <p data-bbox="576 808 647 837">a) 2D</p> <p data-bbox="1166 808 1238 837">b) 3D</p> </div> <p data-bbox="839 875 975 904">Figure 160</p> <div data-bbox="451 943 1353 1346">  <p data-bbox="576 1312 647 1341">a) 2D</p> <p data-bbox="1166 1312 1238 1341">b) 3D</p> </div> <p data-bbox="839 1379 975 1408">Figure 161</p> <p data-bbox="323 1447 1490 1503">Run-out usually applies to complete features, but could be applied to a restricted part of a feature (see Figure 160).</p>


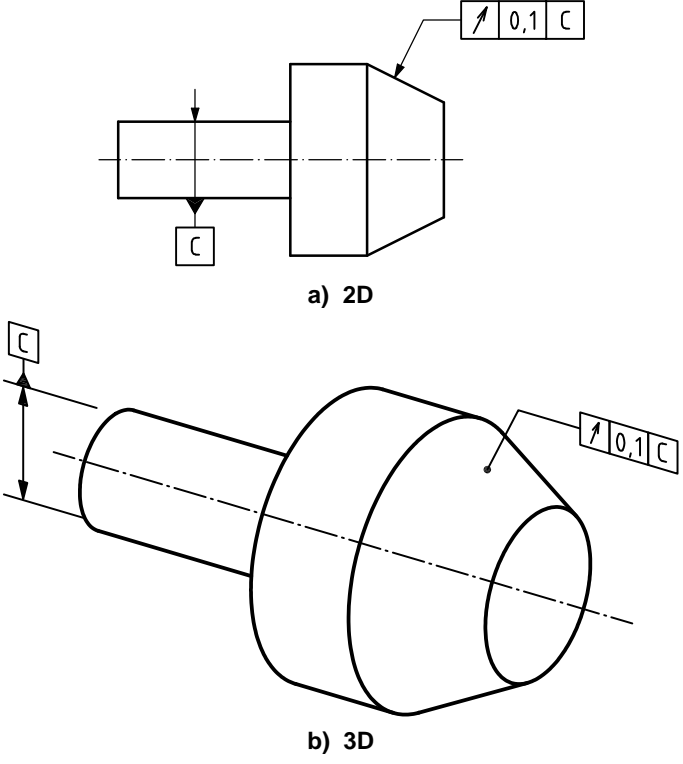
18.15.2 Circular run-out tolerance — Axial

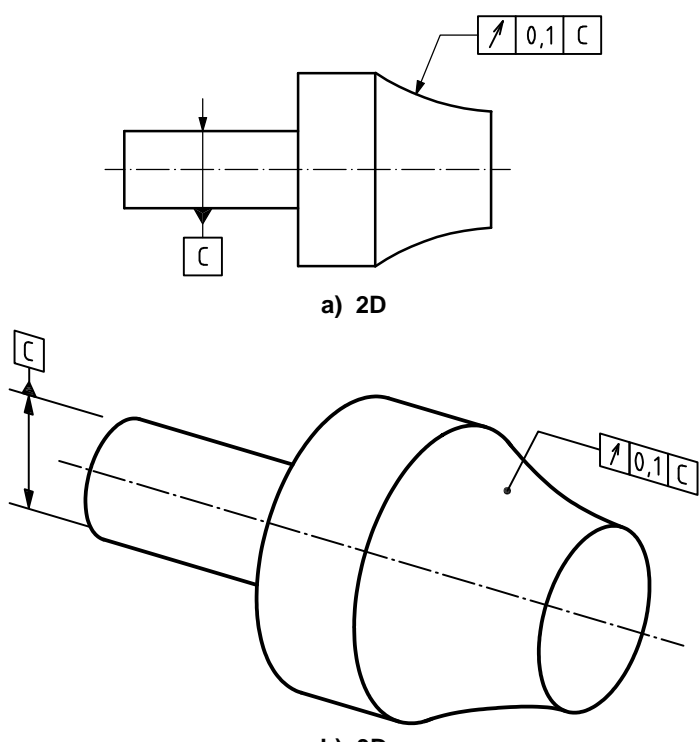
Dimensions in millimetres

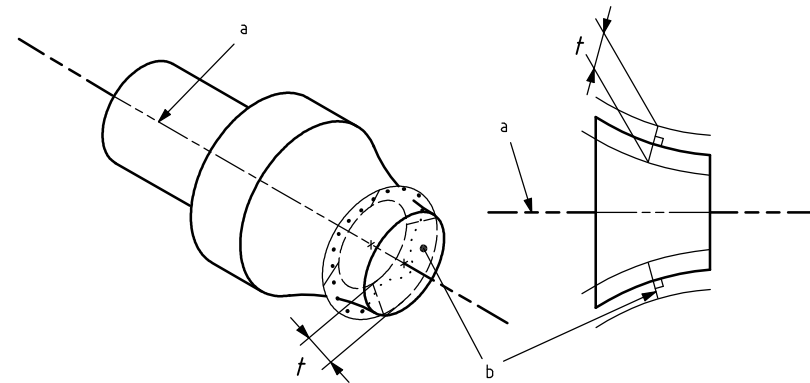
Symbol	Indication and explanation
	<p>The extracted (actual) line in any cylindrical section, the axis of which coincides with datum axis D, shall be contained between two circles with a distance of 0,1.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 162</p> </div>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>The tolerance zone is limited to any cylindrical section by two circles a distance t apart lying in the cylindrical section, the axis of which coincides with the datum.</p> <div style="text-align: center;">  </div> <p>a Datum D. b Tolerance zone. c Any diameter.</p> <p style="text-align: center;">Figure 163</p>

18.15.3 Circular run-out tolerance in any direction

Dimensions in millimetres

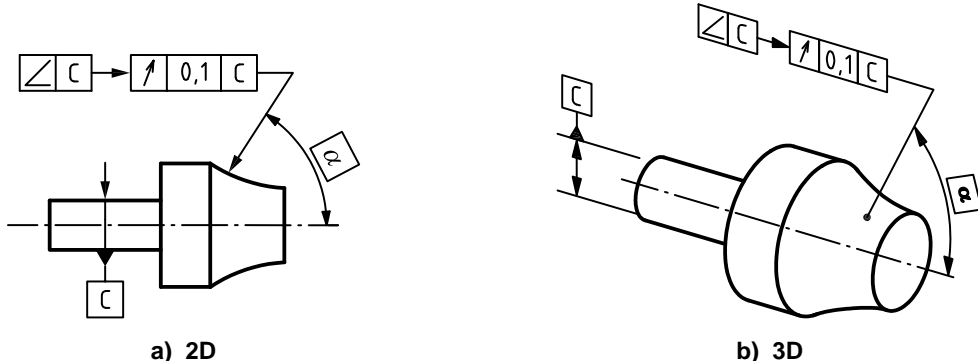
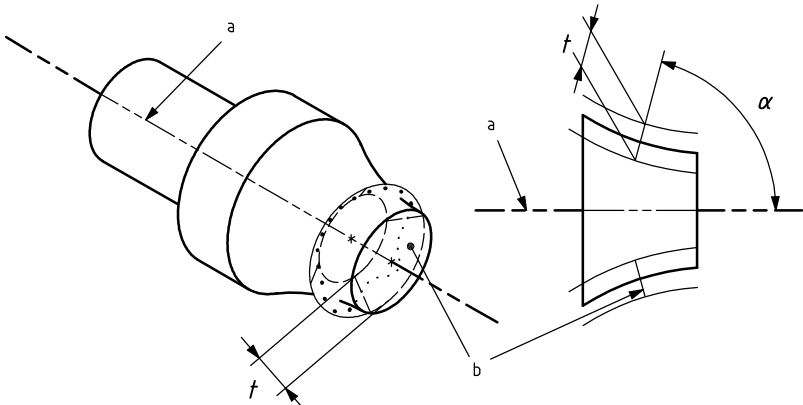
Symbol	Indication and explanation
	<p>The extracted (actual) line in any conical section, the axis of which coincides with datum axis C, shall be contained between two circles within the conical section with a distance of 0,1.</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 164</p>

Symbol	Indication and explanation
	<p>When the generator line for the tolerated feature is not straight, the apex angle of the conical section will change depending on the actual position [see Figure 166 (right) and Figure 165 b)].</p>  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 165</p>

Symbol	Definition of the tolerance zone
	<p>The tolerance zone is limited within any conical section by two circles a distance t apart, the axes of which coincide with the datum.</p> <p>The width of the tolerance zone is normal to the specified geometry unless otherwise indicated.</p>  <p>a Datum C.</p> <p>b Tolerance zone.</p> <p>Figure 166</p>

18.15.4 Circular run-out tolerance in a specified direction


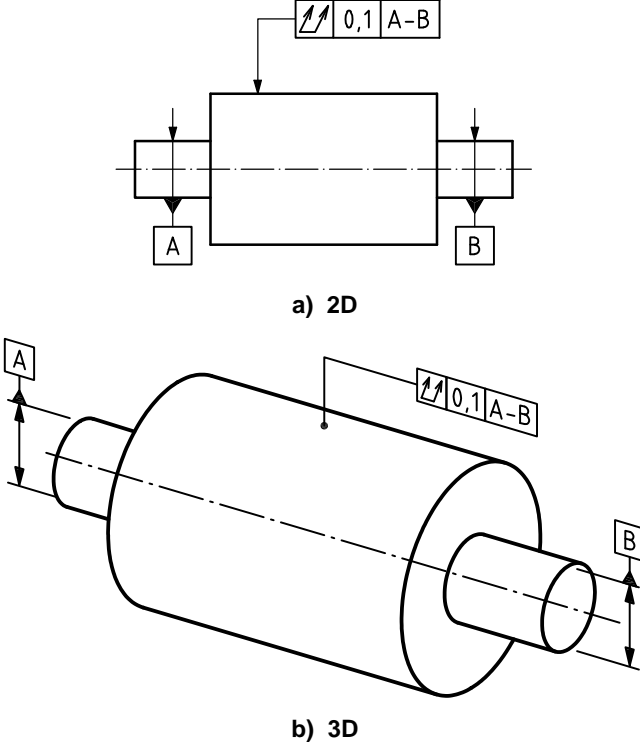
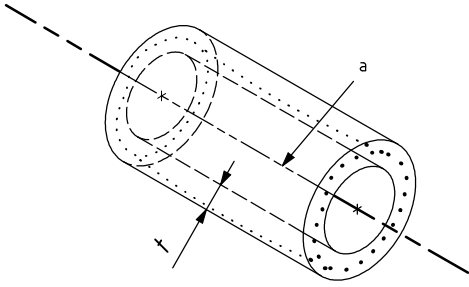
Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) line in any conical section (angle α) corresponding to a direction feature (cone of half-angle α), the axis of which coincides with datum axis C, shall be contained between two circles 0,1 apart within the conical section.</p>  <p style="text-align: center;">Figure 167</p>
<p>↗</p>	<p style="text-align: center;">Definition of the tolerance zone</p> <p>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.</p>  <p>a Datum C. b Tolerance zone.</p> <p style="text-align: center;">Figure 168</p>

18.16 Total run-out tolerance


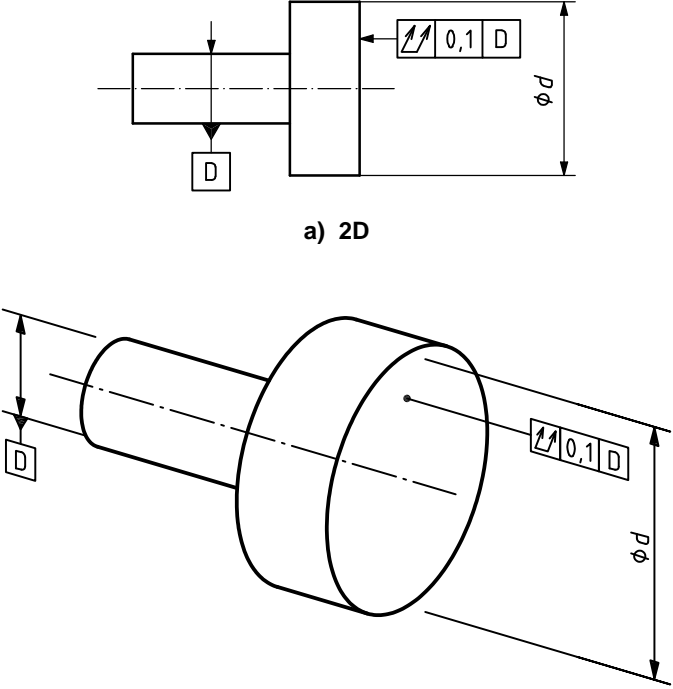
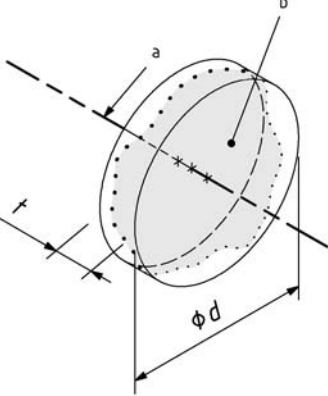
18.16.1 Total radial run-out tolerance

Dimensions in millimetres

Symbol	Indication and explanation
	<p>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.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> </div> <p style="text-align: center;">Figure 169</p>
	<p style="text-align: center;">Definition of the tolerance zone</p> <p>The tolerance zone is limited by two coaxial cylinders with a difference in radii of t, the axes of which coincide with the datum.</p> <div style="text-align: center;">  </div> <p>a Datum A-B.</p> <p style="text-align: center;">Figure 170</p>

18.16.2 Total axial run-out tolerance

Dimensions in millimetres

Symbol	Indication and explanation
	<p>The extracted (actual) surface shall be contained between two parallel planes 0,1 apart, which are perpendicular to datum axis D.</p> <div style="text-align: center;">  <p>a) 2D</p> <p>b) 3D</p> <p>Figure 171</p> </div>
	<p>Definition of the tolerance zone</p>
	<p>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.</p> <div style="text-align: center;">  <p>a Datum D. b Extracted surface.</p> <p>Figure 172</p> </div>

Annex A (informative)

Former practices

A.1 This annex describes former practices that have been omitted and are no longer used. Therefore, they are 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.

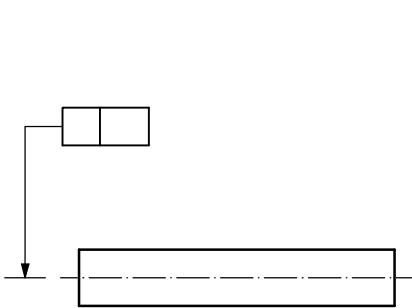


Figure A.1

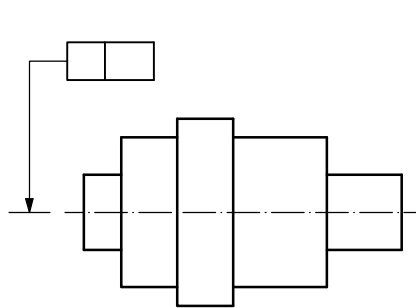


Figure A.2

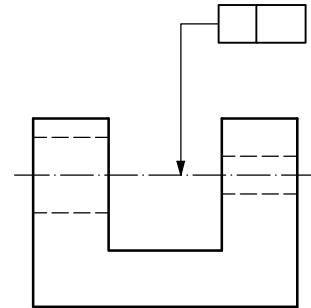


Figure A.3

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 Figures 33 to 35.

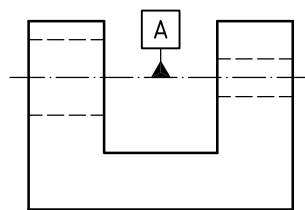


Figure A.4

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 39.

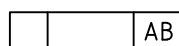


Figure A.5

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.

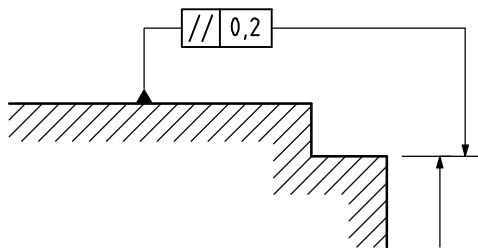


Figure A.6

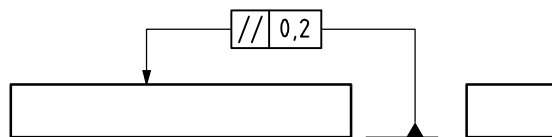


Figure A.7

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.

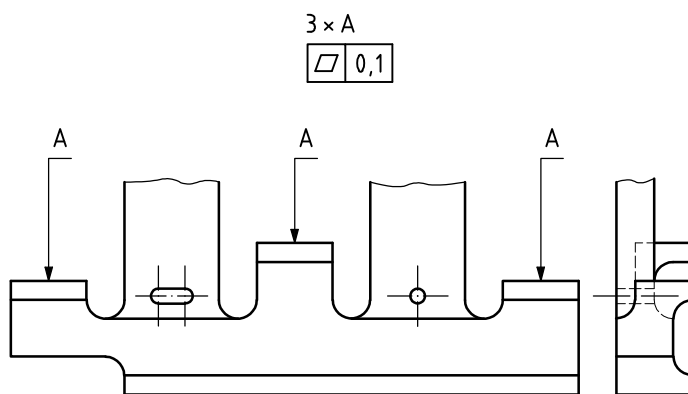


Figure A.8

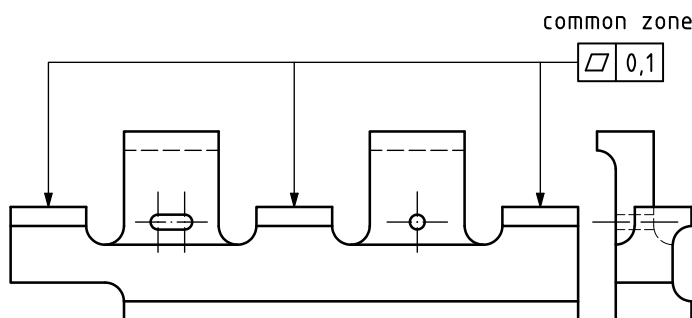



Figure A.9

3 × A
common zone

	0,1
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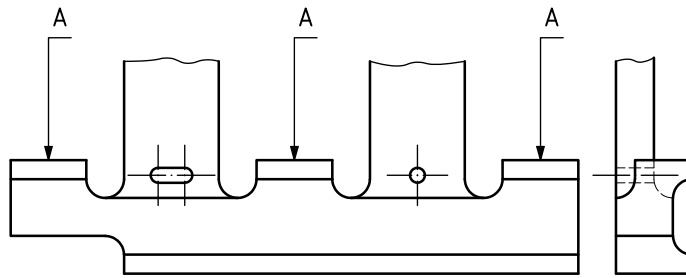


Figure A.10

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 12180-1, ISO 12180-2, ISO 12181-2, ISO 12181-2, ISO 12780-1, ISO 12780-2, ISO 12781-1 and ISO 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 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 notenote).

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:

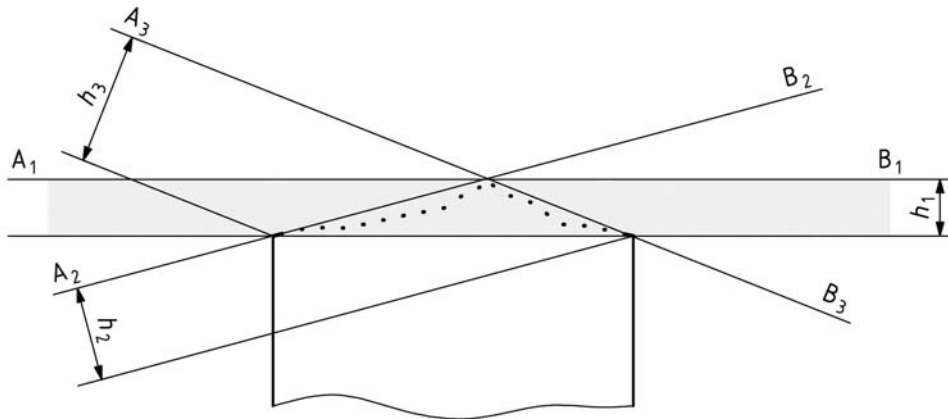


Figure B.1

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:

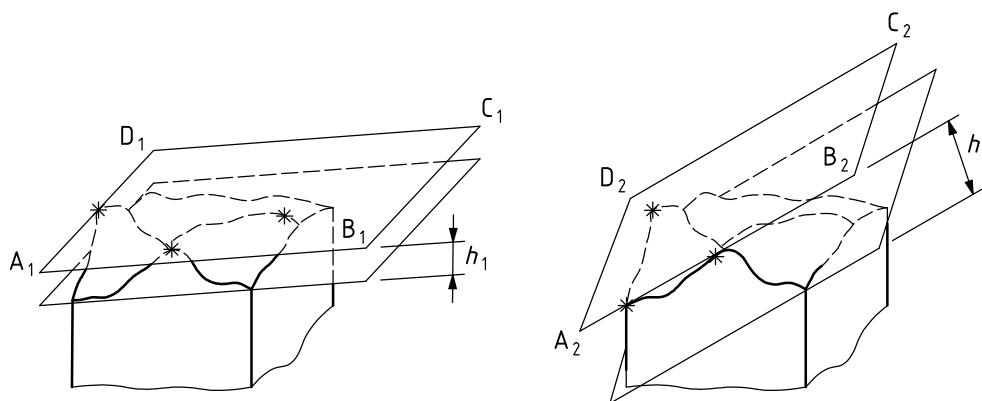


Figure B.2

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 tolerated 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:

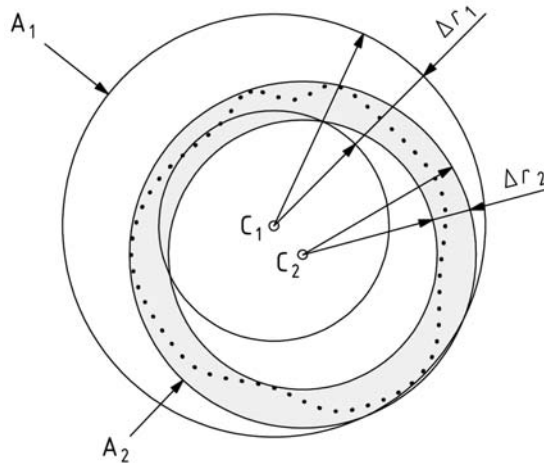


Figure B.3

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 tolerated 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:

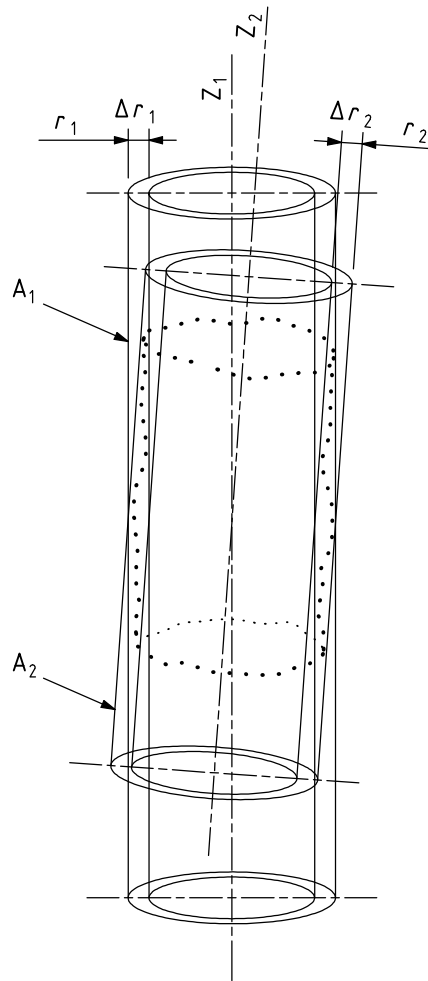


Figure B.4

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)

Relations and dimensions of graphical symbols

To harmonize the sizes of the symbols specified in this International Standard with those of the other inscriptions on the drawing (dimensions, letters, tolerances), the rules given in this annex, which are in accordance with ISO/IEC 81714-1, shall be observed. Further graphical symbols are given in ISO 3098-5.

The graphical symbols described in Table 2 shall be drawn in accordance with Figures C.1 to C.5.

The single-letter symbol given in Table 2 shall be drawn according to Figure C.6.

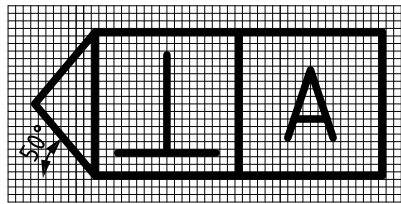


Figure C.1 — Intersection plane indicator

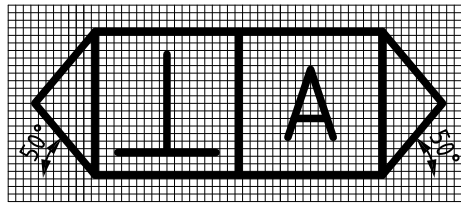


Figure C.2 — Orientation plane indicator

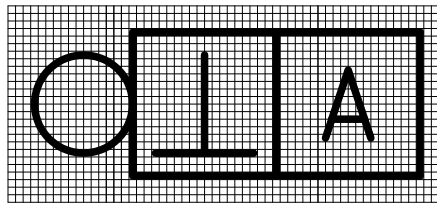


Figure C.3 — Collection plane indicator

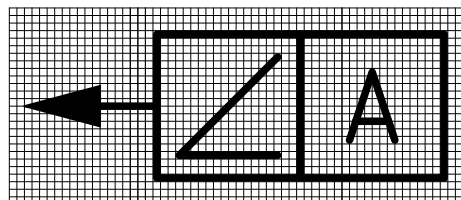


Figure C.4 — Direction feature indicator

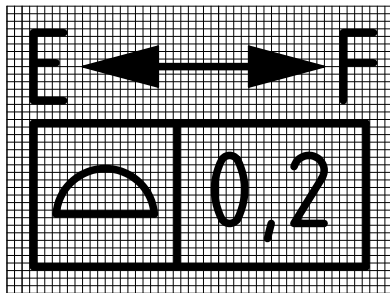


Figure C.5 — “Between” symbol

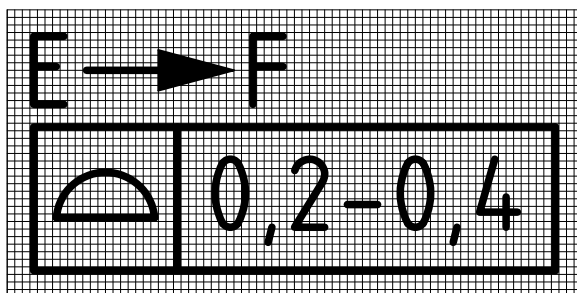


Figure C.6 — “From ... to” symbol

Annex D (informative)

Relation to the GPS matrix model

D.1 General

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

The ISO GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO GPS system of which this document is a part. The fundamental rules of ISO GPS given in ISO 8015 apply to this document. The default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise stated.

D.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.

D.3 Position in the GPS matrix model

This International Standard is a general GPS standard, which influences the chain link 1, 2 and 3 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 D.1.

Global GPS standards							
	General GPS standards						
	Chain link number	1	2	3	4	5	6
Size							
Distance							
Radius							
Angle							
Form of line independent of datum							
Form of line dependent 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							

Fundamental GPS standards

Figure D.1 — Position in the GPS matrix model

D.4 Related standards

The related standards are those of the chains of standards indicated in Figure D.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*
- [9] ISO 16792, *Technical product documentation — Digital product definition data practices*
- [10] ISO 81714-1, *Design of graphical symbols for use in the technical documentation of products — Part 1: Basic rules*
- [11] ISO 3098-5, *Technical product documentation — Lettering — Part 5: CAD Lettering of the Latin alphabet, numerals and marks*

