
**Geometrical Product Specifications
(GPS) — Linear and angular
dimensioning and tolerancing: +/- limit
specifications — Step dimensions,
distances, angular sizes and radii**

*Spécification géométrique des produits (GPS) — Cotation et
tolérancement linéaires et angulaires: Spécifications de limites en +/- —
Ressauts, distances, tailles angulaires et rayons*

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 16570 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

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Introduction

This Technical Report is a geometrical product specification (GPS) technical report and is to be regarded as a general GPS technical report (see ISO/TR 14638). It influences links 1 and 2 of the chains of standards on size, distance, radius and angle.

For more detailed information on the relation of this Technical Report to other standards and the GPS matrix model, see Annex B.

The application of \pm limit specifications usually causes large specification uncertainty (see ISO/TS 17450-2). It must be emphasized that any \pm limit specification in this Technical Report, generally speaking, can be completely substituted by geometrical dimensioning and tolerancing as per ISO 1101 and its related standards. Even the application of this Technical Report might cause large specification uncertainty. Consequently, ISO/TC 213 recommends that the use of \pm limit specifications be restricted to features of size only (see ISO 14660-1 and ISO 14405).

Other geometrical specifications are indicated and toleranced according to the principles given in ISO 1101 and related standards (e.g. by positional tolerancing).

This Technical Report consists of several groups of examples and it needs to be recognized that several different interpretation concepts are applied in the various groups.

ISO 129 contains general rules for dimensioning and dimensional tolerancing with \pm limit specifications in technical drawings. These rules are not always sufficient for an unambiguous description of the workpiece geometry.

EXAMPLE 1 Distances between axes of holes on a pitch cylinder cannot be toleranced by \pm limit specifications suitable for the function (see Figure A.1, left).

EXAMPLE 2 Angles between planes containing axes of holes cannot be toleranced by \pm limit specifications suitable for the function (see Figures A.3 and A.5).

EXAMPLE 3 Linear dimensions and \pm limit specifications, even when related to the same reference (having the same origin as in superimposed running dimensioning), but dimensioned in two or three directions and nominally perpendicular to each other, are ambiguous (see Figure A.1, centre, right).

In certain cases, such as for step dimensions, the function (e.g. assembly) allows for larger tolerances for the form (e.g. flatness) than for the location of the point of the surface, which is the most outward of the material. In these cases the production process including casting, forging and sheet metal working, becomes more beneficial when \pm limit deviation specifications are applied.

For these and similar cases, this Technical Report deals with \pm limit specifications for

- step dimensions (see 4.2),
- distances between an integral feature and a derived feature (see 4.3.1),
- distances between two derived features (see 4.3.2),
- angular sizes (see Clause 5), and
- radii (see 6.4),

only when two features are involved.

Geometrical Product Specifications (GPS) — Linear and angular dimensioning and tolerancing: +/- limit specifications — Step dimensions, distances, angular sizes and radii

1 Scope

This Technical Report describes the \pm limit specification of step dimensions, distances, angular sizes and radii when the function relates to two features only.

The interpretation of \pm limit specifications in accordance with this Technical Report is only applicable to a drawing when "ISO/TR 16570" is referred to on the drawing.

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 129-1:2004, *Technical drawings — Dimensioning — General principles, definitions, methods of execution and special indications*

ISO 1101:—¹, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out*

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

ISO/TS 17450-1:—², *Geometrical product specifications (GPS) — Part 1: Model for geometrical specification and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 129, ISO 1101, ISO 14660-1 and ISO/TS 17450-1 apply.

1) To be published. (Revision of ISO 1101:1983)

2) To be published.

4 Linear dimensioning

4.1 General

Linear dimensioning may be applied for tolerancing sizes and distances between two ideal features, otherwise the requirements of ISO 1101 apply.

4.2 Distance dimensioning between two parallel planes (step dimensioning)

A step dimension is the distance between two parallel planes (integral features) having the same direction outward from the material (see Figure 1).

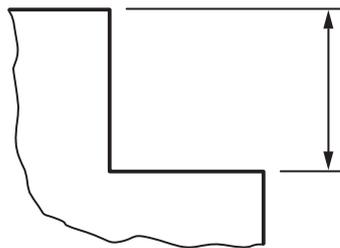
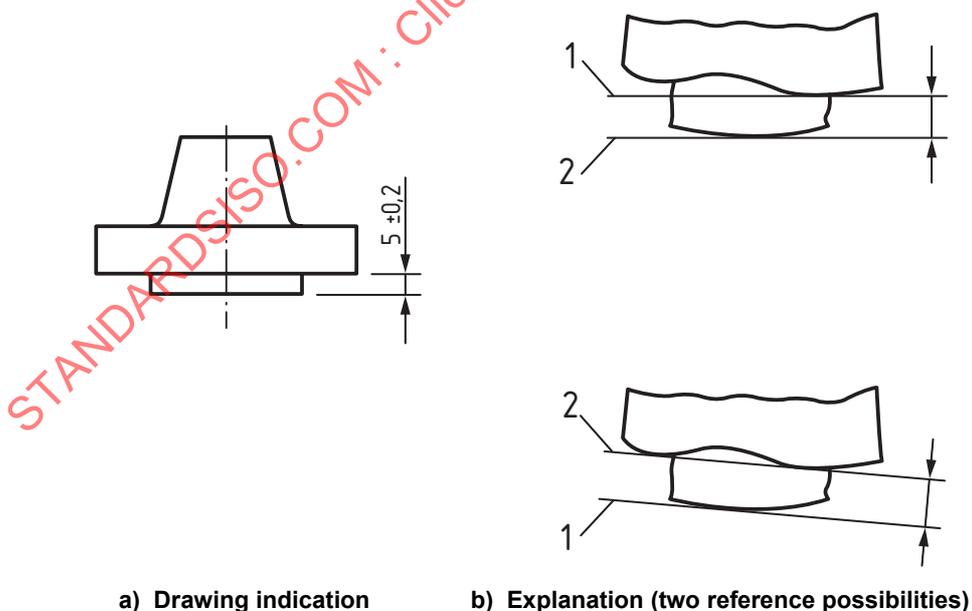


Figure 1 — Step dimension

One of the two parallel planes is to be taken as the reference.

For the purposes of this Technical Report, the step dimension corresponds to the distance between the reference and the contacting associated plane of the other surface parallel to the reference plane (see Figure 2).

The reference is a contacting plane so located and orientated that any motion is equalized.



Key

- 1 contacting associated plane
- 2 reference plane

Figure 2 — Step dimension without origin symbol according to ISO 129

Where the origin symbol indicates a single feature in accordance with ISO 129, this feature applies as the reference feature only (see Figure 3). When there is no reference indicated (dimension line with arrows on both sides) both reference possibilities apply.

NOTE 1 Form and orientation of the features are controlled by individually indicated geometrical tolerances or general tolerances of form (e.g. flatness) and of orientation (e.g. parallelism, perpendicularity).

NOTE 2 This definition of step dimensioning corresponds to the functional requirements of an assembly.

NOTE 3 This concept of step dimensioning is different from the other concepts of distance dimensioning given in 4.3.

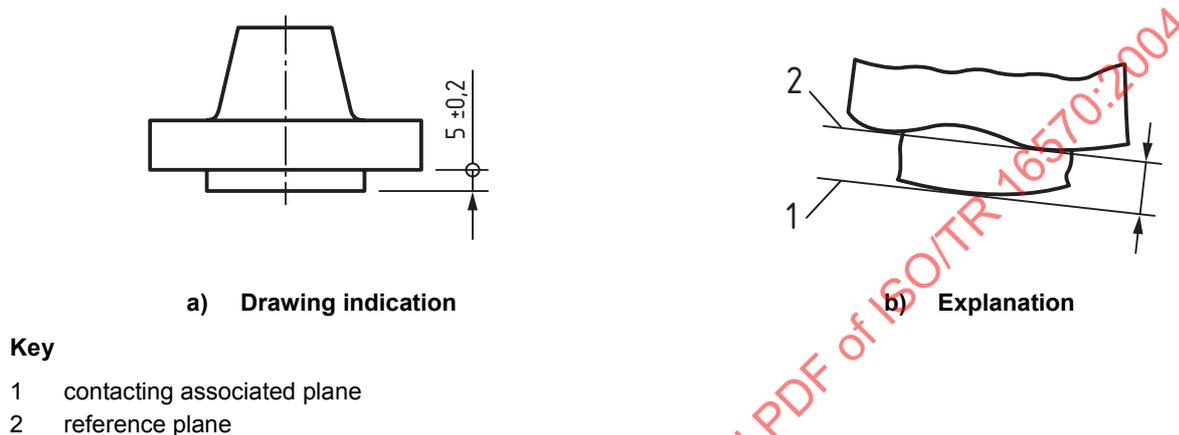


Figure 3 — Step dimension with origin symbol according to ISO 129

4.3 Distance dimensioning between two parallel features, at least one of which is derived

4.3.1 Distance between integral feature (plane surface) and derived feature

For the distance between an integral feature (plane surface) and a derived feature, see Figure 4.

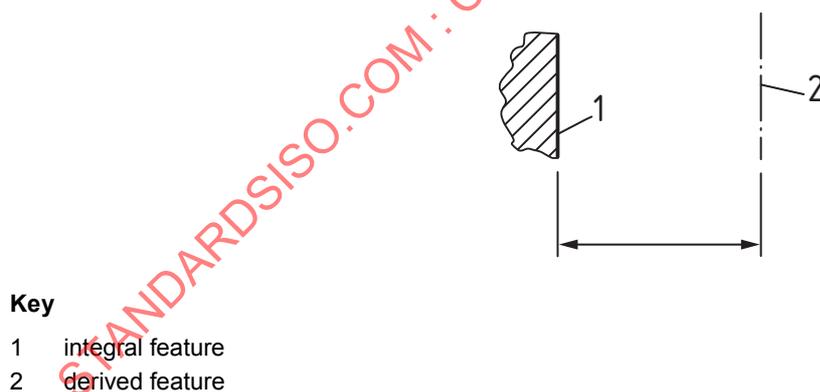


Figure 4 — Distance between integral and derived feature

One of the features is to be taken as a reference.

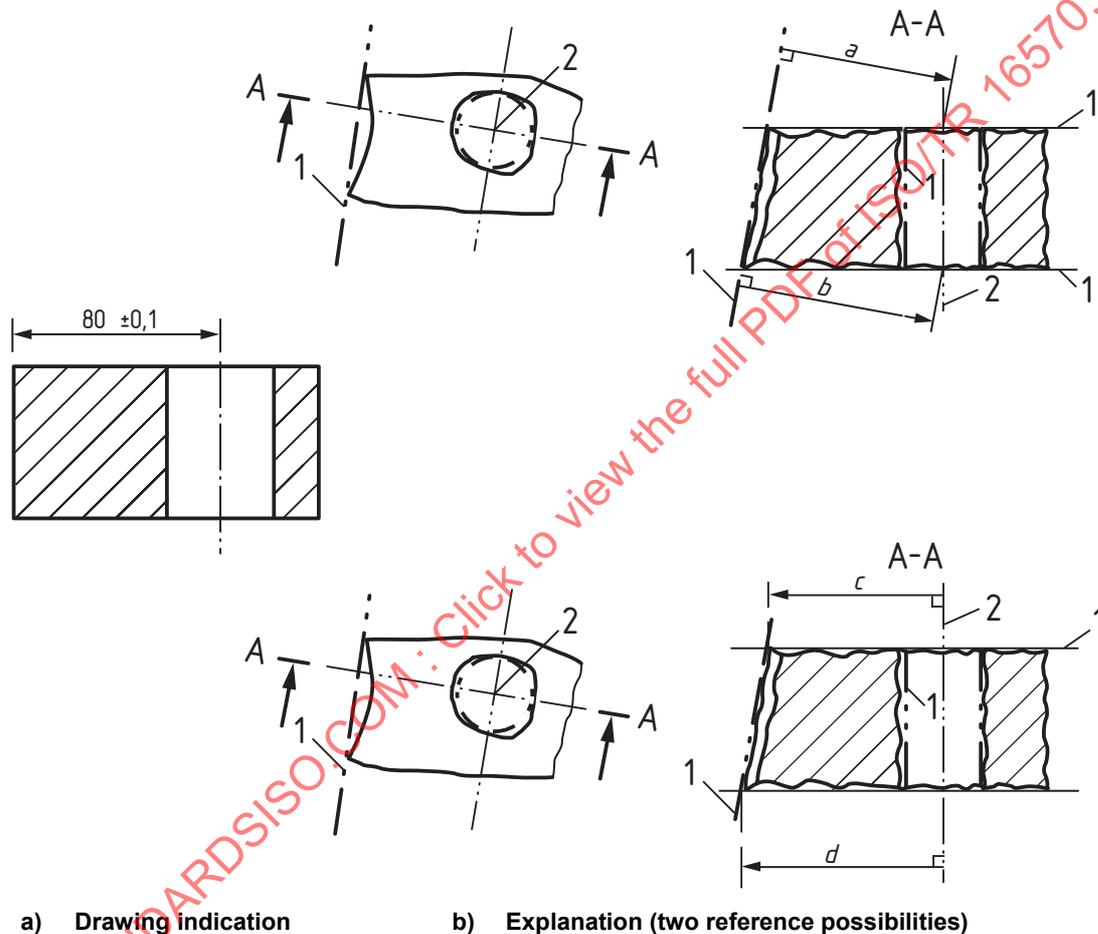
For the purposes of this Technical Report, the distances correspond to the range of distances between the reference and the contacting associated feature of the other feature in any section plane perpendicular to the reference, over the length of the extracted derived feature, or over the length of the extracted plane feature.

The reference is

- for a cylinder, the axis of the largest inscribed cylinder of a hole or the smallest circumscribed cylinder of a shaft, so located and orientated that any motion is equalized, or
- for a plane, a contacting plane located and orientated such that any motion is equalized.

For the feature other than the reference, the contacting associated feature has the same definition as for the reference.

The lengths of the extracted derived feature and the extracted plane feature are determined by the distance of the contacting associated features from the adjacent surfaces (see Figure 5).



Key

- 1 contacting associated feature
- 2 reference cylinder axis

a, b, c, d possible distances between contacting associated feature and reference cylinder axis, depending on choice of reference

Figure 5 — Distance between plane and reference cylinder — Reference possibilities

Where the origin symbol indicates a single feature in accordance with ISO 129, that feature applies as the reference feature only. When there is no reference indicated (dimension line with arrows on both sides) both reference possibilities apply.

NOTE This concept is different from the concept of step dimensioning given in 4.2.

4.3.2 Distance between the two axes of two parallel cylinders (derived features)

For the distance between the two axes of two parallel cylinders (derived features), see Figure 6.

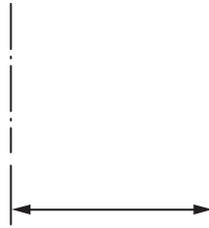


Figure 6 — Distance between two derived features

One of the features is to be taken as a reference.

For the purposes of this Technical Report, the distances correspond to the range of the distances between the reference and the derived contacting associated feature of the other feature in any section plane perpendicular to the reference, over the length of the extracted derived feature.

For the reference and contacting associated features, see 4.3.1.

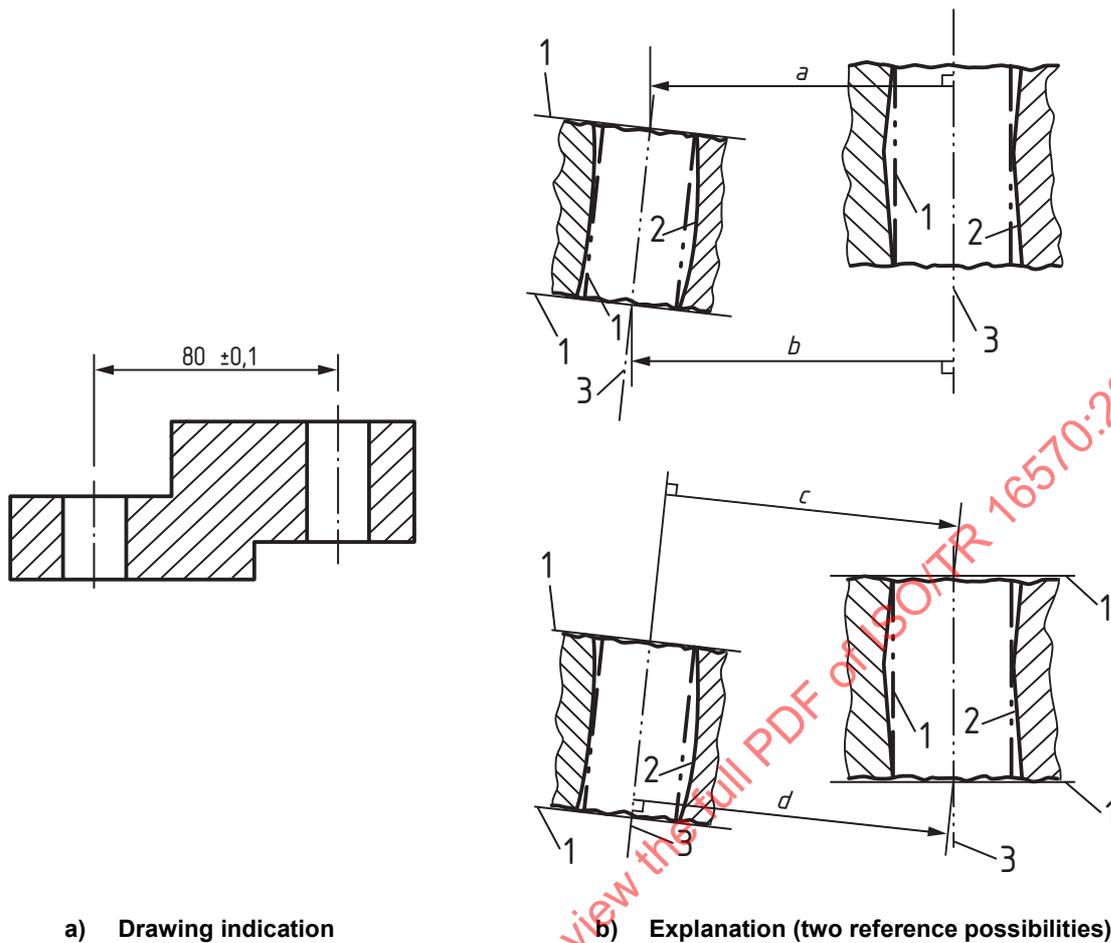
The length of the extracted derived feature is determined by the distance of the contacting associated features to the adjacent surfaces (see Figure 7).

Where the origin symbol indicates a single feature in accordance with ISO 129, this feature applies as the reference feature only. When there is no reference indicated (dimension line with arrows on both sides) both possibilities apply.

NOTE 1 The form of the features is controlled by individually indicated or general form tolerances (e.g. flatness or cylindricity).

NOTE 2 In case of holes, this definition of distance corresponds to the measuring method with the aid of inspection mandrels, suiting some functional requirements.

NOTE 3 This concept is different from the concept of step dimensioning given in 4.2.



Key

- 1 contacting associated feature
- 2 extracted feature
- 3 reference cylinder axis

a, b, c, d possible distances between axes of reference cylinders

Figure 7 — Distance between axes of two parallel cylinders (derived features) — Reference possibilities

5 Angular dimensioning

5.1 Angular distance

See Annex A.

5.2 Angular size

For the purposes of this Technical Report, angular size corresponds to features of size such as cones or wedges. For other angular relationships between features, ISO 1101 applies. For the indication of the angular size of a cone or wedge, see Figure 8.



Figure 8 — Angular sizes

In the case of angular sizes, there is no reference.

Here, angular size corresponds to the angle between two straight lines contacting the extracted feature in a section plane.

The straight lines in the section plane are oriented to their respective features such that the maximum distance to the extracted feature line is maintained at a minimum.

The section plane is oriented such that the maximum angle occurs (see Figure 9).

NOTE 1 The angular size is defined only in a section and not for the total surface.

NOTE 2 The form of the features is controlled by individually indicated or general form tolerances (e.g. flatness).

NOTE 3 The definition of the angular size corresponds to the definition in ISO 8015.

NOTE 4 See Clause A.2 for the angular distance between a derived feature and another feature.

6 Tolerances

6.1 Step dimension with \pm limit specifications

The tolerance is the difference between the maximum step dimension, and the minimum permitted step dimension as given in 4.2.

6.2 Distance with \pm limit specifications

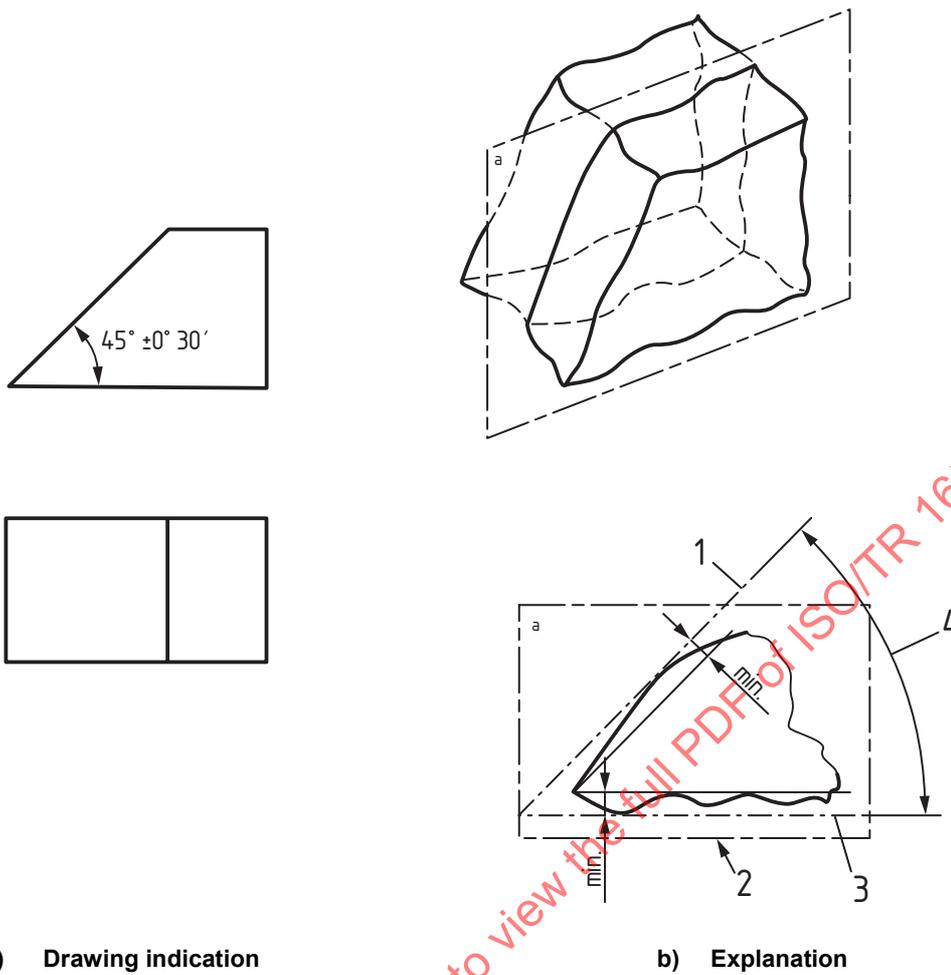
The tolerance is the difference between the maximum permitted distance, and the minimum permitted distance as given in 4.3.

6.3 Angular size with \pm limit specifications

The tolerance is the difference between the maximum permitted angular size, and the minimum permitted angular size as given in Clause 5.

6.4 Radius with \pm limit specifications

For the indication of a tolerance of a radius with \pm limit deviation specifications, see Figure 10.



Key

- 1 contacting straight line
- 2 section plane
- 3 contacting straight line
- 4 extracted angular size in a section

NOTE The angular size varies from section to section.

a Section plane.

Figure 9 — Angular size

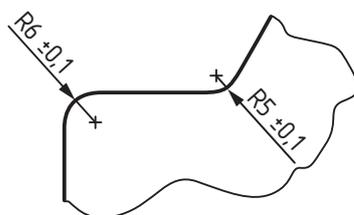


Figure 10 — Radius

The feature (line) must fit within the arcs of the maximum and minimum radii in section planes. The section planes are oriented such that the minimum radius occurs. To fit within the arcs means

- for a convex feature (line), that the extracted feature (line) must contact the maximum radius arc at the zenith region and the minimum radius arc at the side regions [see Figure 11a)], and
- for a concave feature (line), that the extracted feature (line) must contact the maximum radius arc at the side regions and the minimum radius arc at the zenith region [see Figure 11b)].

NOTE 1 The radius with \pm limit specifications is defined only in a section and not for the total surface.

NOTE 2 If necessary, the three-dimensional form of the feature is controlled by individually indicated or general form tolerances.

NOTE 3 The definition of the radius \pm limit deviation corresponds to the inspection method with templates.

NOTE 4 This tolerancing allows features that meet the description given here and have the form shown in Figures 12 and 13.

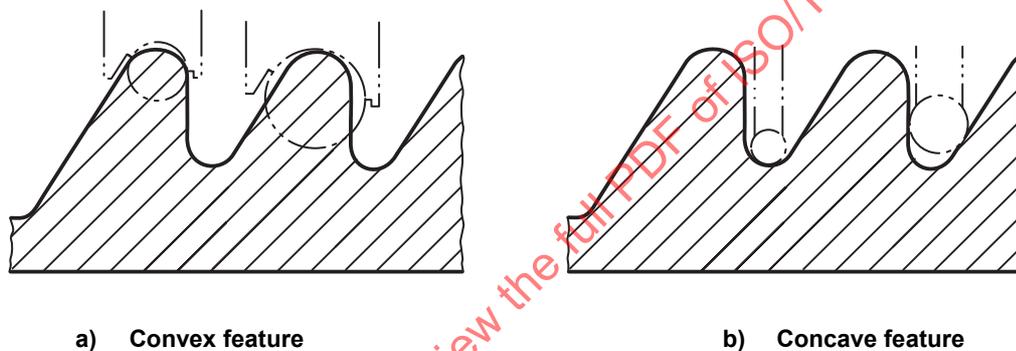


Figure 11 — Radii \pm limit deviations

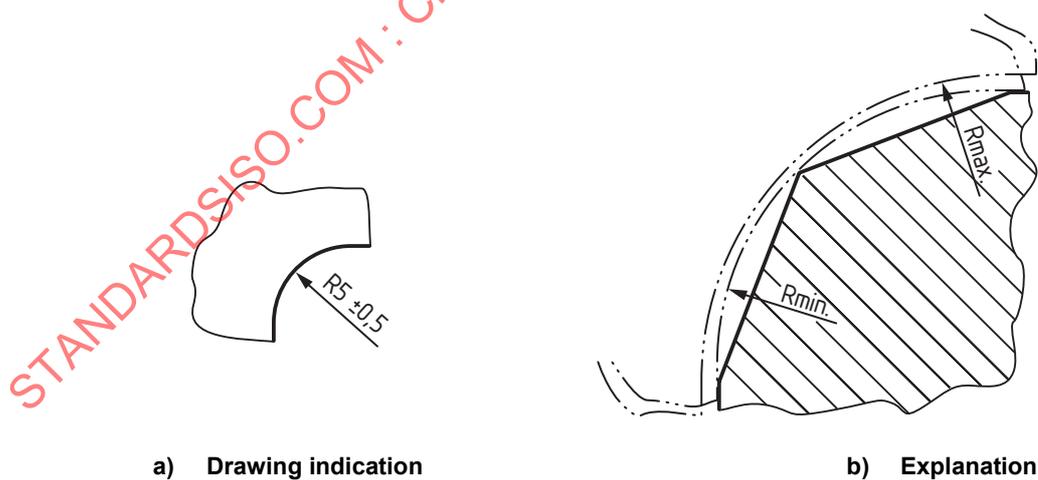


Figure 12 — Permissible shape of feature with \pm limit specifications for outer radius

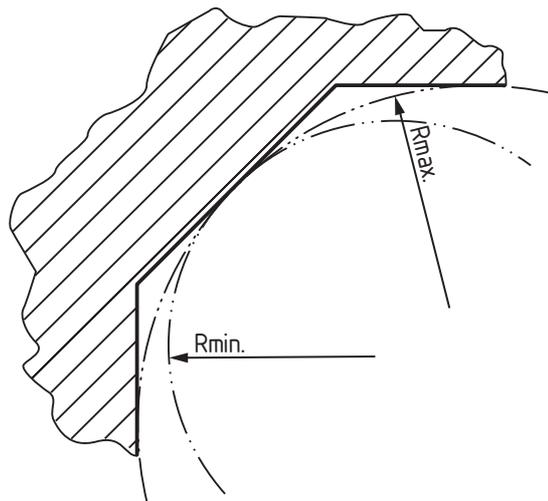


Figure 13 — Permissible shape of feature with \pm limit specifications for inner radius

7 Designation

When this Technical Report is applied on a drawing, the following designation is to be indicated in or near the title block:

ISO/TR 16570

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Annex A (informative)

Examples covered by other standards

A.1 Linear distances between more than two features of size

Distances between more than two features of size functionally related to each other are toleranced by positional tolerancing according to ISO 5458 and not by \pm limit deviation specifications.

This is because the \pm limit deviation specifications do not limit the deviations of the extracted derived features (actual axes) from their common pitch cylinder or common pitch planes, or from the right angles between the pitch planes (see Figure A.1).

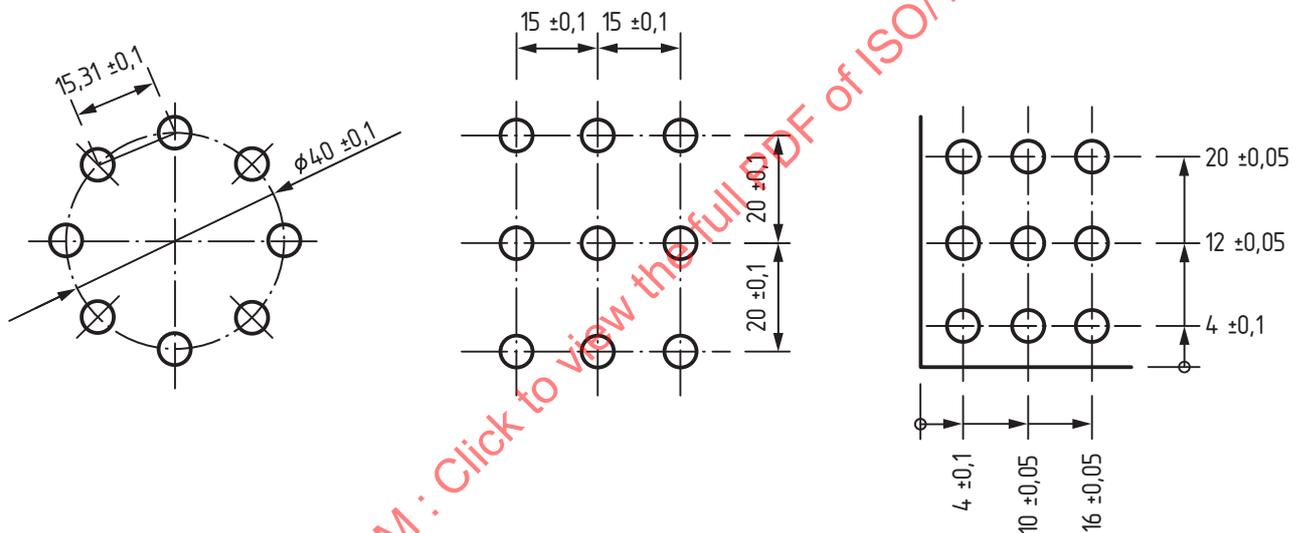


Figure A.1 — Distances within pattern of more than two features of size

Furthermore, \pm limit deviations do not distinguish between the individual derived features (actual axes) commonly represented by the centreline on the drawing, even though the function may allow different tolerances (see Figure A.2). They do not allow

- reference to common datums or datum systems that could be necessary to express functional needs,
- the specification of cylindrical tolerance zones occurring by the function of a fit of cylindrical parts and giving 57 % larger tolerance zones than the squared tolerance zones of \pm tolerancing, or
- the specification of M, L and P, which allows increasing tolerances under certain conditions.

Finally, \pm limit specifications on step dimension and distances for more than two features always lead to smaller tolerances in comparison with geometrical tolerances.