# INTERNATIONAL STANDARD

# ISO 5459

Second edition
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# Geometrical product specifications (GPS) — Geometrical tolerancing — Datums and datum systems

*Spécification géométrique des produits (GPS) — Tolérancement géométrique — Références spécifiées et systèmes de références spécifiées*



Reference number
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## Foreword

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

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

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

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

ISO 5459 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specification and verification*.

This second edition cancels and replaces the first edition (ISO 5459:1981), which has been technically revised.

## Introduction

ISO 5459 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences the chain links 1 to 3 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 standard is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this standard and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this standard unless otherwise indicated.

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

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

The previous version of ISO 5459 dealt only with planes, cylinders and spheres being used as datums. There is a need to consider all types of surfaces, which are increasingly used in industry. The definitions of classes of surfaces as given in Annex B are exhaustive and unambiguous.

This edition of ISO 5459 applies new concepts and terms that have not been used in previous ISO GPS standards. These concepts are described in detail in ISO/TR 14638, ISO 17450-1 and ISO 17450-2; therefore, it is recommended to refer to these standards when using ISO 5459.



This International Standard provides tools to express location or orientation constraints, or both, for a tolerance zone. It does not provide information about the relationship between datums or datum systems and functional requirements or applications.

# Geometrical product specifications (GPS) — Geometrical tolerancing — Datums and datum systems

## 1 Scope

This International Standard specifies terminology, rules and methodology for the indication and understanding of datums and datum systems in technical product documentation. This International Standard also provides explanations to assist the user in understanding the concepts involved.

This International Standard defines the specification operator (see ISO 17450-2) used to establish a datum or datum system. The verification operator (see ISO 17450-2) can take different forms (physically or mathematically) and is not the subject of this International Standard.

NOTE The detailed rules for maximum and least material requirements for datums are given in ISO 2692.

## 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 1101:2004, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 1101:2004/Amd 1:—[1], *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out — Amendment 1: Representation of specifications in the form of a 3D model*

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

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

ISO 3098-5, *Technical product documentation — Lettering — Part 5: CAD lettering of the Latin alphabet, numerals and marks*

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

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

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

ISO 81714-1, *Design of graphical symbols for use in the technical documentation of products — Part 1: Basic rules*

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1) To be published.

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1101, ISO 2692, ISO 14660-1, ISO 17450-1, ISO 17450-2 and the following apply.

**3.1**
**situation feature**
point, straight line, plane or helix from which the location and orientation of features, or both, can be defined

**3.2**
**datum feature**
real (non-ideal) integral feature used for establishing a datum

NOTE 1 A datum feature can be a complete surface, a portion of a complete surface, or a feature of size.

NOTE 2 An illustration showing the relations between datum feature, associated feature and datum is given in Figure 4.

**3.3**
**associated feature**
associated feature for establishing a datum

ideal feature which is fitted to the datum feature with a specific association criterion

NOTE 1 The type of the associated feature is by default the same as the type of the nominal integral feature used to establish the datum (for an exception see 7.4.2.5).



NOTE 2 The associated feature for establishing a datum simulates the contact between the real surface of the workpiece and other components.



NOTE 3 An illustration showing the relations between datum feature, associated feature and datum is given in Figure 4.



**3.4**
**datum**
one or more situation features of one or more features associated with one or more real integral features selected to define the location or orientation, or both, of a tolerance zone or an ideal feature representing for instance a virtual condition

NOTE 1 A datum is a theoretically exact reference; it is defined by a plane, a straight line or a point, or a combination thereof.

NOTE 2 The concept of datums is inherently reliant upon the invariance class concept (see Annex A and Annex B).

NOTE 3 Datums with maximum material condition (MMC) or least material condition (LMC) are not covered in this International Standard (see ISO 2692).

NOTE 4 When a datum is established, for example, on a complex surface, the datum consists of a plane, a straight line or a point, or a combination thereof. The modifier [SL], [PL] or [PT], or a combination thereof, can be attached to the datum letter to limit the situation feature(s) taken into account relative to the surface.

NOTE 5 An illustration showing the relation between datum feature, associated feature and datum is given in Figure 4.

**3.5**
**primary datum**
datum that is not influenced by constraints from other datums

**3.6**
**secondary datum**
datum, in a datum system, that is influenced by an orientation constraint from the primary datum in the datum system

**3.7**
**tertiary datum**
datum, in a datum system, that is influenced by constraints from the primary datum and the secondary datum in the datum system

**3.8**
**single datum**
datum established from one datum feature taken from a single surface or from one feature of size

NOTE The invariance class of a single surface can be complex, prismatic, helical, cylindrical, revolute, planar or spherical. A set of situation features defining the datum (see Table B.1) corresponds to each type of single surface.

**3.9**
**common datum**
datum established from two or more datum features considered simultaneously

NOTE To define a common datum, it is necessary to consider the collection surface created by the considered datum features. The invariance class of a collection surface can be complex, prismatic, helical, cylindrical, revolute, planar or spherical (see Table B.1).

**3.10**
**datum system**
set of two or more situation features established in a specific order from two or more datum features

NOTE To define a datum system, it is necessary to consider the collection surface created by the considered datum features. The invariance class of a collection surface can be complex, prismatic, helical, cylindrical, revolute, planar or spherical (see Table B.1).



**3.11**
**datum target**
portion of a datum feature which can nominally be a point, a line segment or an area



NOTE Where the datum target is a point, a line or an area, it is indicated as a datum target point, a datum target line or a datum target area, respectively.

**3.12**
**moveable datum target**
datum target with a controlled motion

**3.13**
**collection surface**
two or more surfaces considered simultaneously as a single surface

NOTE 1 Table B.1 is used to determine the invariance class of a datum or datum systems when using a collection of surfaces.

NOTE 2 Two intersecting planes may be considered together or separately. When the two intersecting planes are considered simultaneously as a single surface, that surface is a collection surface.

**3.14**
**feature of size**
geometrical shape defined by a linear or angular dimension which is a size

NOTE The features of size can be a cylinder, a sphere, two parallel opposite surfaces, a cone or a wedge.

[ISO 14660-1:1999, 2.2]

NOTE In this International Standard, features which are not features of size according to ISO 14660-1 are used to establish a datum as a feature of size, e.g. a truncated sphere (see the example in C.1.4).

**3.15**
**objective function**
objective function for association

formula that describes the quality of association

NOTE 1 In this International Standard, the term “objective function” refers to “objective function for association”.

NOTE 2 The objective functions are usually named and mathematically described: maximum inscribed, minimum zone, etc.

**3.16**
**association**
operation used to fit ideal feature(s) to non-ideal feature(s) according to an association criterion

[ISO 17450-1:—, 3.2]

**3.17**
**constraint**
limitation on the associated feature

EXAMPLE Orientation constraint, location constraint, material constraint or intrinsic characteristic constraint.

**3.17.1**
**orientation constraint**
limitation to one or more rotational degrees of freedom



**3.17.2**
**location constraint**
limitation to one or more translational degrees of freedom



**3.17.3**
**material constraint**
additional condition to the location of the associated feature, relative to the material of the feature, while optimizing an objective function

NOTE For example, an association constraint can be that all distances between the associated feature and the datum feature are positive or equal to zero, i.e. the associated feature is outside the material.

**3.17.4**
**intrinsic characteristic constraint**
additional requirement applied to the intrinsic characteristic of an associated feature whether it is considered fixed or variable

**3.18**
**association criterion**
objective function with or without constraints, defined for an association

NOTE 1 Several constraints may be defined for an association.

NOTE 2 Association results (associated features) may differ, depending upon the choice of association criterion.

NOTE 3 Default association criteria are defined in Annex A.

**3.19**
**integral feature**
surface or line on a surface

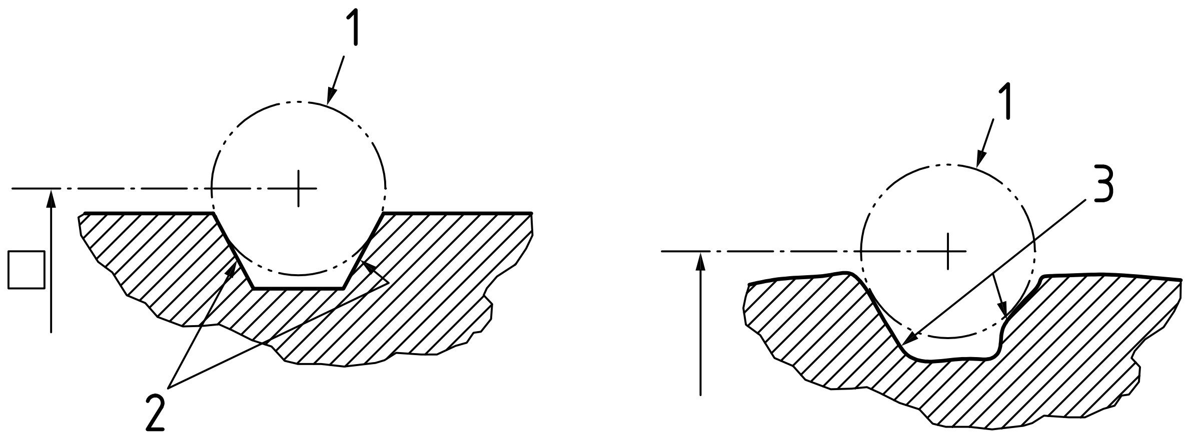
NOTE An integral feature is intrinsically defined.

[ISO 14660-1:1999, 2.1.1]

**3.20**
**contacting feature**
ideal feature of any type which is different from the nominal feature under consideration and is associated with the corresponding datum feature

See Figure 1.




a) **Contacting feature on nominal model**

b) **Contacting feature on real workpiece**

**Key**

1 contacting feature: ideal sphere in contact with the datum feature or the feature under consideration

2 features under consideration: nominal trapezoidal slot (collection of two non-parallel surfaces)

3 datum feature: real feature corresponding to the trapezoidal slot (collection of two non-parallel surfaces)



**Figure 1 — Example of a contacting feature**



**3.21**
**invariance class**
group of ideal features for which the nominal surface is invariant for the same degrees of freedom

NOTE There are seven invariance classes (see Annex B).

**3.22**
**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 an operation (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 theoretically exact orientation or location of one feature relative to one or more other features, or

— the nominal shape of a feature.

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

[ISO 1101:2004/Amd 1:—, 3.7]

## 4 Symbols

Table 1 gives symbols to identify the datum feature or datum target used to establish a datum.

Table 2 gives the list of modifier symbols, which can be associated the datum letter.

**Table 1 — Datum features and datum target symbols**

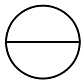
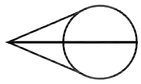
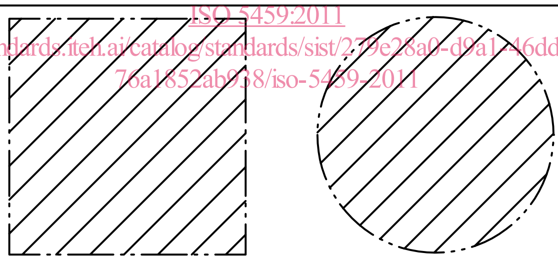
| Description | Symbol | Subclause |
|---|---|---|
| Datum feature indicator |  | 7.2.1 |
| Datum feature identifier | Capital letter (A, B, C, AA, etc.) | 7.2.2 |
| Single datum target frame |  | 7.2.3.2 |
| Moveable datum target frame |  | 7.2.3.2 |
| Datum target point |  | 7.2.3.3 |
| Closed datum target line |  | 7.2.3.3 |
| Non-closed datum target line |  | 7.2.3.3 |
| Datum target area |  | 7.2.3.3 |



**Table 2 — Modifier symbols**

| Symbol | Description | Subclause |
|---|---|---|
| [PD] | Pitch diameter | 7.4.2.1 |
| [MD] | Major diameter | 7.4.2.1 |
| [LD] | Minor diameter | 7.4.2.1 |
| [ACS] | Any cross section | 7.4.2.4 |
| [ALS] | Any longitudinal section | 7.4.2.4 |
| [CF] | Contacting feature | 7.4.2.5 |
| [DV] | Variable distance (for common datum) | 7.4.2.7 |
| [PT] | (situation feature of type) Point | 7.4.2.8 |
| [SL] | (situation feature of type) Straight line | 7.4.2.8 |
| [PL] | (situation feature of type) Plane | 7.4.2.8 |
| >< | For orientation constraint only | 7.4.2.8 |
| Ⓟ | Projected (for secondary or tertiary datum) | 7.4.2.10 |
| Ⓛ | Least material requirement | See ISO 2692 |
| Ⓜ | Maximum material requirement | See ISO 2692 |



## 5 Role of datums

Datums form part of a geometrical specification (see ISO 1101).



Datums are established from real surfaces identified on a workpiece.

Datums allow tolerance zones to be located or orientated (see Examples 1 and 2) and virtual conditions to be defined (for example maximum material virtual condition Ⓜ according to ISO 2692). The datums can be seen as a means to lock degrees of freedom of a tolerance zone. The number of degrees of freedom of the tolerance zone which are locked depends on the nominal shape of the features utilized to establish the datum or datum system; whether the datum is primary, secondary or tertiary; and on the toleranced characteristic indicated in the geometrical tolerance frame.

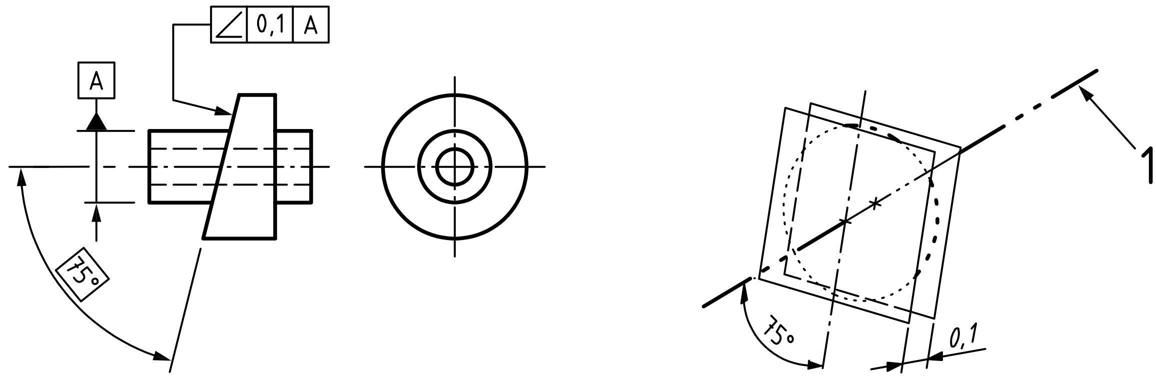
By default, a datum locks all the degrees of freedom of the tolerance zone that it can lock given its shape and which

- are required by the geometrical characteristic indicated in the tolerance frame, and
- have not already been locked by the preceding datum(s) in the datum system.

When a datum locks only orientation degrees of freedom, this shall be indicated by the modifier ><.

EXAMPLE 1 The tolerance zone, which is the space between two parallel planes 0,1 mm apart, is constrained in orientation by a 75° theoretically exact angle from the datum. Here, the datum is the situation feature of a cylinder (axis of associated cylinder). See Figure 2.

Dimensions in millimetres




a) **Indication on the drawing**

b) **Illustration of tolerance zone**

**Key**

1 datum A constituted by the axis of the associated cylinder

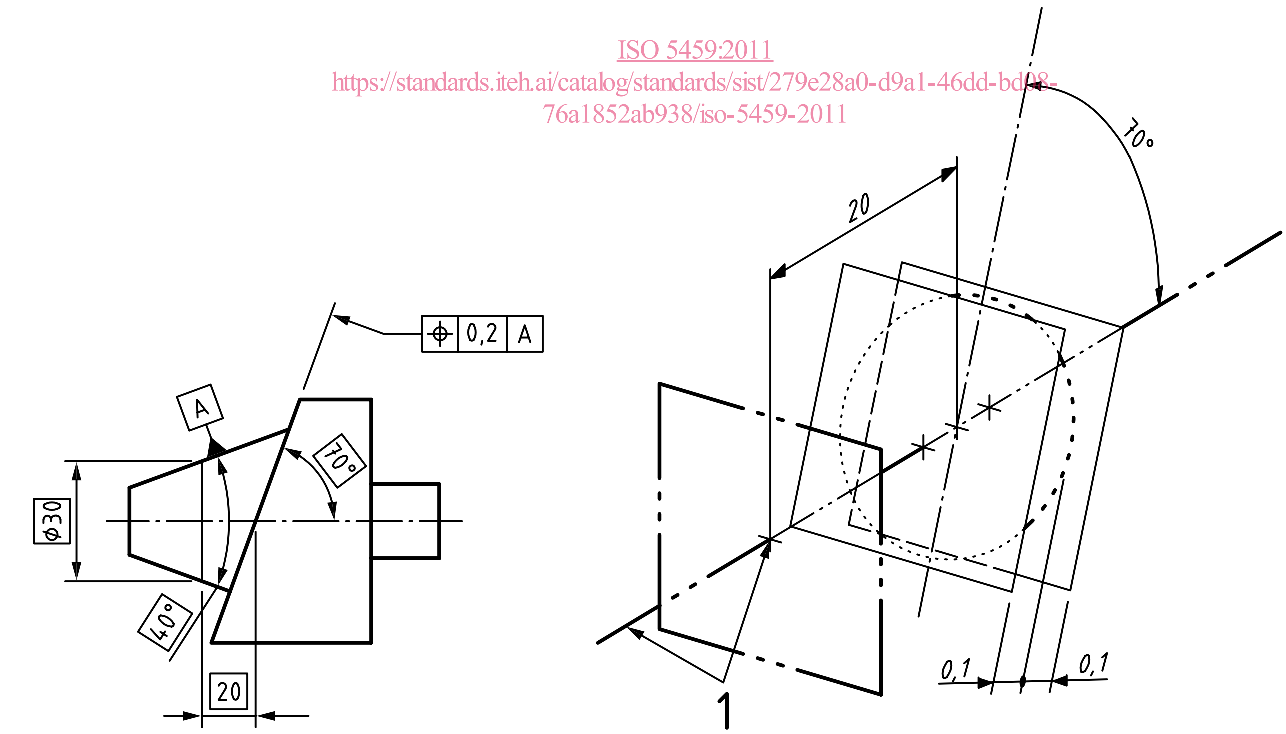
**Figure 2 — Example of tolerance zone constrained in orientation from a datum**

EXAMPLE 2 The tolerance zone, which is the space between two parallel planes 0,2 mm apart, is constrained in orientation by a 70° angle from a datum, and in location by the distance 20 mm from the gauge plane positioned perpendicular to the axis of 40° cone where its local diameter is 30 mm. Here, the datum consists of the set of situation features of the cone with a fixed angle of 40°, i.e. the cone axis and the point of intersection between the gauge plane and that axis. See Figure 3.



Dimensions in millimetres






a) **Indication on the drawing**

b) **Illustration of tolerance zone**

**Key**

1 datum A constituted by the axis of the associated cone, the point of intersection of the gauging plane and this axis

**Figure 3 — Example of a tolerance zone constrained in location from a datum**

# 6 General concepts

## 6.1 General

Datums and datum systems are theoretically exact geometric features used together with implicit or explicit TEDs to locate or orientate

a) tolerance zones for toleranced features, or

b) virtual conditions, e.g. in the case of maximum material requirement (see ISO 2692).

A datum consists of a set of situation features for an ideal feature (feature of perfect form). This ideal feature is an associated feature which is established from the identified datum features of a workpiece. Datum features may be complete features, or identified portions thereof (see Clause 7).

A datum system consists of more than one datum.

The geometrical type of these associated features belongs to one of the following invariance classes:

— spherical (i.e. a sphere);

— planar (i.e. a plane);

— cylindrical (i.e. a cylinder);

— helical (e.g. a threaded surface)[2];

— revolute (e.g. a cone or a torus);

— prismatic (e.g. a prism);

— complex (e.g. a free-form surface).



Each single or collection feature belongs to one invariance class (for an explanation of invariance classes, invariance degree, and degree of freedom, see Annex B).

Associated features are established from the real or extracted single features used for the datum. The associated feature can be defined by an operation of association including constraints coming from the feature itself or from one or more other features. The situation features that make up the datum are defined from these associated features. The default association methods are given in Annex A.

One or more single features can be used to establish a datum. If only one single feature is used, it establishes a single datum. If more than one single feature is used, they can either be considered simultaneously to establish a common datum or in a predefined order to establish a datum system (see 6.3).

The datum feature(s) to be used for establishing each datum shall be designated and identified.

The single datums (see 6.3.2), common datums (see 6.3.3) or datum systems (see 6.3.4), as applicable, shall be specified for each geometrical specification.

When applicable, any additional constraints shall be defined for the association.

2) Helical surfaces as such are not considered in this International Standard. They are regarded as cylindrical surfaces because, in most functional cases where helical surfaces (threads, helical slope, endless screw, etc.) are involved, the combined rotation and translation of the helix is not needed for datum purposes. In these cases, the pitch cylinder surface is used to establish the datum. The major or minor cylindrical surface can also be considered and specified.