INTERNATIONAL STANDARD

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Geometrical product specifications (GPS) — Dimensional tolerancing —

Part 1: Linear sizes

Spécification géométrique des produits (GPS) — Tolérancement dimensionnel —
Partie 1: Tailles linéaires

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 213, *Dimensional and geometrical product specification and verification*.

This second edition cancels and replaces the first edition (ISO 14405-1:2010), which has been technically revised.

The main changes from the previous edition are:

— Clauses 1 and 3, 5.3, 6.1, 6.2, 7.3, 7.8, Tables 1 and 2, and the figures have been technically revised;

— Clause 8 and Annexes D and E have been added.

ISO 14405 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Dimensional tolerancing*:

— *Part 1: Linear sizes*

— *Part 2: Dimensions other than linear sizes*

— *Part 3: Angular sizes*

Introduction

This part of ISO 14405 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences chain links A to C of the chain of standards on size.

The ISO GPS matrix model given in ISO 14638 gives an overview of the ISO GPS system of which this part of ISO 14405 is a part. The fundamental rules of ISO GPS given in ISO 8015 apply to this part of ISO 14405 and the default decision rules given in ISO 14253-1 apply to the specifications made in accordance with this part of ISO 14405, unless otherwise indicated.

For more detailed information of the relation of this part of ISO 14405 to other standards and the GPS matrix model, see Annex F.

Produced workpieces exhibit deviations from the ideal geometric form. The real value of the dimension of a feature of size is dependent on the form deviations and on the specific type of size applied.

The type of size to be applied to a feature of size depends on the function of the workpiece.

The type of size can be indicated on the drawing by a specification modifier for controlling the feature definition.

Geometrical product specifications (GPS) — Dimensional tolerancing —

Part 1: Linear sizes

IMPORTANT — The illustrations included in this part of ISO 14405 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 part of ISO 14405 establishes the default specification operator (see ISO 17450-2) for linear size and defines a number of special specification operators for linear size for features of size, e.g. "cylinder", "sphere", "torus,"[1], "circle", "two parallel opposite planes", or "two parallel opposite straight lines".

It also defines the specification modifiers and the drawing indications for these linear sizes.

This part of ISO 14405 covers the following linear sizes:

a) local size:
   - two-point size;
   - spherical size;
   - section size;
   - portion size;

b) global size:
   - direct global linear size:
     - least-squares size;
     - maximum inscribed size;
     - minimum circumscribed size;
     - minimax size;
   - indirect global linear size;

c) calculated size:
   - circumference diameter;
   - area diameter;
   - volume diameter;

1) A torus is a feature of size when its directrix diameter is fixed.

d) rank-order size:

- maximum size;
- minimum size;
- average size;
- median size;
- mid-range size;
- range of sizes;
- standard deviation of sizes.

This part of ISO 14405 defines tolerances of linear sizes for the following:

- a + and/or – limit deviation (e.g. 0/–0,019) (see Figure 11);
- an upper limit of size (ULS) and/or lower limit of size (LLS) (e.g. 15,2 max., 12 min., or 30,2/30,181) (see Figure 13);
- an ISO tolerance class code in accordance with ISO 286-1 (e.g. 10 h6) (see Figure 12);

with or without modifiers (see Tables 1 and 2).

This part of ISO 14405 provides a set of tools to express several types of size characteristic. It does not present any information on the relationship between a function or a use and a size characteristic.

2 Normative references

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

ISO 286-1, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits*

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

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

ISO 17450-2:2012, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators, uncertainties and ambiguities*

ISO 17450-3, *Geometrical product specifications (GPS) — General concepts — Part 3: Toleranced features*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 286-1, ISO 8015, ISO 17450-1, ISO 17450-2, ISO 17450-3, and the following apply.

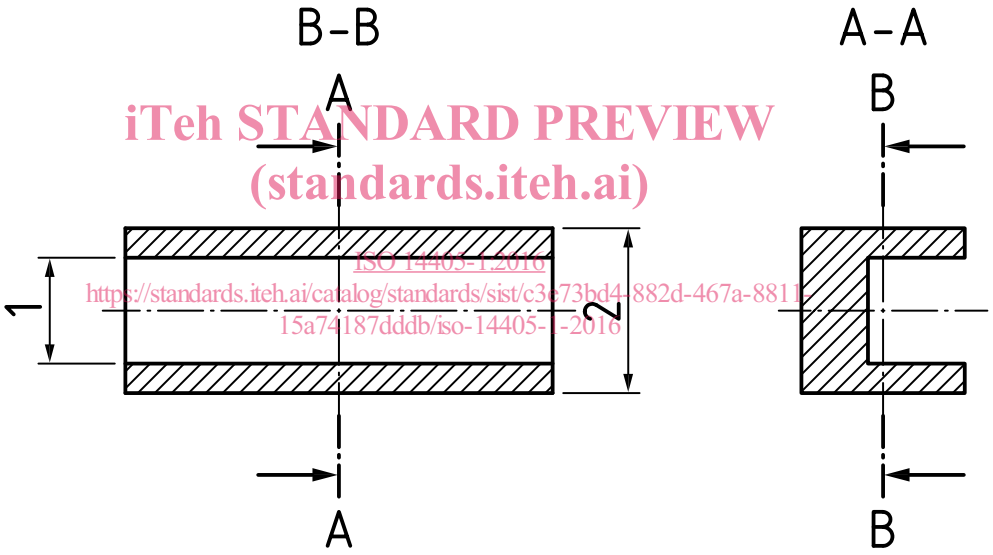
3.1
feature of size
feature of linear size or feature of angular size

Note 1 to entry: Feature of linear size and feature of angular size are synonyms of linear feature of size and angular feature of size, respectively.

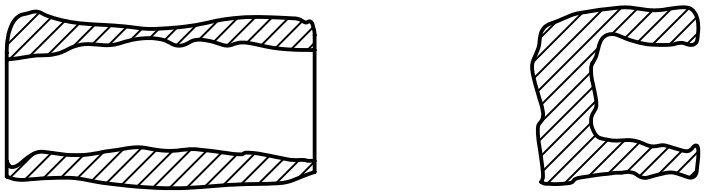
Note 2 to entry: Figures 1 and 2 illustrate a linear feature of size, type cylinder, or two parallel opposite planes.

Note 3 to entry: This part of ISO 14405 only deals with features of linear size which can be a cylinder, a sphere, two parallel opposite planes, a circle (intersection of a revolute surface and a plane perpendicular to the axis of the associated surface), two parallel opposite straight lines (the intersection of a cylindrical surface and a plane containing the associated axis of the cylindrical surface or a prismatic surface and a plane perpendicular to the associated median plane of the prismatic surface), and two opposite circles (the intersection of a pair of coaxial revolute surfaces and a plane perpendicular to the axis of one of the revolute surfaces), i.e. the wall thickness of a tube.

Note 4 to entry: Two opposite straight lines can be symmetrically established from the associated axis for a cylindrical surface or a plane perpendicular to the plane of a prismatic surface. Two opposite circles can be established from the intersection of a pair of coaxial revolute surface and a plane perpendicular to the axis of one the revolute surfaces or intersection of a collection of two single surfaces and a section feature which is a cylinder.



a) Nominal features of linear size (internal and external)

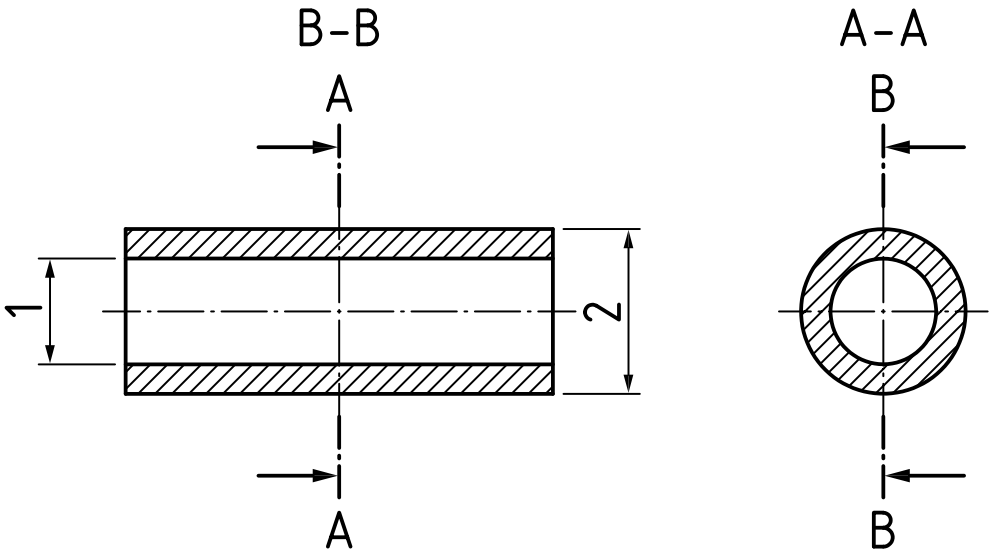


b) Extracted feature

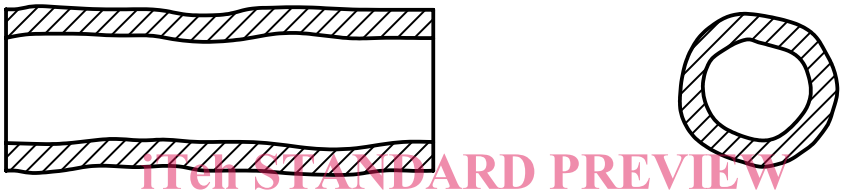
Key

1 size of internal linear feature of size
2 size of external linear feature of size

Figure 1 — Example of a linear feature of size consisting of two opposite planes



a) Nominal features of size (internal and external)



b) Extracted feature

Key

1 size of internal linear feature of size
2 size of external linear feature of size

Figure 2 — Example of a linear feature of size consisting of a cylinder

[SOURCE: ISO 17450-1:2011, 3.3.1.5]

3.2
upper limit of size
upper limit of size characteristic
ULS
largest permissible value for a *size characteristic* (3.5)

3.3
lower limit of size
lower limit of size characteristic
LLS
smallest permissible value for a *size characteristic* (3.5)

3.4
size
dimensional parameter considered variable for a *feature of size* (3.1) that can be defined on a nominal feature or on an associated feature

Note 1 to entry: In this part of ISO 14405, the size is linear, e.g. the diameter of a cylinder or the distance between two parallel opposite planes, two opposing lines, and two concentric circles. Depending on the type of linear feature of size, the terms “diameter”, “width”, and “thickness” are synonyms for size.

Note 2 to entry: A size is angular (e.g. angle of a cone) or linear (e.g. diameter of a cylinder). This part of ISO 14405 only deals with linear size.

3.5
size characteristic
characteristic relative to a *size* (3.4) and defined from an extracted integral feature

Note 1 to entry: See Figure B.1.

Note 2 to entry: A size can be evaluated by more than one size characteristic (e.g. the two-point diameter or the diameter of the associated feature taken on the extracted feature).

3.6
local size
local linear size
local size characteristic
local linear size characteristic
size characteristic (3.5) having by definition a non-unique result of evaluation along and/or around a *feature of size* (3.1)

Note 1 to entry: For a given feature, an infinity of local sizes exists.

Note 2 to entry: A two-point size on two opposite planes can be called a “two-point thickness” or a “two-point width”.

Note 3 to entry: In Figure 3, examples of local size are shown. These examples do not take into account the *rank-order size* (3.7.2.2).

Note 4 to entry: Elementary types of size characteristic are defined in Annex D.

3.6.1
two-point size
<local size> distance between two opposite points on a extracted integral linear feature of size

Note 1 to entry: A two-point size on a cylinder can be called a “two-point diameter”.

Note 2 to entry: A two-point size on two opposite planes can be called a “two-point distance”.

Note 3 to entry: The method establishing a two-point size from any kind of features of size is given in ISO 17450–3.

3.6.2
section size
global size (3.7) for a given cross section of the extracted integral feature

Note 1 to entry: A section size is a *local size* (3.6) for the complete toleranced *feature of size* (3.1).

Note 2 to entry: The cross section is defined with the same criterion as the one taken to define the *direct global size* (3.7.1).

Note 3 to entry: On an extracted feature which is a cylinder, it is possible to define an infinite number of cross sections in which the diameter of the associated circle can be defined (with a specific association criterion). This is a section size.

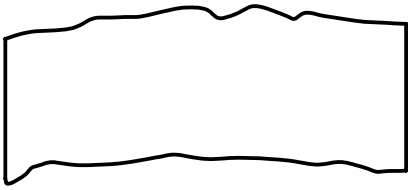
3.6.3
portion size
global size (3.7) for a given portion of the extracted feature

Note 1 to entry: A portion size is a *local size* (3.6) for the complete toleranced *feature of size* (3.1).

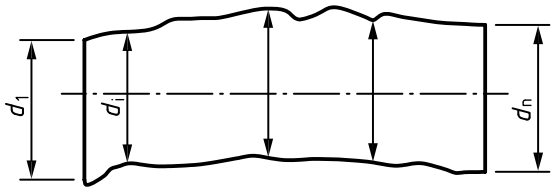
3.6.4
spherical size
<local size> diameter of the maximum inscribed sphere

Note 1 to entry: The maximum inscribed sphere is used when defining the spherical size of both internal and external feature of size.

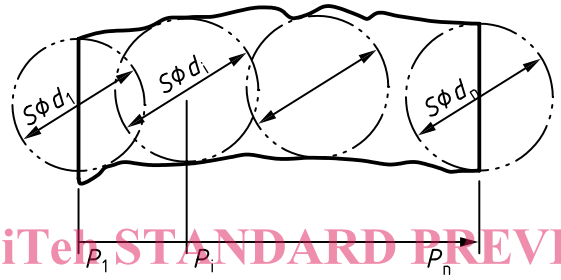
Note 2 to entry: See Figure 3 c).



a) Extracted feature under consideration which could be either an internal or external feature and either a cylinder or two opposite planes

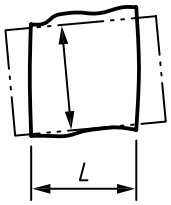


b) Two-point sizes (see ISO 17450–3)



c) Spherical sizes

d) Section size obtained from a direct global size with maximum inscribed criterion (other criteria are possible)



e) Portion size from a direct global size with maximum inscribed criterion (other criteria are possible)

Key

d	size [in Figure 3 b)]	P	position
L	considered length of the portion of the cylinder	*S⌀d*	diameter of the maximum inscribed sphere

NOTE 1 The section size of Figure 3 d) in each cross section is given by the diameter of the maximum inscribed circle defined in that cross section.

NOTE 2 Only a portion of the extracted feature of length, *L*, is considered in Figure 3 e).

Figure 3 — Examples of local size

3.7
global size
global linear size
global size characteristic
global linear size characteristic
size characteristic (3.5) having by definition a unique value along and around a toleranced *feature of size* (3.1)

3.7.1
direct global size
direct global linear size
direct global size characteristic
direct global linear size characteristic
global size (3.7) equals to the size of an associated integral feature which is of the same geometrical type as the *feature of size* (3.1) and which is established without constraint of size, orientation, or location

Note 1 to entry: The different direct global linear sizes are given in Figure 4.

Note 2 to entry: Different criteria may be used for this operation of association and different results are obtained depending on the criterion chosen. The association criteria described in this part of ISO 14405 are total least-squares, maximum inscribed, minimum circumscribed, and minimax criteria.

Note 3 to entry: The associated integral feature (established from the extracted integral feature) has the same ideal shape as the feature of size. Its size is considered variable.

3.7.1.1
least-squares size
direct global size (3.7.1) for which an associated integral feature is established from the extracted integral feature(s) with the total least-squares criterion

Note 1 to entry: In this part of ISO 14405, "total least-squares" is referred to only as "least-squares". It minimizes the sum of the square of distances existing between the associated integral feature and the extracted integral feature.

3.7.1.2
maximum inscribed size
direct global size (3.7.1) for which an associated integral feature is established from the extracted integral feature(s) with the maximum inscribed criterion

Note 1 to entry: In the case of an internal linear feature of size, the maximum inscribed size was previously called "mating size for an internal feature". It maximizes the size of the associated integral feature which can be inscribed in the extracted integral feature (with constraint of contact between the extracted integral feature and the associated integral feature).

3.7.1.3
minimum circumscribed size
direct global size (3.7.1) for which an associated integral feature is established from the extracted integral feature(s) with the minimum circumscribed criterion

Note 1 to entry: In the case of an external linear feature of size, the minimum circumscribed size was previously called "mating size for an external feature". It minimizes the size of the associated feature which can be circumscribed to the extracted integral feature (with constraint of contact between the extracted integral feature and the associated integral feature).

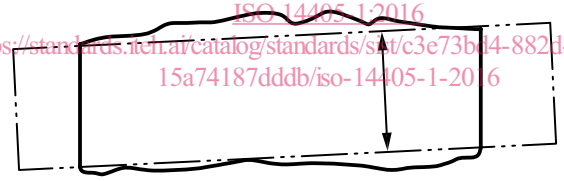
3.7.1.4
minimax size
Chebyshev size
direct global size (3.7.1) for which an associated integral feature is established from the extracted integral feature(s) with the minimax criterion

Note 1 to entry: The minimax criterion without constraint of inside or outside material gives the medium feature of the minimum zone including the extracted integral feature. It minimizes the maximum value of the set of distances between the points of the extracted integral feature and the associated integral feature without material constraint.

3.7.2
indirect global size
indirect global linear size
indirect global size characteristic
indirect global linear size characteristic
rank-order size (3.7.2.2) or global *calculated size* (3.7.2.1)

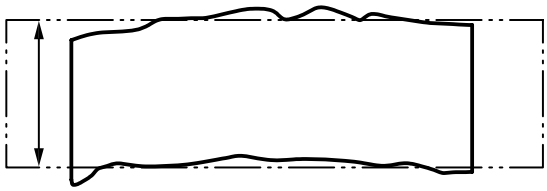
Note 1 to entry: An indirect global size can be, for example, an average of a set of two-point size values taken on the extracted cylindrical surface.

a) Extracted feature under consideration which could be either an internal or external feature and either a cylinder or two opposite planes

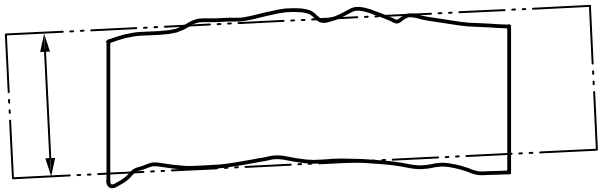


b) Maximum inscribed size

c) Minimum circumscribed size



d) Least-squares size



e) Minimax size

Figure 4 — Illustration of direct global sizes

3.7.2.1
calculated size
size (3.4) obtained by using a mathematical formula that relates the intrinsic characteristic of a feature to one or several other dimensions of the same feature

Note 1 to entry: The calculated size can be a *local size* (3.6) or a *global size* (3.7).

3.7.2.1.1
circumference diameter
<of an extracted cylinder> *calculated size* (3.7.2.1) giving the diameter, *d*, obtained from the following formula:

$$d = \frac{C}{\pi}$$

where *C* is the length of the integral extracted line in a cross section normal to the axis of the least-squares associated cylinder

Note 1 to entry: See Figure 5.

Note 2 to entry: The circumference diameter is defined in a cross section.

Note 3 to entry: Several criteria can be used for the operation of association to orient the cross section and different results are obtained according to the chosen criterion. The default criterion is the least-squares associated cylinder of the feature (see ISO 17450–3).

Note 4 to entry: In cases where the feature is non-convex, the circumference diameter can be larger than the minimum circumscribed diameter.

Note 5 to entry: The circumference diameter depends on the filtration criteria used.

a) **b)**

Key

C length of the outline (extracted line)

d circumference diameter, equal to *C* divided by π

Figure 5 — Example of circumference diameter