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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

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Contents

Page

Foreword ..... **v**
Introduction ..... **vii**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **2**
4 General **13**
4.1 Specification modifiers and symbols 13
4.2 Linear sizes 14
5 Basic linear size specification **14**
5.1 General 14
5.2 Indication of a basic linear size specification 16
5.2.1 General 16
5.2.2 Indication of the diameter symbol 16
5.2.3 Indication of a basic linear size specification on one line 16
5.2.4 Indication of a basic linear size specification on two lines 17
5.3 Tolerancing of fits on assembly drawings 17
6 Default specification operator for linear size **18**
6.1 General 18
6.2 ISO default specification operator for linear size 18
6.3 Drawing-specific default specification operator for linear size 18
7 Indication of a special specification operator for linear size **19**
7.1 Stacked linear size specifications 19
7.2 Indication areas 20
7.3 Sequence of specification elements for the linear size specification 21
7.4 Sequence of specification elements for the upper and left indication areas 24
7.5 Sequence of specification elements for the right indication area 25
8 Indication of the toleranced feature on which the size characteristic is defined **25**
8.1 Default case 25
8.2 Linear size specification applied individually to several features of linear size 25
8.3 Linear size specification applied to several features of linear size considered as a common toleranced feature of linear size 27
8.4 United feature of linear size 27
8.5 Fixed restricted portion of the feature of linear size 28
8.6 Size characteristic in specific cross-sections of a feature of linear size 29
8.6.1 Size characteristic in one specific cross-section of a feature of linear size 29
8.6.2 Size characteristic in several specific cross-sections of a feature of linear size 30
9 Envelope requirement **30**
9.1 Envelope requirement for external features of linear size 30
9.2 Envelope requirement for internal features of linear size 31
10 Indication of linear portion sizes **33**
11 Indication of linear section sizes **33**
12 Filtration **34**
13 Direction feature **34**
Annex A (normative) **Proportions and dimensions of graphical symbols** **35**
Annex B (normative) **Graphical rules for linear size specifications** **37**
Annex C (informative) **Data handling with statistical sizes** **40**
Annex D (normative) **Linear size specification on a circle as specific section of a cone** **42**

Annex E (normative) **Linear size specification on circles as any longitudinal sections of a torus** **43**

Annex F (normative) **Linear size specifications on parallel opposite lines as any longitudinal sections in half planes** **44**

Annex G (informative) **Former practices** **45**

Annex H (informative) **Sequence of the specification elements** **50**

Annex I (informative) **Relation to the GPS matrix model** **51**

Bibliography **53**

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.

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 document 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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html. This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 290, *Dimensional and geometrical product specification and verification*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 14405-1:2016), which has been technically revised.

The main changes are as follows:

— the use of linear size specifications for cones, torus and two opposite circles is now reduced to the cases described in Annexes D, E and F;

— the syntax is changed, and is now defined with several indication areas, and a sequence of specification elements in each area;

— linear size specifications can be stacked upon each other and the rules for stacked specifications are defined;

— the indication *k*×/*n*× is now possible, in order to facilitate stacking with geometrical specifications;

— the graphical rules are modified;

— the specification element “/0” to mean “any restricted portion whose length is equal to zero” has been removed to use the modifier “ACS”;

— when different specification operators applied for the upper and the lower specification limits of size characteristic, the new rule is to indicate two different size specifications;

— the indication of several linear size specifications on the same dimension line or reference line with brackets is removed;

— it is now required to use the “between” symbol to indicate that a linear size specification applies to a fixed restricted portion of a feature of linear size;

— it is now required to indicate “SCS” with the identifier of the section for a specific cross-section;

— the rank-order size specification is now called statistical size specification.

A list of all parts in the ISO 14405 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document 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 document is a part. The fundamental rules of ISO GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to the specifications made in accordance with this document, unless otherwise indicated.

For more detailed information on the relationship of this document to other standards and the GPS matrix model, see Annex I.

This document deals with linear size specifications on the following features of linear size:

— cylinders;

— spheres;

— two parallel opposite planes.

It also deals with the following cases:

— circles as sections of a cone;

— circles as sections of a torus;

— parallel opposite lines as longitudinal sections of cylindrical tubes.

Different specification elements allow specifying local linear sizes or global linear sizes of different types, and, for example, specifications on several features of linear size, specifications in sections and specifications on portions. The many specification elements allow for specifying a variety of functional needs.

Annex D provides the definition of a size for a circle as section of a cone. Annex E provides the definition of sizes for circles as sections of a torus. Annex F provides the definition of sizes for parallel opposite lines as longitudinal sections of cylindrical tubes in half planes containing a specified axis. Annex H gives an overview of the sequence of specification elements for linear size specifications.

ISO 14405-2 gives the difference between linear size, angular size and dimensions other than linear or angular sizes. ISO 14405-2 relies on this document for the rules about indication.

Geometrical product specifications (GPS) — Dimensional tolerancing —

Part 1: Linear sizes

IMPORTANT — The figures included in this document are intended to either illustrate the text or to provide examples of the related technical drawing specification, or both. These figures are not fully specified, showing only the relevant general principles. As a consequence, the figures are not a representation of a complete workpiece and are not of a quality that is required for use in industry and, as such, are not suitable for projection for teaching purposes. Figures are simplified 2D representations and show features that are unlikely (e.g. a minimum circumscribed cylinder with three contact points in the same section).

1 Scope

This document specifies requirements for indicating linear sizes.

This document establishes the default specification operator (see ISO 17450-2) and defines a special specification operator for linear sizes.

This document is applicable to the following features of linear size (see ISO 17450-1):

— cylinders;

— spheres;

— two parallel opposite planes.

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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, *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.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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

Note 1 to entry: A size is angular (e.g. angle of a cone) or linear (e.g. diameter of a cylinder). This document only applies to *linear sizes* (3.2). See ISO 14405-3 for angular sizes.

Note 2 to entry: Depending on the type of feature of linear size, the terms “diameter”, “width, and “thickness” are synonyms for size.

3.2
linear size
dimension in length units characterizing a feature of size

[SOURCE: ISO 14405-2:2018, 3.2]

3.3
size characteristic
characteristic relative to a *size* (3.1) and defined from an extracted integral feature

Note 1 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).

3.4
upper specification limit of size characteristic
largest permissible value for a *size characteristic* (3.3)

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

3.6
local linear size
size characteristic (3.3) having a non-unique result of evaluation either along or around, or both, a feature of *linear size* (3.2)

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

Note 2 to entry: In Figure 3, examples of local linear sizes are shown. These examples do not take into account the *statistical size* (3.7.6).

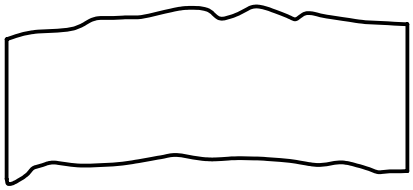
3.6.1
two-point size
<local linear size> distance between two opposite points on an extracted integral feature of *linear size* (3.2)

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

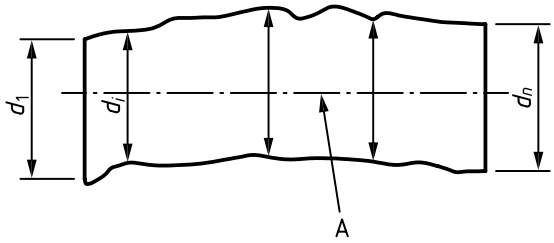
Note 2 to entry: A two-point size on two parallel opposite planes can be called a “two-point thickness” or a “two-point width”.

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

Note 4 to entry: See Figure 1 for examples of two-point sizes. Figure 1 a) shows an extracted feature under consideration, a cylinder which can be either internal or external.



a) Extracted feature under consideration



b) Two-point sizes

Key

d size

A axis of the least-squares associated cylinder with the extracted integral feature

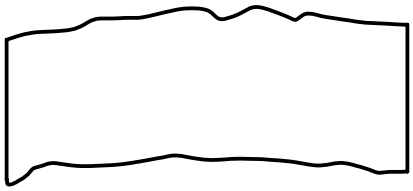
Figure 1 — Examples of two-point sizes

3.6.2
spherical size
<local linear size> diameter of the maximum inscribed sphere

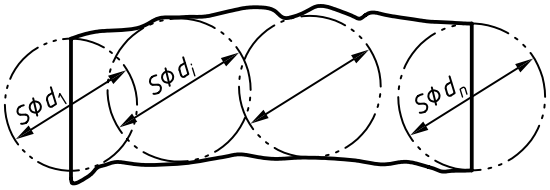
Note 1 to entry: The maximum inscribed sphere is used when defining the spherical size of both internal and external features of *linear size* (3.2).

Note 2 to entry: The spherical size does not apply to spheres.

Note 3 to entry: See Figure 2 for examples of spherical sizes. Figure 2 a) shows an extracted feature under consideration, a cylinder which can be either internal or external.



a) Extracted feature under consideration



b) Spherical sizes

Key

Sød diameter of the maximum inscribed sphere

Figure 2 — Examples of spherical sizes

3.6.3
linear section size

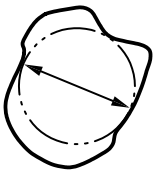
global linear size (3.7) for a given section of the extracted integral feature of *linear size* (3.2)

Note 1 to entry: A linear section size is a global linear size for a given section and is a *local linear size* (3.6) for the entire feature of linear size because it has different results of evaluation along the feature of linear size.

Note 2 to entry: On an extracted feature of linear size, which is a cylindrical surface, 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 linear section size.

Note 3 to entry: See Figure 3 for an example of linear section size. Figure 3 a) shows an extracted feature under consideration, a cylinder which can be either internal or external. Figure 3 b) shows a linear section size obtained from a global linear size with maximum inscribed criterion (other criteria are possible).

a) Extracted feature under consideration



b) Linear section size obtained from a global linear size

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

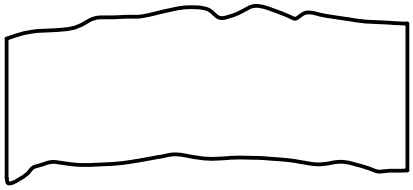
Figure 3 — Example of linear section size

3.6.4
linear portion size

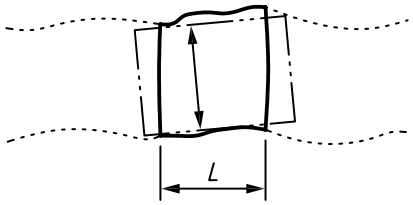
global linear size (3.7) for a given portion of the extracted feature of *linear size* (3.2)

Note 1 to entry: A linear portion size is a global linear size for a given portion and is a *local linear size* (3.6) for the entire feature of linear size because it has different results of evaluation along the feature of linear size.

Note 2 to entry: See Figure 4 for an example of linear portion size. Figure 4 a) shows an extracted feature under consideration, a cylinder which can be either internal or external. Figure 4 b) shows a linear portion size obtained from a global linear size with maximum inscribed criterion (other criteria are possible).



a) Extracted feature under consideration



b) Linear portion size obtained from a global linear size

Key

L considered length of the portion of the cylinder

NOTE Only a portion of length *L* of the extracted feature is considered.

Figure 4 — Example of linear portion size

3.7
global linear size
size characteristic (3.3) having a unique value along and around a feature of *linear size* (3.2)

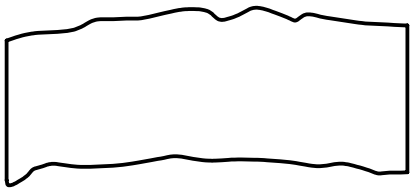
Note 1 to entry: A global linear size can be for a section, for a portion, or for the whole feature of linear size. See *linear section size* (3.6.3) and *linear portion size* (3.6.4).

Note 2 to entry: In Figures 5, 6, 7 and 8, examples of global linear sizes are shown.

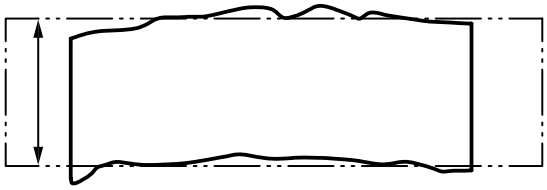
3.7.1
least-squares size
global linear size (3.7) for which an associated integral feature is established from the extracted integral feature(s) with the total least-squares objective function without constraint

Note 1 to entry: In this document, "total least-squares" objective function is referred to only as "least-squares". This objective function minimizes the sum of the squares of distances existing between the associated integral feature and the extracted integral feature, see ISO 4351.

Note 2 to entry: See Figure 5 for an example of least-squares size. Figure 5 a) shows an extracted feature under consideration, which can be either an internal or external feature and either a cylinder or two parallel opposite planes.



a) Extracted feature under consideration



b) Least-squares size

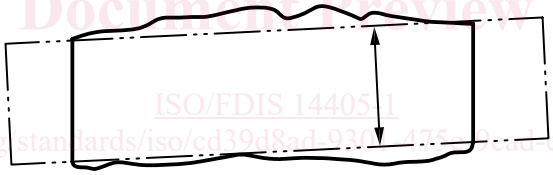
Figure 5 — Example of least-squares size

3.7.2
maximum inscribed size
global linear size (3.7) 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 feature of *linear size* (3.2), the maximum inscribed size was previously called "mating size for an internal feature". It maximizes the size of the associated integral feature that is inscribed in the extracted integral feature.

Note 2 to entry: See Figure 6 for an example of least-squares size. Figure 6 a) shows an extracted feature under consideration, which can be either an internal or external feature and either a cylinder or two parallel opposite planes.

a) Extracted feature under consideration



b) Maximum inscribed size

Figure 6 — Example of maximum inscribed size

3.7.3
minimum circumscribed size
global linear size (3.7) 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 feature of *linear size* (3.2), the minimum circumscribed size was previously called "mating size for an external feature". It minimizes the size of the associated feature that is circumscribed to the extracted integral feature.

Note 2 to entry: See Figure 7 for an example of minimum circumscribed size. Figure 7 a) shows an extracted feature under consideration, which can be either an internal or external feature and either a cylinder or two parallel opposite planes.