International Standard

ISO 14405-1

Third edition
2025-08

Geometrical product specifications (GPS) — Dimensional tolerancing —

Part 1: Linear sizes

Spécification géométrique des produits (GPS) — Tolérancement dimensionnel —

Partie 1: Tailles linéaires

Reference number
ISO 14405-1:2025(en)

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Published in Switzerland

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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 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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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 $k\times/n\times$ 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 ISO 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).

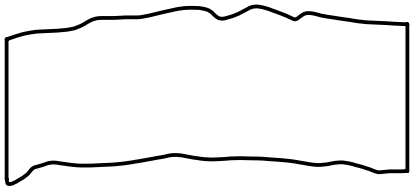
3.6.1
two-point size
<local linear size> distance between two opposite points on an extracted integral feature of *linear size* (3.2)

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

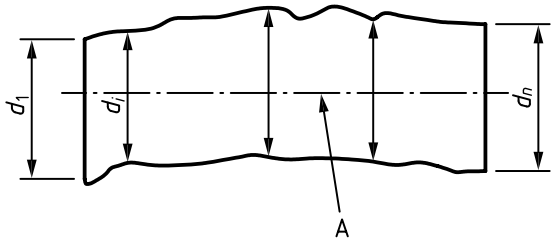
Note 2 to entry: A two-point size on two parallel opposite planes can be called a “two-point thickness” or a “two-point width”.

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

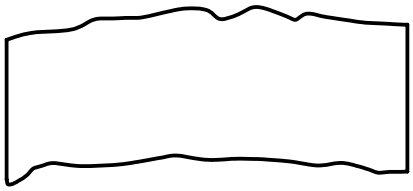
3.6.2
spherical size

<local linear size> diameter of the maximum inscribed sphere

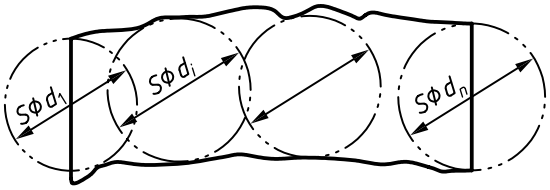
Note 1 to entry: The maximum inscribed sphere is used when defining the spherical size of both internal and external features of *linear size* (3.2).

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

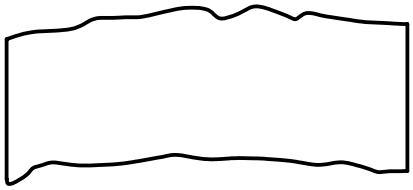
3.6.3
linear section size

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

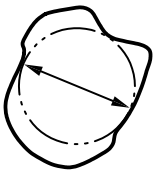
Note 1 to entry: A linear section size is a global linear size for a given section and is a *local linear size* (3.6) for the entire feature of linear size because it has different results of evaluation along the feature of linear size.

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.

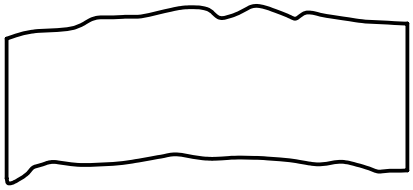
Figure 3 — Example of linear section size

3.6.4
linear portion size

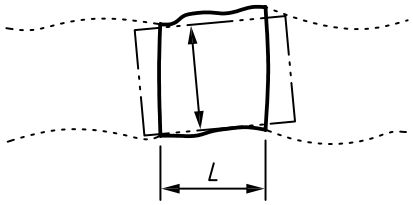
global linear size (3.7) for a given portion of the extracted feature of *linear size* (3.2)

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 *linearsection size* (3.6.3) and *linearportion size* (3.6.4).

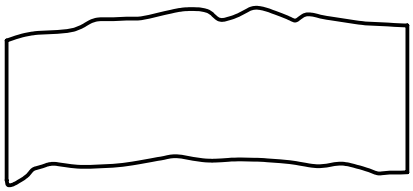
Note 2 to entry: In Figures 5, 6, 7 and 8, examples of global linear sizes are shown.

3.7.1
least-squares size

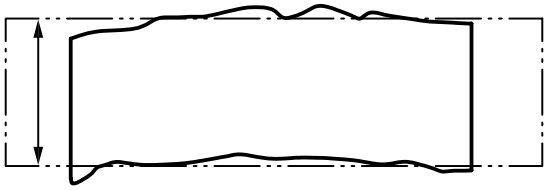
global linear size (3.7) for which an associated integral feature is established from the extracted integral feature(s) with the total least-squares objective function without constraint

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



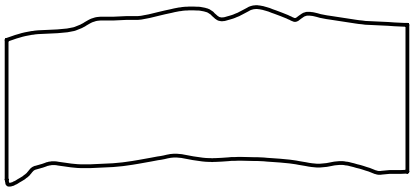
b) Least-squares size

Figure 5 — Example of least-squares size

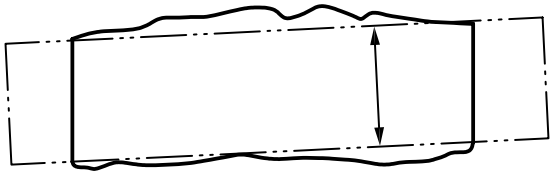
3.7.2
maximum inscribed size
global linear size (3.7) for which an associated integral feature is established from the extracted integral feature(s) with the maximum inscribed criterion

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 maximum inscribed 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



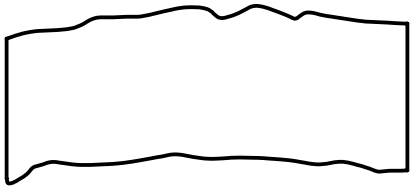
b) Maximum inscribed size

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 integral 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.



a) Extracted feature under consideration

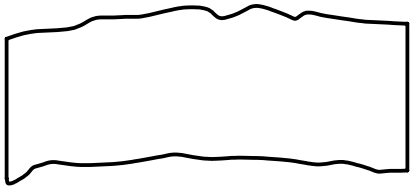
b) Minimum circumscribed size

Figure 7 — Example of minimum circumscribed size

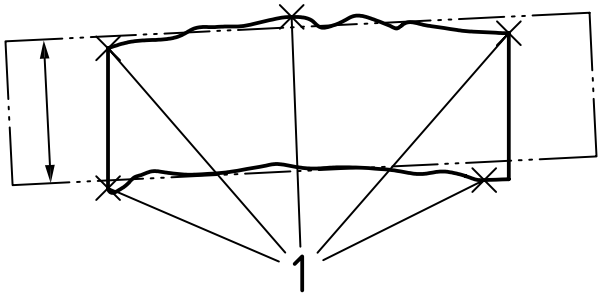
3.7.4
minimax size
Chebyshev size
global linear size (3.7) for which an associated integral feature is established from the extracted integral feature(s) with the minimax objective function and no material constraint

Note 1 to entry: The minimax objective function without constraint 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.

Note 2 to entry: See Figure 8 for an example of minimax size. Figure 8 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) Minimax size

Key

1 places with the same minimized maximum deviation

Figure 8 — Example of minimax size

3.7.5
calculated size
size (3.1) obtained by using a mathematical formula that determines an intrinsic characteristic of a feature from one or several other dimensions of the same feature

Note 1 to entry: The calculated size is only defined for cylinders in this document.

3.7.5.1
circumference diameter
<of an extracted cylinder> *calculated size* (3.7.5) giving the diameter, *d*, obtained from the following formula:

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

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

Note 1 to entry: See Figure 9, which shows an example of circumference diameter.

Note 2 to entry: The circumference diameter is a *linearsection size* (3.6.3).

Note 3 to entry: In cases where the feature is non-convex, the circumference diameter can be larger than the minimum circumscribed diameter.

Note 4 to entry: A filter that builds a continuous line reduces the specification ambiguity in this case.

a) **b)**

Key

E extracted and filtered integral line in a cross-section, of length *C*

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

Figure 9 — Example of circumference diameter

3.7.5.2
area diameter
<of an extracted cylinder> *calculated size* (3.7.5) giving the diameter, *d*, obtained from the following formula:

$$d = \sqrt{\frac{4A}{\pi}}$$

where *A* is the area limited by the extracted and filtered integral line of a cross section normal to the axis of the least-squares associated cylinder

Note 1 to entry: See Figure 10, which shows an example of area diameter.

Note 2 to entry: The area diameter is a *linearsection size* (3.6.3).

Note 3 to entry: A filter that builds a continuous line reduces the specification ambiguity in this case.

a) b)

Key

A area inside the extracted and filtered integral line

d area diameter, calculated from *A*

Figure 10 — Example of area diameter

3.7.5.3
volume diameter
<of an extracted cylinder> *calculated size* (3.7.5) giving the diameter, *d*, obtained from the following formula:

$$d = \sqrt{\frac{4V}{\pi L}}$$

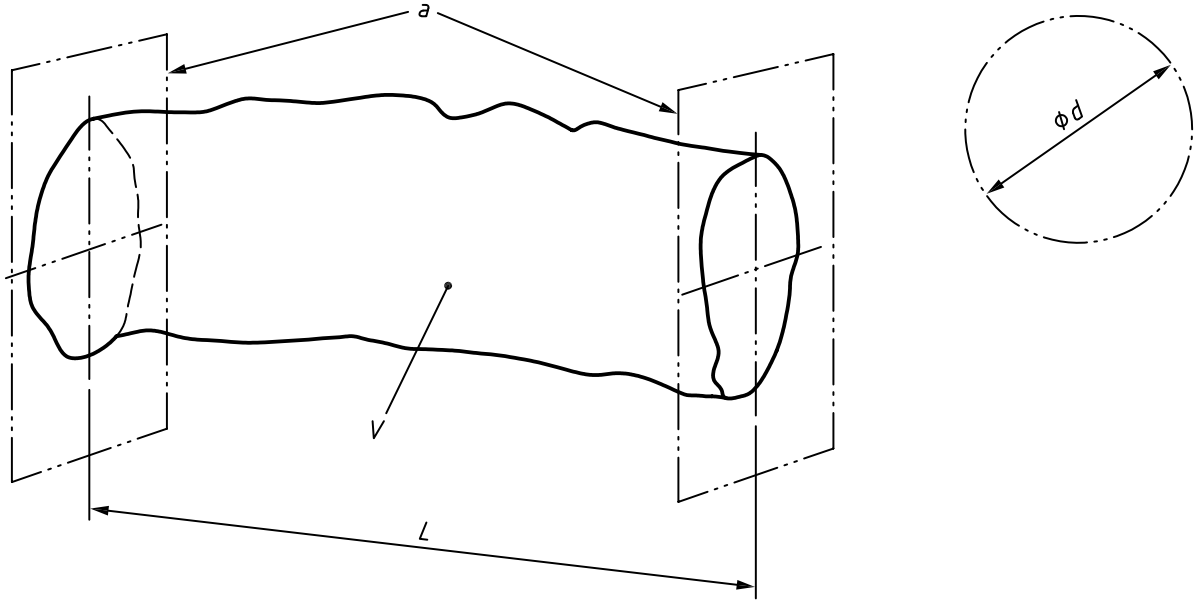
where

L is the distance between two parallel planes perpendicular to the axis of the least-squares associated cylinder, *L* being the maximum distance possible such that the two parallel planes contain a complete section of the feature;

V is the volume limited by the extracted integral cylinder and the two parallel planes.

Note 1 to entry: See Figure 11 for an example of volume diameter.

Note 2 to entry: The volume diameter is a *global linear size* (3.7) for the complete toleranced feature of *linear size* (3.2). It can be a *local linear size* (3.6) when it is a *linearportion size* (3.6.4).



Key

V volume of the extracted integral cylinder

L length of the cylinder

d volume diameter, calculated from *V* and *L*

[a] Two parallel planes perpendicular to the axis of the least-squares associated cylinder with the minimum distance between them and containing a complete section of the feature.

Figure 11 — Example of volume diameter

3.7.6
statistical size

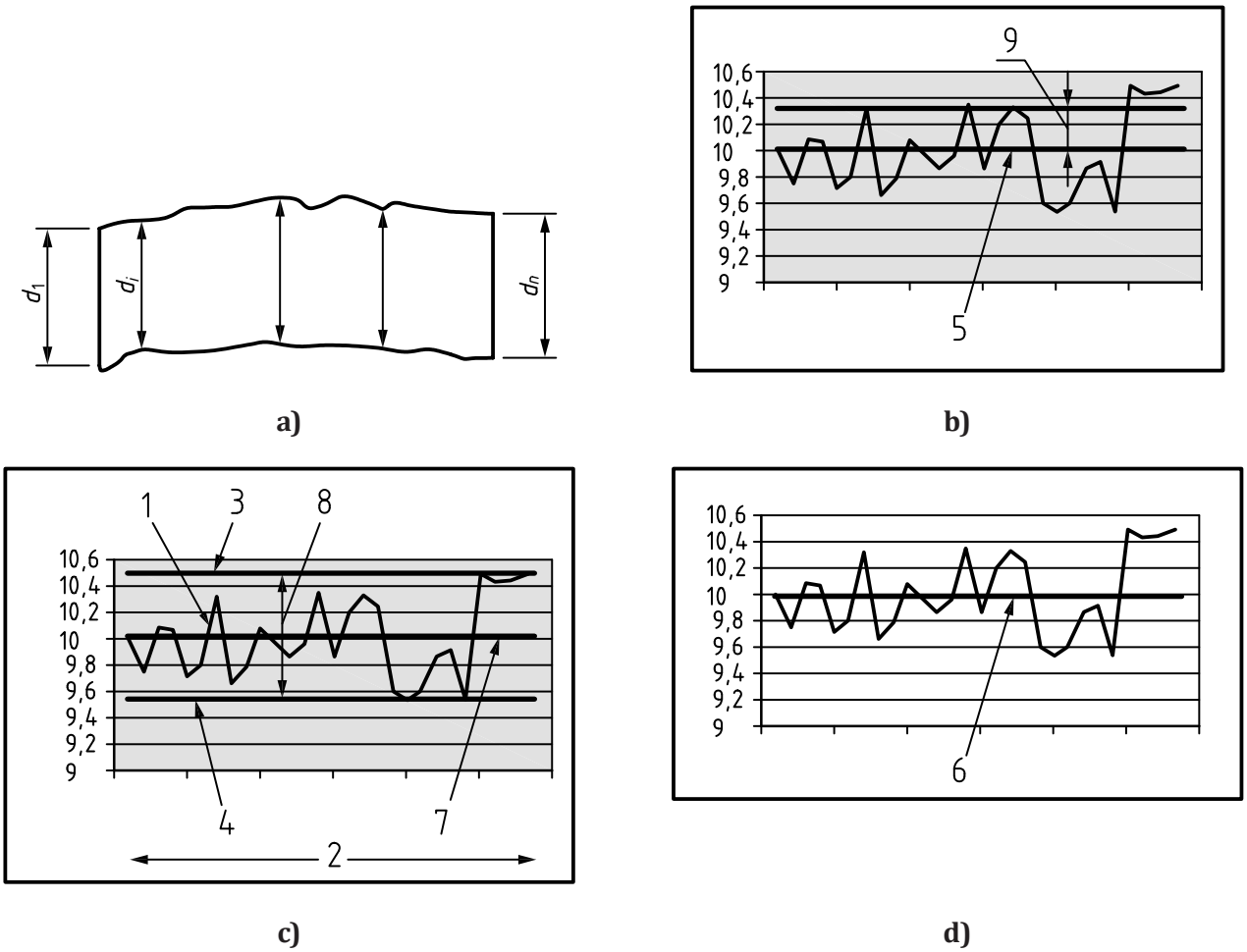
size characteristic (3.3) defined mathematically from a homogeneous set of values of a *local linear size* (3.6)

Note 1 to entry: A statistical size can be used to define a *global linear size* (3.7) from a local linear size [*two-point size* (3.6.1), *spherical size* (3.6.2), *linearsection size* (3.6.3) and *linearportion size* (3.6.4)].

Note 2 to entry: A statistical size can be used to define a local linear size from another local linear size, e.g. to define a statistical linear section size from a two-point size taken in the section.

Note 3 to entry: The different types of statistical sizes defined in this document are illustrated in Figure 12.

Note 4 to entry: Annex C shows an example of a statistical size.



Key

1	set of values of linear section sizes	6	median size (= 9,969)
2	position along the axis	7	mid-range size (= 10,020)
3	maximum size (= 10,497)	8	range of sizes (= 0,955)
4	minimum size (= 9,542)	9	standard deviation of sizes (=0,301)
5	average size (= 10,011)	d_i	values of local linear size

Figure 12 — Example of statistical sizes based on linear section sizes

3.7.6.1
maximum size
statistical size (3.7.6) defined as the maximum of the set of values of a *local linear size* (3.6)

3.7.6.2
minimum size
statistical size (3.7.6) defined as the minimum of the set of values of a *local linear size* (3.6)

3.7.6.3
average size
statistical size (3.7.6) defined as the average of the set of values of a *local linear size* (3.6)

3.7.6.4
median size
statistical size (3.7.6) defined as the median value of the set of values of a *local linear size* (3.6)

Note 1 to entry: The median value allows the population of local linear size values to be split into two equal portions (50 % above and 50 % below). Depending on the function of repartition of the population, the median size and the average size can be identical or different.

3.7.6.5
mid-range size
statistical size (3.7.6) defined as the mean of the maximum and the minimum of the set of values of a *local linear size* (3.6)

3.7.6.6
range of sizes
statistical size (3.7.6) defined as the difference between the maximum and the minimum of the set of values of a *local linear size* (3.6)

3.7.6.7
standard deviation of sizes
statistical size (3.7.6) defined as the standard deviation of the set of values of a *local linear size* (3.6)

3.8
envelope requirement
requirement which specifies both the least material limit of the *size* (3.1) on the *two-point size* (3.6.1) and the maximum material limit of the size on the *maximum inscribed size* (3.7.2) or the *minimum circumscribed size* (3.7.3)

Note 1 to entry: See Clause 9.

3.9
common toleranced feature of linear size
several separate single features of *linear size* (3.2) on which a common tolerance is applied

Note 1 to entry: See 8.3.

3.10
united feature of linear size
set of two or more single integral features considered as one feature of *linear size* (3.2)

Note 1 to entry: A united feature of linear size is a sub-type of united feature. A united feature can be an integral feature which is not a feature of linear size.

Note 2 to entry: See 8.4.

3.11
intersection plane
plane, established from an extracted feature of the workpiece, identifying one or more lines on extracted surfaces (integral or median) or one or more points on extracted lines (integral or median)

Note 1 to entry: The use of intersection planes makes it possible to define toleranced features independent of the view.

Note 2 to entry: For areal surface texture, the intersection plane can be used to define the orientation of the evaluation area, see ISO 25178-1.

[SOURCE: ISO 1101:2017, 3.2, modified — "a line on an extracted surface" changed to "one or more lines on extracted surfaces" and " a point on an extracted line" changed to " one or more points on extracted lines "]

3.12
direction feature
<linear size> ideal feature, established from an extracted feature of the workpiece, identifying the direction of the *size characteristic* (3.3)

Note 1 to entry: See Clause 13.

4 General

4.1 Specification modifiers and symbols

Rule A**:** For the purposes of this document, the specification modifiers (see ISO 17450-2:2012, 3.4.2) in Tables 1 and 2 shall apply, except when the default size specification is used.

The use of these specification modifiers is described in Clauses 5 to 13. The presentation of graphical symbols shall follow the rules given in Annex A.

The presentation of indications of linear size specifications shall follow the rules given in Annex B.

Table 1 — Specification modifiers for linear size specifications

Modifier	Description	Reference
(LP)	Two-point size	3.6.1
(LS)	Spherical size	3.6.2
(GG)	Least-squares size	3.7.1
(GX)	Maximum inscribed size	3.7.2
(GN)	Minimum circumscribed size	3.7.3
(GC)	Minimax size	3.7.4
(CC)	Circumference diameter (calculated size)	3.7.5.1
(CA)	Area diameter (calculated size)	3.7.5.2
(CV)	Volume diameter (calculated size)	3.7.5.3
(SX)	Maximum size (statistical size)	3.7.6.1
(SN)	Minimum size (statistical size)	3.7.6.2
(SA)	Average size (statistical size)	3.7.6.3
(SM)	Median size (statistical size)	3.7.6.4
(SD)	Mid-range size (statistical size)	3.7.6.5
(SR)	Range of sizes (statistical size)	3.7.6.6
(SQ)	Standard deviation of sizes (statistical size)	3.7.6.7

Table 2 — Complementary specification modifiers

Description	Symbol	Reference	Example of indication
United feature of linear size	UF	8.4	UF3× ⌀10 ±0,1 Ⓖ
Envelope requirement	Ⓔ	3.8 Clause 9	10 ±0,1 Ⓔ
Any restricted portion of feature[a]	/	Clause 10	⌀10 ±0,1 Ⓖ /5
Any cross-section	ACS	Clause 11	⌀10 ±0,1 Ⓧ ACS
Specific cross-section	SCS	8.6 Annex D	10 ±0,1 Ⓧ SCS[A]
Any longitudinal section	ALS	Annex E Annex F	10 ±0,1 Ⓧ ALS ⌯ A
More than one feature[b]	×	8.2 8.3 8.4	2× 10 ±0,1 Ⓔ
Common toleranced feature of linear size	CT	8.3	CT2× 10 ±0,1 Ⓔ
Between	↔	8.5	A↔B ⌀10 ±0,1
Intersection plane	▯▯	Annex E Annex F	5 ±0,02 ⌯ A
Direction feature	←▯▯	Clause 13	5 ±0,02 ALS ←⊥ A
Flagnote	⬡	7.5	10 ±0,1 ⬡1

[a] For any restricted portion of a feature, the symbol shall be followed by the length of the portion, see Clause 10.

[b] For more than one feature, the symbol shall be preceded by the number of features, see 8.2, 8.3 and 8.4.

4.2 Linear sizes

Figure 13 illustrates the relations between linear sizes.

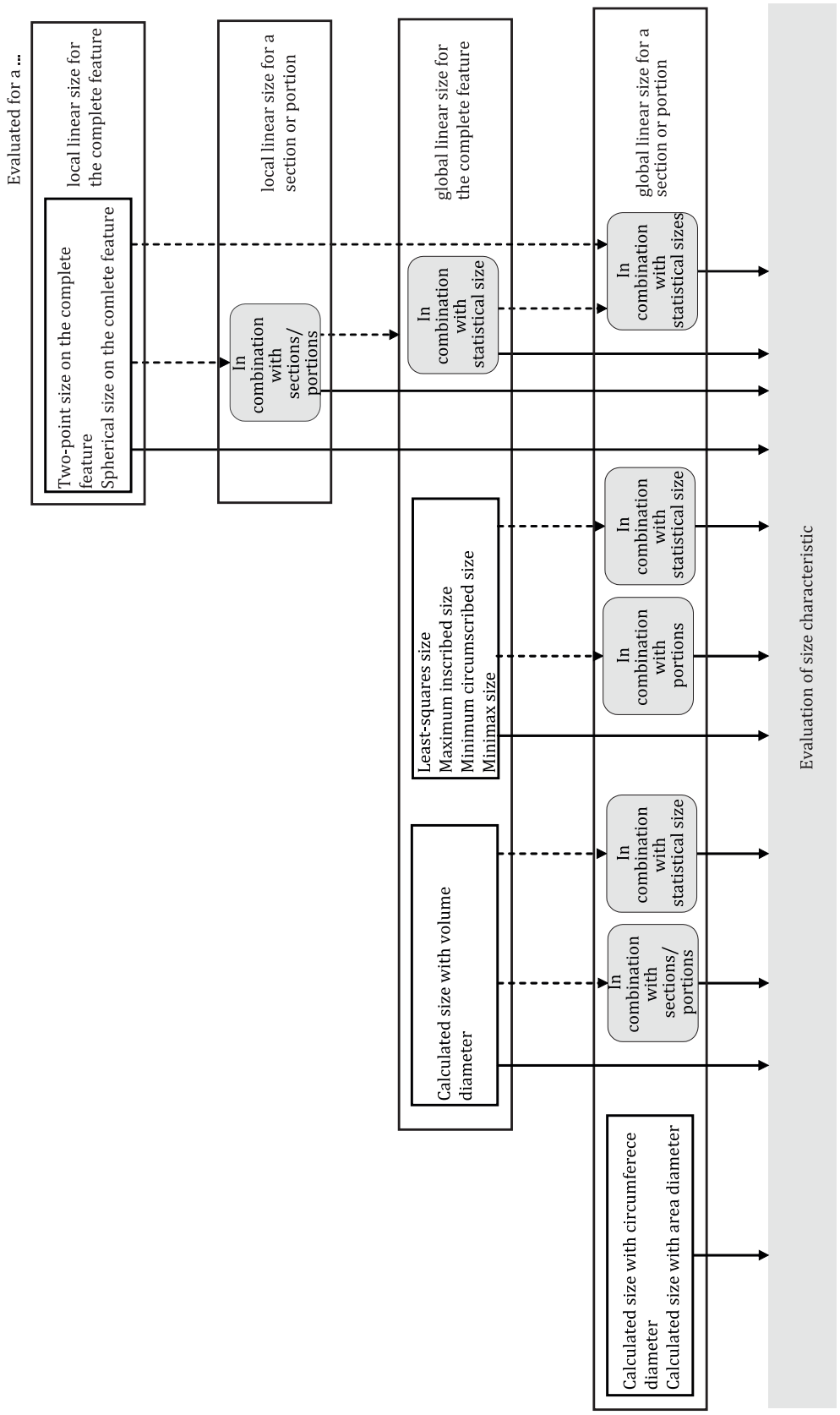


Figure 13 — Local linear sizes and global linear sizes

5 Basic linear size specification

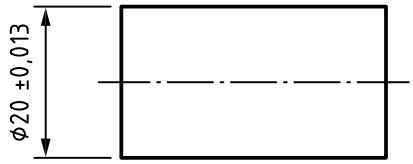
5.1 General

The basic linear size specification can be one of five types (see Table 3).

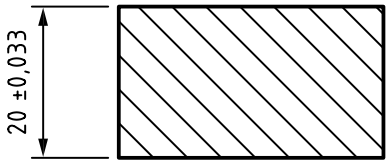
NOTE The specification with the ISO tolerance code or with upper and lower specification limits of size characteristic is equivalent.

Table 3 — Different basic linear size specifications

Basic linear size specification	Examples			Figures
Nominal size and limit deviations	$150^{\ 0}_{-0,2}$	$\varnothing 38^{+0,2}_{-0,1}$	55 ±0,2	14 and 15
Nominal size followed by tolerance code in accordance with ISO 286-1	100 h8	⌀67 k6	165 js10	16
Upper and lower specification limits of size characteristic	150 149,8	⌀38,2 ⌀37,9	55,2 54,8	17
Upper or lower specification limit of size characteristic	85,2 max.		84,8 min.	18
Value of the nominal size neither indicated in brackets nor as a theoretically exact dimension (TED), to which a general tolerance is applied, if a general tolerance standard is referenced in or near the title block	10			—

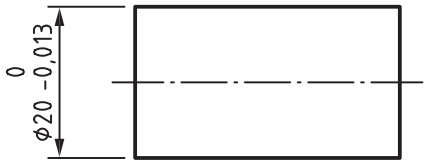


a) Feature of linear size type: cylinder

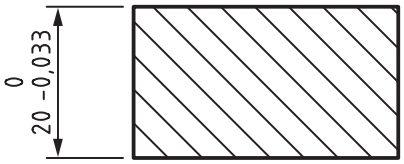


b) Feature of linear size type: two parallel opposite planes

Figure 14 — Example of basic linear size specification— Nominal size and symmetrical limit deviations

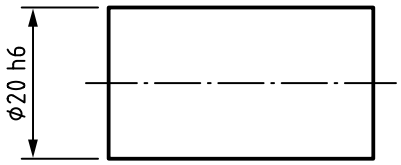


a) Feature of linear size type: cylinder

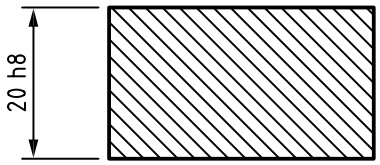


b) Feature of linear size type: two parallel opposite planes

Figure 15 — Example of basic linear size specification— Nominal size and non-symmetrical limit deviations

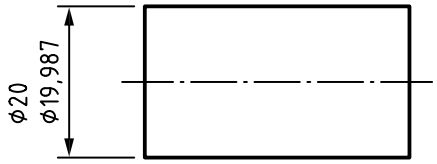


a) Feature of linear size type: cylinder

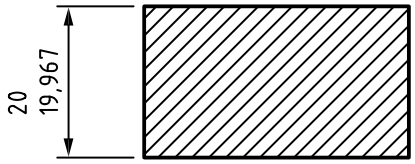


b) Feature of linear size type: two parallel opposite planes

Figure 16 — Example of basic linear size specification — Nominal size followed by tolerance code

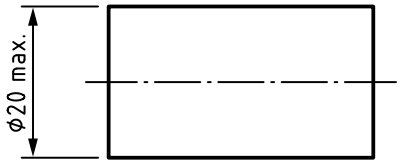


a) Feature of linear size type: cylinder

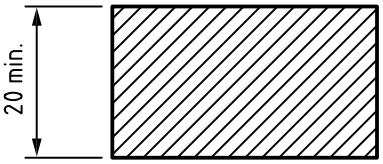


b) Feature of linear size type: two parallel opposite planes

Figure 17 — Example of basic linear size specification — Values of upper and lower specification limits of size characteristic



a) Feature of linear size type: cylinder



b) Feature of linear size type: two parallel opposite planes

Figure 18 — Example of basic linear size specification — Values of upper or lower specification limit of size characteristic

5.2 Indication of a basic linear size specification

5.2.1 General

A basic linear size specification as given in Table 3 can be written on one line (see Figures 14, 16 and 18) or on two lines (see Figures 15 and 17).

5.2.2 Indication of the diameter symbol

Rule B**:** If the size is the diameter of a circle or a cylinder, then the symbol ⌀ shall be indicated. If the size is the diameter of a sphere, then the symbol S⌀ shall be indicated. If the size is the distance between two parallel opposite planes, then no symbol shall be indicated.

5.2.3 Indication of a basic linear size specification on one line

Rule C: The linear size specification shall be indicated on one line when it:

— has two limit deviations symmetrical to zero (see Figure 14); or

— has two limit deviations defined by a tolerance code (see Figure 16 and ISO 286-1); or

— has only one specification limit of size characteristic (upper or lower, see Figure 18); or

— is defined from a general tolerance.

The line shall contain, in the following order:

— if necessary, the symbol ⌀ or S⌀;

— the nominal value, or the upper or lower specification limit of size;

— a space;

— the limit deviation preceded by ± , or the tolerance code, or “min.”, or “max.”.

NOTE There is no space between the symbol ⌀ and the nominal value.

5.2.4 Indication of a basic linear size specification on two lines

Rule D: When a linear size specification is defined by two limit deviations, then it shall be indicated on two lines (see Figure 15).

The lower line shall contain, in the following order:

— if necessary, the symbol ⌀ or S⌀;

— the nominal value;

— a space;

— the lower limit deviation.

NOTE 1 There is no space between the symbol ⌀ and the nominal value.

The upper line shall contain the upper limit deviation.

Each limit deviation (lower and upper) shall be signed, i.e. preceded by its sign (+ or –) without space when its value is different from zero. When a limit deviation (lower or upper) is equal to zero, then the sign + or – shall be omitted.

The unit numbers of the two values for the limit deviations shall be aligned one above the other.

Rule E: When a linear size specification is defined by the direct indication of the upper and lower specification limits of size characteristic, then it shall be indicated on two lines (see Figure 17).

The lower line shall contain, in the following order:

— if necessary, the symbol ⌀ or S⌀;

— the lower specification limit of size characteristic.

The upper line shall contain:

— if necessary, the symbol ⌀ or S⌀;

— the upper specification limit of size characteristic.

NOTE 2 There is no space between the symbol ⌀ and the specification limits of size characteristic.

The unit numbers of the two values for the specification limits of size characteristic shall be aligned one above the other.

5.3 Tolerancing of fits on assembly drawings

Linear size specifications can be indicated on a fit on an assembly drawing when there is no possibility for misinterpretation (see Figures 19 and 20).

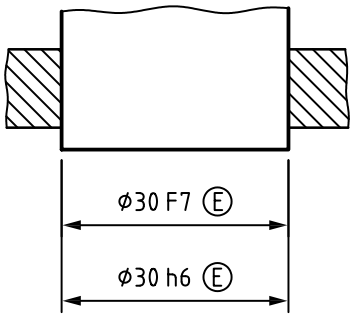


Figure 19 — Example of assembly drawing with ISO code system tolerancing of two features of linear size in a fit

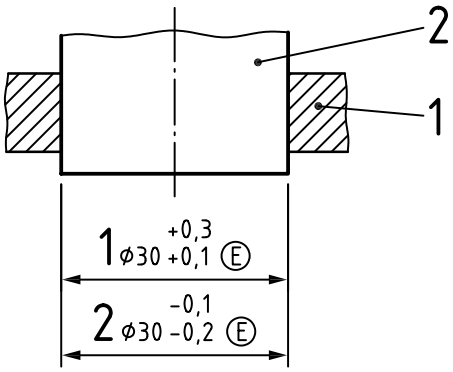


Figure 20 — Example of assembly drawing with plus and minus tolerancing of two features of linear size in a fit

6 Default specification operator for linear size

6.1 General

The default specification operator for linear size can be one of the following:

— the ISO default specification operator (see 6.2 and ISO 8015);

— the drawing-specific default specification operator (see 6.3);

— the altered default specification operator (see ISO 8015).

Rule F: The default specification operator for linear size shall apply when the basic linear size specification is used without any specification modifier.

6.2 ISO default specification operator for linear size

The ISO default specification operator for linear size is the two-point size.

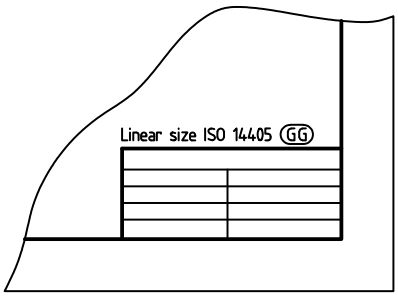
6.3 Drawing-specific default specification operator for linear size

Rule G: When a drawing-specific default specification operator (see ISO 17450-2) for linear size applies, it shall be indicated on the drawing in or near the title block in the following order:

— a reference to this document, i.e. “Linear size ISO 14405”;

— the specification modifier(s) for the default specification operator of linear size.

See Figure 21.



NOTE The default specification operator is not the two-point size, but the least-squares size.

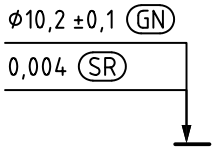
Figure 21 — Example of a drawing-specific default specification operator for linear size

7 Special specification operator for linear size

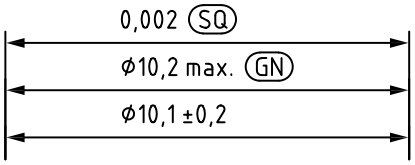
7.1 Stacked linear size specifications

If it is necessary to specify more than one linear size characteristic for a feature of linear size, the linear size specifications can be stacked upon each other, over the reference line or over the dimension line, see Figure 22.

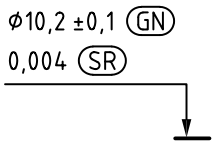
Rule H: The stacked linear size specifications shall be left aligned, see Figure 22.



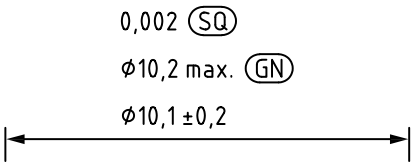
a) Non-stacked linear size specifications on reference lines



b) Non-stacked linear size specifications on dimension lines



c) Stacked linear size specifications on a reference line



d) Stacked linear size specifications on a dimension line

Figure 22 — Stacked linear size specifications

NOTE 1 It used to be possible to indicate specification modifiers on two lines (the upper line for the specification elements that apply to the upper specification limit of size characteristic, and the lower line for the specification elements that apply to the lower specification limit of size characteristic). This is now a former practice, see Annex G.

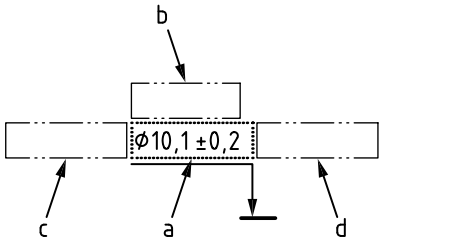
NOTE 2 When several linear size specifications apply to the same size, each linear size specification is independent. There can be a mathematical relationship between the different characteristics defined by the specifications, e.g. the minimum circumscribed diameter is always larger than the least-squares diameter.

EXAMPLE In Figures 22 a) and c), the minimum circumscribed size and the range of the two-point sizes are considered independently.

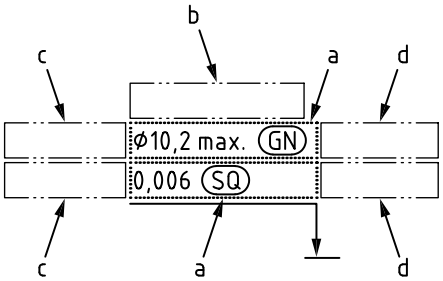
7.2 Indication areas

There are several indication areas adjacent to the linear size specification where supplementary specification elements can be indicated, see Figure 23.

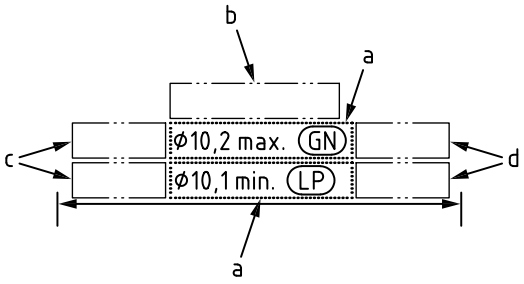
Rule I: The reference line shall be as long as the linear size specification and the left and right indication areas together when they are used.



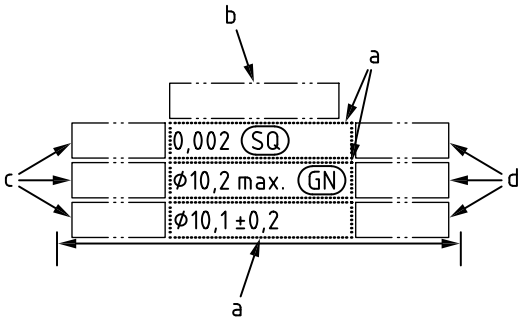
a)



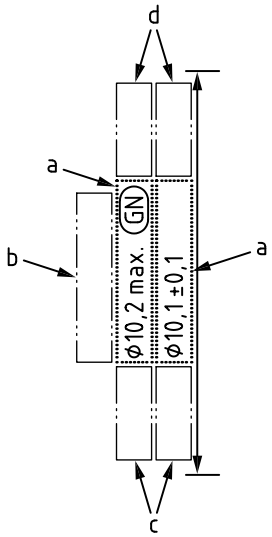
b)



c)



d)



e)

Key

a linear size specification
b upper indication area
c left indication area
d right indication area

Figure 23 — Indication areas

7.3 Sequence of specification elements for the linear size specification

Rule J: When the default specification operator for linear size does not apply, specification modifiers (see Tables 1 and 2) shall be used to indicate which special specification operator applies (see ISO 17450-2:2012, 3.2.7).

Rule K: The specification elements for the linear size specification shall be indicated in the following order (see Table 4, and Figure 24):

— the basic linear size specification;

— if necessary, one specification modifier among the specification modifiers for the envelope requirement, the local linear sizes, the least-squares size, the maximum inscribed size, the minimum circumscribed size, the minimax size and the calculated sizes;

— if necessary, one specification modifier for the section or the portion, which can include an intersection plane if necessary, where the envelope requirement, local linear size, global linear size or calculated size is evaluated;

— if necessary, one specification modifier for the statistical size, which is applicable to the previous specification elements;

— if necessary, one specification modifier for the portion or the section, which can include an intersection plane if necessary, where the statistical size is evaluated;

— if necessary, one specification modifier for the statistical size, which is applicable to the previous specification elements;

— if necessary, the indication of a filter;

— if necessary, one direction feature.

Table 4 — Syntax rules for the linear size specification

Basic linear size specification	Envelope requirement, local linear size, global linear size or calculated size	Portion(s) or section(s) where the envelope, local linear size, global linear size or calculated size is evaluated	Statistical size	Portion(s) or section(s) where the statistical size is evaluated	Statistical size	Filtration	Direction feature
⌀150 ± 0,2 0 120 - 0,1 S ⌀20 h8 2,5 max. 0,004[b]	Ⓔ Ⓛ ⓁⓅ ⒼⒼ ⒼⓍ ⒼⓃ ⒼⒸ ⒸⒸ ⒸⒶ ⓋⓋ	/5 ACS SCS[A, B, C] ALS	ⓈⓍ ⓈⓃ ⓈⒶ ⓈⓂ ⓈⒹ ⓈⓇ ⓈⓆ	/5 ACS SCS[A, B, C] ALS	ⓈⓍ ⓈⓃ ⓈⒶ ⓈⓂ ⓈⒹ ⓈⓇ ⓈⓆ	H0 G50	
1[a]	2	3	4	5	6	7	8
Clause 5	Clause 4	8.6, Clauses 10 and 11 Annexes D, E and F	Clause 4	8.6, Clauses 10 and 11 Annexes D, E and F	Clause 4	Clause 12	Clause 13

NOTE 1 Some combinations of specification elements are not possible. This table illustrates only the syntax rules.

NOTE 2 It was a former practice to indicate different specification modifiers for the upper specification limit of size characteristic and the lower specification limit of size characteristic on the same linear size specification, see Annex G.

[a] The other types of basic linear size specifications are not recommended with specification modifiers (values of upper and lower specification limits of size characteristic, see Figure 17, and general tolerance).

[b] See Rule L.

When a two-point size is specified, the specification element ⓁⓅ can be omitted since it is the default specification operator, see 6.2.

There shall be a space between each specification element (each column in Table 4 except Column 1). See Annex B for space dimensions.

Rule L: When a range of sizes ⓈⓇ or a standard deviation of sizes ⓈⓆ is specified, a nominal size shall not be indicated. In this case, the value indicated in the basic linear size specification is the upper specification limit of size characteristic (without the additional indication “max.”).

EXAMPLE 1 The linear size specification in Figure 24 a) means that the least-squares sizes of the cylinder shall be between 19,965 mm and 20 mm.

EXAMPLE 2 The linear size specification in Figure 24 b) means that the area diameter of the cylinder shall be between 34,8 mm and 35,1 mm.

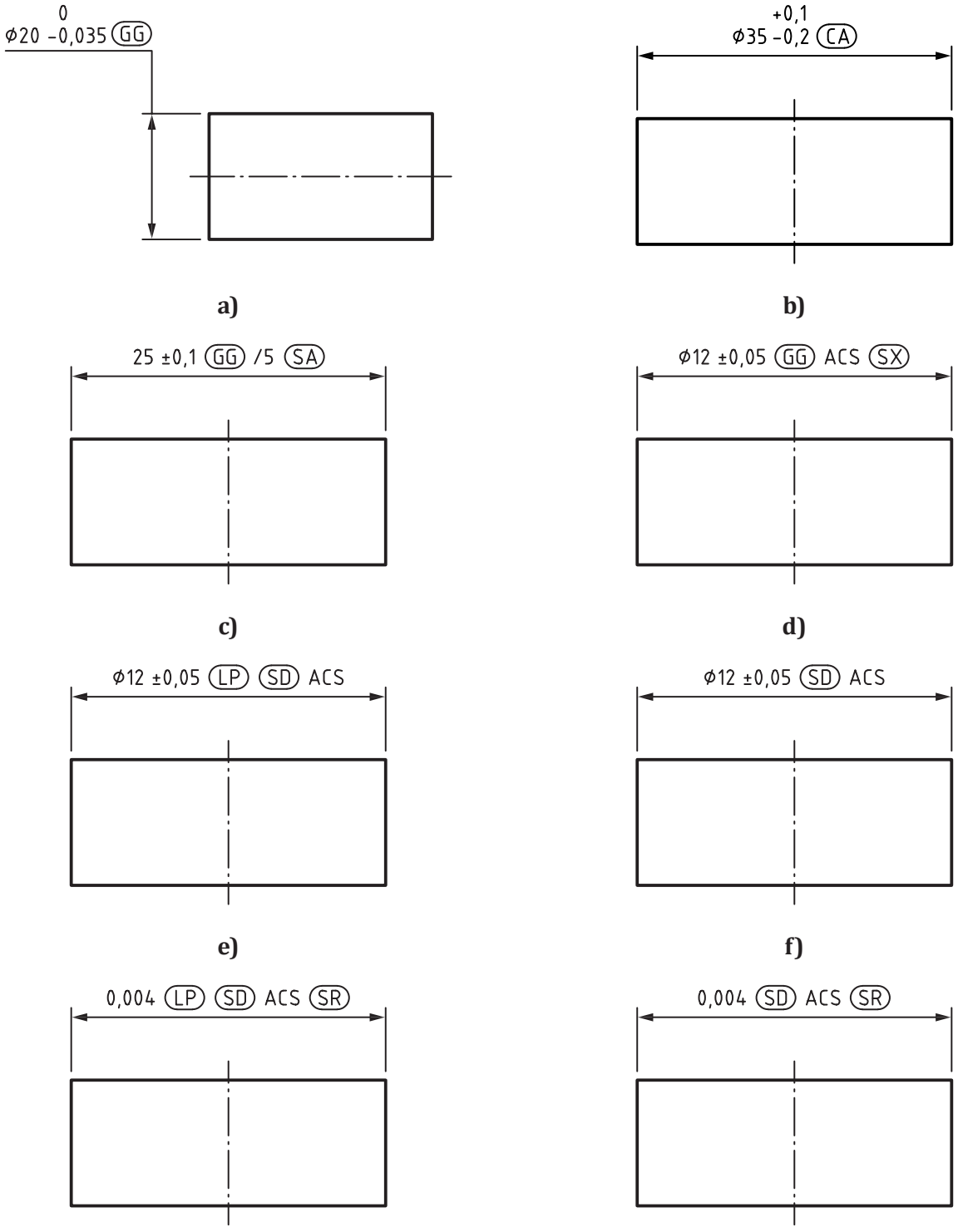
EXAMPLE 3 The linear size specification in Figure 24 c) means that the average value of the least-squares sizes in all portions of length 25 mm shall be between 24,9 mm and 25,1 mm.

EXAMPLE 4 The linear size specification in Figure 24 d) means that the maximum value of all the least-squares sizes from all cross-sections shall be between 11,95 mm and 12,05 mm. This defines one characteristic, the maximum of all local least-squares size characteristics.

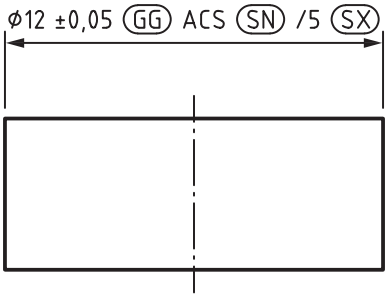
EXAMPLE 5 Because two-point size is the default specification operator, the linear size specifications in Figures 24 e) and f) mean that the mid-range size of the local two-point sizes is calculated in each cross-section separately. Each of these values shall be between 11,95 mm and 12,05 mm. This defines a local characteristic for each cross-section.

EXAMPLE 6 Because two-point size is the default specification operator, the linear size specifications in Figures 24 g) and h) define the same set of local characteristics as in EXAMPLE 5, and from that set the range of sizes is calculated. The range of sizes shall be less than 0,004. This defines a global characteristic.

EXAMPLE 7 The linear size specification in Figure 24 i) defines global linear sizes in cross-sections in restricted portions of length 5 mm. For each restricted portion of length 5 mm, the minimum value of all least-squares diameters is retained. Hence, a set of local linear size characteristics is defined. Then the maximum value of these size characteristics is retained. This defines a global characteristic, which shall be between 11,95 mm and 12,05 mm.



g) h)



i)

Figure 24 — Examples of linear size specifications

Rule M: The filtration specification element shall not be specified with a general tolerance, in order to avoid ambiguity with tolerance codes from ISO 286-1.

EXAMPLE 8 Writing 20 F7 for a nominal 20 with a general tolerance and a filter F7 is not permitted because most readers will read it as a nominal 20 with tolerance code, according to ISO 286-1.

7.4 Sequence of specification elements for the upper and left indication areas

Rule N: If necessary, the specification elements for the upper and left indication areas, see Figure 23, keys b and c, shall be indicated in the following order (see Table 5):

— a specification modifier for more than one feature;

— a specification modifier for united feature of linear size or a specification modifier for common toleranced feature of linear size;

— the indication of the specific portion with “between” symbol.

Table 5 — Syntax rules for the upper and left indication areas

More than one feature	United feature of linear size, common toleranced feature of linear size	Portion
k× *k*×A *k*×/*n*× *k*×A/*n*×B	UF*n*× UF CT*n*× CT	A ◄► B
1	2	3
8.2, 8.3 and 8.4	8.3 and 8.4	8.5

There shall be a space between each specification element (between each column of Table 5).

Indications that apply to all the linear size specifications attached to the leader line shall be indicated in the upper indication area, see Figure 23, key b.

Indications that only apply to one linear size specification shall be indicated in the left indication area for that linear size specification, see Figure 23, key c.

When there is only one linear size specification, indications in the upper indication area and in the left indication area mean the same. In this case, only one indication area shall be used.

Indications in the upper indication areas shall be left aligned. There shall be a space between the indications in the left indication area and the linear size specification.

7.5 Sequence of specification elements for the right indication area

Rule O: If necessary, the specification elements for the right indication area, see Figure 23, key d, shall be indicated in the following order (see Table 6):

— specification elements from ISO 10579;

— flagnotes.

Table 6 — Syntax rules for the right indication area

Specification elements from ISO 10579	Flagnote
	⬡
1	2
ISO 10579	ISO 129-1

There shall be a space between each specification element (between each column of Table 6).

There shall be a space between the linear size specification and the right indication area.

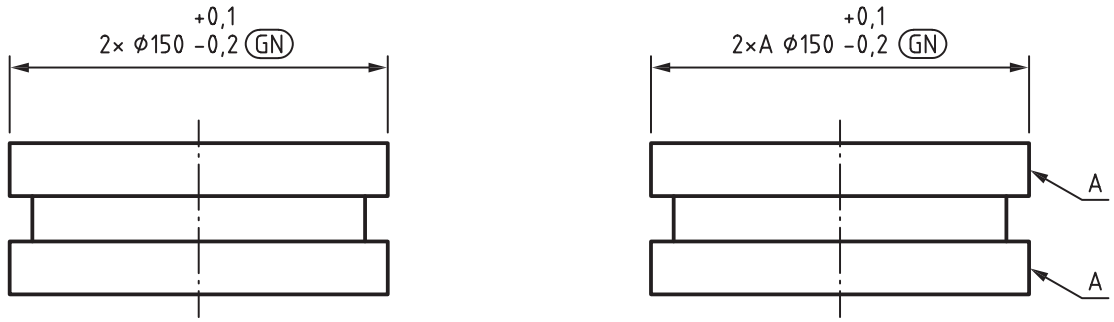
8 Indication of the toleranced feature on which the size characteristic is defined

8.1 Default case

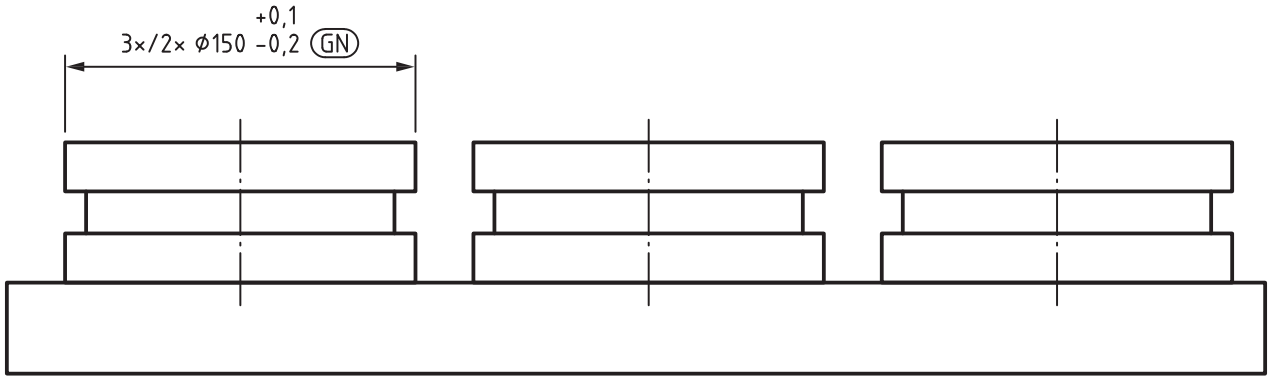
Rule P: By default, the linear size specification shall apply to one single complete feature of linear size.

8.2 Linear size specification applied individually to several features of linear size

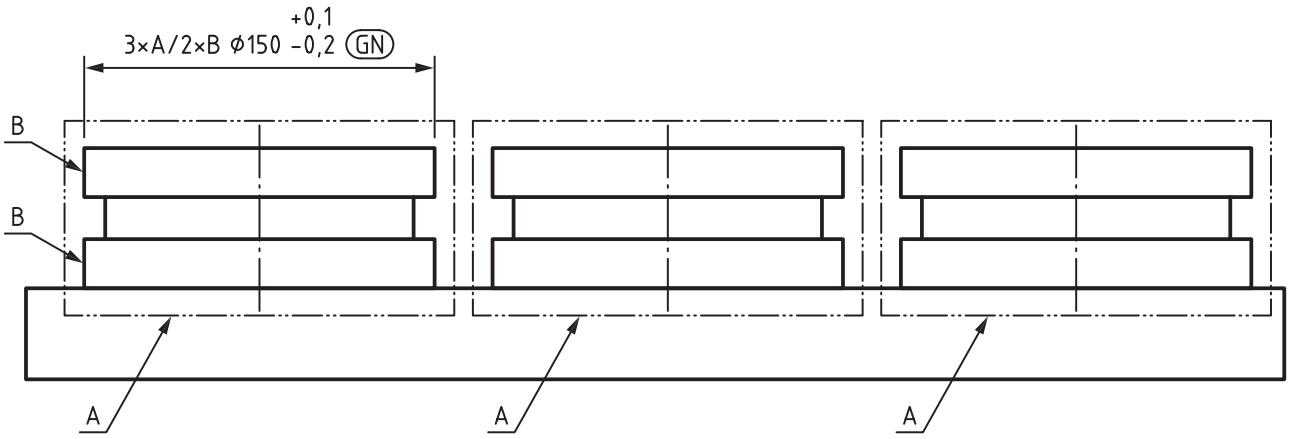
Rule Q: If the linear size specification applies individually to several features of linear size, the specification elements "*n*×", "*n*×A", "*k*×/*n*×" or "*k*×A/*n*×B" shall be used to indicate the number of features to which the linear size specification applies (see Figure 25).



a) **b)**



c)



d)

NOTE The specification operator "minimum circumscribed cylinder diameter" applies to the upper and lower limits of size characteristic for each cylindrical surface individually.

Figure 25 — Examples of linear size specifications applied individually for several features of linear size

These specification elements "*n*×" and "*k*×/*n*×" should only be used when there is no doubt, as to which features the specification applies.

The specification elements "*k*×/*n*×" and "*k*×A/*n*×B" are useful when the linear size specification is stacked with a geometrical specification, see ISO 5458. They have the same meaning as "*m*×", *m* being equal to *k*×*n*.

8.3 Linear size specification applied to several features of linear size considered as a common toleranced feature of linear size

Rule R: If the linear size specification applies to a common toleranced feature of linear size, the specification modifier "CT" or "CT*n*×" shall be used (see Figure 26).

If the linear size specification applies individually to several common toleranced features of linear size, the specification element "*k*×" and the specification modifier "CT*n*×" shall be used, *k* being the number of common toleranced features of linear size and *n* being the number of single features of linear size in each common toleranced feature of linear size.

NOTE The indication of the modifier "CT" on the right of the linear size specification is a former practice, see Annex G.

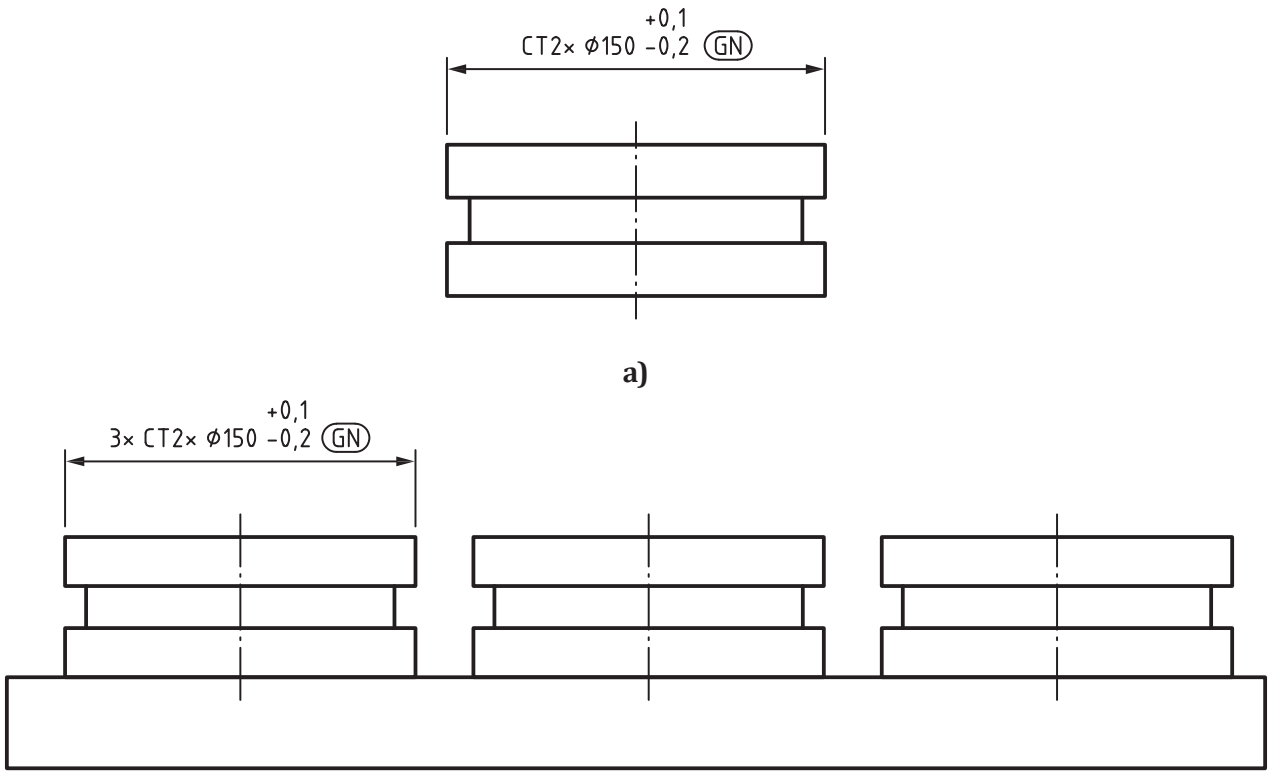
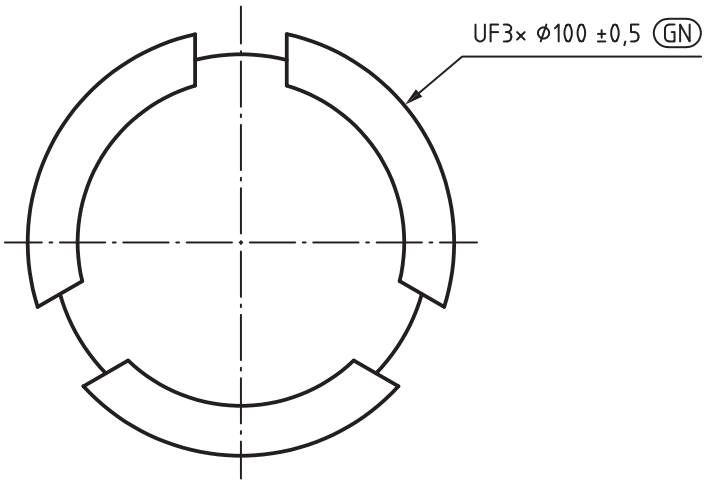


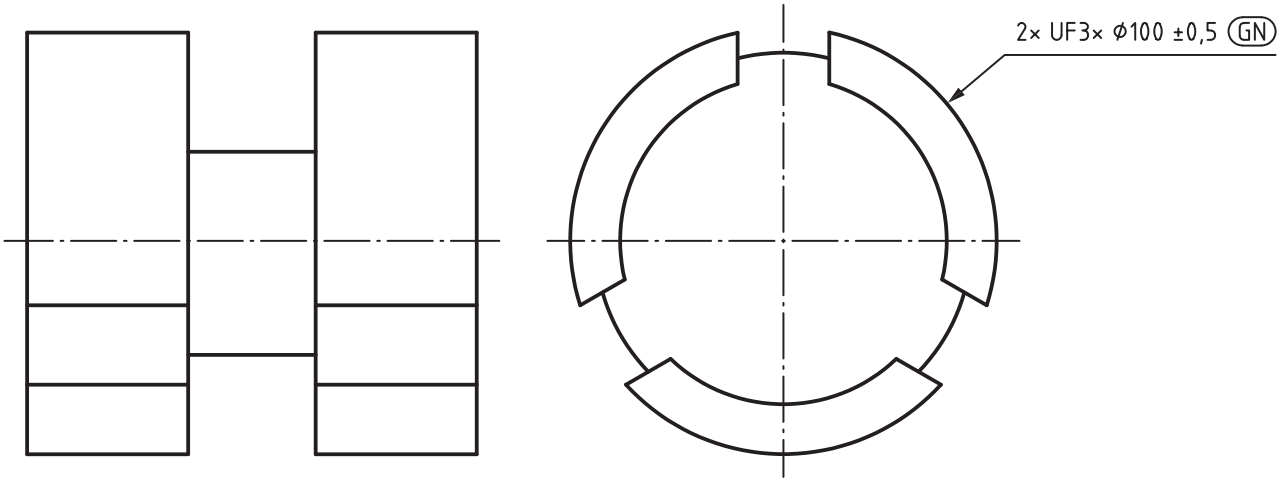
Figure 26 — Examples of linear size specifications for common toleranced features of linear size

8.4 United feature of linear size

Rule S**:** If the linear size specification applies to a united feature of linear size, then the specification element "UF*n*×" shall be indicated, *n* being the number of single features that form the united feature of linear size (see Figure 27).

If the linear size specification applies individually to several united features of linear size, then the specification element "*k*×" and the specification element "UF*n*×" shall be indicated, *k* being the number of united features of linear size and *n* being the number of single features in each united feature of linear size.





b)

Figure 27 — Examples of linear size specifications on united features of linear size

8.5 Fixed restricted portion of the feature of linear size

Rule T: If the linear size specification applies to a fixed restricted portion of the complete feature of linear size, then it shall be indicated by using two letters defining the beginning and the end of the restricted portion, separated by the "between" symbol (see Figure 28).

The extent of the portion and its location shall be defined by TEDs.

NOTE The indication of the restricted portion with a long-dashed dotted wide line placed over the restricted portion of the complete feature is a former practice, see Annex G.

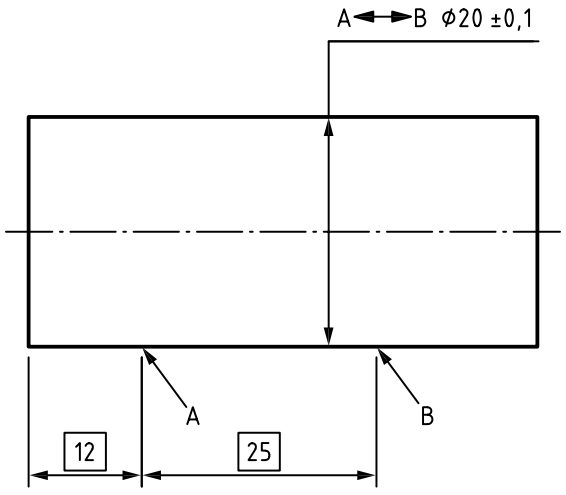


Figure 28 — Example of a fixed restricted portion of the feature of linear size

8.6 Size characteristic in specific cross-sections of a feature of linear size

8.6.1 Size characteristic in one specific cross-section of a feature of linear size

Rule U: If the linear size specification applies to one specific cross-section of the complete feature of linear size, then:

a) the section shall be indicated with a leader line connected to a section identifier;

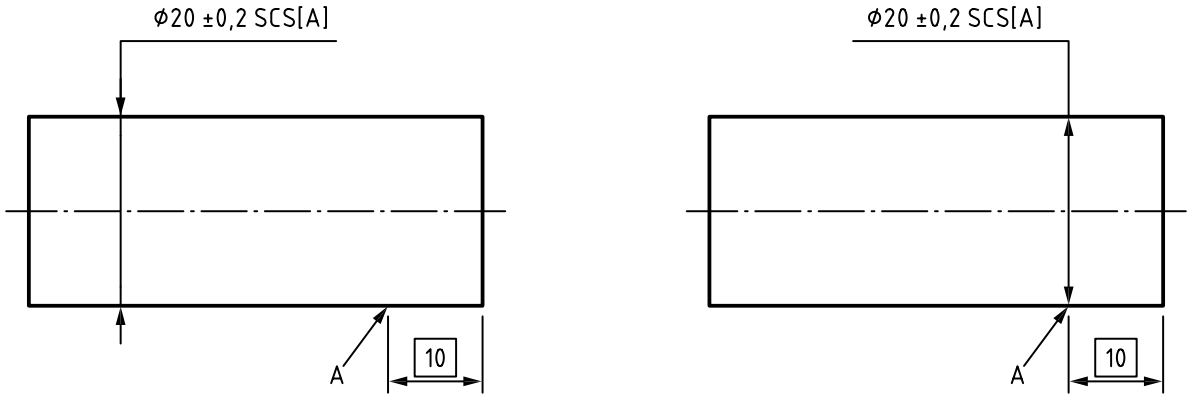
b) the location of the section shall be defined by a TED;

c) the modifier “SCS” shall be indicated followed by the identifier of the section placed into square brackets.

See Figure 29 for illustration.

The location of the section should not be at the beginning or the end of the feature (defining an implicit TED of 0 mm) to ensure that the section exists on the real workpiece.

NOTE The indication without “SCS” or without the identifier of the section placed into square brackets is a former practice, see Annex G.



a) **b)**

Figure 29 — Examples of indications for a specific cross-section of the complete feature of linear size

8.6.2 Size characteristic in several specific cross-sections of a feature of linear size

Rule V: If the linear size specification applies to several specific cross-sections of the complete feature of linear size, then:

a) each section shall be indicated with a leader line connected to a section identifier;

b) the location of each section shall be defined by a TED;

c) the modifier “SCS” shall be indicated followed by the identifiers of the sections placed into square brackets, each separated by a comma and a space.

See Figure 30 for illustration.

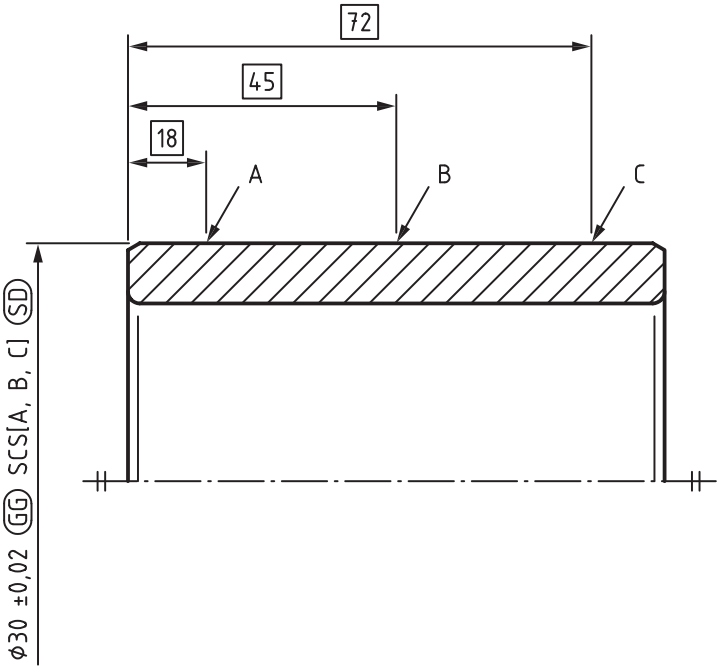
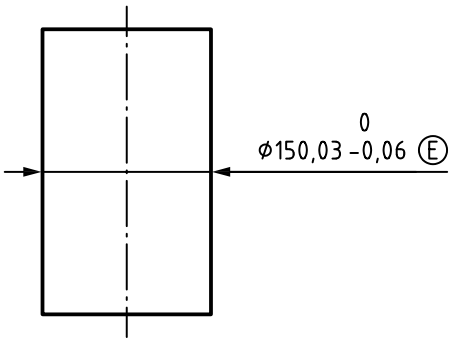


Figure 30 — Example of indication of several specific cross-sections

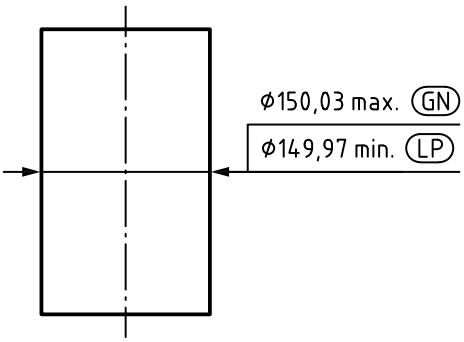
9 Envelope requirement

9.1 Envelope requirement for external features of linear size

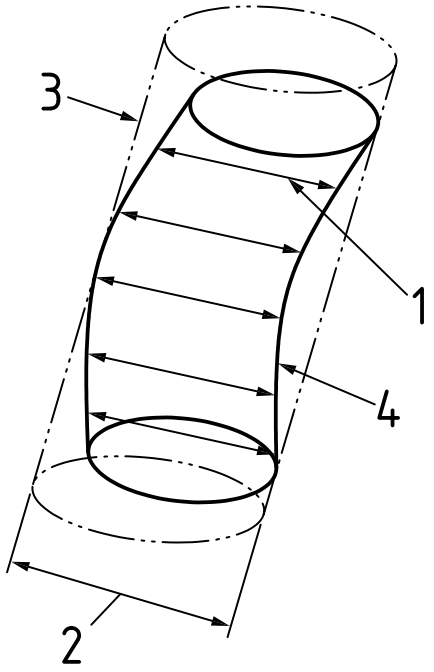
On external features of linear size, the envelope requirement specifies both the lower limit on the two-point size and the upper limit on the minimum circumscribed size, see Figure 31.



a) Specification of an envelope requirement for an external feature of linear size



b) Equivalent specification with a two-point size and a minimum circumscribed size



c) Interpretation

Key

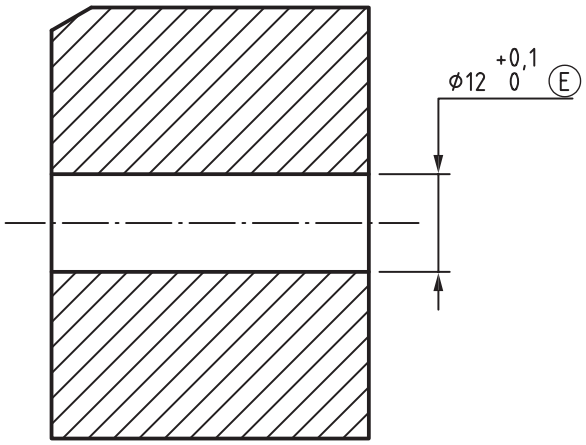
1 two-point sizes (required to be larger than or equal to 149,97)
2 minimum circumscribed size (required to be smaller than or equal to 150,03)
3 minimum circumscribed cylinder including 4
4 extracted integral feature

NOTE On an external feature of linear size, specifications in a) and b) have the same meaning.

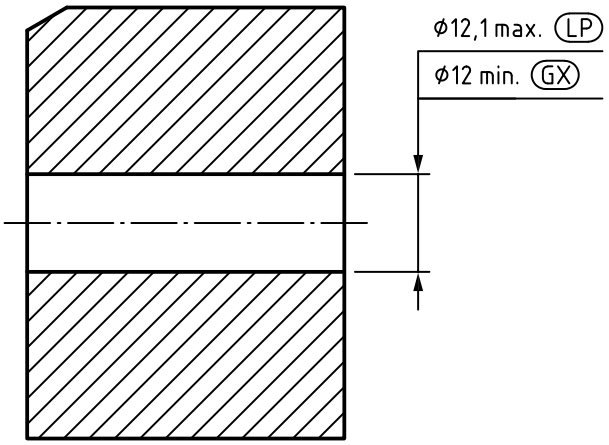
Figure 31 — Example of an envelope requirement for an external feature of linear size

9.2 Envelope requirement for internal features of linear size

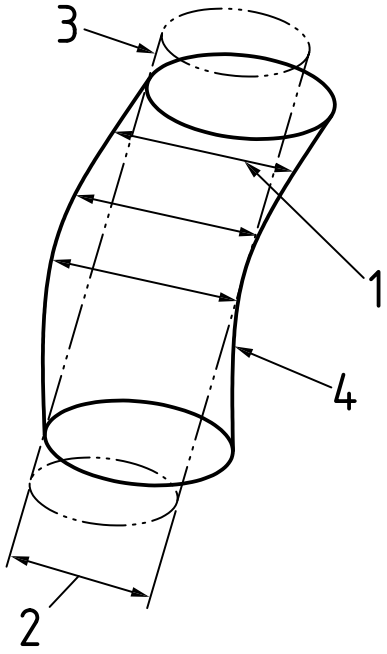
On internal features of linear size, the envelope requirement specifies both the upper limit on the two-point size and the lower limit on the maximum inscribed size, see Figure 32.



a) Specification of an envelope requirement for an internal feature of linear size



b) Equivalent specification with a two-point size and a maximum inscribed size



c) Interpretation

Key

1 two-point sizes (required to be smaller than or equal to 12,1)
2 maximum inscribed size (required to be larger than or equal to 12)
3 maximum inscribed cylinder included within 4
4 extracted integral feature

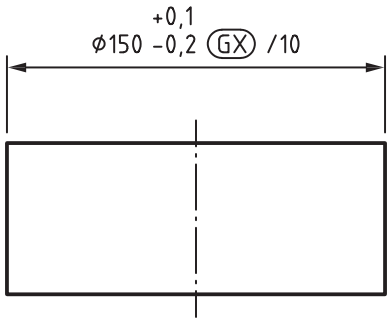
NOTE On an internal feature of linear size, specifications in a) and b) have the same meaning.

Figure 32 — Example of an envelope requirement for an internal feature of linear size

10 Indication of linear portion sizes

Rule W: If the linear size specification applies to any restricted portion of either the complete feature of linear size or a fixed restricted portion of it, it shall be indicated with the specification modifier "/" followed by the value of the length of the restricted portion (considered as a TED) (see Figure 33).

NOTE The indication "/0", meaning that the length of the restricted portion is zero, is a former practice, see Annex G.



NOTE The same specification operator applies to both the upper and lower limits of size characteristic and defines as size characteristic the diameter of the maximum inscribed cylinder for any portion of length 10 mm.

Figure 33 — Example of a linear portion size for any restricted portion of length 10 mm

11 Indication of linear section sizes

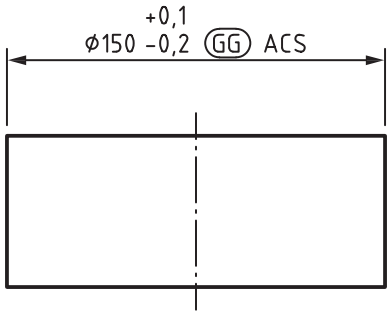
Rule X: If the linear size specification applies to any cross-section of either the complete feature of linear size or a fixed restricted portion of it, it shall be indicated by one of the following ways:

— indicating an intersection plane;

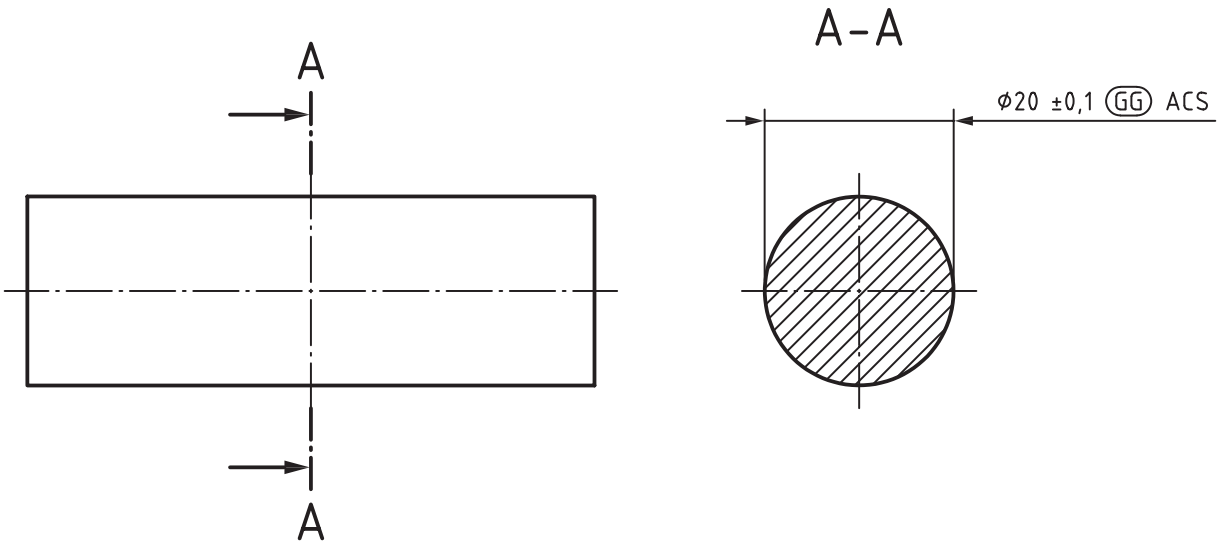
— indicating the specification modifier "ACS" for any cross-section, if the sections are perpendicular to the axis of the feature of linear size itself (see Figure 34).

NOTE 1 The calculated size with circumference diameter and the calculated size with area diameter are linear section sizes in cross-sections, even if "ACS" is not indicated.

NOTE 2 The indication of any longitudinal sections ("ALS") is described in Annexes E and F.



a) Indication in a view



b) Indication in a cross-section

NOTE The upper and lower limits of size characteristic apply to the least-squares diameter in any cross-section of the cylindrical feature.

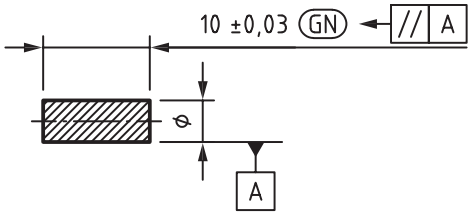
Figure 34 — Examples of indication of the specification modifier "ACS"

12 Filtration

All the terms related to filtration are defined in ISO 16610-1. The specific filters are defined in the other parts of the ISO 16610 series.

13 Direction feature

Rule Y: If it is necessary to clarify the direction of the dimension to be considered, then a direction feature shall be indicated (see Figure 35).



NOTE The size characteristic is the minimum circumscribed size in a direction parallel to datum A (e.g. to avoid instability when the extent of the opposite areas is small).

Figure 35 — Example of indication of a direction feature

Annex A
(normative)

Proportions and dimensions of graphical symbols

A.1 General requirement

Rule A.1: In order to harmonize the size of the symbols specified in this document with those of other inscriptions on technical drawings (dimensions, geometrical tolerances, etc.), the requirements specified in ISO 81714-1 shall be applied.

A.2 Proportions

Rule A.2**:** The graphical symbols shall be drawn in accordance with Figures A.1 and A.2.

The symbol XX in Figure A.1 designates all the different letter combinations for the specification modifiers given in Table 1.

The symbol X in Figure A.2 designates, in this document, the letter E for the envelope requirement.

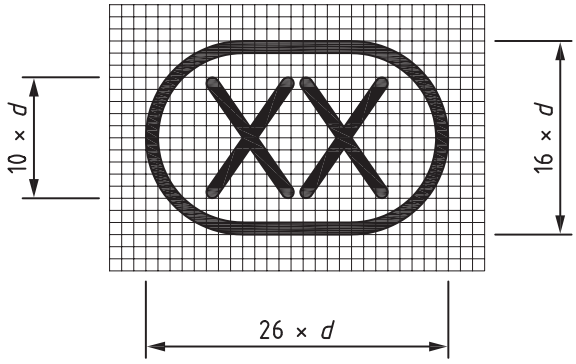


Figure A.1 — Graphical symbol for the local linear size or global linear size or calculated size

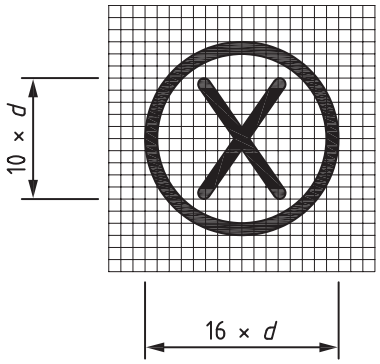


Figure A.2 — Graphical symbol for the envelope requirement

A.3 Dimensions

The dimensional requirements of the graphical symbols and the additional indications are specified in Table A.1, see ISO 3098-1, lettering type B.

NOTE These requirements are in accordance with ISO 3098-2.

Table A.1 — Dimensions

Dimensions in millimetres

Lettering height, *h*	2,5	3,5	5	7	10	14
Line thickness for symbols and lettering, *d*	0,25	0,35	0,5	0,7	1	1,4

Annex B
(normative)

Graphical rules for linear size specifications

This annex presents the drawing rules for indication of linear size specifications.

Rule B.1: The specification elements shall be drawn in accordance with Figures B.1 to B.5, respecting distances between several indications on the drawing and between specification elements of one specification. The bottom reference line illustrated in Figures B.1 to B.5 can be the reference line of a linear size specification or the upper line of a tolerance indicator indicating a geometrical specification.

The graphical distances are established from the width of the narrow line, identified by *d*, defining the height of a character is equal to 10 *d* (see also Annex A). The text line height is equal to 16 *d*.

The distance between the base line and the reference line (or the tolerance indicator) shall be 7 *d* (see Figures B.1 and B.2).

When linear size specifications are stacked upon each other, the distance between their base lines shall be 21 *d*.

When no horizontal space exists between two specification elements of a size specification, a distance of 2 *d* separates them.

When a horizontal space exists between two specification elements of a size specification, a distance of 6 *d* separates them (see Figures B.1 and B.3).

See 5.2.3, 5.2.4, 7.3, 7.4 and 7.5 to know where horizontal spaces exist.

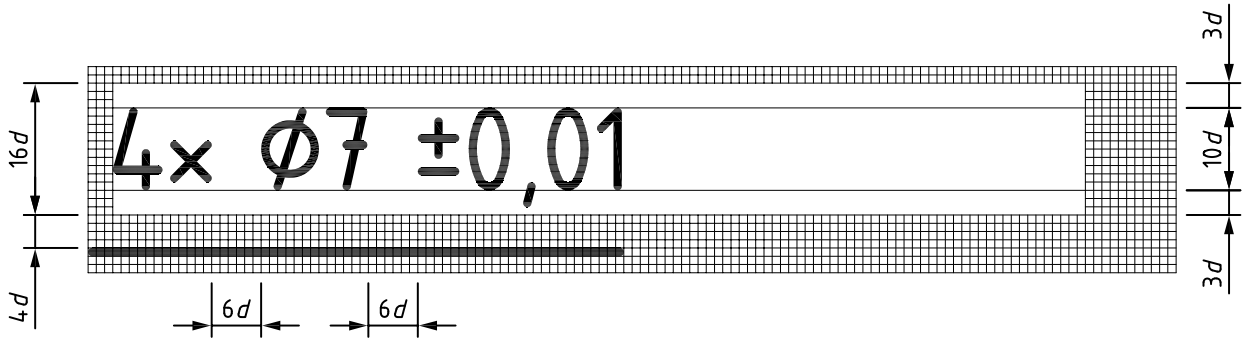


Figure B.1 — Example of a linear size specification indicated on one line without symbol

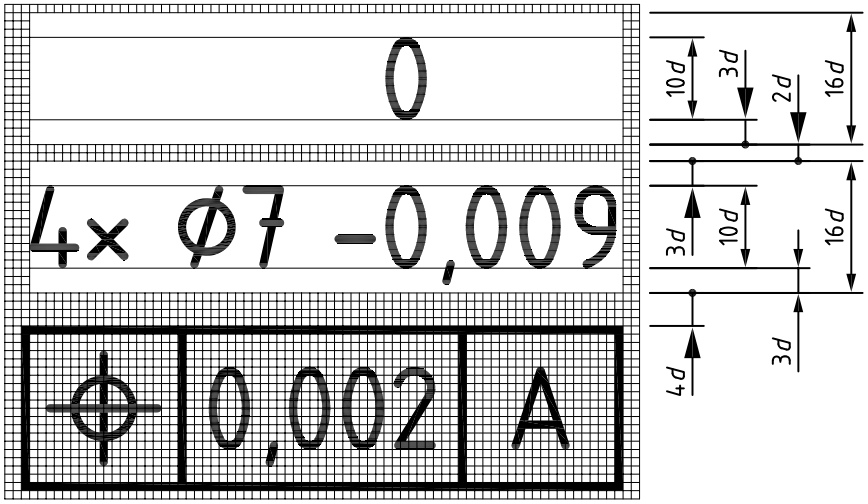


Figure B.2 — Example of a linear size specification indicated on two lines without symbol

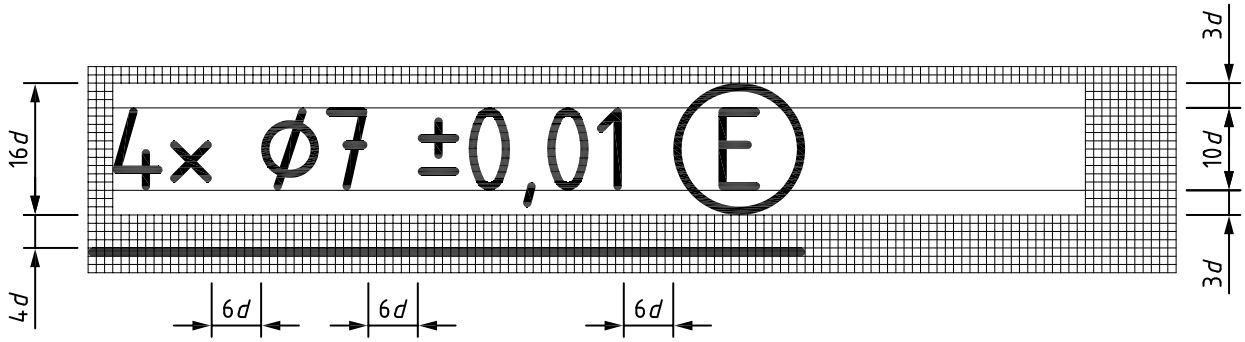


Figure B.3 — Example of a linear size specification indicated on one line with symbols

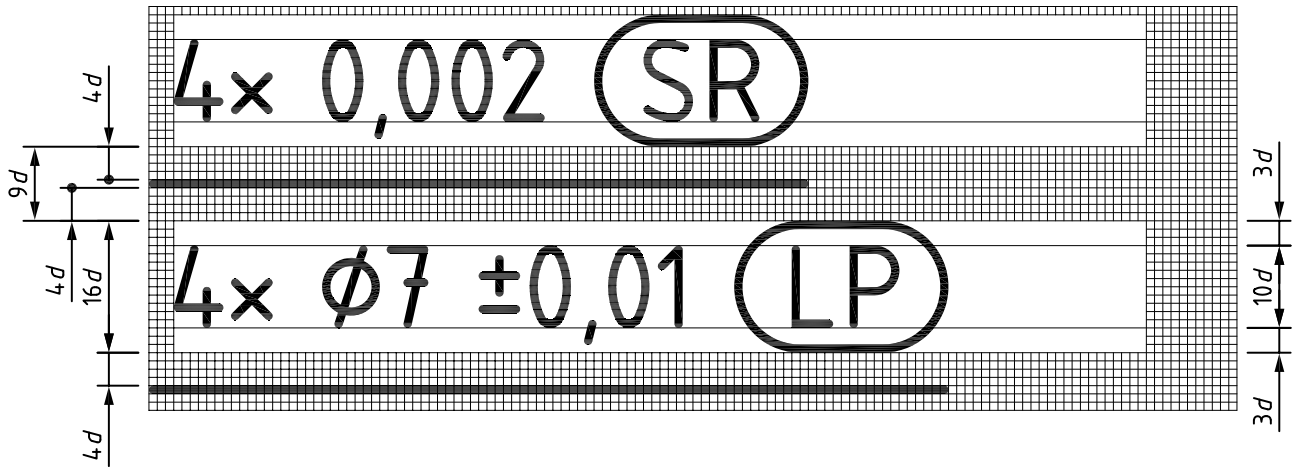


Figure B.4 — Example of two linear size specifications indicated for each one on one line with symbol

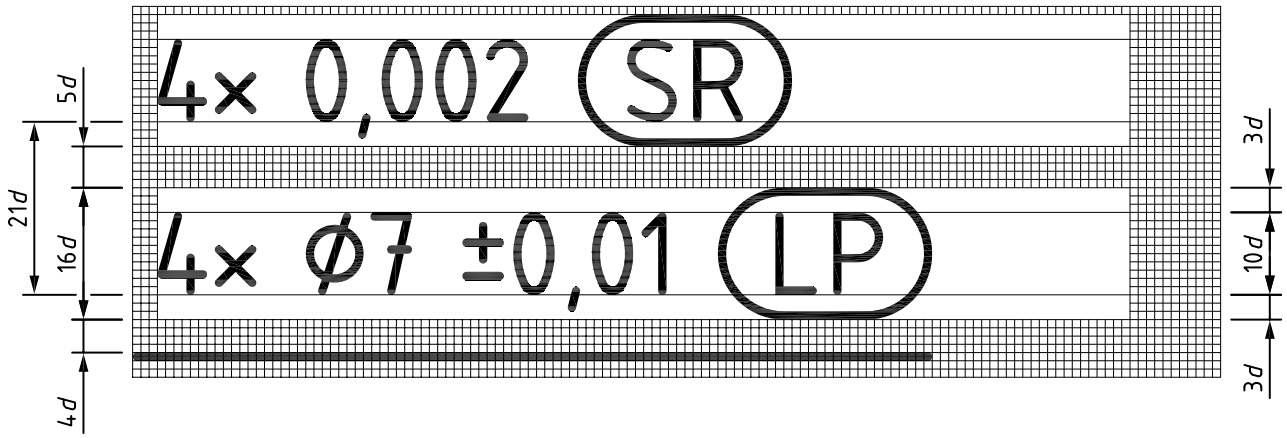


Figure B.5 — Example of two stacked linear size specifications

Annex C
(informative)

Data handling with statistical sizes

If a linear size specification is a linear portion size or a linear section size, then there is a data set for each portion or section.

If a global linear size (including a statistical size) is specified for each portion or section, then each section or portion data set is reduced to one global section value for the portion or section.

If a global linear size (including a statistical size) is specified for the complete feature of size, then the set of results is reduced to one global value.

EXAMPLE 0,005 (LP) (SD) ACS (SR).

Assuming that 12 local two-point sizes have been measured in each of the five cross-sections as given in Table C.1 (the bold values are maxima or minima within one section).

Table C.1 — Primary data set (two-point sizes obtained in five sections and in 12 angular locations)

No.*j* in a section	Angular location in a section in °	Section no.*i*				
		1	2	3	4	5
1	0	10,000	10,000	9,996	9,995	**9,990**
2	15	10,010	10,015	10,016	10,003	10,008
3	30	10,012	10,009	10,005	10,017	10,008
4	45	10,009	10,007	10,011	10,009	10,013
5	60	10,011	10,010	10,016	**10,021**	10,007
6	75	**10,015**	**10,025**	**10,022**	10,009	10,006
7	90	10,005	9,997	10,007	10,013	9,996
8	105	10,006	10,002	10,006	10,014	**10,014**
9	120	10,004	10,012	10,013	10,006	10,006
10	135	9,997	10,002	10,002	**9,988**	10,002
11	150	**9,995**	**9,986**	**9,987**	9,993	10,000
12	165	9,999	10,008	10,007	10,007	9,996

Table C.2 — Results of evaluation for the three types of specified characteristic

Characteristic	Result of measurement for this sequence of modifiers					
(LP) (SD) ACS	10,005	**10,005 5**	10,004 5	10,004 5	**10,002 0**	—
(LP) (SD) ACS (SR)	—	—	—	—	—	0,003 5
Type of size characteristic	Local					Global

Let *i* be the cross-section index and *j* the value index in each cross-section:

LP (i, j)	represents the value number j evaluated in the section i
$\mu_i = E_i(\mathrm{LP}(i, j))$	represents the average value in section i evaluated from the set of values LP (i, j)
$R = \mathrm{Max}(\mu_i) - \mathrm{Min}(\mu_i)$	represents the range evaluated from the set of values μ_i

The example shows the sequence of operations on the primary data set. A linear portion size or linear section size (in this case, a linear section size) generates a secondary set of section data sets from the primary set. For each section data set, a mid-range value is calculated. Then, from the set of mid-range values of individual sections, a range value is calculated. Graphically, this sequence of operations can be depicted as in Figure C.1, where B is the primary data set (as given in Table C.1), the C_i are the section data sets for each cross-section and R is the global result (see Table C.2).

NOTE The sequence of operations on the data set does not always follow the sequence of the modifiers of the specification. For example, the subdivision of the primary data result set by section or portion, if applicable, is always the first operation, regardless of where the corresponding modifier is in the sequence.

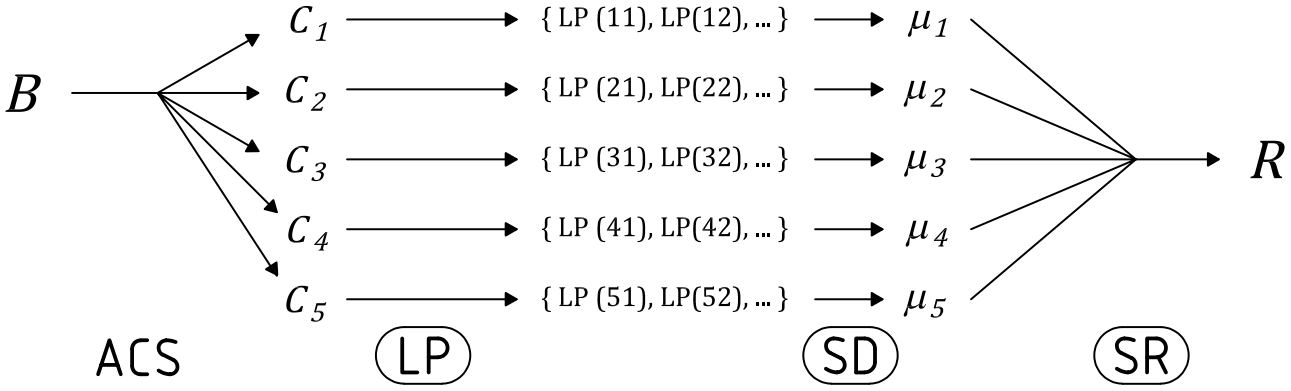


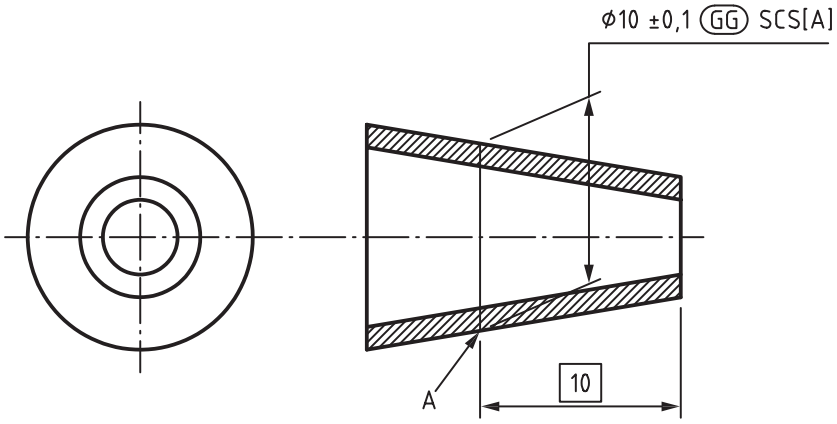
Figure C.1 — Schematic illustration of the example, from the primary data set to the global result

Annex D
(normative)

Linear size specification on a circle as specific section of a cone

Rule D.1: If the linear size specification applies to a specific circle, which is the section of a cone, it shall be indicated with the specification modifier “SCS” for specific cross-section (see Figure D.1).

NOTE This document does not cover linear size specifications on cones other than circles in specific cross-sections. See also ISO 3040 for specification of cones.



NOTE This figure is provided to show an indication of a diameter in a specific cross-section of a cone.

Figure D.1 — Example of a linear size specification in a specific cross-section of a cone

Annex E
(normative)

Linear size specification on circles as any longitudinal sections of a torus

Rule E.1: If the linear size specification applies to circles which are the sections of a torus, it shall be indicated with the specification modifier “ALS” for any longitudinal section (see Figure E.1), and a mandatory intersection plane indicator, with the symmetry symbol and a datum which is an axis identical to the axis of the torus.

NOTE This document does not cover other linear size specifications on tori.

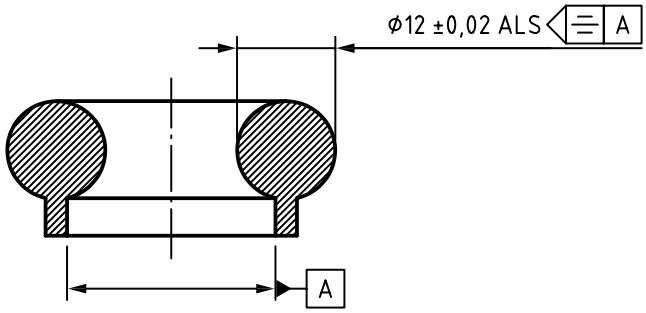


Figure E.1 — Example of a linear size specification on circles as sections of a torus

Annex F
(normative)

Linear size specifications on parallel opposite lines as any longitudinal sections in half planes

Rule F.1: If the linear size specification applies to any longitudinal sections of either the complete feature or a fixed restricted portion of it, it shall be indicated with the specification modifier “ALS” for any longitudinal section, followed by an intersection plane with the symmetry symbol and an axis as datum (see Figure F.1). The longitudinal sections are the half planes including the axis.

NOTE The longitudinal sections can be defined:

— from two parallel opposite planes in order to get parallel opposite lines;

— from a cylindrical or a conic tube of constant thickness, in order to get parallel opposite lines (see Figure F.1).

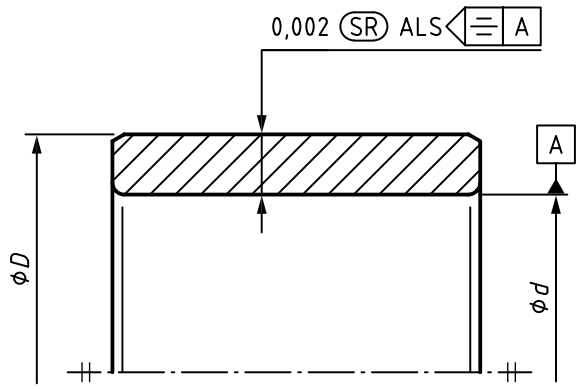


Figure F.1 — Example of a linear size specification on lines as longitudinal sections of a tube

Annex G
(informative)

Former practices

G.1 General

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

The term deviation limit was replaced by limit deviation.

The following drawing indications were described in ISO 14405-1:2016. Their use in practice has shown that their interpretation was ambiguous. Therefore, these drawing indications should no longer be used.

G.2 Former indication of the specification element "/0"

It was a former practice to use the specification element "/0" to mean "any restricted portion whose length is equal to zero" (see Figure G.1). Practice has been changed to use the modifier "ACS", see Clause 11.

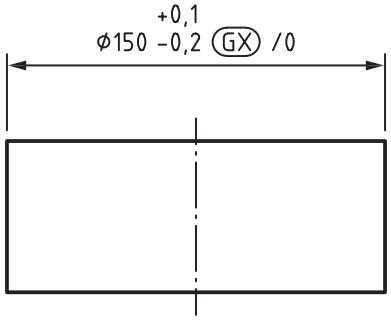


Figure G.1 — Former practice "/0"

G.3 Former indications for different specification operators for upper limit of size characteristic and lower limit of size characteristic

When different specification operators were applied for the upper and the lower specification limits of size characteristic, it was a former practice to indicate them by one of the following ways:

a) attached to each of the specification limits of size characteristic or limit deviations or tolerance code indications [see Figure G.2 a)]; or

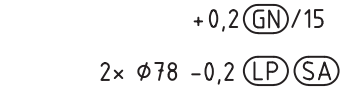
b) written on the same line in the following order:

   1) the specification operator for the upper specification limit of size characteristic, in square brackets;

   2) a space, a hyphen and a space;

   3) the specification operator for the lower specification limit of size characteristic, in square brackets [see Figure G.2 b)].

Practice has been changed to indicate two different linear size specifications in this case, see Clause 7.



a) Indication on two lines

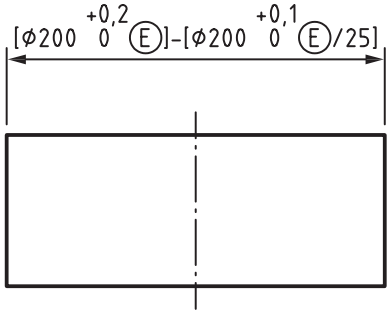
b) Indication on one line

Figure G.2 — Former practices for different specification operators for the upper and lower specification limits of size characteristic

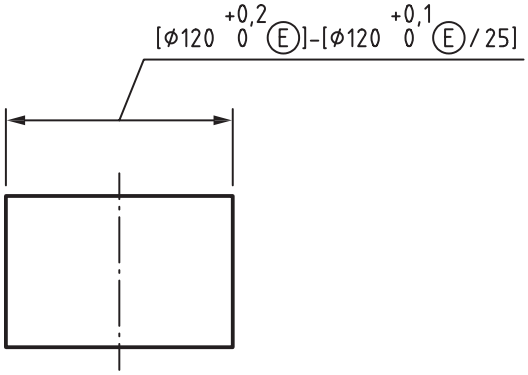
G.4 Former indication of several linear size specifications applied to a feature of linear size

When more than two specification operators were applied to a feature of linear size, it was a former practice to indicate them on one dimension line, on which were indicated directly [see Figure G.3 a)] or indirectly with an attached reference line [see Figure G.3 b)] more than one linear size specifications separated by a dash and each being written into square brackets.

Practice has been changed to indicate several linear size specifications on several lines in that case, see Clause 7.



a) Indication on the dimension line



b) Indication with an attached reference line

Figure G.3 — Former indications of several linear size specifications applied to a feature of linear size

G.5 Former indication of a fixed restricted portion of the feature of linear size

When a linear size specification applies to only one fixed restricted portion of the complete feature of linear size, it was a former practice to indicate it by a long-dashed dotted wide line placed over the restricted portion of the complete feature [see Figure G.4)].

The practice has been changed to the use of the “between” symbol, see 8.5.

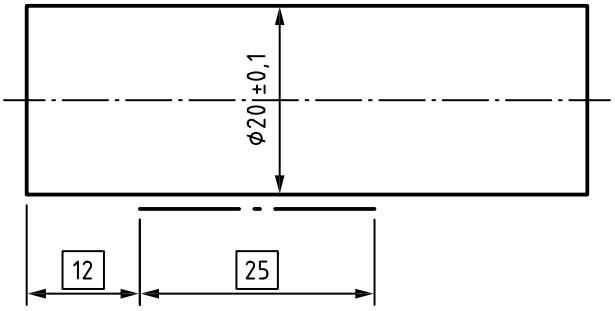
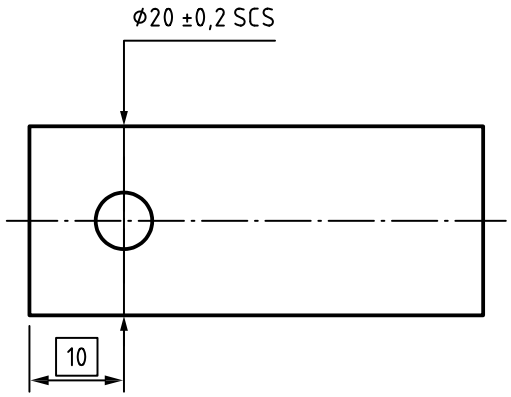


Figure G.4 — Former indication of a fixed restricted portion of the feature of linear size

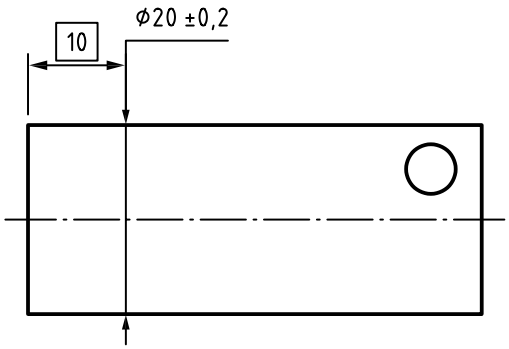
G.6 Former practices for the indication of a specific cross-section of the feature of liner size

When the specification applies to one specific cross-section of the complete feature of linear size, there were former practices to indicate the section without the modifier “SCS” or without the identifier of the section placed into square brackets (see Figure G.5).

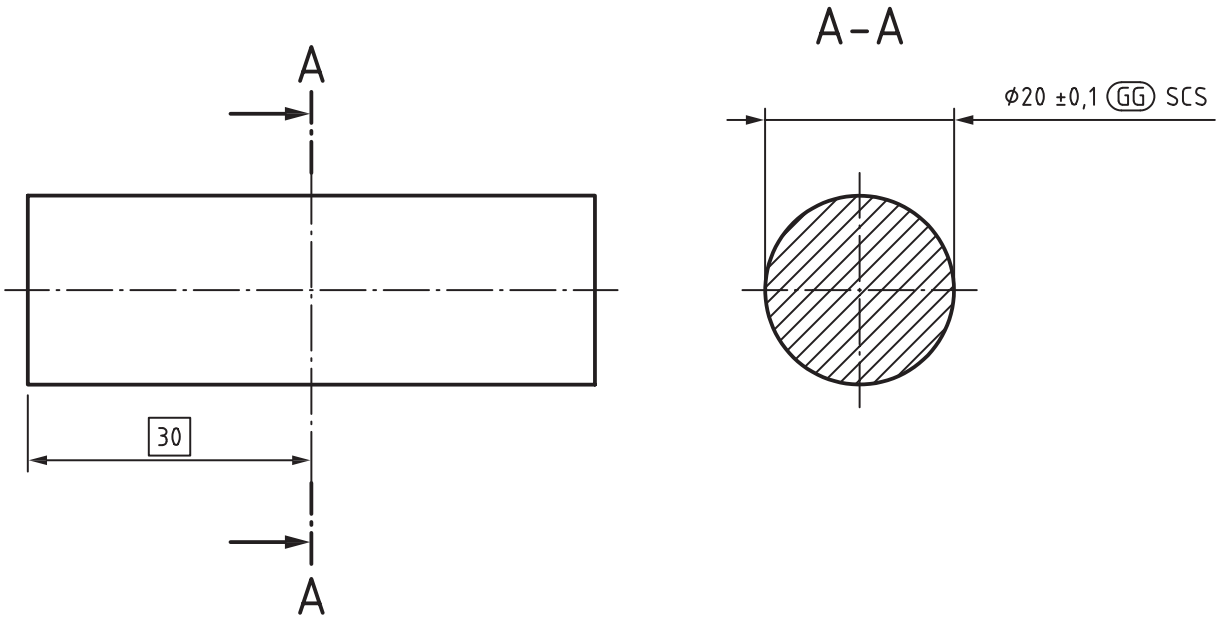
The practices have been changed to the indication of “SCS” with the identifier of the section placed into square brackets, see 8.6.



a) Location of the cross-section and indication in the same view with the modifier “SCS” but without the identifier of the section placed into square brackets



b) Location of the cross-section and indication in the same view without the modifier “SCS”



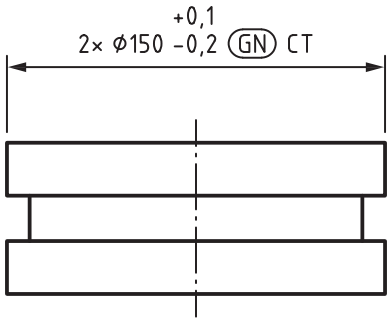
c) Location of the cross-section in a view and indication in this cross-section

Figure G.5 — Former practices for the indication of a specific cross-section

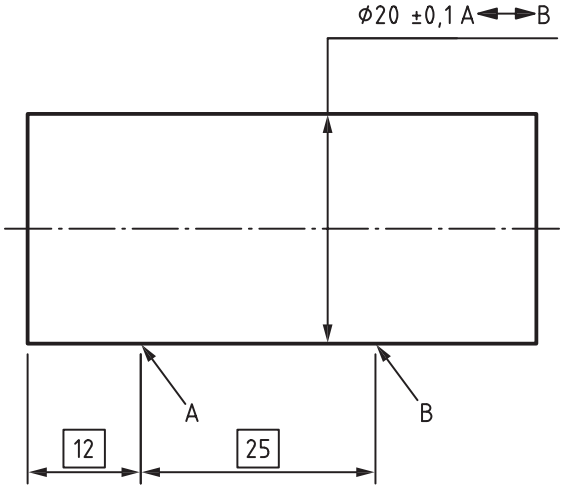
G.7 Former practices for the indication of a common toleranced feature of linear size, and the indication of a portion

There were former practices to indicate a common toleranced feature of linear size and a fixed restricted portion on the right of the indication (see Figure G.6).

The practices have been changed to indicate them in the upper or left indication areas, without changing the meaning of the indication, see 7.4.



a) Former indication of a common toleranced feature of linear size



b) Former indication of a fixed restricted portion

Figure G.6 — Former practices for the indication of a common toleranced feature of linear size, and the indication of a fixed restricted portion

Annex H
(informative)

Sequence of the specification elements

Table H.1 gives an overview of the sequence of specification elements for linear size specifications.

Table H.1 — Overview of the sequence of the specification elements for linear size specifications

Upper and left indication areas				Linear size specification								Right indication area	
More than one feature	United feature of linear size, common toleranced feature of linear size	Portion		Basic linear size specification	Envelope requirement, local linear size, global linear size or calculated size	Portion(s) or section(s) where the envelope, local linear size, global linear size or calculated size is evaluated	Statistical size	Portion(s) or section(s) where the statistical size is evaluated	Statistical size	Filtration	Direction feature	Specification elements from ISO 10579	Flagnote
k× *k*×A *k*×/*n*× *k*×A/*n*×B	UF*n*× UF CT*n*× CT	A↔B		⌀150 ±0,2 0 120 -0,1 S⌀20 h8 2,5 max. 0,004	Ⓔ Ⓛ Ⓢ Ⓖ Ⓧ Ⓝ Ⓒ Ⓒ Ⓐ Ⓥ	/5 ACS SCS[A, B, C] ALS	Ⓢ Ⓝ Ⓐ Ⓜ Ⓓ Ⓡ Ⓠ	/5 ACS SCS[A, B, C] ALS	Ⓢ Ⓝ Ⓐ Ⓜ Ⓓ Ⓡ Ⓠ	H0 G50			
1.1	1.2	1.3		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.1	3.2
8.2, 8.3 and 8.4	8.3 and 8.4	8.5		Clause 5	Clause 4	8.6, Clauses 10 and 11 Annexes D, E and F	Clause 4	8.6, Clauses 10 and 11 Annexes D, E and F	Clause 4	Clause 12	Clause 13	ISO 10579	ISO 129-1

Annex I
(informative)

Relationship to the ISO GPS matrix model

I.1 General

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 specifications made in accordance with this document, unless otherwise indicated.

I.2 Information about this document and its use

This document establishes the default specification operator for linear sizes, and defines special specification operators for linear sizes.

I.3 Position in the ISO GPS matrix model

This document is a general ISO GPS standard which influences chain links A to C of the chains of standards on size in the ISO GPS matrix model. The rules and principles given in this document apply to all segments of the ISO GPS matrix which are indicated with a filled dot (•).

Table I.1 — Position in the ISO GPS standards matrix model

	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	**Feature requirements**	**Feature properties**	**Conformance and non-conformance**	**Measurement**	**Measurement equipment**	**Calibration**
Size	•	•	•				
Distance							
Form							
Orientation							
Location							
Run-out							
Profile surface texture							
Areal surface texture							
Surface imperfections							

I.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Table I.1.

Bibliography

[1] ISO 129-1,, *Technical product documentation (TPD) — Presentation of dimensions and tolerances — Part 1: General principles*

[2] ISO 1101:2017, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

[3] ISO 3040, *Geometrical product specifications (GPS) — Dimensioning and tolerancing — Cones*

[4] ISO 3098-1, *Technical product documentation — Lettering — Part 1: General requirements*

[5] ISO 3098-2, *Technical product documentation — Lettering — Part 2: Latin alphabet, numerals and marks*

[6] ISO 4351, *Geometrical product specifications (GPS) — Association*

[7] ISO 5458, *Geometrical product specifications (GPS) — Geometrical tolerancing — Pattern and combined geometrical specification*

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

[9] ISO 14253-1, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for verifying conformity or nonconformity with specifications*

[10] ISO 14405-2:2018, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 2: Dimensions other than linear or angular sizes*

[11] ISO 14405-3, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 3: Angular sizes*

[12] ISO 14638, *Geometrical product specifications (GPS) — Matrix model*

[13] ISO 16610 (all parts), *Geometrical product specifications (GPS) — Filtration*

[14] ISO/TS 17863, *Geometrical product specification (GPS) — Tolerancing of moveable assemblies*

[15] ISO 25178-1, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 1: Indication of surface texture*

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