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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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Foreword

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

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

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

ISO 14405-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

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

— *Part 1: Linear sizes*

— *Part 2: Dimensions other than linear sizes*

Introduction

This part of ISO 14405 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain links 1 to 3 of the chain of standards on size.

The ISO/GPS Masterplan given in ISO/TR 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.

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

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

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

The type of size can be indicated on the drawing by a specification modifier for controlling the feature definition and evaluation method to be used.

Geometrical product specifications (GPS) — Dimensional tolerancing —

Part 1:
Linear sizes

1 Scope

This part of ISO 14405 establishes the default specification operator for linear size and defines a number of special specification operators for linear size for feature of size types "cylinder" and "two parallel opposite planes". It also defines the specification modifiers and the drawing indications for these linear sizes. This part of ISO 14405 covers the following linear sizes:

— local size;

    — two-point size;

    — spherical size;

    — section size;

    — portion size;

— global size;

    — direct global linear size;

        — least-squares size;

        — maximum inscribed size;

        — minimum circumscribed size;

    — indirect global linear size;

— calculated size;

    — circumference diameter;

    — area diameter;

    — volume diameter;

— rank-order size;

    — maximum size;

    — minimum size;

    — average size;

    — median size;

— mid-range size;

— range size.

This part of ISO 14405 defines tolerances of linear sizes when there is:

— a + and/or − limit deviation (e.g. 0/−0,019) (see Figure 9);

— an upper limit of size (ULS) and/or lower limit of size (LLS) (e.g. 15,2 max., 12 min. or 30,2/30,181) (see Figure 11);

— an ISO tolerance class code in accordance with ISO 286-1 (e.g. 10 h6) (see Figure 10)

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

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

2   Normative references

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

ISO 286-1:2010, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits*

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

ISO 8015:—[1], *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

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

ISO 14660-2:1999, *Geometrical product specifications (GPS) — Geometrical features — Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

ISO 17450-1:—[2], *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

ISO 17450-2:—[3], *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

ISO 81714-1:—[4], *Design of graphical symbols for use in the technical documentation of products — Part 1: Basic rules*

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1) To be published. (Revision of ISO 8015:1985)

2) To be published. (Revision of ISO/TS 17450-1:2005)

3) To be published. (Revision of ISO/TS 17450-2:2002)

4) To be published. (Revision of ISO 81714-1:1999)

3 Terms and definitions

For the purposes of this document, the terms and definitions of ISO 286-1, ISO 8015, ISO 14660-1, ISO 14660-2, ISO 17450-1, ISO 17450-2 and the following apply.

3.1
specification modifier
GPS specification element that changes the default definition of the basic GPS specification when applied

NOTE   Specification modifiers may be defined by International Standards, national standards or by company standards/documents.

[ISO 17450-2:—, 3.5.2]

3.2
feature of size
geometrical shape defined by a linear or angular dimension which is a **size** (3.8)

NOTE 1   The features of size can be a cylinder, a sphere, two parallel opposite surfaces, a cone or a wedge.

NOTE 2   In International Standards such as ISO 286-1 and ISO/R 1938, the meanings of the terms "plain workpiece" and "single features" are close to that of "feature of size".

[ISO 14660-1:1999, 2.2]

NOTE 3   The types of feature of size covered by this part of ISO 14405 are given in Figures 1 and 2.
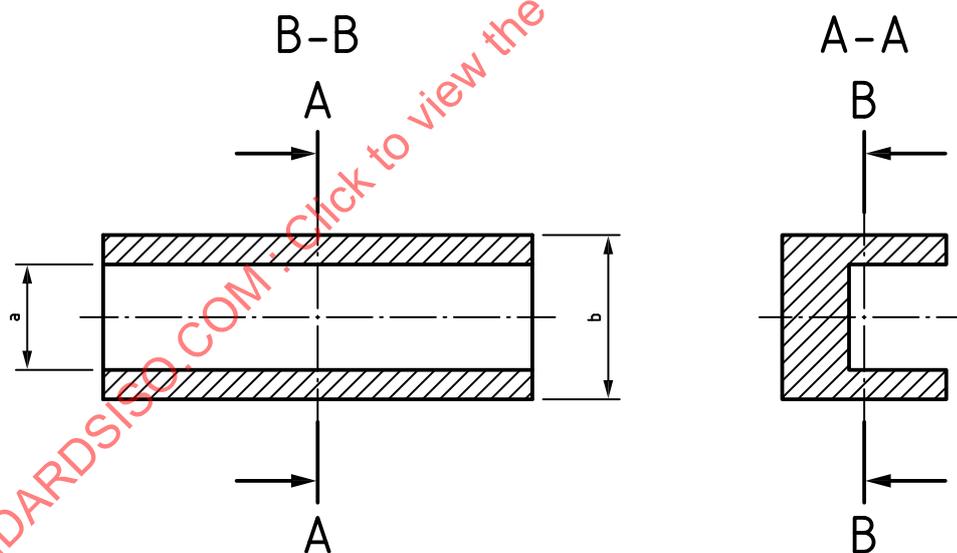
a) **Nominal features of size (internal and external)**
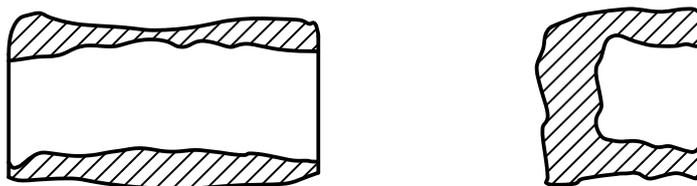
b) **Extracted feature**

a   Size of internal feature of size.

b   Size of external feature of size.

Figure 1 — Feature of sizes relative to two opposite planes

3

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

b) **Extracted feature**

a Size of internal feature of size.
b Size of external feature of size.

Figure 2 — Example of feature of size relative to a cylinder

3.3
upper limit of size
ULS
largest permissible size of a **feature of size** (3.2)

[ISO 286-1:2010, 3.2.3.1]

3.4
lower limit of size
LLS
smallest permissible size of a **feature of size** (3.2)

[ISO 286-1:2010, 3.2.3.2]

3.5
default specification operator
ordered set of default specification operations only, in the default order
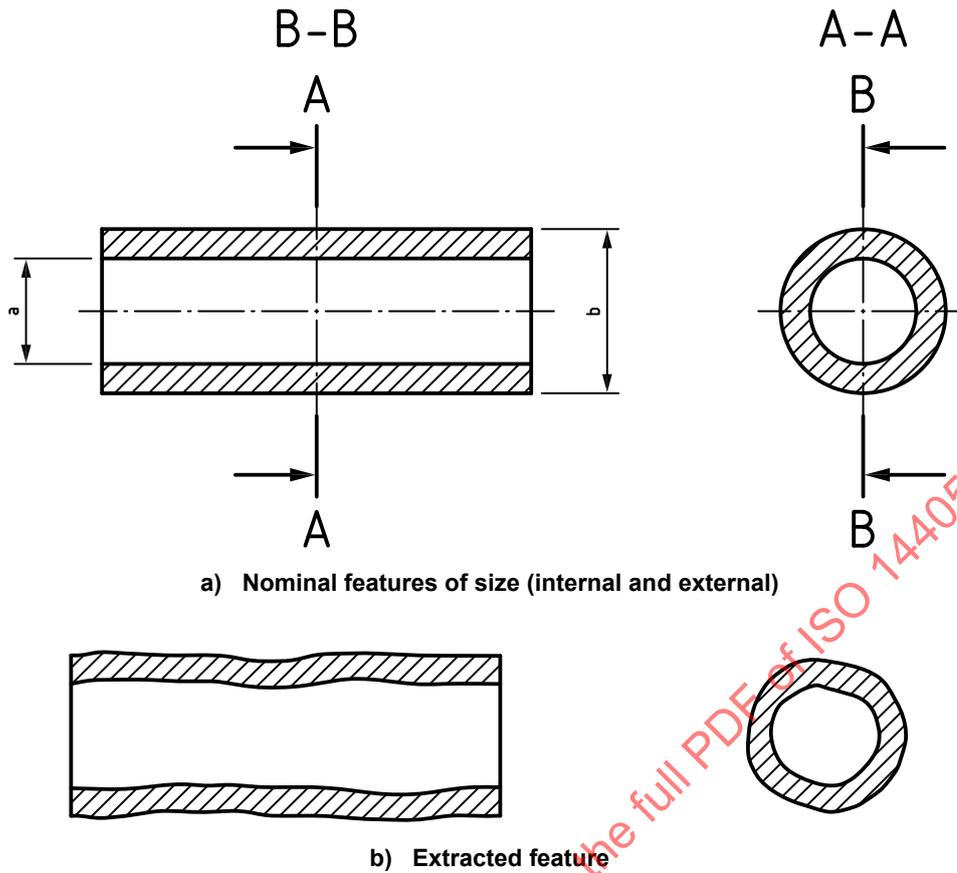
NOTE 1   The default specification operator can be

⎯   an ISO default specification operator specified by ISO International Standards, or

⎯   a national default specification operator specified by national standards, or

⎯   a company default specification operator specified by company standards/documents, or

⎯   a drawing default specification operator indicated on the drawing according to one of the above.

NOTE 2   The default specification operator applies when the ISO basic GPS specification is used on the drawing.

NOTE 3   According to the ISO basic GPS specification for size, the tolerance is indicated by upper and/or lower deviation limits, or upper and/or lower limits of size (see Table 4), or by ISO tolerance codes in accordance with ISO 286-1 with no **specification modifiers** (3.1).

NOTE 4   The ISO default specification operator for size is given in this part of ISO 14405 (see 5.2).

NOTE 5   Adapted from ISO 17450-2:—. The definition and first note are identical and the original second note and examples are not included here. Notes 2 to 4 have been added.

3.6
drawing-specific default GPS specification operator
specification operator required by technical documentation, applicable only for the actual specification and containing only default specification operations in the default order

NOTE 1   See ISO 8015.

NOTE 2   The drawing-specific default specification operator of size is indicated by a specific statement close to the title block (see 5.3).

3.7
special specification operator
specification operator including one or more special specification operations

NOTE 1   The special specification operator is defined by a GPS specification.

NOTE 2   A special specification operator may be a complete specification operator or an incomplete specification operator.

EXAMPLE 1   The specification for a shaft of $\varnothing 30 \pm 0,1$ Ⓔ is a special specification operator, because one of the specification operations, the association of the minimum circumscribed cylinder, is not a default specification operation.

EXAMPLE 2   The specification of Ra 1,5 using a 2,5 mm filter for a surface is a special specification operator, because one of the specification operations, the cut-off length used in the filtration, is not a default specification operation.

[ISO 17450-2:—, 3.3.7]

3.8
size
intrinsic characteristic of a **feature of size** (3.2) that can be defined on a nominal feature or on an associated feature

NOTE 1   In this part of ISO 14405, the size corresponds to the diameter of a cylinder, or to the distance between two parallel opposite planes. Depending on the type of feature of size, the terms "diameter" and "distance" are synonyms for size.

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

3.9
size characteristic
characteristic relative to a **size** (3.8) and defined on an extracted feature

See Figure B.1.

NOTE   A size can be evaluated by more than one size characteristic (e.g. the two-point diameter or the diameter of the associated feature, taken on the extracted feature).

3.10
local size
local linear size
local size characteristic
local linear size characteristic
size characteristic (3.9) having by definition a non-unique result of evaluation along and/or around the **feature of size** (3.2)

NOTE 1   For a given feature, an infinity of local sizes exists.

NOTE 2   In this part of ISO 14405, "local size" is used instead of "local linear size".

NOTE 3   In Figure 3, examples of local size are shown. These examples do not take into account the **rank-order size** (3.11.2.2).

3.10.1
two-point size
⟨local size⟩ distance between two opposite points taken on the **feature of size** (3.2)

NOTE 1   A two-point size taken on cylinder can be called a "two-point diameter". In ISO 14660-2, this is defined as a local diameter of an extracted cylinder.

NOTE 2   A two-point size taken on two opposite planes can be called a "two-point distance". In ISO 14660-2, this is defined as a local size of two parallel extracted surfaces.

3.10.2
section size
global size (3.11) for a given cross section of the extracted feature

NOTE 1   A section size is a **local size** (3.10) for the complete toleranced **feature of size** (3.2).

NOTE 2   The cross section is defined with the same criterion as the one taken to define the **direct global size** (3.11.1).

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

3.10.3
portion size
global size (3.11) for a given portion of the extracted feature

NOTE   A portion size is a **local size** (3.10) for the complete toleranced **feature of size** (3.2).
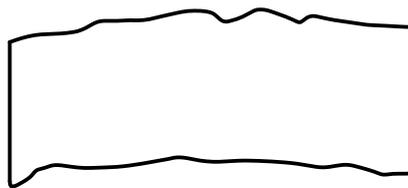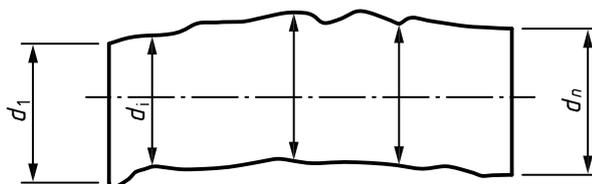
3.10.4
spherical size
⟨local size⟩ diameter of the maximum inscribed sphere

NOTE   This local size, defined by a sphere, applies to the feature of size types "cylinder" and "two parallel opposite planes".

See Figure 3 c).

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

b) Two-point size
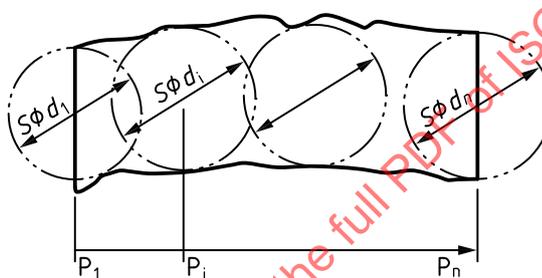
c) Spherical size
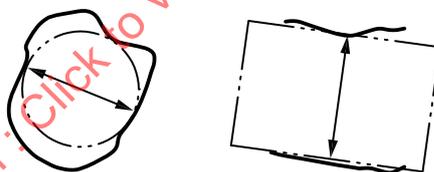
d) Section size obtained from a direct global size with maximum
inscribed criterion (other criteria are possible)

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

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

Key

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

Figure 3 — Examples of local size

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3.11
global size
global linear size
global size characteristic
global linear size characteristic
size characteristic (3.9) having by definition a unique result of evaluation along and around the toleranced
feature of size (3.2)

3.11.1
direct global size
direct global linear size
direct global size characteristic
direct global linear size characteristic
⟨global size⟩ **size** (3.8) of the associated feature, which is of the same geometrical type as the **feature of size** (3.2)

NOTE 1   The different direct global linear sizes on the complete tolerance feature are given in Figure 4.

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

3.11.1.1
least-squares size
⟨global size⟩ **size** (3.8) of the associated feature established from the extracted feature(s) with the total least-squares criterion

NOTE   In this part of ISO 14405, "total least-squares" is referred to only as "least-squares".

3.11.1.2
maximum inscribed size
⟨global size⟩ **size** (3.8) of the associated feature established from the extracted feature(s) with the maximum inscribed criterion

NOTE   In the case of an internal feature of size, the maximum inscribed size was previously called "mating size for an internal feature".

3.11.1.3
minimum circumscribed size
⟨global size⟩ **size** (3.8) of the associated feature established from the extracted feature(s) with the minimum circumscribed criterion

NOTE   In the case of an external feature of size, the minimum circumscribed size was previously called "mating size for an external feature".

3.11.2
indirect global size
indirect global linear size
indirect global size characteristic
indirect global linear size characteristic
rank-order size (3.11.2.2) or global **calculated size** (3.11.2.1)

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

a) Extracted feature under consideration which could be either an internal or external feature and either a cylinder or two opposite planes
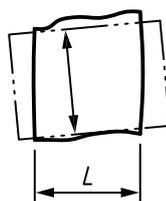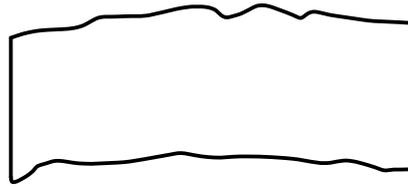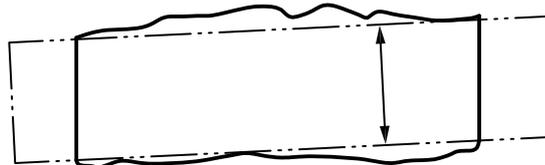
b) Maximum inscribed size
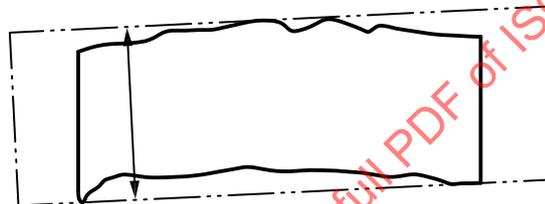
c) Minimum circumscribed size
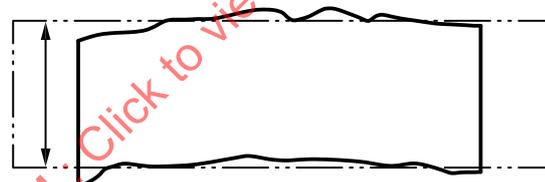
d) Least-squares size

Figure 4 — Illustration of direct global sizes

3.11.2.1
calculated size
size (3.8) obtained by using a mathematical formula that relates the intrinsic characteristic of a feature to one or several other dimensions of the same feature

NOTE   The calculated size can be a **local size** (3.10) or a **global size** (3.11).

3.11.2.1.1
circumference diameter
⟨of an extracted cylinder⟩ **calculated size** (3.11.2.1), giving the diameter, d, obtained from the following equation:

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

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

See Figure 5.

NOTE 1   The circumference diameter is defined in a cross section.

NOTE 2   Several criteria can be used for the operation of association to orient the cross section, and different results are obtained according to the chosen criterion. The default criterion is the least-squares associated cylinder of the feature (see ISO 14660-2:1999, 4.2.1).

NOTE 3   In cases where the feature is non-convex, the circumference diameter can be larger than the minimum circumscribed diameter and depends on the filtration criteria used.

Key

L length of the outline (extracted line)

d circumference diameter, equal to L divided by π

Figure 5 — Example of circumference diameter

3.11.2.1.2
area diameter
⟨of an extracted cylinder⟩ **calculated size** (3.11.2.1), giving the diameter, d, obtained from the following equation:

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

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

See Figure 6.

NOTE 1   The area diameter is defined in a cross section.

NOTE 2   Several criteria may be used for the operation of association to orient the cross section, and different results are obtained according to the chosen criterion. The default criterion is the least-squares associated cylinder of the feature (see ISO 14660-2:1999, 4.2.1).

Key

A area inside outline of the extracted line

d area diameter, calculated from A

Figure 6 — Example of area diameter

3.11.2.1.3
volume diameter
⟨of an extracted cylinder⟩ **calculated size** (3.11.2.1), giving the diameter, d, obtained from the following equation:

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

where

V is the volume limited by the integral extracted cylinder;

L is the height of the cylinder taken between two parallel planes perpendicular to the axis of the least-squares associated cylinder with the maximum distance between them and containing a complete section of the feature

See Figure 7.

NOTE   Several criteria may be used for the operation of association to orient the cross sections intersecting the extracted cylinder and defining L; different results are obtained according to the chosen criterion. The default criterion is the least-squares associated cylinder of the feature (see ISO 14660-2:1999, 4.2.1).
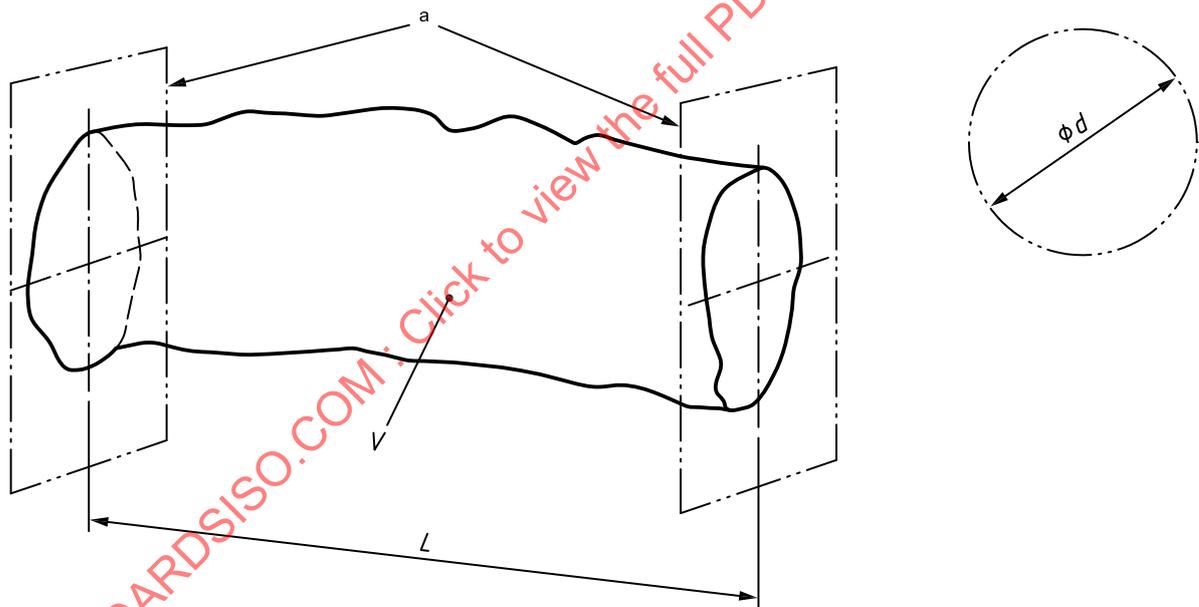
Key
V volume of the extracted feature
L length of the cylinder
d volume diameter, calculated from V and L

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

Figure 7 — Example of volume diameter

3.11.2.2
rank-order size
size characteristic (3.9) defined mathematically from a homogeneous set of **local size** (3.10) values obtained along and/or around the toleranced feature

NOTE 1   A rank-order size can be used to define an **indirect global size** (3.11.2) from a **local size** (3.10) [**portion size** (3.10.3), **section size** (3.10.2), **spherical size** (3.10.4), **two-point size** (3.10.1)].

NOTE 2   A rank-order size can be used to define a local size from another local size (for example to define a rank order section size from a two-point size taken in the section).

NOTE 3   The different types of rank-order size defined in this part of ISO 14405 are illustrated in Figure 8.

3.11.2.2.1
maximum size
rank-order size (3.11.2.2) defined as the maximum of the set of values of a **local size** (3.10) along and/or around the toleranced feature

3.11.2.2.2
minimum size
rank-order size (3.11.2.2) defined as the minimum of the set of values of a **local size** (3.10) along and/or around the toleranced feature

3.11.2.2.3
average size
rank-order size (3.11.2.2) defined as the average of the set of values of a **local size** (3.10) along and/or around the toleranced feature

3.11.2.2.4
median size
rank-order size (3.11.2.2) defined as the median value of the set of values of a **local size** (3.10) along and/or around the toleranced feature median size

NOTE   The median value allows the population of local 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.

3.11.2.2.5
mid-range size
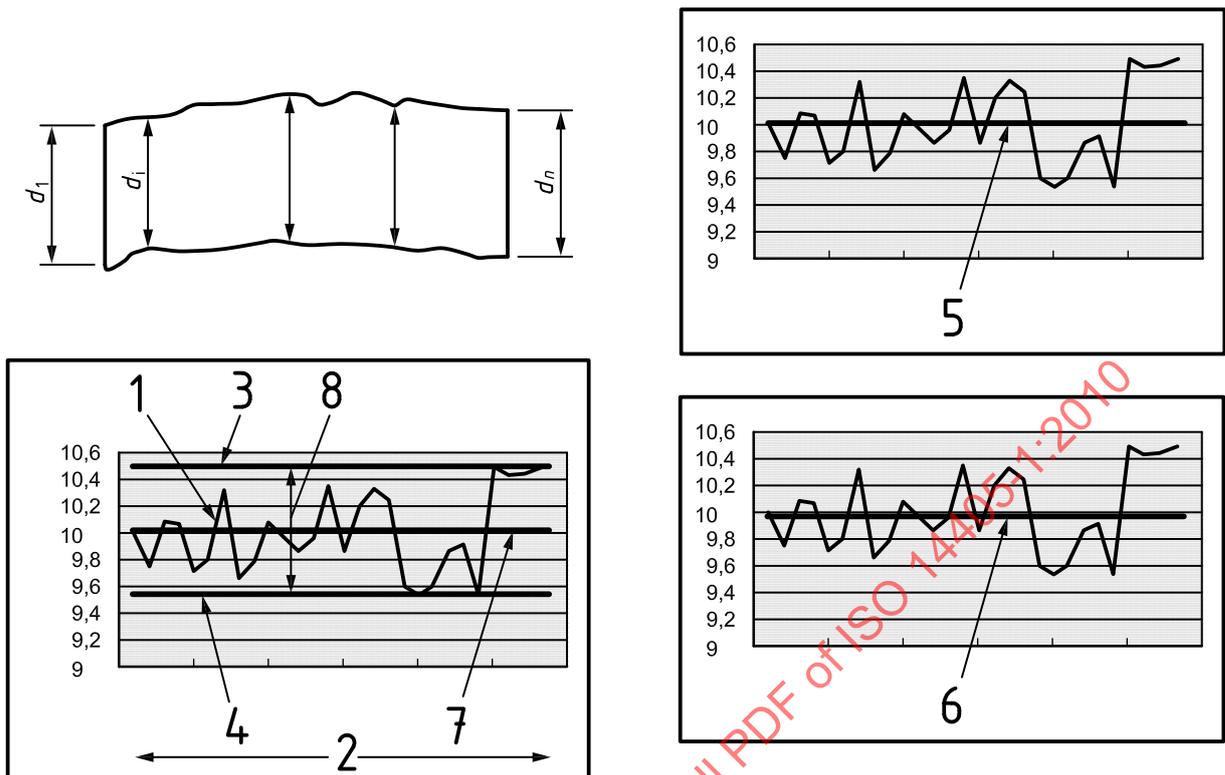**rank-order size** (3.11.2.2) defined as the mean of the maximum and the minimum of the set of values of a **local size** (3.10) along and/or around the toleranced feature

3.11.2.2.6
range of sizes
rank-order size (3.11.2.2) defined as the difference between the maximum and the minimum of the set of values of a **local size** (3.10) along and/or around the toleranced feature

Key

1	set of values of local sizes	5	average size ($= 10{,}011\ 69$)
2	position along the axis	6	median size ($= 9{,}969\ 86$)
3	maximum size ($= 10{,}497\ 88$)	7	mid-range size ($= 10{,}020\ 345$)
4	minimum size ($= 9{,}542\ 81$)	8	size range ($= 0{,}955\ 07$)
d	values of local size		

Figure 8 — Example of rank-order sizes based on the two-point size

3.12
envelope requirement
simultaneous use of a combination of the **two-point size** (3.10.1) as the specification operator applied for the least material limit of the **size** (3.8) and either the **minimum circumscribed size** (3.11.1.3) or the **maximum inscribed size** (3.11.1.2) as the specification operator applied for the maximum material limit of the size

NOTE   The "envelope requirement" was previously referred to as the "Taylor principle".

3.12.1
envelope requirement for external features of size
simultaneous use of a combination of the **two-point size** (3.10.1) as the specification operator applied for the **lower limit of size** (LLS) (3.4) and the **minimum circumscribed size** (3.11.1.3) as the specification operator applied for the **upper limit of size** (ULS) (3.3)

3.12.2
envelope requirement for internal features of size
simultaneous use of a combination of the **two-point size** (3.10.1) as the specification operator applied for the **upper limit of size** (ULS) (3.3) and the **maximum inscribed size** (3.11.1.2) as the specification operator applied for the **lower limit of size** (LLS) (3.4)

3.13
common feature of size tolerance
single tolerance applied to several separate features considered as one **feature of size** (3.2)

See 7.7 and Figure 27.

4 Specification modifiers and symbols

For the purposes of this part of ISO 14405, the specification modifiers and symbols in Tables 1 and 2 apply.

To define in a dimensional specification a specific type of size characteristic available for upper and/or lower limit specification, modifiers or symbols shall be used in the sequence as defined in Table 3.

The combination of these modifiers and symbols is described in Clauses 5, 6 and 7. Rules for the presentation of graphical symbols are given in Annex A.

Table 1 — Specification modifiers for linear size

Modifier	Description
(LP)	Two-point size
(LS)	Local size defined by a sphere
(GG)	Least-squares association criterion
(GX)	Maximum inscribed association criterion
(GN)	Minimum circumscribed association criterion
(CC)	Circumference diameter (calculated size)
(CA)	Area diameter (calculated size)
(CV)	Volume diameter (calculated size)
(SX)	Maximum size[a]
(SN)	Minimum size[a]
(SA)	Average size[a]
(SM)	Median size[a]
(SD)	Mid-range size[a]
(SR)	Range of sizes[a]
[a] Rank-order size can be used as a supplement to calculated portion size or global portion size or local size (see 3.11.2.2 and 6.2).	

Table 2 — General specification modifiers for size

Description	Symbol	Reference	Example of indication
Envelope requirement	Ⓔ	6.2.2	10 ± 0,1 Ⓔ
Any restricted portion of feature	/Length	7.3	10 ± 0,1 ⒼⒼ/5
Any cross section	ACS	7.4	10 ± 0,1 ⒼⓍ ACS
Specific fixed cross section	SCS	7.5	10 ± 0,1 ⒼⓍ SCS
More than one feature	Number ×	7.6 7.7	2 × 10 ± 0,1 Ⓔ
Common tolerance	CT	7.7	2 × 10 ± 0,1 Ⓔ CT
Free-state condition	Ⓕ	7.8	10 ± 0,1 ⓁⓅⓈⒶⒻ
Between	◄►►	7.2 to 7.3	10 ± 0,1 A◄►►B

NOTE   The specification modifier Ⓔ was previously defined in ISO 8015:1985. There has been no change in the meaning of Ⓔ as defined in this part of ISO 14405.

Table 3 — Sequence of modifiers to refer to a specific size characteristic

Type of size characteristic	Subtype	Additional definition	Associated modifiers
Local size	Two-point size		ⓁⓅ
	Spherical size		ⓁⓈ
	Section size	With least-squares association criteria	ⒼⒼ ACS
		With maximum inscribed association criteria	ⒼⓍ ACS
		With minimum circumscribed association criteria	ⒼⓃ ACS
		Calculated size with circumference diameter	ⒸⒸ
		Calculated size with area diameter	ⒸⒶ
		Rank-order size of spherical size or two-point size	Example: ⓁⓈ ACS ⓈⒶ
	Portion size of length L	With least-squares association criteria	Example: ⒼⒼ/20
		With maximum inscribed association criteria	Example: ⒼⓍ/15
		With minimum circumscribed association criteria	Example: ⒼⓃ/30
		Calculated size with volume diameter	Example: ⒸⓋ/10
		Rank-order size of section size or spherical size or two-point size	Example: ⓁⓈ /20 ⓈⓍ

Table 3 (*continued*)

Type of size characteristic	Subtype	Additional definition		Associated modifiers
Global size	Direct global size	With least-squares association criteria		Ⓖ Ⓖ
		With maximum inscribed size		Ⓖ Ⓧ
		With minimum circumscribed size		Ⓖ Ⓝ
	Calculated global size	Calculated size with volume diameter		Ⓒ Ⓥ
	Indirect global size	Rank-order size based on a local size		Example: Ⓛ Ⓢ Ⓢ Ⓝ
Local and global size	Envelope requirement	Combination of Ⓛ Ⓟ and Ⓖ Ⓧ or Ⓖ Ⓝ		Ⓔ

5 Default specification operator for size

5.1 General

When the basic GPS indication is used for linear size, the default specification operator for size applies. The default specification operator for size can be:

— the ISO default GPS specification operator (see 5.2 and ISO 8015:—);

— the drawing-specific default GPS specification operator (see 5.3);

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

The basic GPS specification for linear size has no specification modifier attached and can be one of five types; see Table 4.

NOTE   The specification with the ISO tolerance code or with upper and lower values is equivalent.

Table 4 — Different basic GPS specifications for size

Basic GPS specification for linear size	Examples			Figure
Nominal size ± deviation limits	$150 \, ^{0}_{-0,2}$;	$\varnothing 38 \, ^{+0,2}_{-0,1}$;	$55 \pm 0,2$	9
Nominal size followed by tolerance code in accordance with ISO 286-1	68 H8;	$\varnothing$ 67 k6;	165 js10	10
Values of upper and lower limits of size	85,2 84,8	29,000 28,929	120,2 119,8	11
Values of upper or lower limits of size	85,2 max. 84,8 min.			—
General tolerancing defined by a nominal size neither indicated in brackets nor as a theoretically exact dimension (TED) (squared dimension)	10 and in the title block ISO 2768-m[a]			—
[a] See ISO 2768-1 for information on general tolerancing.				

5.2 ISO default specification operator for size

The ISO default specification operator for size (without specification modifier) is the two-point size.

The ISO default specification operator for size applies when there is no indication on the drawing referring to another default specification for size as defined in 5.3.

If the two-point size (default) is applied for both specified limits, the (LP) modifier shall not be indicated.

If the two-point size is applied only for one of the two specified limits, the (LP) modifier shall be indicated after the relevant limit of size or deviation limit (see 6.2.2).

See Figures 9, 10 and 11. The consequences of this default definition are given in Annex C.

a) Feature of size type: cylinder   b) Feature of size type: two parallel opposite planes

Figure 9 — Example: ISO basic GPS specification of size — Nominal size ± deviation limits

a) Feature of size type: cylinder   b) Feature of size type: two parallel opposite planes

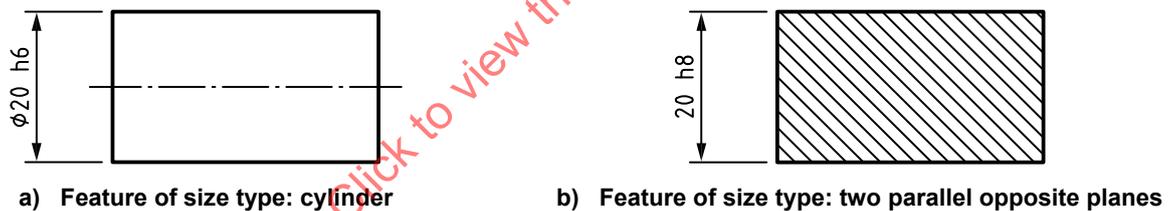**Figure 10 — Example: ISO basic GPS specification of size —
Nominal size followed by ISO tolerance code — ISO 286-1**

a) Feature of size type: cylinder   b) Feature of size type: two parallel opposite planes
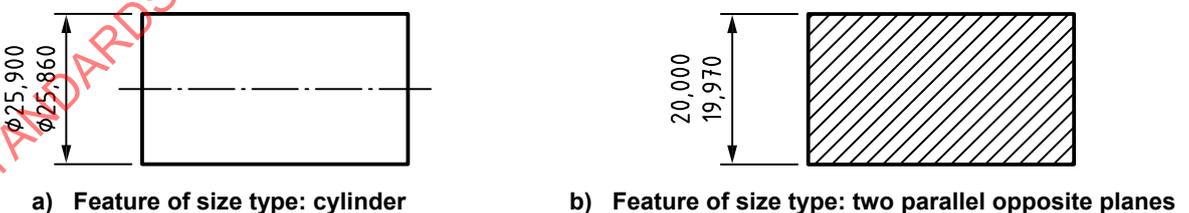
**Figure 11 — Example: ISO basic GPS specification of size —
Values of upper and lower limits of size (ULS and LLS)**

5.3 Drawing-specific default specification operator for size

When a drawing-specific default specification operator for size applies, it shall be indicated on the drawing in or near the title box in the following order:

— reference to this International Standard, i.e. "Size ISO 14405";

— the specification modifier(s) for the chosen default definition of size.

See also Figure 12.
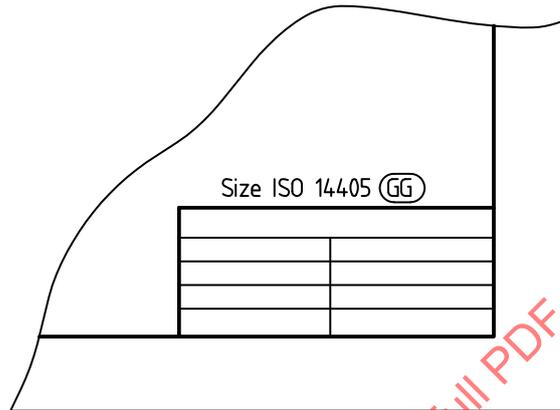
NOTE 1   The default specification operator for this drawing is not the two-point size but is changed to the least-squares size. Other examples can be

"Size ISO 14405 Ⓔ "   changing the default specification operator to the envelope requirement, or

"Size ISO 14405 ⒸⒸ "   changing the default specification operator to the circumference diameter, etc.

NOTE 2   The default specification operator is the default size, unless otherwise stated.

NOTE 3   To facilitate the reading of the drawing, it is possible to indicate all other types of modifiers by listing them in brackets after the specific default specification indication, for example

"Size ISO 14405 Ⓔ (ⓁⓅ ACS ⓈⒶ)".

Figure 12 — Example: Change of default specification operator for size for the entire drawing

6   Drawing indication for special specification operators for size

6.1   General

A tolerance indication for size by default applies to one single complete feature of size (see 6.2 and 7.1). It is possible to indicate that

a)   the tolerance applies to any restricted part or a fixed restricted part of the feature of size (see 7.2, 7.3, 7.4 and 7.5), or that

b)   the tolerance applies to more than one feature of size (see 7.6 and 7.7).

Dimensioning and tolerancing of a fit may take place on an assembly drawing, eliminating the possibility for misinterpretation (see Figures 13 and 14).

When the ISO default specification operator for size characteristics does not apply, the tolerance indication shall indicate which special specification operator(s) for size(s) applies.

When the ISO default specification operator for size characteristics does not apply, specification modifiers (see Tables 1 and 2) shall be used to select the appropriate size characteristics.

The specification modifiers shall be used in a set with the basic GPS specification for size. The modifier "Number ×" for more than one feature shall be placed in front of the nominal size value(s), e.g. 2× and 5× (see 7.6 and 7.7).

The other specification modifiers shall be used in the following order (some modifiers may be omitted in a tolerance specification) after the tolerance value or the tolerance code or the value(s) of the limit of size:

— modifier for type of size characteristic: local size or global size or calculated size, e.g. (LP), (GG), (CC) and (E);

— modifier for a fixed restricted portion or any restricted portion or any cross section of the complete feature, e.g. "/ 25" and "ACS" (see 7.2, 7.3, 7.4);

— modifier for specific cross section "SCS" (see 7.5);

— modifier for rank order, e.g. (SX), (SN) or (SA); when the toleranced feature is "any portion of the feature" or "any cross section of the feature" or "any cross section in part of the feature", the rank-order modifier shall be placed after the modifier for restricted portion or a cross section of the complete feature, e.g. 25 ± 0,1 (GG)/25(SA) and 12 ± 0,05 (GG)ACS(SX);

— modifier for common feature of size tolerance, i.e. "CT" (see 7.7);

— modifier for free-state condition, i.e. (F) (see 7.8).

When the set of specification modifiers applies to both the upper and lower limits of size, only one set of specification modifiers shall be used (see Figures 15, 16, 17, 23, 24, 25, 26, 27 and 28).

When different specification modifiers are chosen for the upper and lower limits of size, a set of specification modifiers shall be attached to the upper and the lower deviation limits indication (see 6.2.2). There is an exception to this rule which relates to the use of the envelope requirement.

NOTE   The envelope requirement indicated by the specification modifier (E) is a simplified indication of two different specification operators (see 3.12, 6.2.3 and Figures 13, 14, 19, 20 and 28).

When a range (rank-order) size is required, the indication of the tolerance limits does not need the nominal value and is not mandatory, as defined in Clause 5. In this case, the value is defined by default in the general unit of the drawing and corresponds to the upper limit without the additional indication "max.". For example, 0,004 (SR) means that the difference between the maximum value and the minimum value of the two-point size characteristic shall be less than or equal to 0,004 (see Figure 17).

When a unilateral tolerance indication is used, the modifiers shall be placed after the "max" or "min" symbol, e.g. ∅54,6 max(GG) and ∅45,9 min(GG).
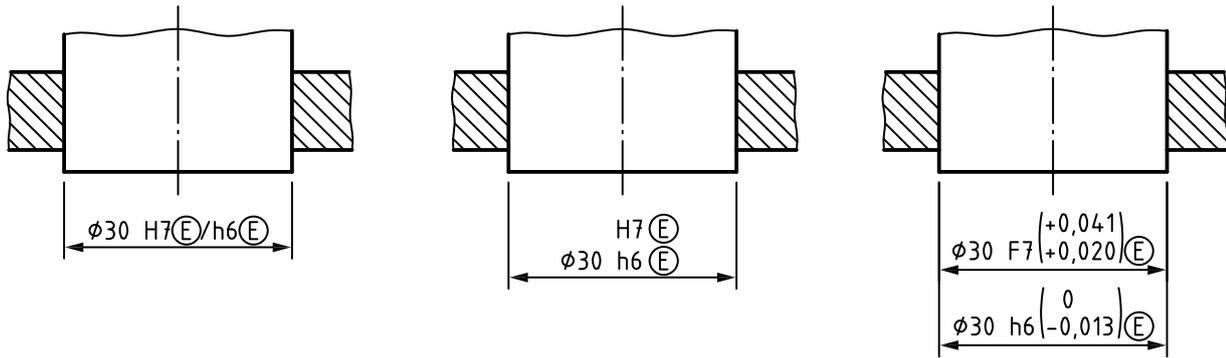
Figure 13 — Examples of assembly drawing with ISO code system tolerancing of two features in a fit
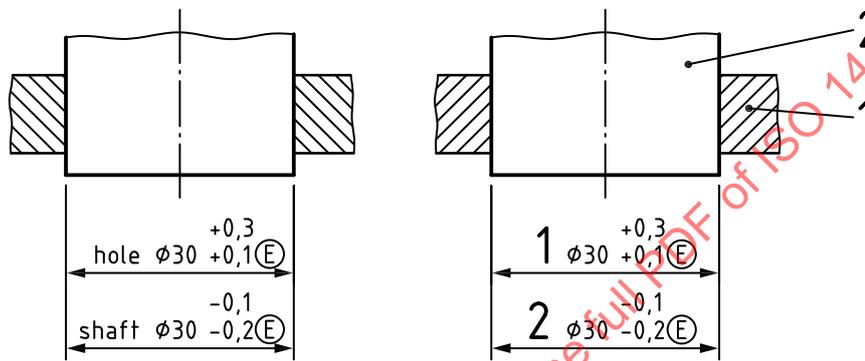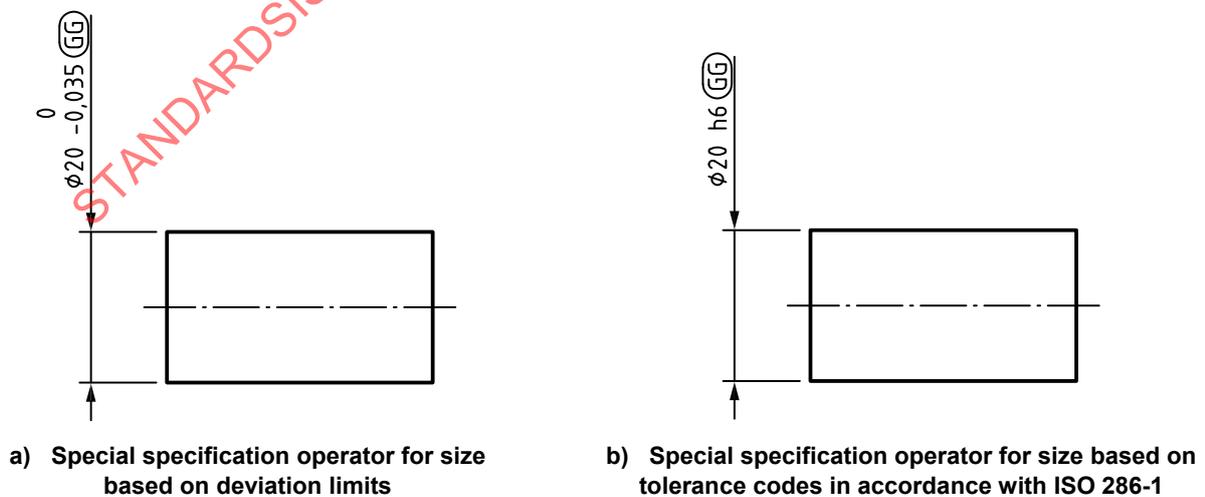

Figure 14 — Examples of assembly drawing with plus and minus tolerancing of two features in a fit

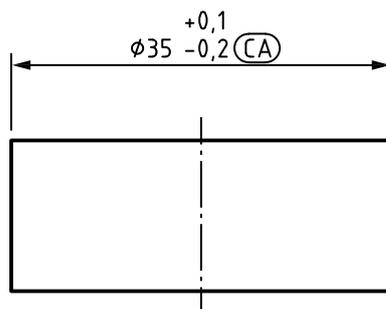## 6.2 Indication with one or more specification operators

6.2.1 Same specification operator for upper limit of size and lower limit of size

If the same special specification operator applies to the upper limit of size as well as the lower limit of size, only one set of specification modifiers shall be used (see Figures 15, 16 and 17).


a) Special specification operator for size based on deviation limits

b) Special specification operator for size based on tolerance codes in accordance with ISO 286-1

NOTE   The specification operator "least-squares size" applies to the upper as well as the lower deviation limit.

Figure 15 — Example: Indication of a special specification operator for size

NOTE   The specification operator "area diameter" applies to the upper and lower limits of size.

Figure 16 — Example: Same specification operator for upper limit of size and lower limit of size
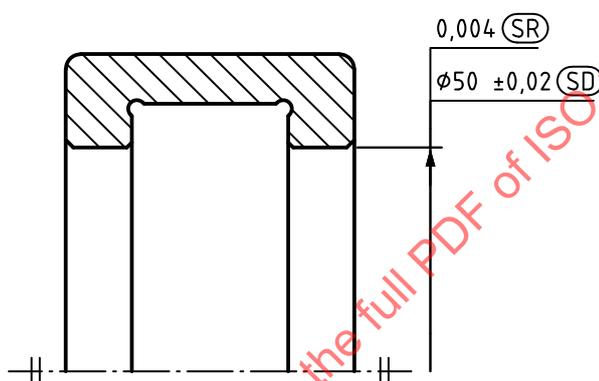
NOTE   Indicated specification operators: the upper and lower limit of size ($\varnothing 50 \pm 0,02$) apply to the mid-range size of the two-point size values and the upper limit (0,004) applies to the size range of the two-point size values.

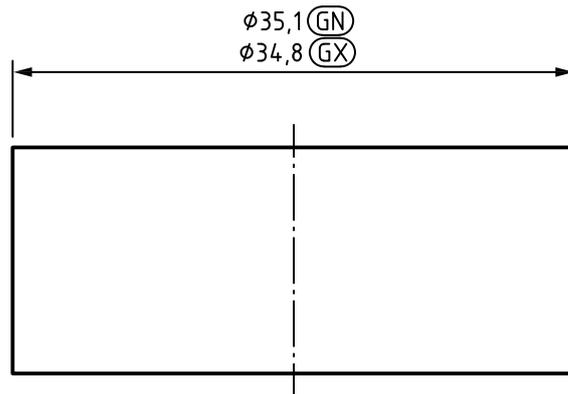**Figure 17 — Examples of the use of rank-order specification modifier**

6.2.2   Different specification operator for upper limit of size and lower limit of size

If different specification operators apply for the upper and the lower limit of size, the specification operators are indicated either

a)   attached to each of the limits of size or deviation limits or tolerance code indications (see Figures 18 and 19), or

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

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

2)   a space, a hyphen and a space;

3)   the specification operator for the lower limit of size, in square brackets.

NOTE   When different specification operators are applied for the upper limit and the lower limit, each specification operator is described using modifiers, even if one is the default operator.

EXAMPLE $2 \times \varnothing 78 \begin{array}{l} +0,2 \text{ (GN) / 15} \\ -0,2 \text{ (LP) (SA)} \end{array}$ or $2 \times \varnothing 78 \ [+ 0,2 \ \text{(GN)} / 15] - [-0,2 \ \text{(LP) (SA)}]$

Ø35,1 GN
Ø34,8 GX

NOTE   The specification operators indicated are "minimum circumscribed" which applies to the upper limit of size and "maximum inscribed" which applies to the lower limit of size.

Figure 18 — Example: Different specification operators for the upper and lower limits of size

The envelope requirement, Ⓔ, is a simplification of two specific specification operators. The envelope requirement can also be specified using two different specification modifiers: one for the upper limit of size and one for the lower limit of size (see Figure 19).

For external features of size, the specification modifier Ⓔ has the same meaning as:

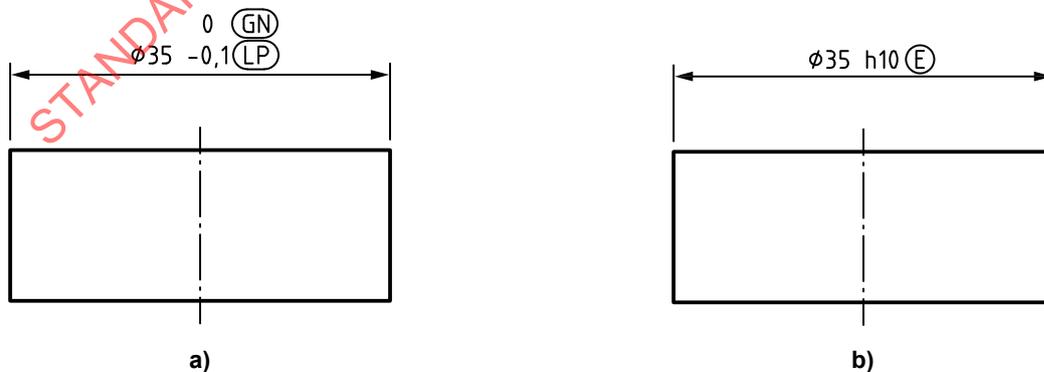GN applied to the upper limit of size, and LP applied to the lower limit of size.

EXAMPLE 1

$$165 \begin{array}{c} 0 \\ -0,25 \end{array} Ⓔ \quad \text{is the same as} \quad 165 \begin{array}{cc} 0 & GN \\ -0,25 & LP \end{array}$$

For internal features of size, the specification modifier Ⓔ has the same meaning as:

LP applied to the upper limit of size, and GX applied to the lower limit of size.

EXAMPLE 2

$$165 \begin{array}{c} +0,25 \\ 0 \end{array} Ⓔ \quad \text{is the same as} \quad 165 \begin{array}{cc} +0,25 & LP \\ 0 & GX \end{array}$$

Ø35 $\begin{array}{cc} 0 & GN \\ -0,1 & LP \end{array}$

Ø35 h10 Ⓔ

a)   b)

NOTE   The specification operators indicated are "minimum circumscribed" which applies to the upper limit of size and "two-point size" which applies to the lower limit of size.

Figure 19 — Possible indications to express the envelope requirement

6.2.3   More than one size characteristic requirement applied to a feature of size

If more than one size characteristic requirement is applied to a feature of size, it shall be specified on a separate dimension line [see Figure 20 a)] or simultaneously on one dimension line [see Figures 20 b) and c)].

NOTE   If the space is not sufficient on the dimension line, the specifications can be placed on a reference line connected to the dimension line with a leader line; see Figure 20 c).

a)   b)   c)
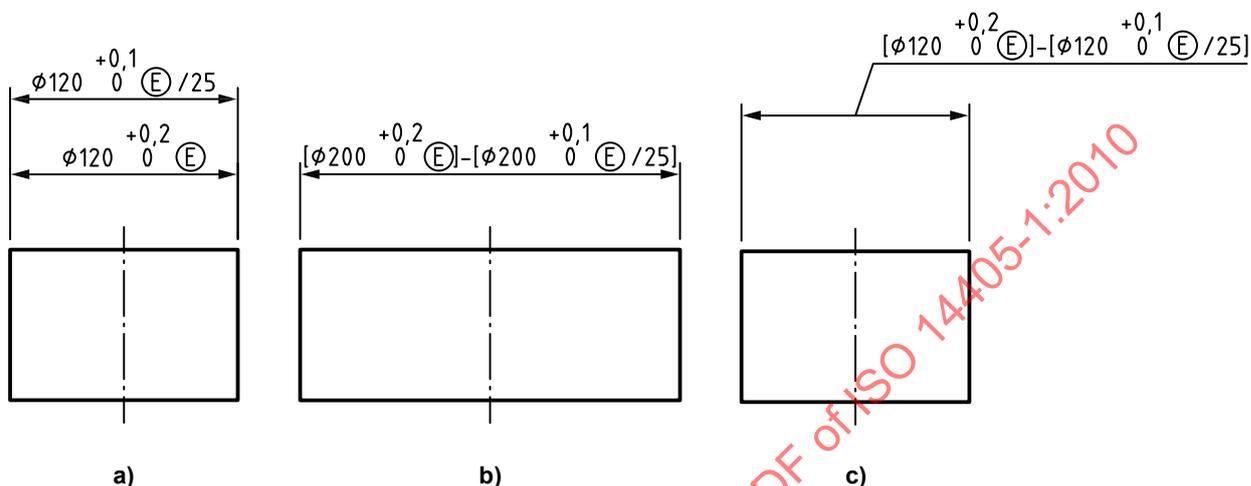
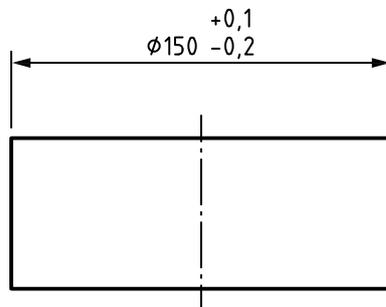NOTE   The two specification operators indicated in Figure 20 a), b) and c) are

1)   the envelope requirement 0/+0,2 for the complete feature of size, and

2)   the envelope requirement 0/+0,1 for any restricted length of 25 mm of the feature of size.

Figure 20 —Example: More than one requirement for size for the same feature of size

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

7.1   Complete toleranced feature of size

The specification applies by default to the complete toleranced feature of size. When the toleranced feature is the complete feature, no additional indication is necessary (see Figure 21).

NOTE   The specification operators indicated are the default operators. The two-point diameter for any cross section of the complete feature of size applies to both the upper and the lower deviation limits.

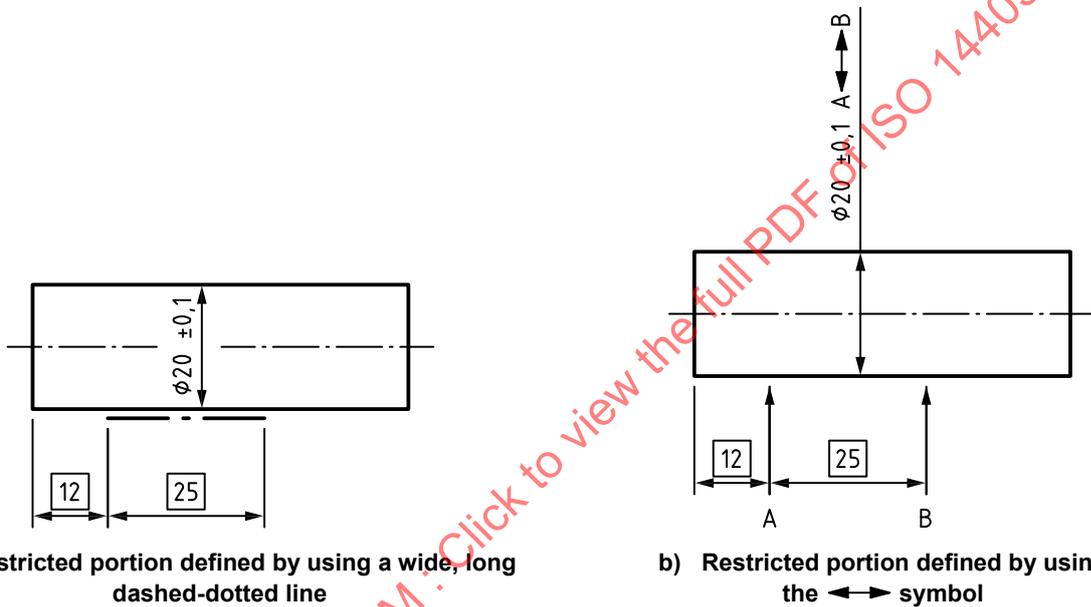**Figure 21 — Example: Requirement for the complete feature of size**

7.2   Specific fixed restricted portion of the feature of size

If the specification applies to only one fixed restricted portion of the complete feature of size, it shall be indicated by

⎯ a long-dashed dotted wide line to specify the restricted part of the complete feature, with the dimension line pointed over it [see Figure 22 a)], or

⎯ using the two letters defining the beginning and the end of the fixed restricted portion; these two letters follow the tolerance of the size and are separated by the "between" symbol [see Figure 22 b)].

The extension of the portion and its location shall be defined by theoretical exact dimensions (TEDs).

NOTE   Dimensions specifying the restricted part are stated without tolerance.

a)   **Restricted portion defined by using a wide, long dashed-dotted line**

b)   **Restricted portion defined by using the ◄──► symbol**

NOTE   The specification operators indicated are the default operators. The two-point diameter for any cross section of the restricted portion of the feature of size applies to both the upper and lower limits of size.

Figure 22 — Example: Requirement for a specified fixed restricted portion of the feature of size
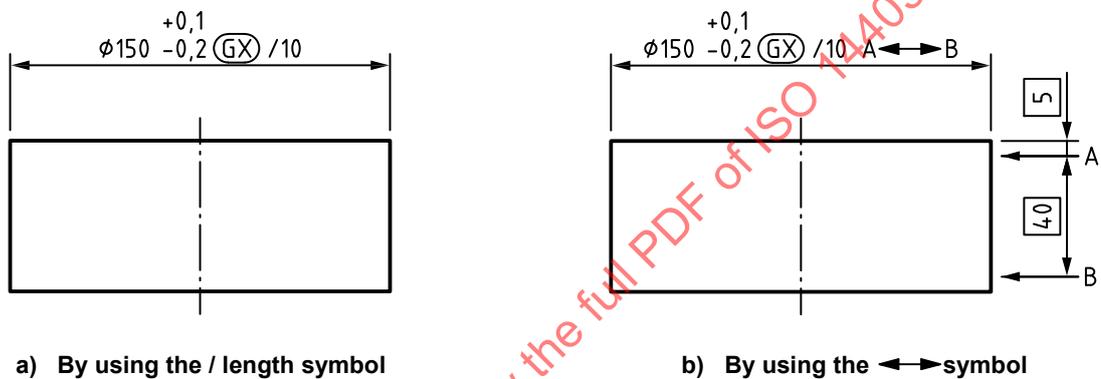
7.3   Any restricted portion of the feature of size of a specified length

If the specification applies to any restricted portion of either the complete feature of size or a fixed restricted portion of it, it shall be indicated in the sequence of the specification with the specification modifier "/" followed by the value of the length of the restricted portion (considered as a TED) [see Figure 23 a)].

If any of these restricted portions are taken on a fixed restricted portion of the complete feature of size, this restricted portion shall be indicated by

— using a long-dashed dotted wide line, with the dimension line pointed to it, or

— using two letters defining the beginning and the end of the restricted portion, and indicating in the sequence of specification these two letters separated by the "between" symbol [see Figure 23 b)].

The extension and the location of the restricted portion shall be indicated by TEDs.

a) **By using the / length symbol**   b) **By using the ◄─► symbol**
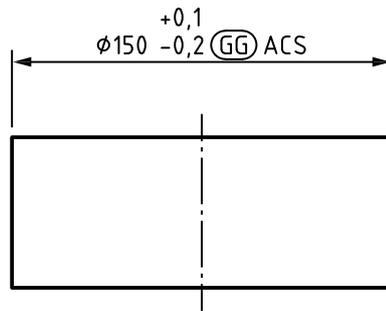
NOTE   The specification operators are indicated. The maximum inscribed diameter for any part of the cylindrical feature of length 10 applies to both the upper and lower limits of size.
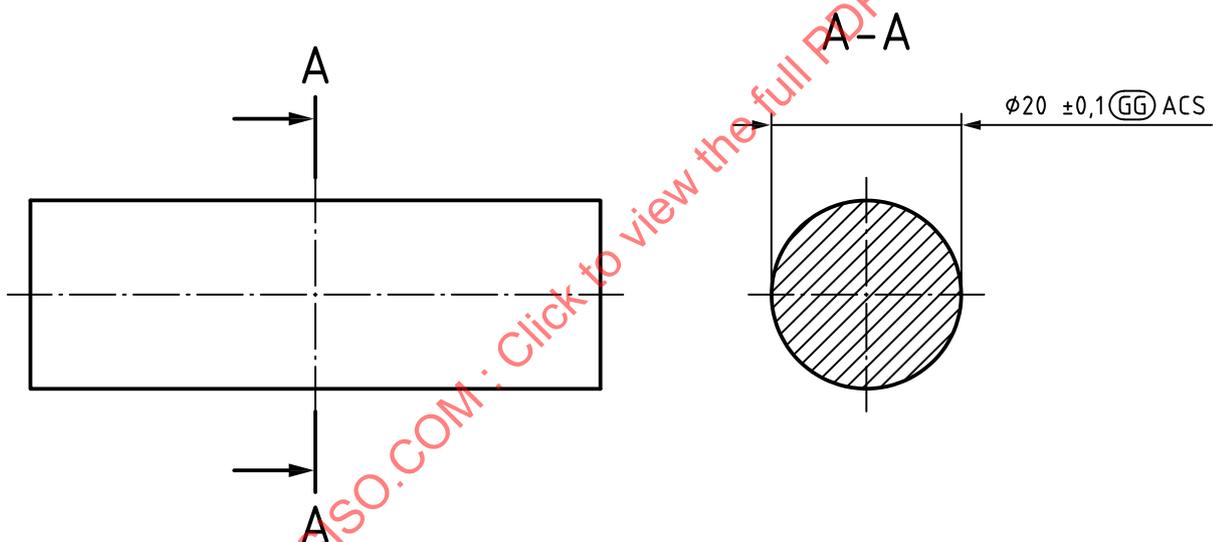
Figure 23 — Example: Requirement for any restricted part of the feature of size

7.4 Any cross section of a feature of size

If the specification applies to any cross section of either the complete feature of size or a fixed restricted portion of it, it shall be indicated with the specification modifier "ACS" [see Figure 24 a)], or the cross section shall be toleranced and indicated on the drawing and the specification modifier "ACS" shall be added to that tolerance [see Figure 24 b)]. Moreover, if any cross sections are taken on a restricted portion of the complete feature of size, then the restricted portion shall be indicated by using a long-dashed dotted wide line or by using the "between" symbol. For the extension of an application for a restricted portion, see Figure 23 b).
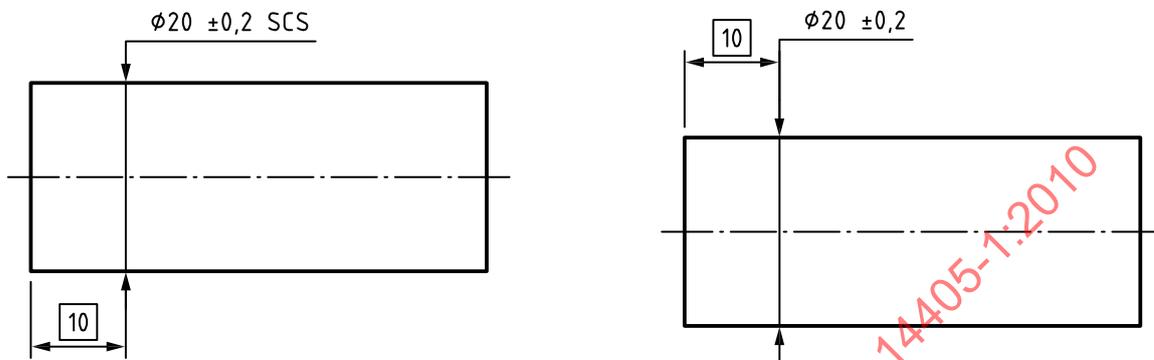

a) Indication in a view

b) Indication in a cross section

NOTE   The specification operator "least-squares diameter" for any cross section of the cylindrical feature applies to both the upper and lower limits of size.

**Figure 24 — Example: Using the ACS modifier to express a requirement
for any cross section of the feature of size**

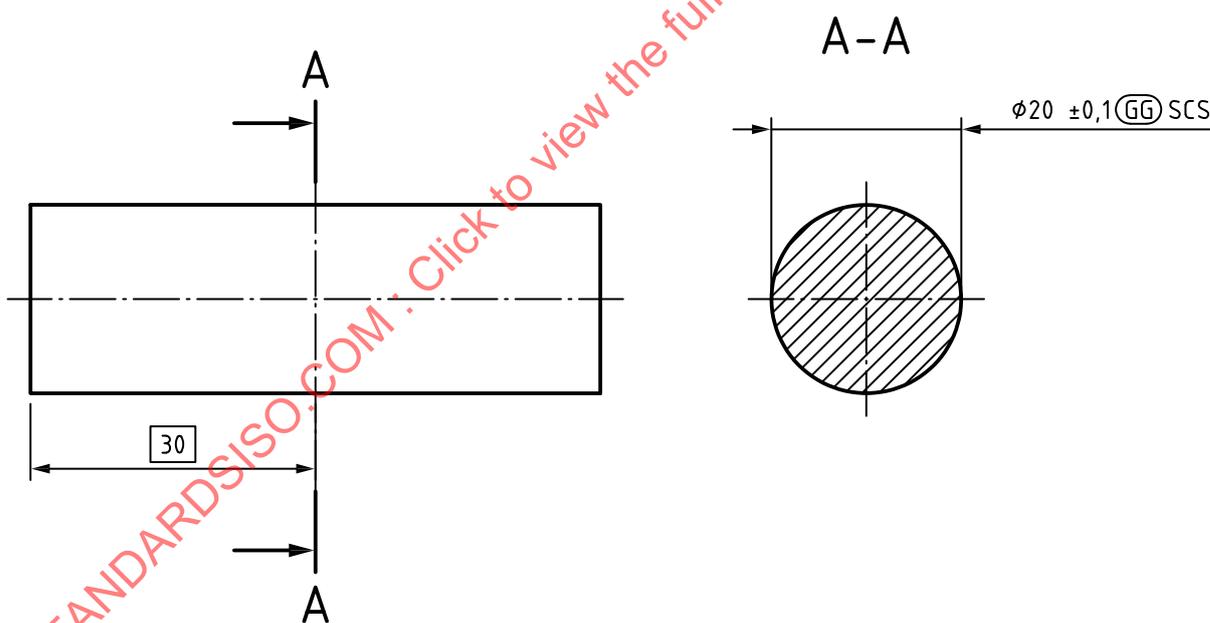## 7.5   Specific cross section of a feature of size

If the specification applies to one defined cross section of the complete feature of size, the cross section shall be placed in the feature by a dimension and the specification shall be indicated in the cross section on the drawing [see Figures 25 a) and 25 c)] and the modifier "SCS" shall be indicated. When no confusion about the nature of the specific cross section is possible, the symbol "SCS" can be omitted [see Figure 25 b)].

NOTE   The TED 10 can be used for a geometrical specification of location.

a) **Location of the cross section and indication in the same view, with the modifier "SCS"**

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 25 — Example of an indication for a specific cross section of the complete feature of size