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Geometrical product specifications (GPS) — Geometrical tolerancing — Pattern and combined geometrical specification

Spécification géométrique des produits (GPS) — Tolérancement géométrique — Spécification géométrique de groupes d'éléments et spécification géométrique combinée

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Foreword

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

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

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This third edition cancels and replaces the second edition (ISO 5458:1998), which has been technically revised.

The main changes to the previous edition are as follows:

— exception from the independency principle removed according to ISO 8015;

— rules harmonized to align with ISO 1101;

— unstated rules in ISO 5458:1998 removed;

— concept of "pattern" to control all types of geometrical features introduced more generically, rather than applying it only with position symbol.

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, B and C for form, orientation and location.

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.

For more detailed information of the relation of this document to the GPS matrix model, see Annex F.

ISO 1101 and other relevant documents, such as those dealing with the least and maximum material requirement (ISO 2692) and the datum system (ISO 5459), should be taken into consideration when using this document.

This document provides rules for the tolerancing of a tolerance zone pattern, i.e. a collection of tolerance zones constrained to each other with or without reference to a datum system which does not lock all degrees of freedom.

For the presentation of lettering (proportions and dimensions), see ISO 3098-2.

All figures in this document for the 2D drawing indications have been drawn in first-angle projection with dimensions and tolerances in millimeters. It should be understood that third-angle projection and other units of measurement could have been used equally well without prejudice to the principles established.

Annexes A and B provide more information on the changes in practice and differences between this document and ISO 1101 on one hand and ISO 5458:1998 on the other hand.

Geometrical product specifications (GPS) — Geometrical tolerancing — Pattern and combined geometrical specification

IMPORTANT — The illustrations included in this document are intended to illustrate the text and/or to provide examples of the related technical drawing specification; these illustrations are not fully dimensioned and toleranced, showing only the relevant general principles. In particular, many illustrations do not contain filter specifications. As a consequence, the illustrations are not a representation of a complete workpiece, and are not of a quality that is required for use in industry (in terms of full conformity with the standards prepared by ISO/TC 10 and ISO/TC 213), and as such are not suitable for projection for teaching purposes.

1 Scope

This document establishes complementary rules to ISO 1101 to be applied to pattern specifications and defines rules to combine individual specifications, for geometrical specifications e.g. using the symbols POSITION, SYMMETRY, LINE PROFILE and SURFACE PROFILE, as well as STRAIGHTNESS (in the case where the toleranced features are nominally coaxial) and FLATNESS (in the case where the toleranced features are nominally coplanar) as listed in Annex C.

These rules apply when a set of tolerance zones are grouped together with location or orientation constraints, through the use of the CZ, CZR or SIM modifiers.

This document does not cover the use of the pattern specifications when the least and maximum material requirement is applied (see ISO 2692).

This document does not cover the establishment of common datum (see ISO 5459) based on pattern features.

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 1101, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

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 22432, *Geometrical product specifications (GPS) — Features utilized in specification and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8015, ISO 1101, ISO 17450-1, ISO 17450-2, ISO 22432 and the following apply.

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

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

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

3.1
pattern specification
combined requirement indicated by a set of geometrical specifications, and controlled by a tolerance zone pattern

Note 1 to entry: The geometrical features controlled by a pattern specification can be a set of compound features, united features or single features, which can be features of size (linear or angular).

Note 2 to entry: Annex C provides examples of pattern specifications in Table C.1.

Note 3 to entry: The set of pattern features controlled by a pattern specification does not define a united feature. A united feature can be a pattern feature, i.e. one of the members of the toleranced features controlled by a pattern specification.

3.2
pattern feature
geometrical feature which is a member of the set of features controlled by a pattern specification

3.3
tolerance zone pattern
combination of more than one tolerance zone, having, without priority between them, constraints of orientation and location, or constraints of orientation

Note 1 to entry: A tolerance zone pattern is composed of several tolerance zones which can have different nominal geometries.

Note 2 to entry: A tolerance zone pattern can be established without external constraint or with orientation constraint and/or location constraint from a datum system.

3.4
pattern characteristic
geometrical characteristic controlled by a pattern specification

3.5
theoretical exact feature pattern
TEF pattern
combination of more than one TEF having, without priority between them, constraints of orientation and location, or constraints of orientation, used to establish the pattern characteristic

Note 1 to entry: A TEF pattern is composed of several TEFs which can have different nominal geometries and constrained between them, with respect to their relative location and/or orientation.

Note 2 to entry: A TEF pattern can be established without external constraint or with orientation constraint and/or location constraint from a datum system.

3.6
single indicator pattern specification
pattern specification, controlled by one tolerance indicator specification

3.7
multiple indicator pattern specification
pattern specification, controlled by more than one tolerance indicator specification

3.8
multi-level single indicator pattern specification
single indicator pattern specification applied to more than one group of toleranced features

3.9
internal constraint
location constraint and/or orientation constraint between the individual tolerance zones of the tolerance zone pattern

3.10
external constraint
location constraint and/or orientation constraint between a tolerance zone or tolerance zone pattern and a datum system

4 Symbols and specification modifiers

For the purposes of this document, the specification modifiers of Table 1 shall apply.

Rules for the presentation of graphical symbols shall be in accordance with Annex D.

Table 1 — Specification modifiers

Applied to	Symbol	Description	Internal constraint	Modifier defined in
Toleranced feature	UF	United feature	Not applicable	ISO 1101
Tolerance zones	SZ	Separate zones	None	5.1
	SIM*i*[a,b]	Simultaneous requirement No. *i*	Orientation and location constraints	5.4.4
	CZ	Combined zone	Orientation and location	5.4.3, 5.4.5 and ISO 1101
	CZR	Combined zone rotational only	Orientation constraint only	5.4.3 and 5.4.5

a An identification number *i* can be associated to the modifier SIM. In this case there is no space between SIM and *i*.

b "SIM" in ISO 8785 is used for a family of "surface imperfection" parameters with indices (e.g. a, n, t, w, cd, ch, sh, n/A). The modifier simultaneous requirement (SIM) as indicated in this document shall not be confused with the indication of a surface imperfection parameter (e.g. SIM1 versus SIMt).

5 Principles

5.1 General

According to the feature principle (see ISO 8015:2011, 5.4), by default a geometrical specification applies to one complete single feature as defined in ISO 22432. It is the designer's responsibility to select the features or portions of features to which a specification applies and either indicate that on a 2D drawing using appropriate symbology or define it in the CAD model.

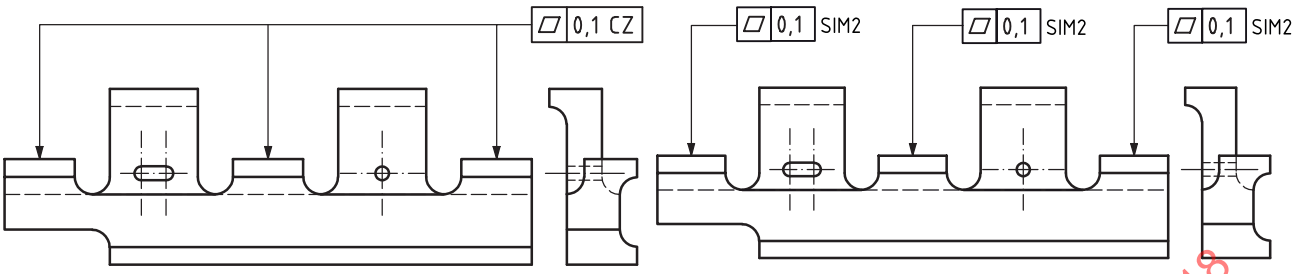
According to the independency principle (see ISO 8015:2011, 5.5), by default a geometrical specification that applies to more than one single feature applies to those features independently. The tolerance zones defined by one tolerance indicator or by several tolerance indicators shall be considered independently by default; this corresponds to the meaning of the modifier SZ. When the same geometrical specification is applied to several toleranced features, for all geometrical specifications other than position specifications, the indication of SZ modifier is redundant (see rule A for position specification, 5.3).

If it is required that the geometrical specification applies to the features simultaneously with some constraint between the tolerance zones, it is the designer's responsibility to either indicate this on a 2D drawing or in the CAD model using appropriate pattern specifications.

In order to manage functional requirements for a set of features, they can be controlled simultaneously by means of a pattern specification, using tolerance zone pattern modifiers CZ, CZR or SIM*n*.

The use of the concept of "simultaneous requirement" transforms a set of more than one geometrical specification into a combined specification, i.e. a pattern specification.

There are two ways to create a tolerance zone pattern, either by using a single indicator pattern specification with the CZ or CZR modifiers [see Figure 1 a) and rules C and E] or by using a multiple indicator pattern specification using SIM modifiers [see Figure 1 b) and rule D (5.4.4)].



a) Single indicator pattern specification **b) Multiple indicator pattern specification**

Figure 1 — Example of pattern specifications

5.2 Concepts

A pattern specification consists of both a set of more than one geometrical feature and a tolerance zone pattern. The set of tolerance zones in the tolerance zone pattern have internal constraints, which are defined by implicit or explicit TEDs.

If necessary, external constraints to a tolerance zone pattern can be defined by referencing a datum system, as defined in ISO 5459. The values of external constraints are defined by implicit or explicit TEDs.

The main specification elements of a pattern specification are:

— the identification of a single indicator pattern specification or a multiple indicator pattern specification;

— the internal constraint (in orientation and/or in location) between the individual tolerance zones of the tolerance zone pattern defined by TEDs;

— the tolerance zone pattern defined as a collection of individual tolerance zones;

— if applicable, external constraints (in orientation and/or in location) of the tolerance zone pattern defined by TEDs from a datum system, see ISO 5459.

There is no functional difference between using *n* identical specifications or a pattern specification (with *n* members) when these specifications refer to a datum system which locks all degrees of freedom of the related tolerance zones. However, there is a difference from a characteristic point of view: there is only one pattern characteristic defined for a pattern specification, whereas there are *n* geometrical characteristics defined each one for the *n* individual specifications.

There is a functional difference between using *n* identical specifications or a pattern specification (with *n* members) when the pattern specification refers to a datum system which does not lock all degrees of freedom of the related tolerance zones, or when the pattern specification does not refer to a datum system.

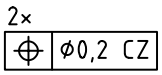
The rules, applied for pattern specification and their repetitions, are given in 5.3 and 5.4. A concept diagram in Annex E illustrates these rules. Examples with their meanings are given in Annex C.

5.3 Rule A: for position specification

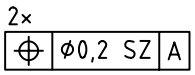
When a position specification is applied to several geometrical features and the tolerance zones have at least one unlocked non-redundant degree of freedom, either the SZ or CZ or CZR modifier shall always be indicated in the tolerance section, see Figure 2 and for former practice, see Annex A.

Using the SZ modifier to a position specification without datum section makes the specification meaningless.

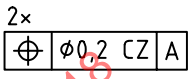
NOTE This rule is in line with the independency principle stated in ISO 8015. However, ISO 5458:1998 was in conflict with the independency principle, since a pattern specification without the CZ modifier implied that the tolerance zones for the repeated specifications were related with internal constraints, and thus dependent on each other (see Annex A and Annex B). Rule A (5.3), which includes the exception for position specification, eliminates this conflict.



a) Pattern specification without a datum



b) Not a pattern specification: Two independent specifications with a datum



c) Pattern specification with a datum

Figure 2 — Example of geometrical specifications which are or are not pattern specification

5.4 Rules for pattern specification

5.4.1 General

To create a single indicator pattern specification, a geometrical specification shall be applied to a set of more than one geometrical feature simultaneously. Internal constraints to define the tolerance zone pattern between the individual tolerance zones shall be defined and, if necessary, external constraints from a datum or datum system shall also be defined.

To create a multiple indicator pattern specification, a set of more than one separate geometrical specification shall be applied to a set of more than one geometrical feature simultaneously. Internal constraints to define the tolerance zone pattern between the individual tolerance zones shall be defined and, if necessary, external constraints from a datum or datum system shall also be defined.

It is possible to indicate a repetition of an identical geometrical specification, as described in ISO 1101, to control several geometrical features.

5.4.2 Rule B: constraints

A pattern specification defines internal constraints.

A pattern specification can define external constraints when the geometrical specification includes a datum or datum system.

The internal constraints consist of the location constraints and/or the orientation constraints linking the individual tolerance zones composing a tolerance zone pattern.

The external constraints define the location constraints and/or the orientation constraints linking the tolerance zone pattern to a datum or datum system.

These internal or externals constraints are defined by TEDs, which can be explicit or implicit.

The following TEDs are implicit:

— 0 mm, when drawing lines appear straight and/or aligned and there is no explicit indication to the contrary, see Figure 3, key a1 and a5;

— 0°, 90°, 180°, 270°, when drawing lines appear aligned (0°/180°) or perpendicular (90°/270°) and there is no explicit indication to the contrary, see Figure 3, key a2;

— equally disposed angle, 360°/*n*, where *n* is the number of features in a pattern shown equally disposed on a circle and there is no explicit indication to the contrary, see Figure 3, key a3.

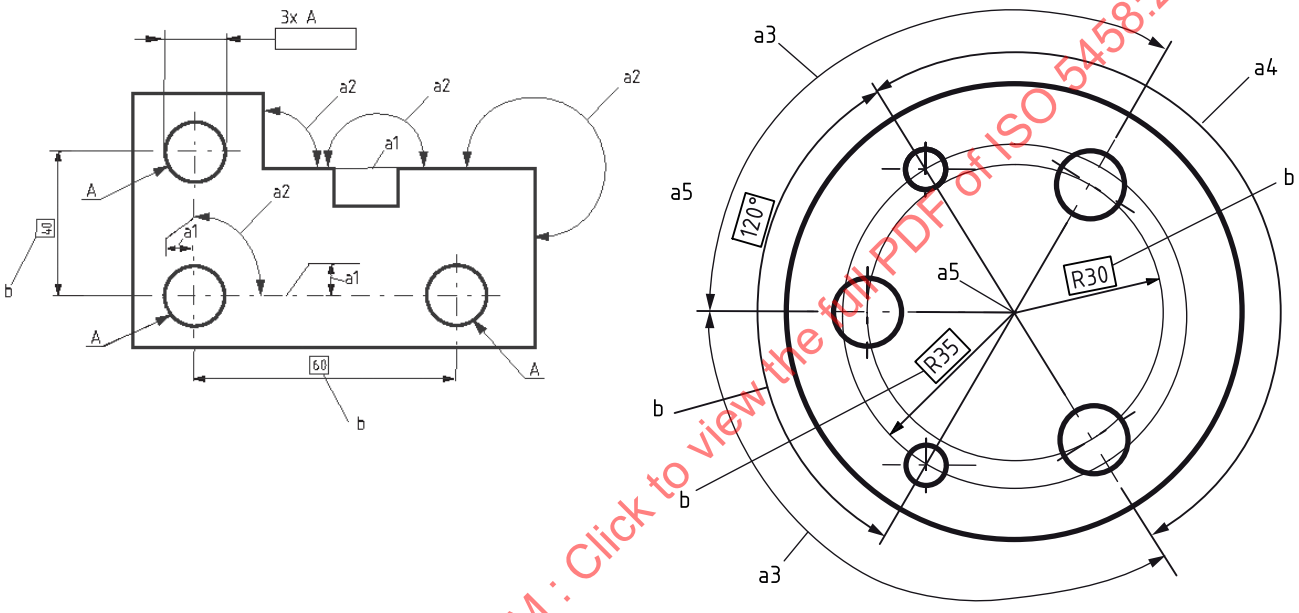
— angular alignment between coaxial patterns (0° or 180° equivalent), see Figure 3, key a4.

NOTE To facilitate readability, it can be useful to indicate explicitly the TEDs, which could be considered as implicit.

Figure 3 illustrates different implicit and explicit TEDs.

Without annotation, the explicit TEDs are indicated directly on the drawing with a dimension value which is framed.

If the values of TEDs are extracted from the CAD model, then this shall be indicated near the title block (as given in ISO 1101). Figure 3 is intended to illustrate and explain the implicit and explicit TEDs.



Key

a1 implicit linear TED of 0 mm
a2 implicit angular TED of 90° or 180° or 270°
a3 implicit equally disposed angular TED
a4 implicit symmetrically disposed angular TED
a5 implicit coaxially disposed linear TED of 0 mm
b explicit TED

Figure 3 — Implicit or explicit TEDs

5.4.3 Rule C: indication of a single indicator pattern specification

To create a single indicator pattern specification (see Figure 4), the modifier CZ or CZR shall appear in a tolerance indicator which is applied to more than one geometrical feature. The modifier (CZ or CZR) shall be shown in the tolerance section following the tolerance value (see ISO 1101).

When a single indicator pattern specification is defined, each individual tolerance zone in the tolerance zone pattern has the same size and the same shape.

To create an additional level of pattern specification, see rule E (5.4.5).

a) Single indicator pattern specification without a datum

b) Single indicator pattern specification with a datum

Figure 4 — Example of single indicator pattern specifications

The modifier CZ indicates that a tolerance zone pattern is defined with internal orientation and location constraints between the individual tolerance zones.

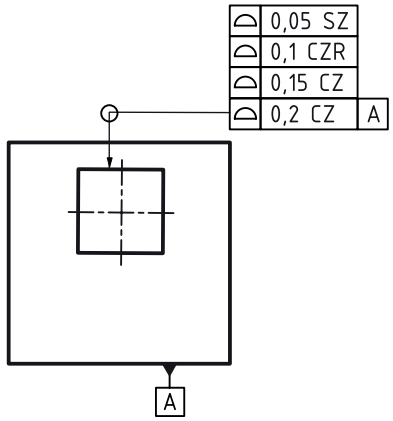
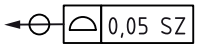
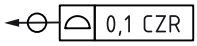
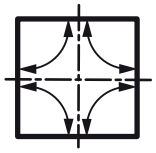
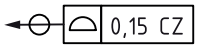
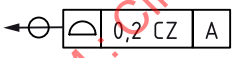
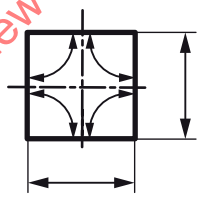
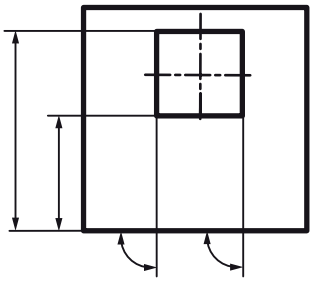
The modifier CZR indicates that a tolerance zone pattern is defined with internal orientation constraints between the individual tolerance zones.

The internal constraints (orientation constraints and location constraints) shall be defined respectively by angular TEDs and linear TEDs (implicit or explicit) (see rule B, 5.4.2).

NOTE The modifiers “CZ” or “CZR” do not constrain the sizes of the features of size.

Table 2 provides examples which illustrate the internal constraints introduced by the CZ or CZR modifiers and the external constraints introduced by the datum or datum system.

Table 2 — Example of internal constraints with CZ or CZR and external constraints with datum or datum system

Drawing indication	Tolerance indicator	Dimensions considered as TEDs for	
		Internal constraints in the tolerance zone pattern	External constraints To locate or orientate tolerance zone or tolerance zone pattern
 TEDs according to CAD model 123 rev c		None (no pattern specification)	None (no datum or datum system)
		 Introduced by CZR	None
			None
		 Introduced by CZ	 Introduced by the datum A in link with symbol characteristic

5.4.4 Rule D: indication of a multiple indicator pattern specification

To create one multiple indicator pattern specification (see Figure 1), the modifier SIM, optionally followed by an identification number without a space, shall be indicated in the adjacent indication area of each related geometrical specification (see Figure 5).

The use of the SIM modifier (simultaneous requirement) transforms a set of more than one geometrical specification into a combined specification (pattern specification). The tolerance zones for all the specifications are locked together with location and orientation constraints (see Figures 6 and 7).

The specifications locked together with the SIM indications may or may not have

— the same tolerance value, and

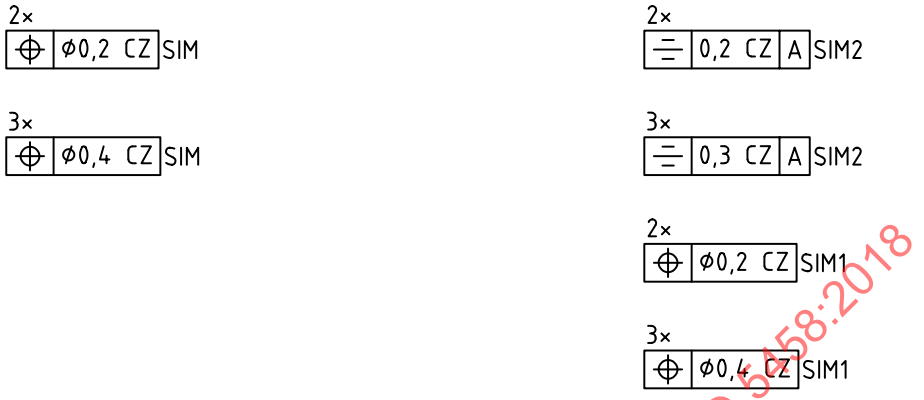
— the same shape of tolerance zones (see Figure 7).

In the case of a multiple pattern specification defined with the SIM modifier:

— the individual geometrical specification shall not include the CZR modifier;

— the individual geometrical specification can include the CZ modifier, but this is superfluous and may be omitted.

NOTE Two tolerance zone patterns, to be related and rotationally aligned, both belong to the same SIM group.



a) Example 1 **b) Example 2**

Figure 5 — Examples of indication of simultaneous requirements from two separate specifications

In Figure 5 a), the SIM modifier adjacent to the two tolerance indicators means that the two tolerance zone patterns are combined into a single requirement. All five tolerance zones are locked together by location and orientation constraints.

In Figure 5 b), the SIM1 modifier creates one simultaneous requirement, and the SIM2 modifier creates a separate simultaneous requirement. The SIM1 and SIM2 requirements are unrelated to each other.

In Figure 6, there are two simultaneous requirements defined by the indication of SIM1 and SIM2. Each simultaneous requirement shall be considered individually.

— SIM1: the two specifications linked together with the SIM1 indication each use a CZ modifier to create a tolerance zone pattern. One of them is a pattern of three Ø0,1 tolerance zones for the three extracted median lines of the Ø20 holes, and the other is a tolerance zone pattern of three Ø0,2 tolerance zones for the three extracted median lines of the Ø22 holes. The SIM1 modifier locks the two tolerance zone patterns together into a combined tolerance zone pattern of six (3x + 3x) cylindrical tolerance zones. All six tolerance zones are constrained with the following internal constraint and external constraints.

  Internal constraints:

  — the axes of the individual cylindrical tolerance zones are on pitch cylinder of R40 and R35, respectively;

  — the axes of the individual cylindrical tolerance zones are parallel in each tolerance zone pattern, implicit TEDs of 0°;

  — the axes of the individual cylindrical tolerance zones are equally disposed on the pitch cylinders implicit TED of 120° in each tolerance zone pattern;

  — the axes of the two pitch cylinders are parallel, implicit TED 0°;

  — distance of 0 mm between the axes of the two pitch cylinders, implicit TED of 0 mm;

  — the two tolerance zone patterns are rotationally aligned, implicit TED of 0°.

  External constraints:

- the two tolerance zone patterns are both located by the common datum axis, A-B, by the implied TED of 0 mm between the axis of each pitch cylinder and the datum axis.

— SIM2: the two specifications linked together with the SIM2 indication each use a CZ modifier to create a tolerance zone pattern. The tolerance zone pattern is composed of two tolerance zone patterns combined:

  - the first is a set of three tolerance zones consisting of two parallel planes 0,1 mm apart for the three extracted median surfaces of the 35 mm slots;
  - the second is a set of three tolerance zones consisting of two parallel planes 0,2 mm apart for the three extracted median surfaces of the 34 mm slots.

  The SIM2 modifier locks the two tolerance zone patterns together into a combined tolerance zone pattern of six (3x + 3x) tolerance zones. All six tolerance zones are constrained with the following internal constraints and external constraints.

  Internal constraints:

  - the three median planes of the individual tolerance zones have a straight line, implicit TED 0 mm, as common intersection;
  - the three median planes of the individual tolerance zones are equally angularly disposed around the common intersecting straight line, implicit spacing of 120° (in each tolerance zone pattern);
  - the common intersecting straight line of each tolerance zone pattern are parallel, implicit TED 0°;
  - distance of 0 mm between the common intersecting straight lines of each tolerance zone, implicit TED of 0 mm;
  - the two tolerance zone patterns are rotationally aligned, implicit TED of 0°.

  External constraints:

  - the two tolerance zone patterns are both located by the common datum axis A-B by the implied TEDs of 0mm and 0° between the common intersecting straight lines (of each tolerance zone pattern) and the datum axis.

— The six tolerance zones constituting the SIM2 requirement are independent of, and unrelated to, the six tolerance zones constituting the SIM1 requirement.

If the four pattern specifications on Figure 6 were indicated without any SIM modifiers, the four tolerance zone patterns would be mutually unconstrained. Each of the four pattern specifications shall be considered independently of the others. All four tolerance zone patterns are constrained externally to datum A-B, but are rotationally independent from each other, i.e. without consideration of implicit angular TEDs between the four tolerance zone patterns.

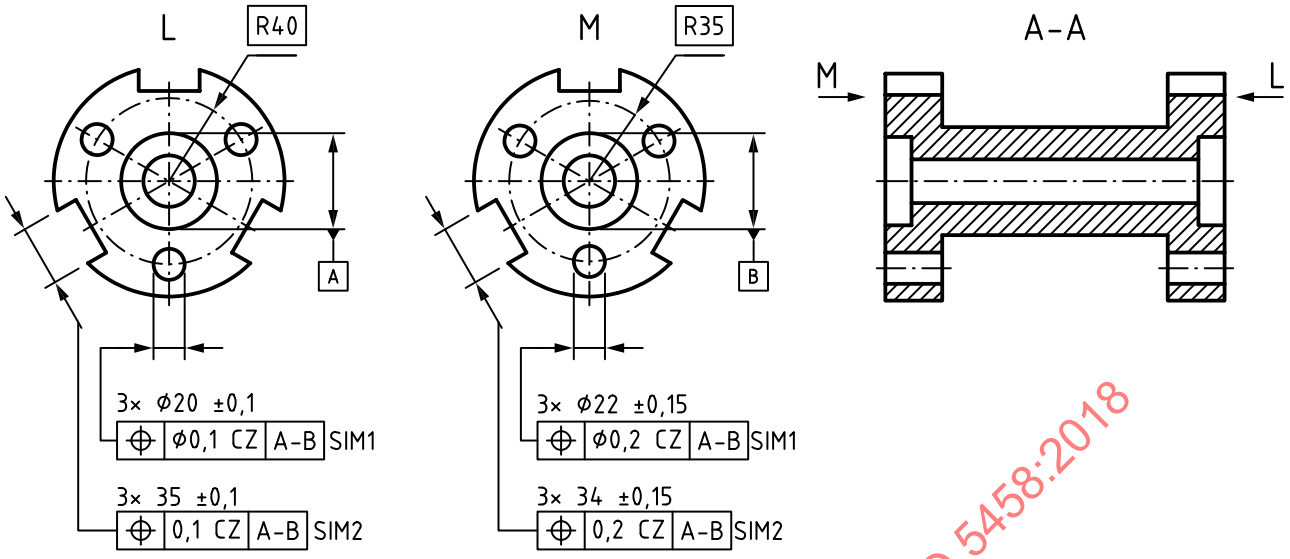
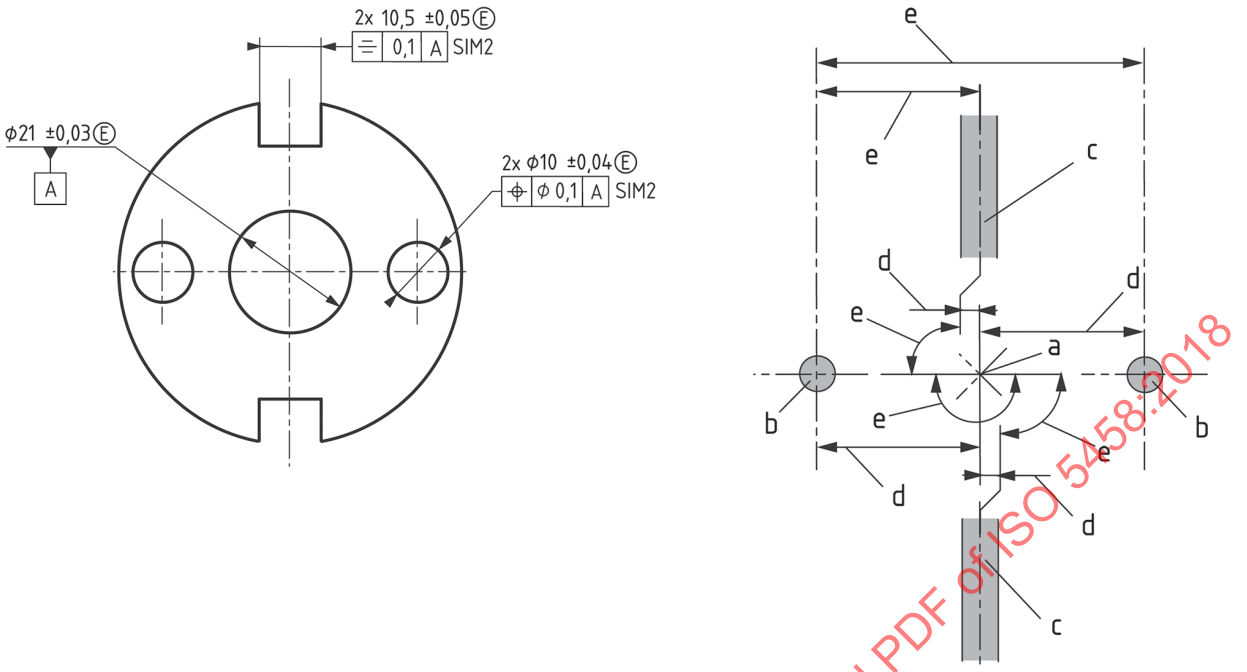


Figure 6 — Example of two separate simultaneous requirements applied to different pattern specifications

Figure 7 illustrates a multiple indicator pattern specification, and its interpretation, where the shapes of tolerances zones constituting the tolerance zone pattern are different.

The symmetry specification defines two tolerance zones consisting of two parallel planes, and the position specification defines two cylindrical tolerance zones. All four tolerance zones are locked together by the SIM2 indication. The four tolerance zones have internal constraints (location and orientation) to each other, and external constraints to datum A (location and orientation).

The use of tolerance zones with different shapes or different tolerance values in one tolerance zone pattern can create difficulties in verification.



a) Drawing indication **b) Illustration of the tolerance zone pattern**

Key

a datum
b cylindrical tolerance zone
c two opposite planes tolerance zone
d external constraint
e internal constraint

Figure 7 — Example of a multiple indicator pattern specification composed of tolerance zones with different shapes

5.4.5 Rule E: indication of multi-level single indicator pattern specification

5.4.5.1 General

The symbols give in Table 3 are used to describe a multi-level single indicator pattern specification.

Table 3 — Symbols

Symbol	Description
k	Number of identical groups
n	Number of identical features

To create a multi-level single indicator pattern specification, the following shall be indicated:

a) a set of *k* groups, each consisting of *n* single features using:

   1) *n* leader lines connecting the tolerance indicator to the *n* geometrical features and *k*x indicated in the adjacent indication area, or

2) an “all around” symbol (covering *n* features) defining one group and *k*x indicated in the adjacent indication area, or

3) *k*x indicated in front of *n*x in the adjacent indication area with a slash as separator and a space on both sides of the slash. The *k*x and *n*x shall be followed by a space and the identifier letter or symbol to avoid ambiguities (e.g. 4x / 2x or 4x A / 2x B). The identification letter can be used to establish a link with individual integral features, or with a group of integral features. When used to identify a group of features, the group may be indicated on a drawing by surrounding the features with a long-dashed double-dotted narrow line (line type 05.1 according to ISO 128-24) (see Figure 9);

4) If the integral feature related to the toleranced feature is a feature of size, then the number of groups shall be indicated followed by a space and the group identifier letter if applicable, followed by a space, a slash and a space, followed by the number of features and a space and the nominal size and its specification (general or individual), followed by a space and the feature identifier letter if applicable (e.g. 3x B / 2x 10±0,05 A or 3x / 2x 10±0,05 or 3x / 2x 10).

b) in the tolerance section, a sequence of CZ and/or SZ and/or CZR:

1) if all the elements of the sequence are SZ, then

i) this specification does not define a pattern specification;

ii) the specification consists of a set of *k*x *n* independent tolerance zones, each applying to one geometrical feature [see Figure 8 a)], and defining *k*x*n* geometrical characteristics;

2) if the first element of the sequence is SZ and the following elements are CZ, then the CZ indication(s) defines each of the tolerance zone patterns, while the SZ indicates that the tolerance zone patterns are separate and independent of each other:

i) there are *k* independent tolerance zone patterns (SZ), composed of *n* individual tolerance zones locked together with orientation and location constraints (CZ);

ii) the specification consists of a set of *k* independent combined zones (tolerance zone pattern), each applied to a set of *n* geometrical features [see Figure 8 b)], defining *k* pattern characteristics;

3) if the first element of the sequence is CZR and the following elements are all CZ, then the CZ indication(s) defines each of the tolerance zone patterns, while the CZR indicates that the tolerance zone patterns are locked together with orientation constraints only:

i) there is one tolerance zone pattern, consisting of *k* tolerance zone patterns;

ii) the specification consists of one combined zone with orientation constraints only between the *k* tolerance zone patterns [see Figure 8 c)] and defining one pattern characteristic;

4) if the first element of the sequence is SZ, followed by CZR, then the CZR indication defines each of the tolerance zone patterns with internal constraints of orientation only, while the SZ indicates that the tolerance zone patterns are separate and independent of each other:

i) there are *k* tolerance zone patterns, composed of *n* individual tolerance zones locked together with orientation constraints only (no location constraints exist between the individual tolerance zones);

ii) the specification consists of a set of *k* independent combined zones (tolerance zone patterns), each applied to a set of *n* geometrical features [see Figure 8 d)], defining *k* pattern characteristics;

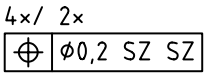
5) if all the elements of the sequence are CZ, then

i) there is one tolerance zone pattern (a tolerance zone pattern of tolerance zone patterns);

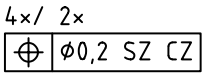
ii) the specification consists of one combined zone (tolerance zone pattern), applied to a set of *k*x*n* geometrical features [see Figure 8 e)] and defining one pattern characteristic.

NOTE A specification, applied to *k* identical tolerance zone patterns, each consisting of *n* geometrical features, indicated by a CZ CZ modifier in the tolerance section, has the same meaning as a specification applied to one tolerance zone pattern consisting of *m*(=*k*×*n)* geometrical features, indicated by one CZ modifier in the tolerance section. These possibilities are shown in Figures 9 and 10.

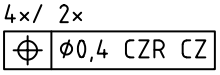
Additional pattern levels can be indicated following the same logic (see 5.4.5.2).



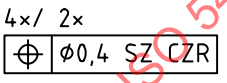
a) Eight independent specifications



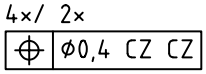
b) Four independent pattern specifications (with internal orientation and location constraint)



c) One pattern specification defined from four dependent pattern specifications (in orientation)



d) Four independent pattern specifications (with internal orientation constraint)



e) One pattern specification defined from four dependent pattern specifications (in orientation and location)

Figure 8 — Sets of single indicator pattern specifications with or without dependency

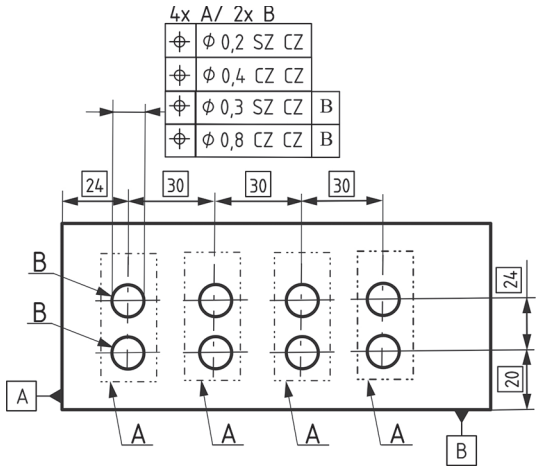
Indication	Meaning
	The first specification (SZ CZ without datum) controls four independent pattern specifications. For each pattern specification, the first specification is defined: a) as toleranced feature, the collection of two extracted median lines; b) as tolerance zone, the tolerance zone pattern (combined zone) composed of two cylindrical zones of diameter 0,2 mm with orientation constraint (parallel between them) and with location constraint between them at 24 mm apart. The second specification (CZ CZ without datum) controls four dependent pattern specifications resulting in only one pattern specification considering: a) as toleranced feature, the collection of eight extracted median lines; b) as tolerance zone, the tolerance zone pattern (combined zone) composed of eight cylindrical zones of diameter 0,4 mm with orientation constraint (parallel between them) and with location constraint between them at 24 mm apart in vertical direction and 30 mm in a horizontal direction. The third specification (SZ CZ with datum B) defines four independent pattern specifications constrained in location from datum B. For each pattern specification, the third specification is defined: a) as toleranced feature, the collection of two extracted median lines; b) as tolerance zone, the tolerance zone pattern (combined zone) composed of two cylindrical zones of diameter 0,3 mm with orientation constraint (parallel between them) and with location constraint between them 24 mm apart and constrained from datum B to a distance of 20 mm. The fourth specification (CZ CZ with datum system B) controls four dependent pattern specifications, constrained in location from datum B, resulting in only one pattern specification considering: a) as toleranced feature, the collection of eight extracted median lines; b) as tolerance zone, the tolerance zone pattern (combined zone) composed of eight cylindrical zones of diameter 0,8 mm with orientation constraint (parallel between them) and with location constraint between them 24 mm apart in vertical direction and 30 mm apart in a horizontal direction and constrained from the datum system B to a distance of 20 mm.

Figure 9 — Example of indication of multi-level single indicator pattern specification

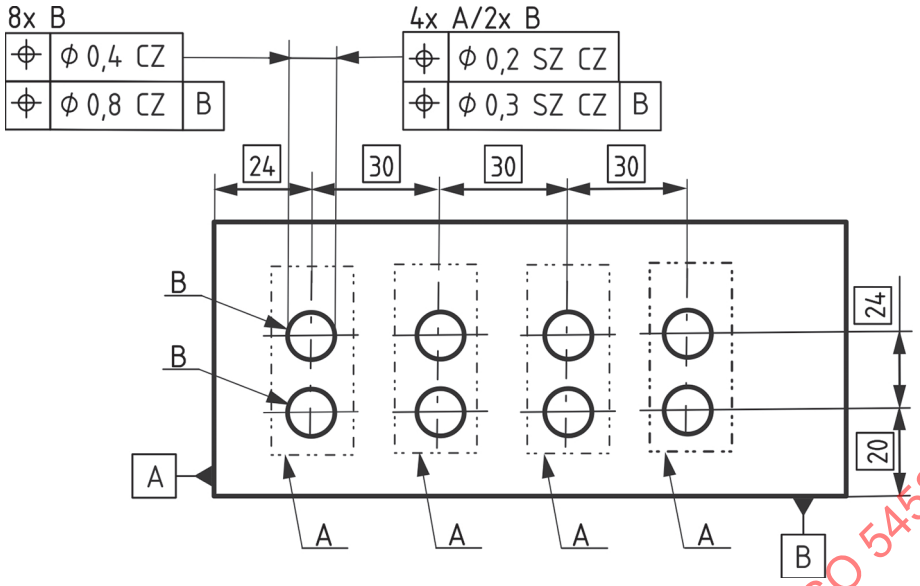


Figure 10 — Alternative indication with the same meaning as in Figure 9

5.4.5.2 Sequences of modifiers

There shall be as many CZ/SZ/CZR indications as there are levels in the pattern.

If all non-redundant degrees of freedom for the tolerance zones are locked by datums, functionally there is no difference between two sequences consisting of SZ only or CZ only. If a sequence of SZ/CZ is omitted then it is equivalent to a sequence of SZ modifiers only.

CZ or CZR indications shall not precede an SZ indication.

CZ indications shall not precede a CZR indication.

For a set of k tolerance zone patterns each consisting of n tolerance zones, the last CZ applies to the n individual tolerance zones. The previous element (CZ, CZR or SZ) applies to the k tolerance zone patterns.

Table 4 shows sequences of modifiers (SZ, CZ and CZR) and whether they have a meaning.

Table 4 — Sequences of modifiers and their meaning

Sequence	Meaning
SZ SZ	Indicates independency of all features
SZ CZR	Indicates independency between tolerance zone patterns (first level), each tolerance zone pattern being composed of several tolerance zones with orientation constraints only (no location constraint).
SZ CZ	Indicates independency of tolerance zone patterns (first level)
CZR SZ	Meaningless
CZR CZR	Meaningless
CZR CZ	Indicates dependency between tolerance zone patterns (first level) rotationally only, each tolerance zone pattern being composed of several tolerance zones with orientation and location constraints
CZ SZ	Meaningless
CZ CZR	Meaningless
CZ CZ	Indicates dependency between tolerance zone patterns with orientation and location constraints
NOTE Subsequent CZ/CZR/SZ indications apply to the next tolerance zone pattern levels following the same logic.	

Table 4 *(continued)*

Sequence	Meaning
SZ SZ CZ	Indicates three levels of repetitions where only the first level creates tolerance zone patterns
SZ CZR CZ	Indicates three levels of repetitions where the tolerance zone patterns of the first level are only constrained rotationally between them
SZ CZ CZ	Indicates three levels of repetitions where the first, with the second level, creates tolerance zone patterns
CZR SZ CZ	Meaningless
CZR CZR CZ	Meaningless
CZR CZ CZ	Indicates three levels of repetitions where the first, with the second level, creates tolerance zone patterns which are only constrained rotationally between them
CZ CZ CZ	Indicates three levels of repetitions where the first, with the second level and the third level, creates a tolerance zone pattern
NOTE Subsequent CZ/CZR/SZ indications apply to the next tolerance zone pattern levels following the same logic.	

5.5 Pattern characteristic

The pattern characteristic is evaluated from the theoretical exact feature (TEF) pattern, considered as the reference feature (see ISO 22432) and the set of pattern features, considered as the input feature.

The TEF pattern is the set of ideal geometrical features which corresponds to the median features of each tolerance zone composing the tolerance zone pattern, constrained between them in location and/or orientation.

When the pattern specification is a single indicator pattern specification, then the pattern characteristic consists by default in the maximum value of the parameter evaluated from the local geometrical deviation (see ISO 17450-4) defined between the set of pattern features and its TEF pattern.

The pattern characteristic is dependent of the association method, default method or non-default method defined in ISO 1101.

If necessary, a parameter specification element such as T (default), P, or V may be applied in the tolerance indicator (see ISO 1101).

Annex A
(informative)

Former practice, important changes

A.1 Important changes

To avoid ambiguity on a geometrical specification, using a position characteristic symbol applied to more than one geometrical feature, either a SZ or a CZ modifier should be indicated in the tolerance section. It is very important when the geometrical specification applies to several features and at least one non-redundant degree of freedom of the tolerance zones is unlocked by the datum system.

The SIM modifier should be used in order to unambiguously identify which groups of tolerance zone patterns shall be regarded simultaneously as a single tolerance zone pattern.

NOTE 1 It was former practice to consider a set of features equally arranged around an axis (i.e. in a complete circle) and toleranced with one or several position specifications controlled by a unique tolerance zone pattern when they were not all related to any datum or when they were all related to the same datum system, whatever the tolerance values. This former practice has been replaced by the use of CZ modifier when all position specifications have the same tolerance value or SIM modifier when at least one position specification has a tolerance value different from the others (see Figure A.3, simultaneous requirement between two tolerance zone patterns). Special statements such as “angular location optional” are no longer necessary to indicate that there are several independent pattern specifications (see Figure A.2, independent requirements for two patterns).

NOTE 2 The use of the SIM modifier was not possible in ISO 5458:1998 unless two or more groups of features were shown on the same axis. A precondition in ISO 5458:1998 and for the use of the SIM modifier is that all the implicated tolerance zones are unrelated to a datum or related to the same datum or datum system.

A.2 Former practice

Former practice appeared to avoid ambiguities. Examples are presented in Figures A.1, A.2 and A.3.

2× ⌖ ⌀0,2	2× ⌖ ⌀0,2 CZ
ISO 5458:1998	**This document**

Figure A.1 — Evolution of indication for position specification without datum

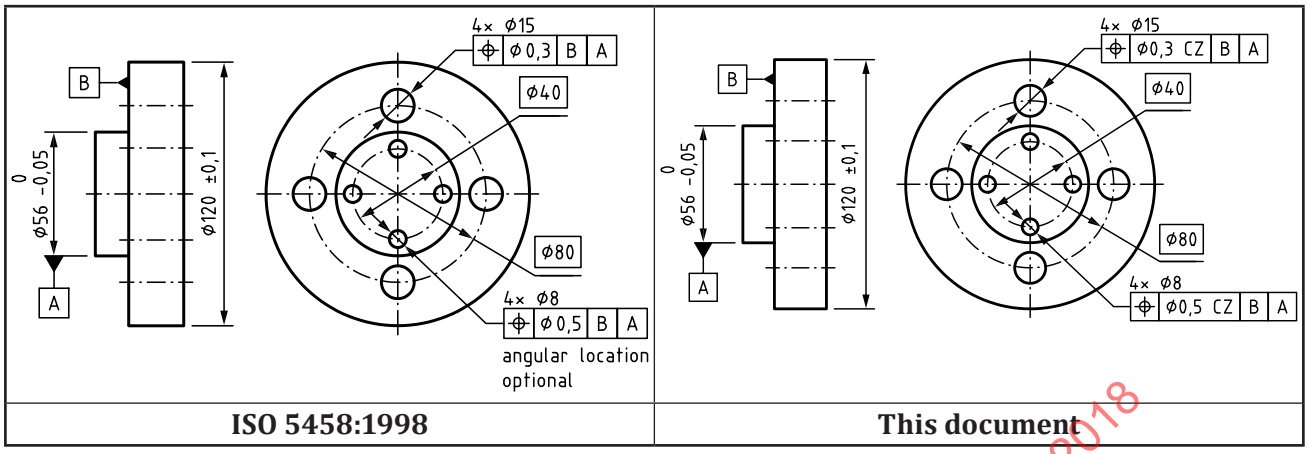


Figure A.2 — Evolution of indication for position specifications for two groups of features circularly disposed, with the same axis and without simultaneous requirement

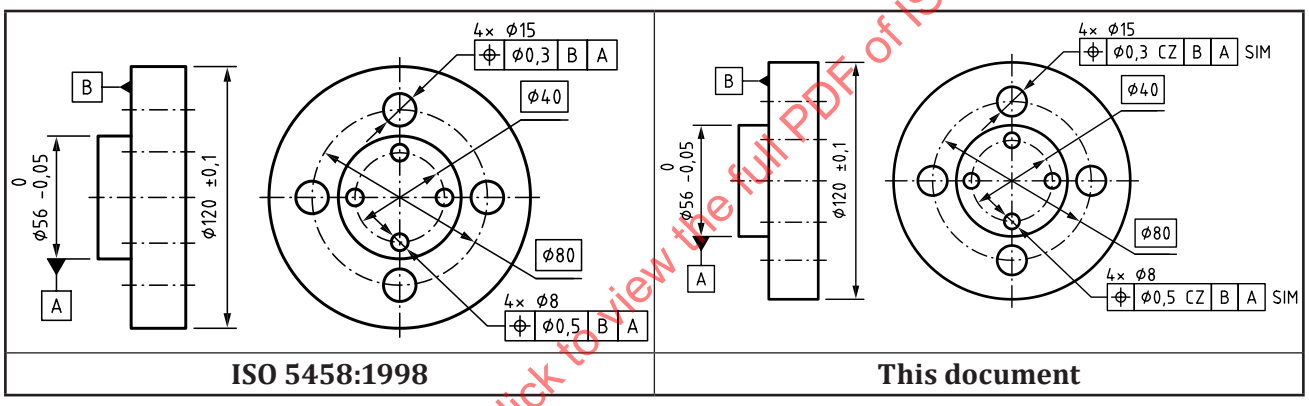


Figure A.3 — Evolution of indication for position specifications for two groups of features circularly disposed, with the same axis and with simultaneous requirement

Annex B
(informative)

Differences between ISO 5458:1998 and this document

B.1 General

ISO 1101:2012 implemented the independency principle as defined in ISO 8015:2011. It defined the CZ modifier to indicate dependency between several tolerance zones (creating a tolerance zone pattern). This document takes into account the principles and rules developed in ISO 1101. The differences noted between ISO 1101:2012 and ISO 5458:1998 apply also between this document and ISO 5458:1998. These differences exist also between ISO 5458:1998 and ISO 1101:2017.

The previous edition, ISO 5458:1998, covered geometrical specification with position characteristic symbol only and was based on an exception from the independency principle. In ISO 5458:1998 a position specification for a group of *n* geometrical features, that was unrelated to a datum or related to a datum or a datum system that did not lock all degrees of freedom and with no modifier indicated in the tolerance section, defined an implicit tolerance zone pattern (the term "pattern" was not yet defined).

In order to avoid ambiguity and misinterpretation, this document

— eliminates the unstated rules in ISO 5458:1998;

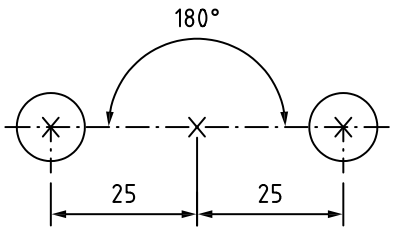
— removes the exception in ISO 5458:1998 which is not in accordance with the independency principle defined in ISO 8015:2011;

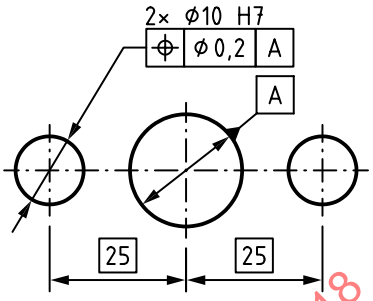
— harmonizes the rules to align with ISO 1101:2017.

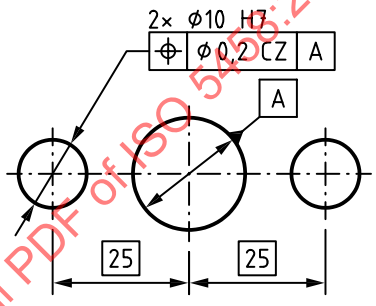
The rules in this document apply to geometrical specifications not only with position symbol characteristics but also with line profile, surface profile, straightness, flatness and symmetry characteristic symbols. This document allows generic written rules from ISO 5458:1998 to be extracted and corrected, if necessary, in accordance with ISO 1101:2017, to avoid ambiguity and misinterpretation. These rules are applicable not only to the position characteristic.

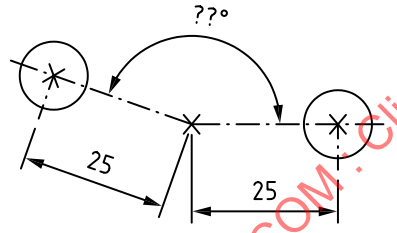
B.2 Examples of indication between ISO 5458:1998, ISO 1101:2017 and this edition of ISO 5458

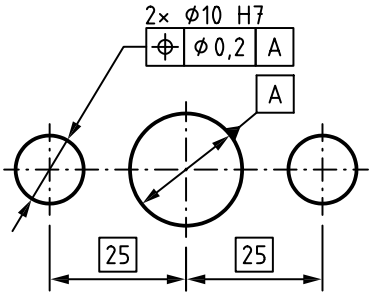
Figure B.1 presents different meanings which are expressed individually by different indications according to the previous edition, ISO 5458:1998, ISO 1101:2017 and this document. Some of these indications can be contradictory. The intent of this document is to avoid these contradictions in GPS standards.

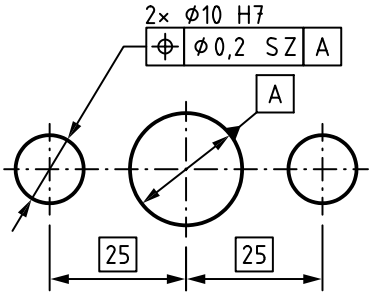
<table>
<tr><th>Meaning</th><th>Indication</th></tr>
<tr><td rowspan="2"> 

Two tolerance zones constrained between them to a distance of 50 mm apart and located from datum A</td><td> 

ISO 5458:1998</td></tr>
<tr><td> 

ISO 1101:2017 and this document</td></tr>
<tr><td rowspan="3"> 

Two independent tolerance zones located from datum A</td><td>Indication not available
ISO 5458:1998</td></tr>
<tr><td> 

ISO 1101:2017</td></tr>
<tr><td> 

This document</td></tr>
</table>

Figure B.1 — Differences in interpretation of indications between ISO 5458:1998, ISO 1101:2017 and this document

Annex C
(informative)

Examples of pattern specifications

Table C.1 — Examples of pattern specifications

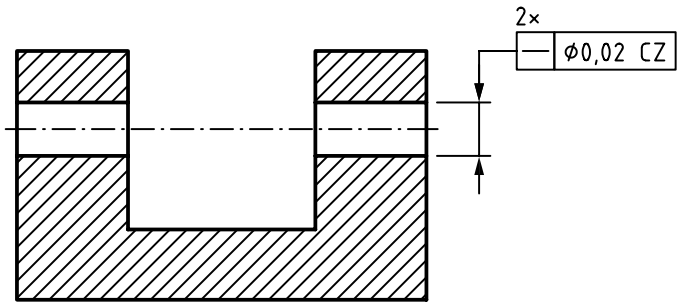
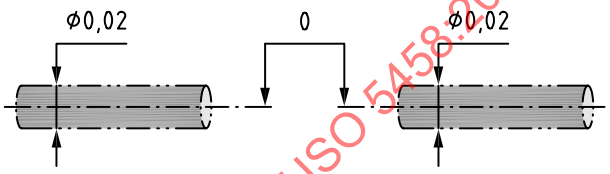
Indication	Meaning
Example 1 	 The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of two (2x) extracted median lines. Each nominal median line is a straight line. The tolerance zone is a tolerance zone pattern (CZ modifier) composed of two (2x) cylindrical zones with a diameter of 0,02 mm, where their axes are constrained in orientation to be parallel (implicit TED of 0°) and in location to be coaxial (implicit TED of 0 mm, defined by the indicated through-going line of symmetry).

Table C.1 *(continued)*

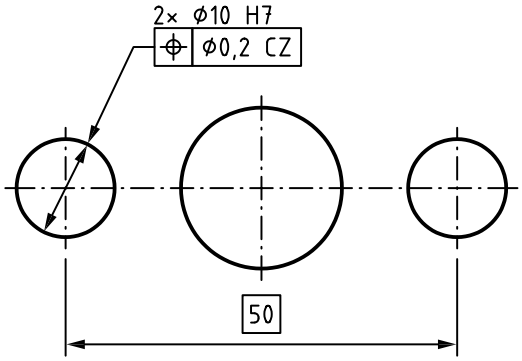
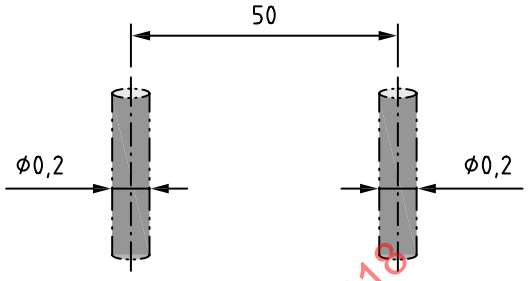
Indication	Meaning
Example 2 	 The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of two (2x) extracted median lines. Each nominal median line is a straight line. The tolerance zone is a tolerance zone pattern (CZ modifier) composed of two (2x) cylindrical zones with a diameter of 0,2 mm, where their axes are constrained in orientation to be parallel (implicit TED of 0°) and constrained in location to be 50 mm apart, with an explicit TED, without external constraint coming from a datum (no datum or datum system is indicated in the tolerance indicator).

Table C.1 *(continued)*

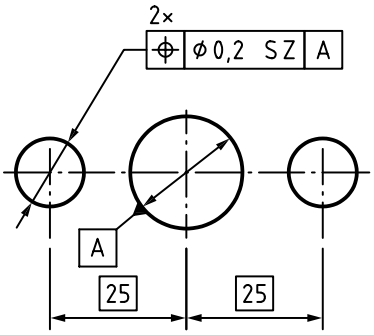
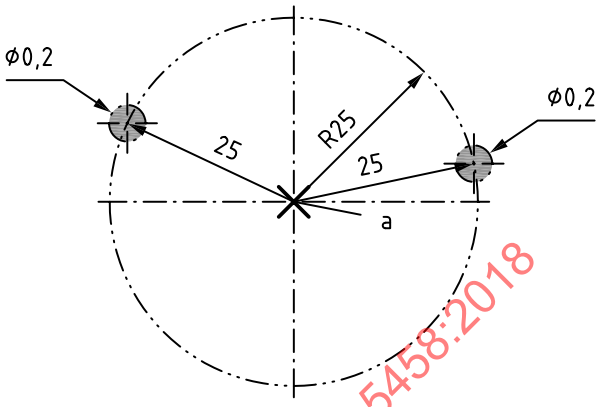
Indication	Meaning
Example 3 	 **Key** a datum A The specification is not a pattern specification (SZ modifier). The toleranced feature is the collection of two (2x) extracted median lines. Each nominal median line is a straight line. Each individual tolerance zone is considered independently (SZ modifier) and does not constitute a tolerance zone pattern. Each tolerance zone is a cylindrical zone with a diameter of 0,2 mm, where the axis is externally constrained in orientation to be parallel (implicit TED of 0°) and in location at a distance 25 mm (explicit TED) from the datum A . The tolerance zones for the two toleranced features are independent and are not constrained between them. The distance 50 mm (25+25) is not considered as an internal constraint between the tolerance zones (SZ modifier).

Table C.1 *(continued)*

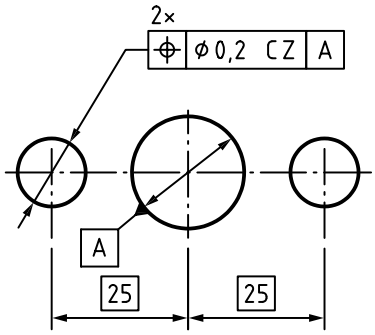
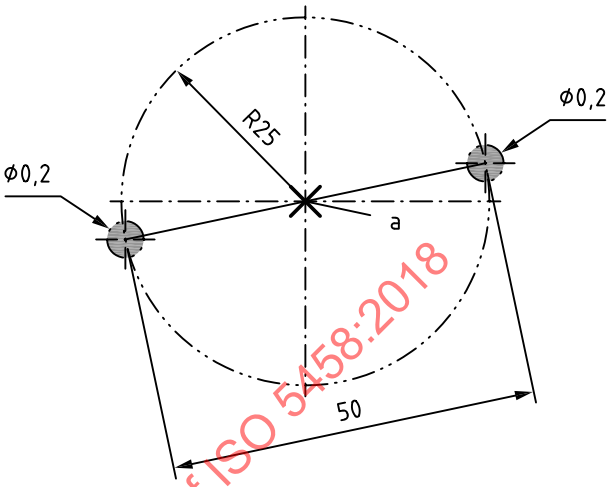
Indication	Meaning
Example 4 	 **Key** a datum A The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of two (2x) extracted median lines. Each nominal median line is a straight line. The tolerance zone is a tolerance zone pattern (CZ modifier) composed of two (2x) cylindrical zones with diameters of 0,2 mm, where their axes are internally (CZ modifier) constrained in orientation to be parallel (implicit TED of 0°) and in location at a distance 50 mm apart (two explicit TEDS of 25 mm and diametrically disposed). Moreover, the tolerance zones are externally constrained in location from the datum A at a distance of 25 mm.

Table C.1 *(continued)*

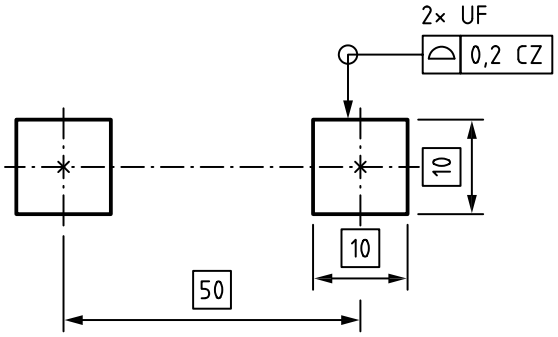
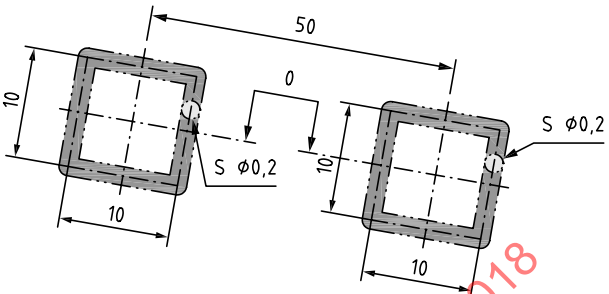
Indication	Meaning
Example 5  NOTE 1 A specification with "all-around" modifier can be considered with a collection plane indicator as given by ISO 1101. The "all around" modifier does not create a united feature or a pattern specification. NOTE 2 When the modifier UF is placed above the tolerance indicator, the collection of the integral features is considered as a single feature. It does not transform a single geometrical specification to a pattern specification.	 The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of two (2x) united features (UF modifier), each consisting of four extracted unified integral surfaces (all around symbol). The tolerance zone is a tolerance zone pattern (CZ modifier) composed of two tolerances zones, each one consisting of two offset surfaces from the nominal shape of the united feature and constrained in orientation to be parallel (implicit TED of 0°) and in location to be 50 mm apart in one direction (explicit TED) and 0 mm in another perpendicular direction (implicit TED) without external constraint coming from a datum or datum system.

Table C.1 *(continued)*

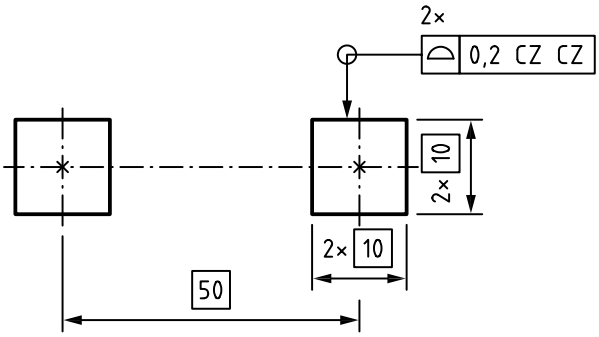
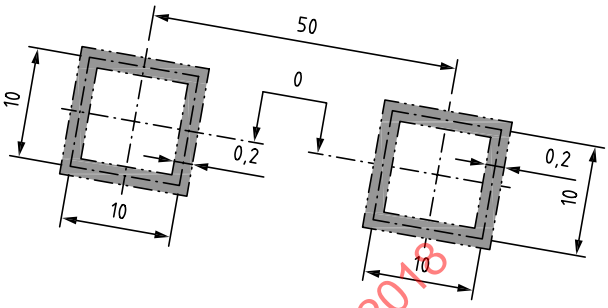
Indication	Meaning
Example 6  NOTE An "all-around" specification is considered with a collection plane indicator as given by ISO 1101.	 The specification is a pattern specification (first CZ in the sequence CZ CZ) defined by two (2x) tolerance zone patterns (last CZ in the sequence). There are two (2x) pattern specifications (last CZ) which are dependent (first CZ), creating a global pattern specification The toleranced feature is the collection of eight extracted integral surfaces (2x and all around symbol). The tolerance zone is a tolerance zone pattern consisting of two tolerance zone patterns (CZ CZ), composed of four tolerance zones, space between two parallel planes 0,2 mm apart and constrained in orientation (implicit TEDs 4x 90°) and in location 2x 10 mm apart (explicit TEDs). The two tolerance zone patterns are constrained in orientation to be parallel (implicit TED of 0°) and in location to be 50 mm apart in one direction (explicit TED) and aligned (implicit TED of 0 mm apart) in the perpendicular direction, without external constraint coming from a datum. NOTE The last CZ modifier in the sequence CZ CZ creates a tolerance zone pattern composed of four tolerance zones. The first CZ in the sequence CZ CZ creates the dependency between the two tolerance zone patterns.

Table C.1 *(continued)*

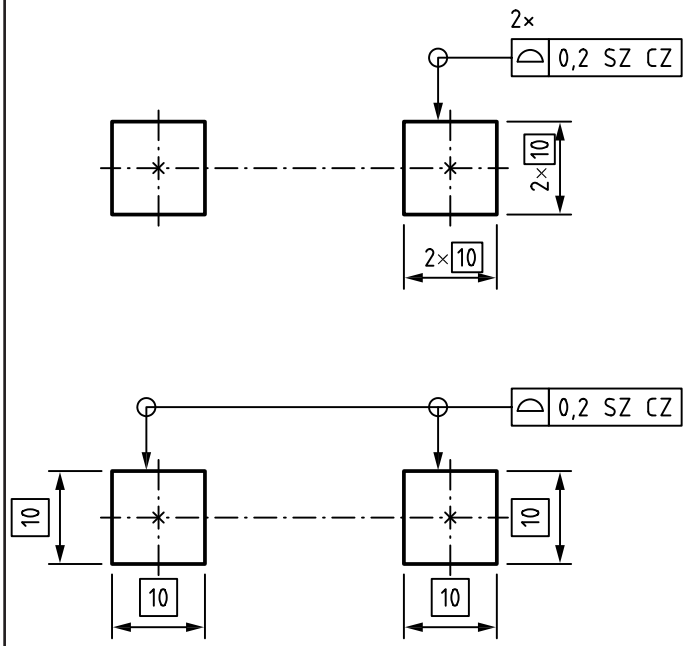
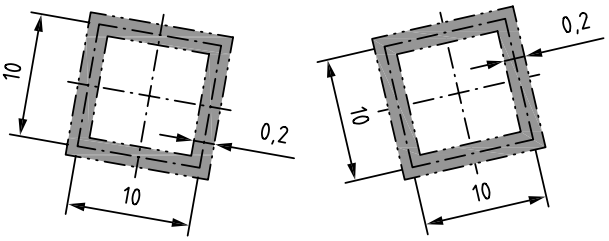
Indication	Meaning
Example 7  NOTE An "all-around" specification is considered with a collection plane indicator as given by ISO 1101.	 The specifications are two (2x or two leader lines) pattern specifications (CZ in the sequence SZ CZ) considered independently (first SZ in the sequence). There are two (2x or two leader lines) pattern specifications (CZ), which are independent (SZ). For each pattern specification, the toleranced feature is the collection of four extracted integral surfaces (all around symbol). For each pattern specification, the tolerance zone pattern (a combined tolerance zone) is composed of four tolerances zones, constrained between them in orientation (implicit TED 0° and 90°) and in location to be 10 mm (in one direction) and 10 mm (in another perpendicular direction) apart, with explicit TEDs, without external constraint coming from a datum or a datum system. NOTE The two tolerance zone patterns are independent, i.e. they are free to move and rotate in relation to each other.

Table C.1 *(continued)*

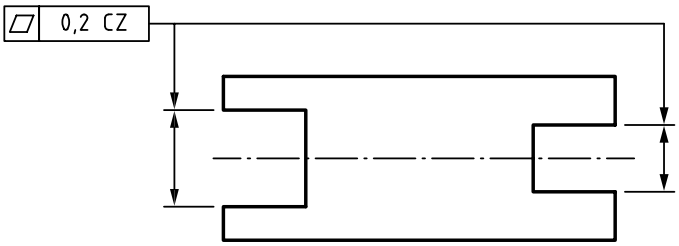
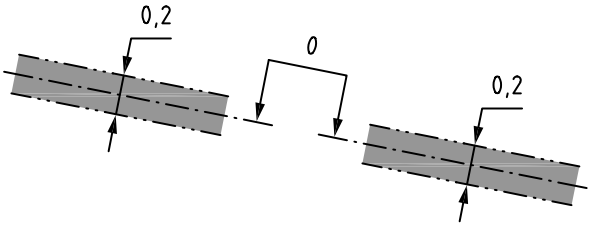
Indication	Meaning
Example 8 	 The toleranced feature is the collection of two extracted derived surfaces (two leader lines). The tolerance zone is a tolerance zone pattern (CZ modifier), composed of two tolerances zones, which are the spaces between two parallel planes 0,2 mm apart and constrained in orientation to be parallel (implicit TED 0°) and in location to be coplanar (implicit TED of 0 mm, symmetry drawing line indication), without external constraint coming from a datum or datum system.

Table C.1 *(continued)*

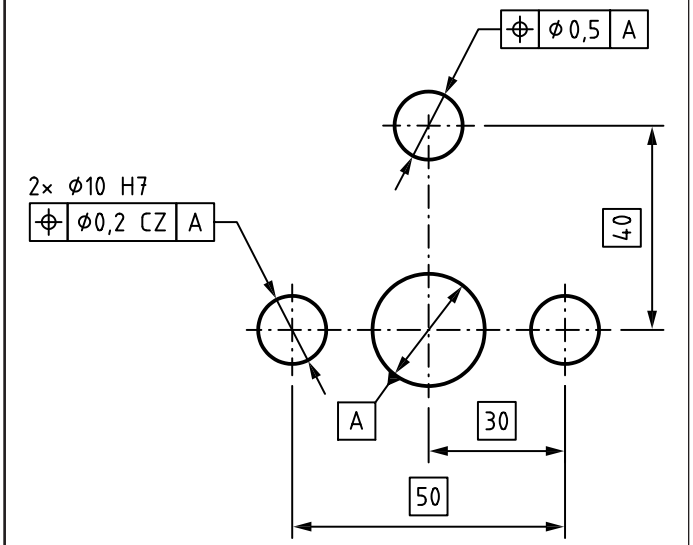
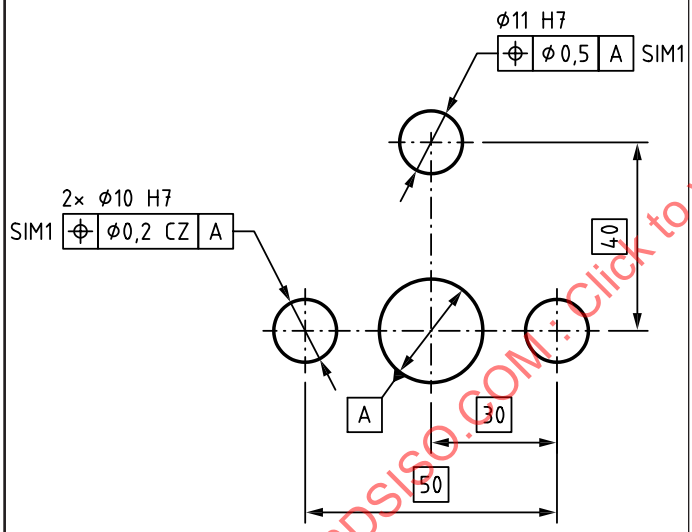
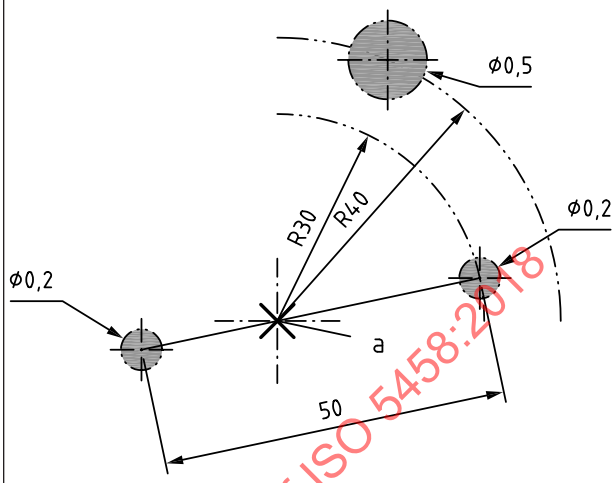
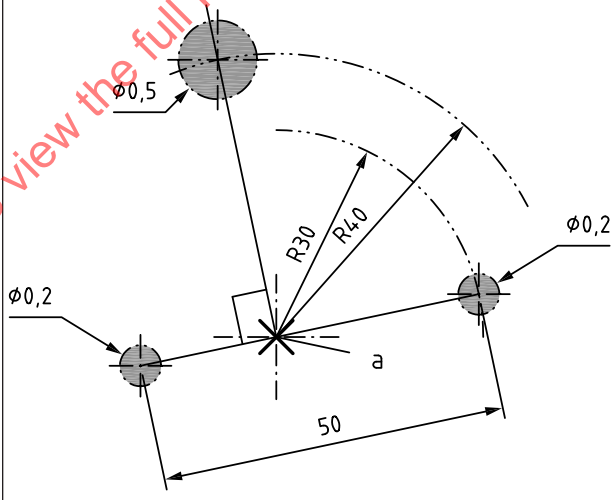
Indication	Meaning
Example 9  	 Without SIM modifier  With SIM modifier

Table C.1 *(continued)*

Indication	Meaning
	Key a datum A The set of geometrical specifications, linked together with the indication of SIM1(not independent), defines a pattern specification (SIM1 modifier). The tolerance indicator with CZ defines, as toleranced feature, a set of two extracted median lines and, as tolerance zone, a tolerance zone pattern defined by two cylindrical zones of diameter 0,2 mm constrained in orientation to be parallel (implicit TED 0°) and in location to be 50 mm apart and externally constrained from the datum A to be diametrically opposed (implicit angle of 180°) and 30 mm apart for one of them (explicit TED). The tolerance indicator without CZ defines as toleranced feature an extracted median line and as tolerance zone a cylindrical zone of diameter 0,5 mm externally constrained in location from the datum A at 40 mm apart. Without SIM modifier, the two specifications are independent: the datum A does not lock all degrees of freedom of the tolerance zone pattern and the cylindrical zone of diameter 0,5 mm can be moved rotationally relatively. With SIM modifier numbered 1, the cylindrical zone of diameter 0,5 mm and the tolerance zone pattern are not independent. They are constrained in orientation (implicit TED of 0°) and in location (explicit TED of 40 mm and implicit TED of 90°), combining these specifications in one pattern specification.

Table C.1 *(continued)*

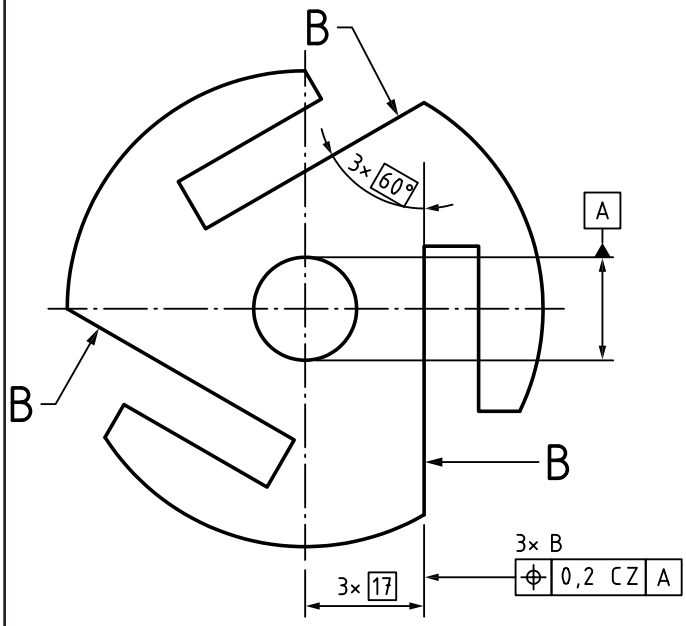
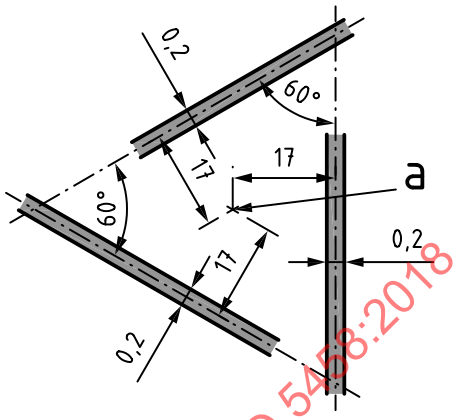
Indication	Meaning
Example 10 	 **Key** a datum A The geometrical specification is a pattern specification (CZ modifier). The toleranced feature is the collection of three (3x, identified by the letter B) extracted integral surfaces. The tolerance zone is a tolerance zone pattern (CZ modifier) composed of three tolerances zones, which are the spaces between two parallel planes 0,2 mm apart and constrained in orientation to be inclined with an angle of 60° (explicit TED) and in location to be 17 mm from a centre straight line for each (3x explicit TED), and with external constraint in location, to have this centre straight line of construction coaxial from the datum A (implicit TED of 0 mm).

Table C.1 *(continued)*

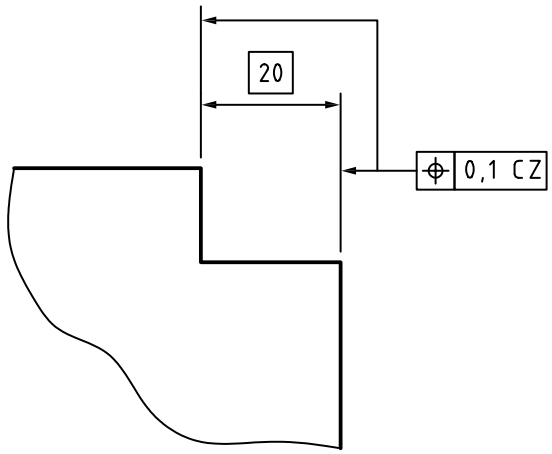
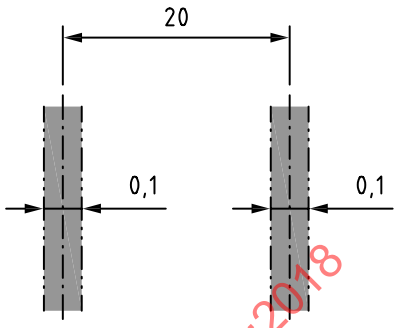
Indication	Meaning
Example 11 	 The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of the two extracted integral surfaces (identified by the two leader lines of the tolerance indicator). The tolerance zone is a tolerance zone pattern (CZ modifier), which is the set of two pairs of parallel planes (two leader lines). Each pair of planes is 0,1 mm apart. The pairs are constrained between them (CZ modifier) at a distance of 20 mm between their median planes (explicit TED).

Table C.1 *(continued)*

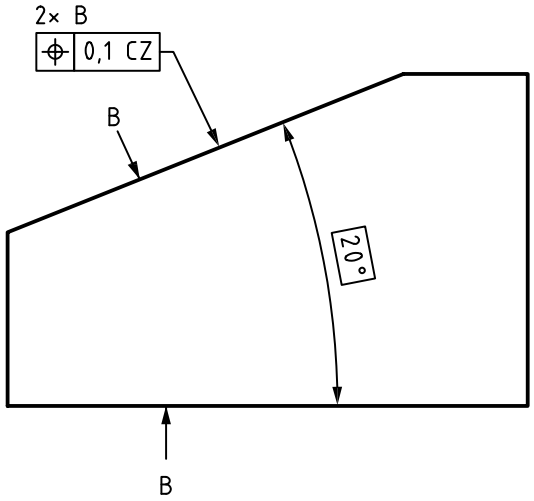
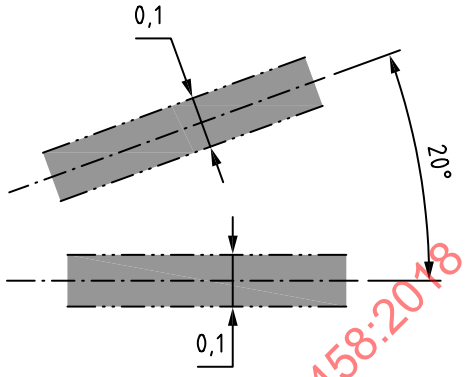
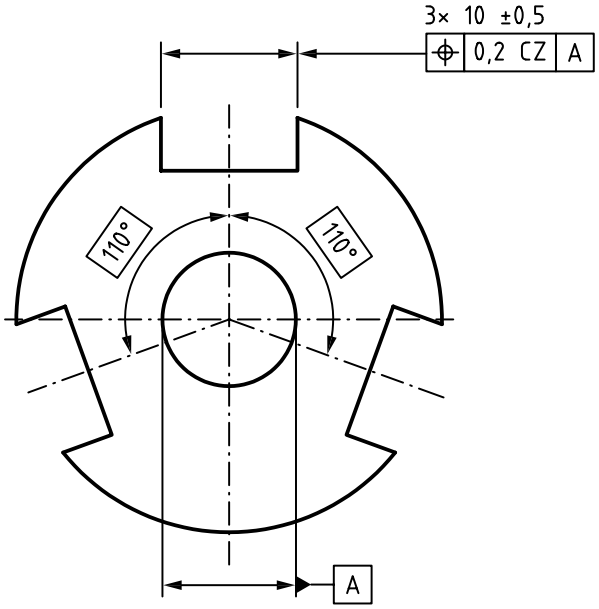
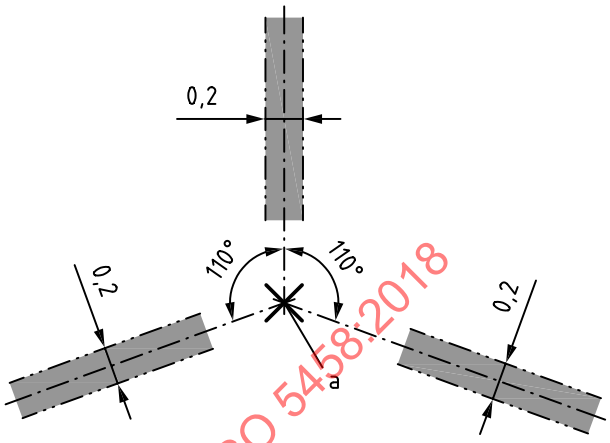
Indication	Meaning
Example 12  NOTE In this case the constraint given by CZ concerns only orientation constraint, not location constraint. It is equivalent to use CZR instead of CZ.	 The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of the two extracted integral surfaces identified by the letter B. The tolerance zone is a tolerance zone pattern composed of two pairs of two parallel planes. Each pair of planes is 0,1 mm apart and the pairs are constrained between them (CZ modifier) in orientation with an angle of 20° NOTE In this case, the distance cannot be constrained in the collection of the two nominal integral surfaces which creates a wedge defined only by an angle.

Table C.1 *(continued)*

Indication	Meaning
Example 13  NOTE In this example, the meaning does not change if the characteristic symbol is the position symbol or the symmetry symbol (the symmetry symbol does not need to show the drawing line to see the implicit TEDs of 0 mm from datum A, as requested with position symbol).	 **Key** a datum axis A The specification is a pattern specification (CZ modifier). The toleranced feature is the collection of the three extracted derived surfaces identified by the upper indication above the tolerance indicator (3x 10 ± 0,05). The tolerance zone is a tolerance zone pattern composed of three pairs of parallel planes 0,2 mm apart constrained between them (CZ modifier) in orientation with angles of 110° (explicit angle 2x and the implicit angle of 140° = 360°-2x110°) and in location with a common intersecting straight line (implicit TED of 0 mm). Moreover, this tolerance zone pattern is externally constrained from datum A. Each of the three tolerance zones is symmetrically disposed around datum A (implicit TED of 0 mm as distance between datum A and the median plane of each of the tolerance zones).