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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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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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).

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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.

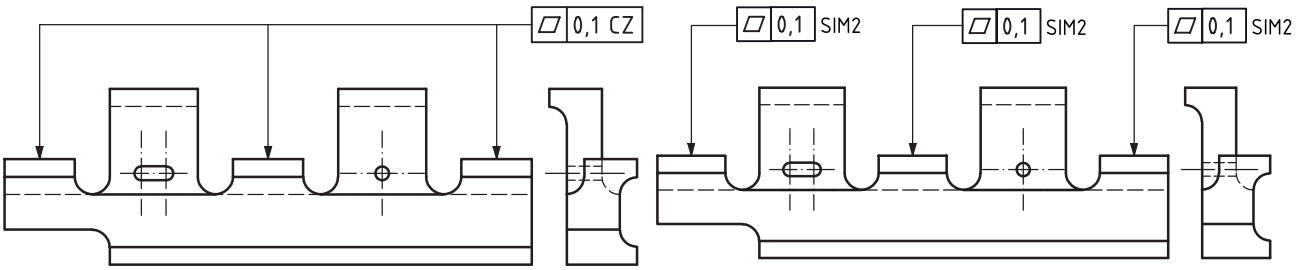
According to the independency principle (see ISO 8015:2011, 5.5), by default a geometrical specification that applies to more than one single feature applies to those features independently. The tolerance zones defined by one tolerance indicator or by several tolerance indicators shall be considered 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.

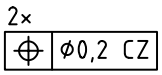
The rules, applied for pattern specification and their repetitions, are given in 5.3 and 5.4. A concept diagram in Annex E illustrates these rules. Examples with their meanings are given in Annex C.

5.3 Rule A: for position specification

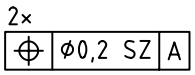
When a position specification is applied to several geometrical features and the tolerance zones have at least one unlocked non-redundant degree of freedom, either the SZ or CZ or CZR modifier shall always be indicated in the tolerance section, see Figure 2 and for former practice, see Annex A.

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

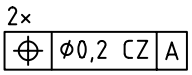
NOTE This rule is in line with the independency principle stated in ISO 8015. However, ISO 5458:1998 was in conflict with the independency principle, since a pattern specification without the CZ modifier implied that the tolerance zones for the repeated specifications were related with internal constraints, 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.

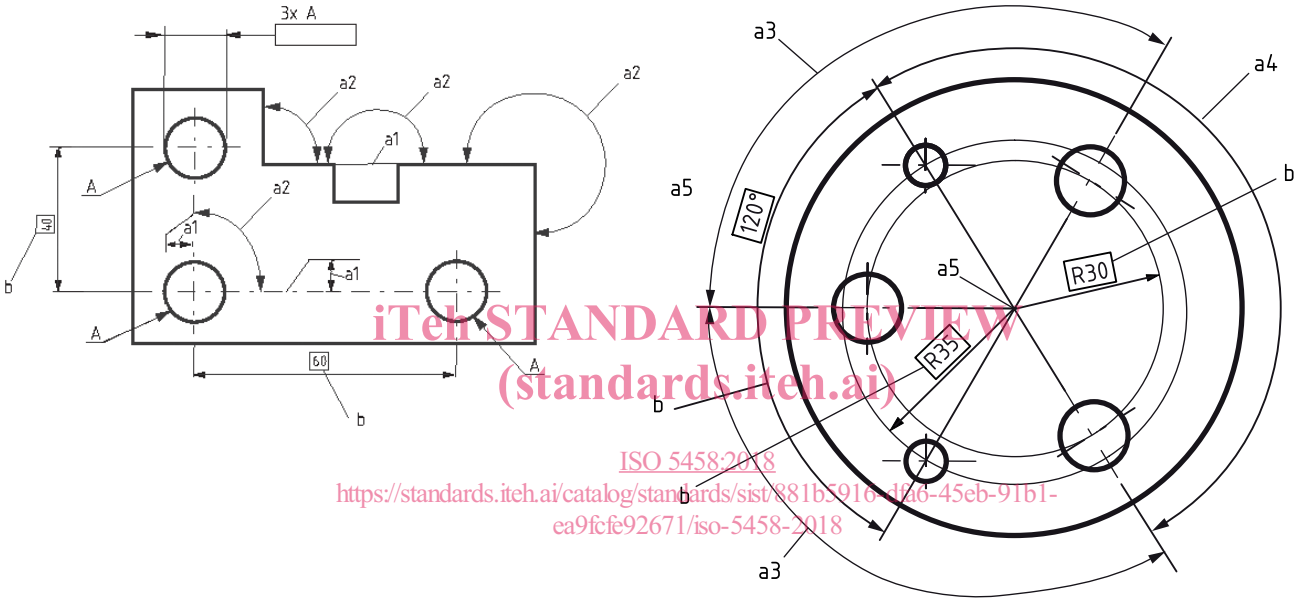
— angular alignment between coaxial patterns (0° or 180° equivalent), see Figure 3, key a4.

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

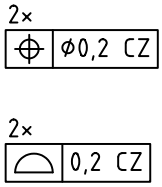
Figure 3 — Implicit or explicit TEDs

5.4.3 Rule C: indication of a single indicator pattern specification

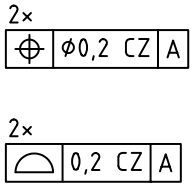
To create a single indicator pattern specification (see Figure 4), the modifier CZ or CZR shall appear in a tolerance indicator which is applied to more than one geometrical feature. The modifier (CZ or CZR) shall be shown in the tolerance section following the tolerance value (see ISO 1101).

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.

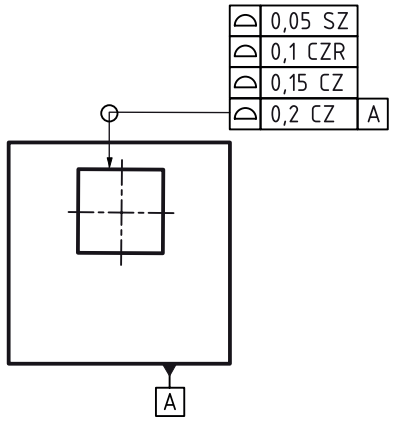
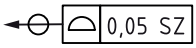
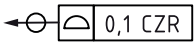
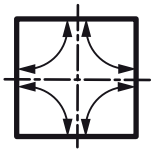
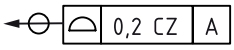
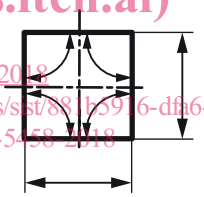
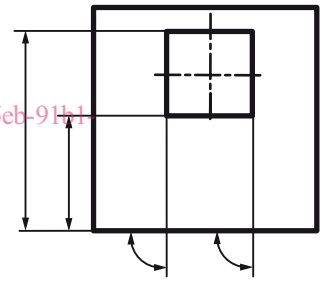
The modifier CZR indicates that a tolerance zone pattern is defined with internal orientation constraints between the individual tolerance zones.

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	Dimensions considered as TEDs for: 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: