INDICATION OF FUNCTIONAL DIMENSION ACCORDING ISO GPS – HOW SHALL WE APPLICATE?

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Abstract
The ISO GPS (Geometrical Product Specifications) define an internationally uniform description language, that allows expressing unambiguously and completely all requirements for the micro and macro geometry of a product with the corresponding requirements for the inspection process in technical drawings, taking into account current possibilities of measurement and testing technology. On the drawing are indicated many specifications (dimensions, geometrical tolerances ...) on many features and not always correctly. Current practice in many companies – many function specification on drawing. Not all specifications in drawing are functional specification! For example are 250 specifications in the drawing, and 200 are functional specification. Here are questions to think about: How many functional specifications are needed? How shall we specification applicate?

Key words: *feature of size; GPS; standard; deviations; longitudinal specification; geometrical specification.*

INTRODUCTION

Engineering drawings without longitudinal tolerances, roughness, geometrical tolerances and datums or datum systems are in most cases incomplete, ambiguous, and therefore not unambiguously interpretable. The incomplete, ambiguous tolerancing of components in engineering drawings causes not only increased production and inspection costs but also makes impossible reasoned complaints of shortcomings and ultimately lead to an incalculable liability risk in the case of legal disputes. Therefore the designers and metrology engineers must have good knowledge on ISO GPS and verification methodology which ought to be given during studies or refreshed and supplemented by specialized training courses on the new standards.
ISO default specification operators and number of fundamental principles that apply to all GPS standards and technical product documentation are indicate in fundamental ISO GPS standards (ISO 8015, 2011). Each ISO GPS standard is placed in ISO GPS matrix model (see Fig. 1).

ISO 14638:2015 ISO GPS Standards matrix model	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibrations
Size	X	X	X	X	X	X	X
Distance	X	X	X	X	X	X	X
Form	X	X	X	X	X	X	X
Orientation	X	X	X	X	X	X	X
Location	X	X	X	X	X	X	X
Run-out	X	X	X	X	X	X	X
Profile surface texture	X	X	X	X	X	X	X
Areal surface texture	X	X	X	X	X	X	X
Surface imperfections	X	X	X	X	X	X	X

Fig. 1 Position in ISO GPS Standard matrix model for (ISO 8015, 2011).

MATERIALS AND METHODS

Feature Principle and Independency Principle - Base principles according (ISO 8015, 2011) which are necessary to keep are:

- Feature principle - a workpiece shall be considered as made up of a number of features limited by natural boundaries. By default, every ISO GPS specification for a feature or relation between features applies to the entire feature or features; and each ISO GPS specification applies only to one feature or one relation between features.

- Independency principle - by default, every ISO GPS specification for a feature or relation between features shall be fulfilled independent of other specifications except when it is stated in a standard or by special indication (e.g. (M) in circle; (L) in circle ; (E) in circle; (R) in circle; CT； CZ) as part of the actual specification.

For the indication of specifications on the drawing is very important keep up rules (principles) description in ISO 8015, especially feature principle and independency principle.

Longitudinal Specification – Linear and Angular Sizes – Application of Specification Modifier

Produced workpieces exhibit deviations from the ideal geometric form (Mazínová, 2015). The real value of the dimension of a feature of size is dependent on the form deviations and on the specific type of size applied. The type of size can be indicated on the drawing by a specification modifier (Fig 2) for controlling the feature definition.

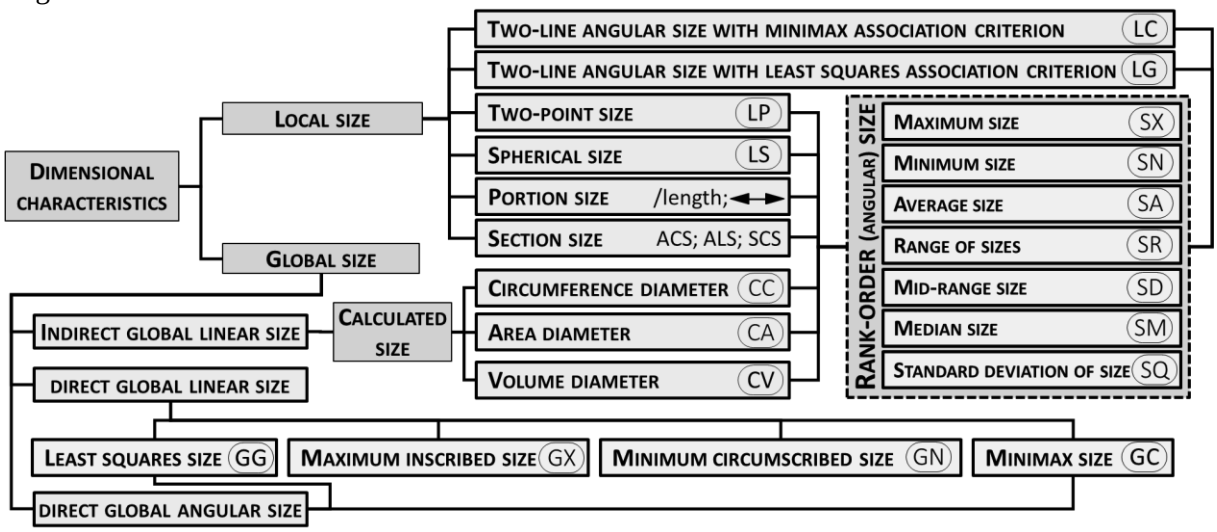

Fig. 2 Specification modifiers for linear (ISO 14405-1, 2016) and angular (ISO 14405-3, 2016) size.

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

- LINEAR SIZE ISO 14405 … Specification modifiers … - for linear size.
- ANGULAR SIZE ISO 14405 … Specification modifiers … - for angular size.

In basic principle is specification indicate on all feature of size, or only on restricted portion, if the specification applies to only one fixed restricted portion of the complete feature of size (see Fig. 3). Other choice is indicate specification in the section (SCS – specific cross section; ACS – any cross section; ALS – any longitudinal section) – see Fig. 6.

If the specification applies as an individual requirement for more than one feature of size (modifier Nx) or applies specification to a collection of more than one feature of size and this collection shall be considered as one feature of size (modifier Nx with modifier CT – common tolerance) – see Fig. 5.

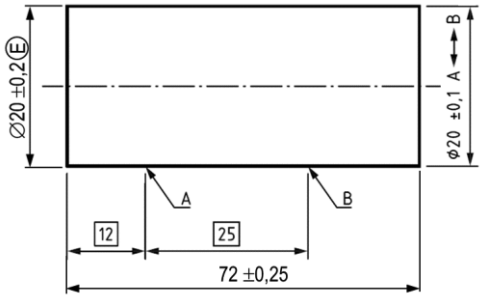

Fig. 3 Restricted portion (A↔B), length of feature of size 72±0.25.

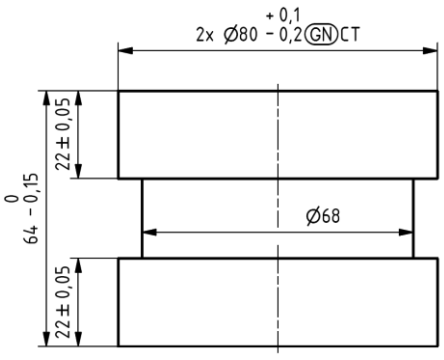

Fig. 4 Example of requirement for two features of size considered as one feature of size.

The specification applies by default to the complete toleranced feature of size. When the toleranced feature is the complete feature, no additional indication is necessary, see Fig. 4. When the specification applies to a united feature (UF) of size, see Fig. 6. An upper limit 0.004 applies to the range of the two-point size values defined in any cross section perpendicular to axis (Intersection plane indicator). An upper limit 0.006 applies to the range of the two-point size values defined in any longitudinal section symmetry to axis (Intersection plane indicator).

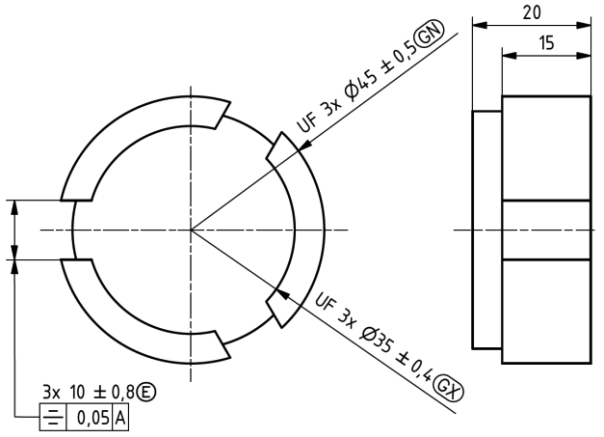

Fig. 5 Requirement for the complete united feature of size (UF).

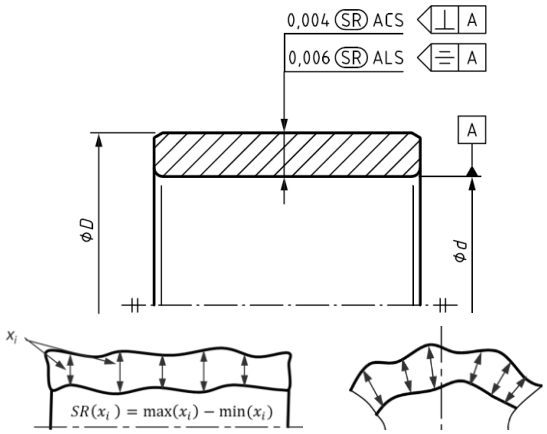

Fig. 6 Examples of the use of rank-order, section and plane specification modifier.

Geometrical Specification

A geometrical specification applies to a single complete feature (see Fig. 7), unless an appropriate modifier is indicated. When the toleranced feature is not a single complete feature, see Fig. 7 (R↔S).

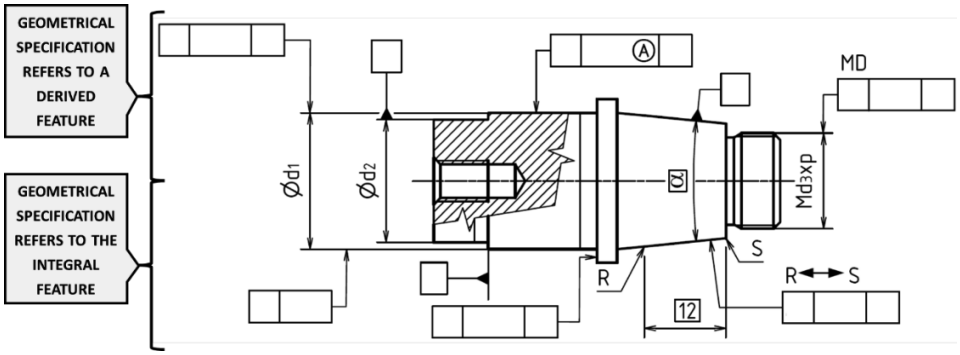

Fig. 7 Geometrical specification applies to drawing.

When the geometrical specification refers to the integral feature, the geometrical specification indication shall be connected to the toleranced feature by a reference line, and a leader line terminating according Fig. 7 (The bottom half of the figure). When the geometrical specification refers to a derived feature (a median point, a median line, or a median surface), it shall be indicated either by a reference line and a leader line terminated by an arrow on the extension of the dimension line of a feature of size or by modifier (A) in circle, see Fig. 7 (The upper half of the figure).

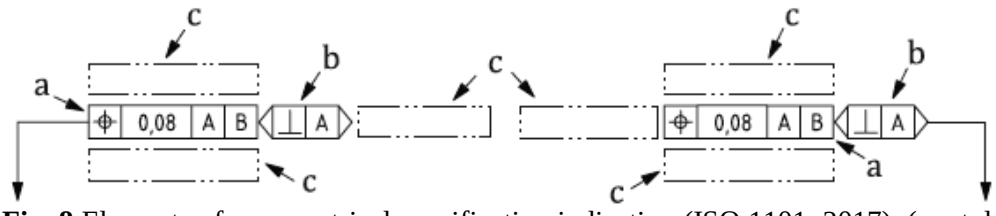

Fig. 8 Elements of a geometrical specification indication (ISO 1101, 2017). (a – tolerance indicator; b – plane and feature indicator; c – adjacent indications).

A geometrical specification indication consists of a tolerance indicator, optional plane and feature indications and optional adjacent indications (See Fig. 8).

Example of Application Geometrical Specification on Feature(s)

The drawing indications in Fig. 9 (2D drawing indication) shall be interpreted as follows: According to the feature principle, the specification applies to one complete feature, i.e. the feature identified by the leader line, which is a feature that forms a 90° section of a cylinder with a nominal radius of 15 (TED - Theoretically Exact Dimensions). In this case, the toleranced feature is defined as part of a cylinder with a radius of 15. The tolerance zone is limited by two equidistant surfaces enveloping spheres with a diameter equal to the tolerance value, the centres of which are situated on the TEF (Theoretically Exact Feature). This results in the tolerance zone limits being 90° sections of coaxial cylinders with radius 14.9 and 15.1, respectively (see Fig. 9 – tolerance zone) according (ISO 1660, 2016).

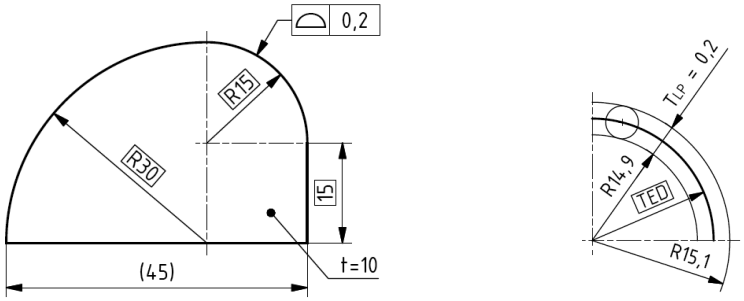

Fig. 9 Surface profile specification for a single feature 2D drawing indication – left; Tolerance zone – right).

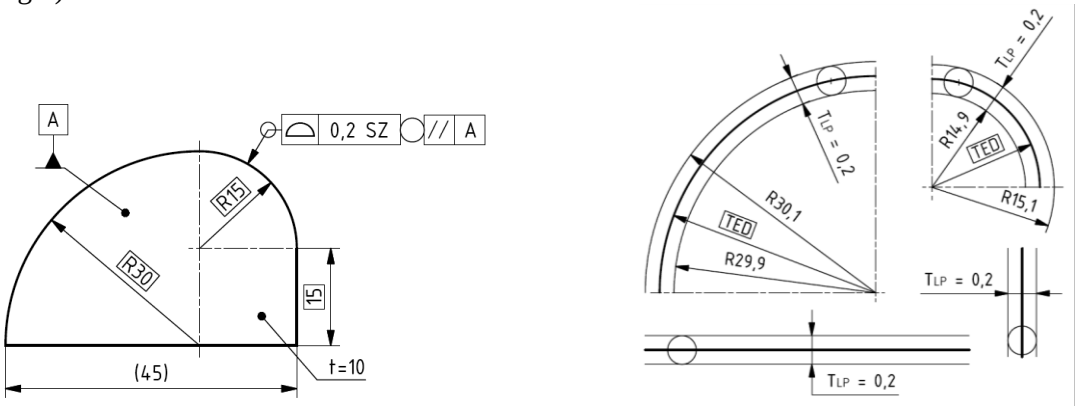

Fig. 10 Surface profile specification for a set of independent features (2D drawing indication – left; Tolerance zone – right).

The drawing indications in Fig. 10 (left) differ from the ones in Fig. 9 in that the "all around" modifier is used. The indication shall be interpreted as follows: The specification applies to a set of features that make up the periphery of the workpiece when seen in a plane parallel to datum A as indicated by the collection plane indicator.

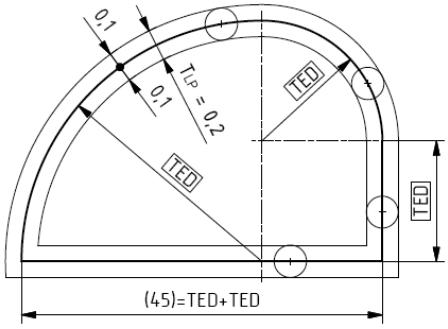

Fig. 11 Tolerance zone for a UF modifier.

The features are considered independent, i.e. the tolerance zones are not related to each other (see Fig. 10 – right). In this case, the toleranced features are defined as a part of a cylinder with a radius of 15, a part of a cylinder with a radius of 30, and two planar surfaces. If the UF (on top tolerance indicator) modifier is used instead of the SZ (separate zone), then the specification applies to a united feature built from the features that make up the periphery of the workpiece (see Fig. 11).

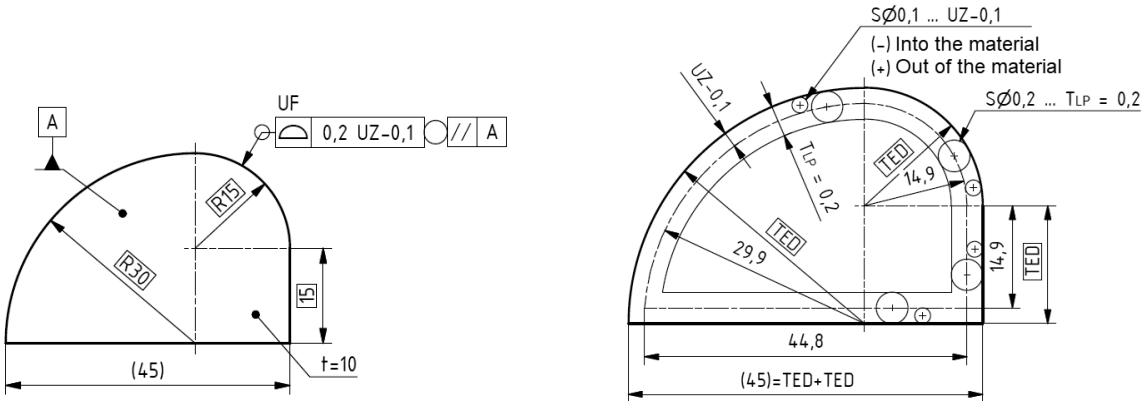

Fig. 12 Unequally disposed surface profile specification for a united feature (2D drawing indication – left; Tolerance zone – right).

The drawing indications in Fig. 12 (left) differ from the ones in Fig. 11 in that the UZ modifier is used to indicate that the tolerance zone is moved 0.1 into the material Fig. 12 (right). The indication shall be interpreted as follows: The specification applies to a united feature built from the features that make up the periphery of the workpiece when seen in a plane parallel to datum A, as indicated by the collection plane indicator. Because the UZ-0.1 modifier is used, the tolerance zone is unequally disposed around the TEF. An equidistant surface enveloping spheres with a diameter of 0.1 placed on the material side of the TEF, because the value is negative, defines the offset nominal geometry.

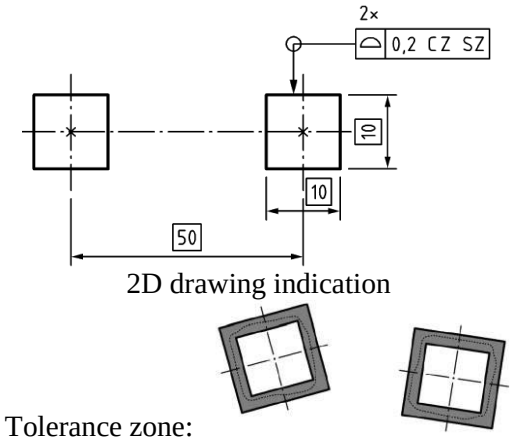

Fig. 13 Two independent patterns.

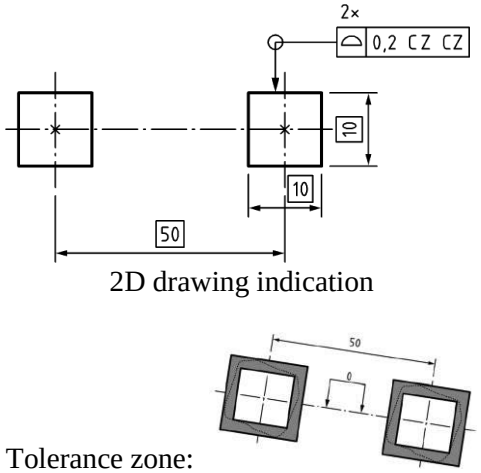

Fig. 14 Unequally disposed surface profile specification for a united feature (2D drawing indication – left; Tolerance zone – right).

RESULTS AND DISCUSSION

Example of Specification for Patterns according (ISO/DIS 5458, 2017). Pattern – compound feature, consisting of a set of more than one individual feature with defined nominal orientation and/or location to each other (without priority).

For indication on Fig. 13 it is possible to say – For each pattern, the tolerance zone is a pattern (a collected tolerance zone), constituted by four tolerances zones, constrained in location to be 10 mm (in a direction) and 10 mm (in another perpendicular direction) apart between them, with explicit TEDs,

without external constraint coming from a datum (CZ). The tolerance zones of each pattern are independent (SZ).
For indication on Fig. 14 it is possible to say – The tolerance zone is a pattern (a collected tolerance zone), constituted by two tolerances zones, constrained in location to be 50 mm (in a direction) and 0 mm (in another perpendicular direction) apart between them, with an explicit TED and an implicit TED, without external constraint coming from a datum (CZ). The 1st CZ modifier creates a collected feature (collection in link with all around symbol – collection of four planes constraints between them in location and orientation). The second CZ modifier creates the collection of two collected features constrained in location between them.

CONCLUSIONS

What to say at the end? The ISO GPS (Geometrical Product Specifications) define an internationally uniform description language, that allows expressing unambiguously and completely all requirements. On the drawing are indicated many specifications (dimensions, geometrical tolerances …), but do not forget, than each specification is only for one feature or for part of feature (if we used modifier). For applicate for more than one specification, we must used modifier. Not all specifications in drawing are functional specification!

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