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Geometrical product specifications (GPS) — Characteristics and conditions — Definitions

Spécification géométrique des produits — Caractéristiques et conditions — Définitions

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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.

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

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

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

ISO 25378 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

Introduction

This International Standard is a Geometrical product specifications (GPS) standard and is to be regarded as a global GPS standard (see ISO/TR 14638). It influences all chain links of all chains of standards in the general GPS matrix.

To facilitate the reading and the understanding of this International Standard, it is essential to refer to ISO 17450-1 and ISO/TS 17450-2.

Geometrical characteristics exist in three "worlds":

— the world of nominal geometrical definition, where an ideal representation of the future workpiece is defined by the designer;

— the world of specification, where several representations of the future workpiece are imagined by the designer;

— the world of verification, where one or several representations of a given workpiece are identified in the application of measuring procedure(s).

A GPS specification defines requirements through a geometrical characteristic and condition.

In the world of verification, mathematical operations can be distinguished from physical operations. The physical operations are the operations based on physical procedures; they are generally mechanical, optical or electromagnetic. The mathematical operations are mathematical treatments of the sampling of the workpiece. This treatment is generally achieved by computing or electronic treatment.

It is important to understand the relationship between these three worlds.

These specifications, characteristics and conditions, generically defined in this International Standard, are well suited to define requirements of rigid parts and assemblies and can also be applied to non-rigid parts and assemblies.

Geometrical product specifications (GPS) — Characteristics and conditions — Definitions

1 Scope

This International Standard defines general terms for geometrical specifications, characteristics and conditions. These definitions are based on concepts developed in ISO 17450-1 and ISO 22432 and they are given by using a mathematical description based on Annex B of ISO 17450-1:2011.

This International Standard is not intended for industrial use as such among designers, but is aimed to serve as the "road map" mapping out the requirements based on geometrical features, thus enabling future standardization for industry and software makers in a consistent manner.

This International Standard defines general types of geometrical characteristics and conditions which can be used in GPS. These descriptions are applicable to

— a workpiece,

— an assembly,

— a population of workpieces, and

— a population of assemblies.

These definitions are based on concepts of operators and the duality principle contained in ISO 17450-1 and ISO/TS 17450-2 and on the description of types of geometrical features defined in ISO 22432.

Conceptually, these specification operators can be used as specification operators or as verification operators (duality principle).

This International Standard is not intended to define GPS specifications, symbology or other types of expression.

2 Normative references

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

ISO 3534-1:2006, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-2, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

ISO 17450-1:2011, *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

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

ISO 22432[1)], *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 3534-1, ISO 3534-2 and ISO 17450-1 and the following apply.

3.1
geometrical specification
expression of a set of one or more conditions on one or more geometrical characteristics

NOTE 1 A specification can express a combination of individual conditions on an individual characteristic or a population condition on a population characteristic.

NOTE 2 A specification consists of one or more single specifications. These single specifications can be individual specifications, population specifications or any combination.

3.2
condition
combination of a limit value and a binary relational mathematical operator

EXAMPLE 1 “be less than or equal to 6,3”, the expression of this condition can be, for instance: 6,3 max or U 6,3. Mathematically: let X be the considered value of the characteristic, the condition is $X \leqslant 6{,}3$.

EXAMPLE 2 “be greater than or equal to 0,8”, the expression of this condition can be, for instance: 0,8 min or L 0,8. Mathematically: let X be the considered value of the characteristic, the condition is $0{,}8 \leqslant X$.

EXAMPLE 3 a set of two complementary conditions (lower and upper limits) can be expressed through, for instance: 10,2 – 9,8, $9{,}8^{+0{,}4}_{0}$, 10 ± 0,2, or $9{,}9^{+0{,}3}_{-0{,}1}$. Mathematically: let X be the considered value of the characteristic, the condition is $9{,}8 \leqslant X \leqslant 10{,}2$.

EXAMPLE 4 “be less than or equal to R, R being given by a function, $R = (X^2 + Y^2) \times 0{,}85$, X and Y being the ordinates of the coordinate system.

NOTE 1 A binary relational mathematical operator is a mathematical concept which generalizes the notion as “greater than or equal to” in arithmetic, or “is item of the set” in set theory.

NOTE 2 The limit value can be defined for any individual workpiece or for populations of workpieces.

NOTE 3 The limit value can be independent of a coordinate system or dependent upon it. In the latter case, the limit value depends on the function of the ordinates of the coordinate system or graphical ordinate system.

NOTE 4 The limit value can be determined by a statistical tolerancing approach, by an arithmetical tolerancing (worst case) approach or by other means. The manner of determining the limit value and the choice of condition is not the subject of this International Standard.

NOTE 5 Two possible inequality relations exist:

— the characteristic value can be less than or equal to the limit value (upper limit);

— the characteristic value can be greater than or equal to the limit value (lower limit).

1) In preparation.

3.2.1
individual condition
condition where the limit value applies to any value of an individual characteristic coming from any workpiece

EXAMPLE An individual condition used in an individual specification: the individual characteristic value shall be less than or equal to 10,2. Mathematically: let X be the considered value of the individual characteristic, the condition is $X \leqslant 10{,}2$.

NOTE An individual condition can be used alone or in combination with a population condition on the corresponding population characteristic.

3.2.2
population condition
condition where the limits apply to the value of the population characteristic

EXAMPLE A population condition used in a population specification: the value of a population characteristic shall be less than or equal to 10,1. Mathematically: let $\overline{X}$ be the considered value of the population characteristic (mean value of the population of global individual characteristic values), the condition is $\overline{X} \leqslant 10{,}1$.

NOTE The population condition can be used for statistical process control (SPC).

3.3
geometrical characteristic
individual characteristic or population characteristic related to the geometry

NOTE 1 This International Standard applies to the field of geometry and therefore, throughout this standard, only “geometrical characteristics” are used. The term “characteristic” is defined in ISO 9000:2005, 3.5.1.

NOTE 2 The geometrical characteristic permits the evaluation of a quantity which could be associated to, for instance, an angular dimension, a linear dimension, an area, a volume, etc.

3.3.1
individual characteristic
individual geometrical characteristic
single geometrical property of one or more geometrical features belonging to a workpiece

EXAMPLE The two-point diameter is an individual characteristic and the result is mathematically varying along the cylindrical feature: it is a local individual characteristic. The minimum circumscribed cylinder diameter is an individual characteristic and the result is mathematically unique: it is a global individual characteristic.

NOTE 1 A local characteristic can be single or calculated.

NOTE 2 The evaluation of an individual characteristic does not necessarily give a unique result (it can be characterized as a local individual characteristic or a global individual characteristic).

3.3.1.1
local individual characteristic
individual characteristic of which the result of evaluation is not unique

EXAMPLE 1 The two-point diameter is an individual characteristic and the result varies mathematically along the cylindrical feature: it is a local individual characteristic.

EXAMPLE 2 See 5.3.

NOTE 1 A local individual characteristic is evaluated on portion feature(s) and can be a direct characteristic or a calculated characteristic. The local diameter measured between two points is a direct local characteristic. The mean of local diameters measured between two points for a given section is a calculated local characteristic.

NOTE 2 The result of an evaluation is related to an entire feature; a single two-point diameter is in itself unique.

3.3.1.2
global individual characteristic
individual characteristic of which the result of evaluation is unique

EXAMPLE 1 The minimum circumscribed cylinder diameter is a direct global individual characteristic (the result is mathematically unique).

EXAMPLE 2 The maximum of two-point diameters along a given cylinder is a calculated global individual characteristic (the result comes from a statistic and is mathematically unique).

NOTE The result of evaluation of a global individual characteristic can come from a unique evaluation or a statistic of a set of results of evaluation of a local individual characteristic, characterized as direct and calculated, respectively.

3.3.2
population characteristic
statistic defined from the characteristic values, obtained on the population of workpieces or the population of assemblies

NOTE 1 Population characteristics are used to consider a total population of workpieces.

EXAMPLE 1 The arithmetic mean or the standard deviation on the population of workpieces of a global individual characteristic are population characteristics.

NOTE 2 Population characteristics are only statistically meaningful for GPS characteristics when the value is the result of global individual characteristics.

EXAMPLE 2 The minimum circumscribed cylinder diameter has one unique value for a given cylindrical feature. Therefore, a population characteristic based on this individual characteristic value will be statistically meaningful. The two-point diameter for a given cylindrical feature will vary within a range, dependent upon the form deviations of the feature. In this case, a population characteristic cannot be defined from the population of values. It could be possible, in this case, to establish a population characteristic from the maximum value of the two-point diameter along the feature. In this case, the individual characteristic is a global individual characteristic which is the maximum two-point diameter on a given workpiece.

NOTE 3 The population characteristic can be used, for example, for statistical process control (SPC).

3.4
statistic
completely specified function of random variables

EXAMPLE See Table 1. More information can be found in the ISO 3534 series.

NOTE 1 This definition, taken from ISO 3534-1:2006, 1.8, is associated to notes which are not reproduced in this International Standard.

NOTE 2 In GPS, the random variables which are used are, in most cases, one-dimensional (scalar). Multidimensional (vector) variables also exist.

NOTE 3 For a population or a sample of individual characteristic values, at least one statistic can be applied. In GPS, a statistic can be used on a population of local individual characteristic values taken on one workpiece, or on a population of global individual characteristic values taken on a population of workpieces.

Table 1 — Non-exhaustive list of statistics

Description of the statistic	Mathematical description according to ISO 3534-1[a]
the minimum	minimum (X)
the maximum	maximum (X)
the expected value (mean)	$\mu = E(X^k) = \frac{1}{n}\sum_{i=1}^{n} X_i^k$, or $\mu = E\left[g(X)\right] = \int g(X)\mathrm{d}p = \int g(x)\mathrm{d}F(x)$
the difference between the average and the target value (TV)	$\mu - TV$
the standard deviation	$\sigma = \sqrt{V(X)}$
the variance	$V(X) = E\left[X - E(X)\right]^2$

[a] Where X is the characteristic value.

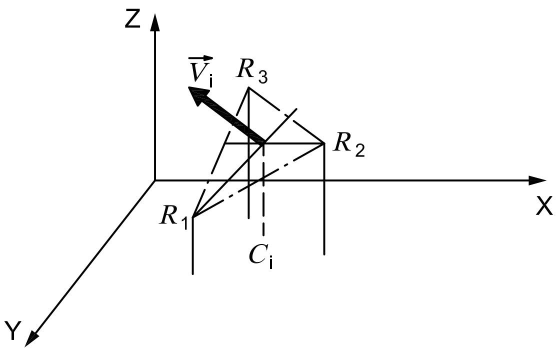
NOTE 4 For some statistical applications (like SPC), it can be necessary to define a “Target Value” (see ISO 7966 and ISO 3534-2).

3.5
calculated characteristic
local or global individual characteristic obtained from a collection of a set of values of one local individual characteristic by using a function and not changing the nature of the initial characteristic

EXAMPLE 1 The normal vector obtained from three local individual characteristic vector values is a calculated characteristic, which is a local individual characteristic (see Figure 1).

EXAMPLE 2 The expected value (mean value) obtained from the population of values of local diameter of the cylinder in a specific section is a local individual characteristic.

EXAMPLE 3 The expected value (mean value) obtained from the population of values of local diameter of the cylinder (taking into account the entire cylinder) is a global individual characteristic.



Key

R_1, R_2, R_3	local individual characteristic vector values in a coordinate system
C_i	coordinates assigned to the normal vector of the surface
$\vec{V}_i$	normal vector of the surface

Figure 1 — Calculated characteristic consisting of the angles of a normal vector of a surface coming from three values of a local individual characteristic

3.5.1
direct characteristic
local or global characteristic derived from a single evaluation

3.5.2
transformed characteristic
local or global characteristic which changes the initial characteristic

3.6
combination characteristic
geometrical characteristic obtained from a collection of values related to a set of geometrical characteristics by using a function

EXAMPLE The volume of a cylinder can be seen as a combination characteristic which is a function of two geometrical characteristic values: the length and the diameter of the cylinder.

3.7
value of a geometrical characteristic
geometrical characteristic value
signed value with or without a unit resulting from an evaluation of a geometrical characteristic, quantified on a workpiece or the population of workpieces

NOTE The characteristic value is, in most cases, a uni-dimensional value but can be multidimensional (vector value).

EXAMPLE Local two-point diameter, global minimum circumscribed diameter, vector describing the location and orientation of a hole axis.

3.7.1
value of an individual characteristic
signed value with or without a unit resulting from an evaluation of an individual characteristic, quantified on one workpiece

3.7.2
value of a population characteristic
signed value with or without a unit resulting from an evaluation of a population characteristic, quantified on the population of workpieces

NOTE 1 By using sampling (instead of the whole population), a sampling uncertainty is introduced (see E.4 of ISO/IEC Guide 98-3:2008).

NOTE 2 The evaluation of a population characteristic is a two-step process:

— evaluation of a set of results of an individual characteristic;

— statistical evaluation of the results of step 1.

NOTE 3 For any individual characteristic value, the value obtained from a simplified verification operator will, in general, differ from the value obtained from a perfect verification operator. In general, there is no simple way to estimate the variation of this difference and, in most practical cases, it is simply impossible. It is not unusual for this difference to be of the same magnitude as the population variation. The variation in the difference may increase or decrease the evaluated population variation. Because this difference enters into the statistical calculation and affects it in such a significant and unpredictable way, a meaningful estimation of the uncertainty of the evaluation of the variation of a characteristic in a population by a simplified verification operator is, in general, very difficult and in most cases impossible. Therefore, it is only meaningful to use population characteristics in specifications that will be evaluated by verification operators without method uncertainty.

EXAMPLE 1 It is impossible to define the relationship between the standard deviation of two-point diameters on a population of workpieces and the standard deviation of the minimum circumscribed cylinder diameter of the same population of workpieces without complete knowledge of the form deviations of the workpieces and the locations of the two-point diameters.

EXAMPLE 2 Average length of a population of rods: 5,342 mm (where the length is defined as the distance between two parallel planes between which each rod fits).

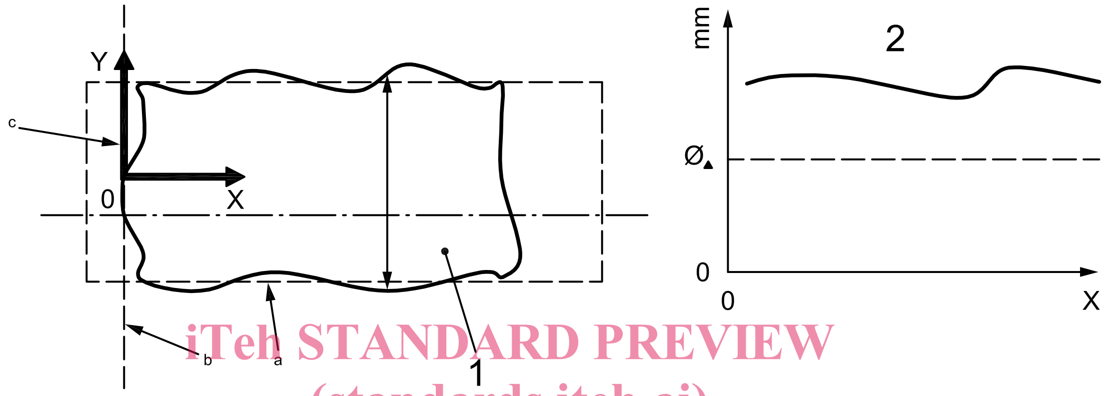
3.7.3
variation characteristic
set of local individual characteristic values recorded along a feature

NOTE 1 A characteristic variation may or may not be related to a coordinate system.

NOTE 2 To obtain a curve of the variation of characteristic values, it is necessary to define a coordinate system.

NOTE 3 To obtain the dispersion of the variation, it is not necessary to define a coordinate system.

EXAMPLE 1 The minimum circumscribed circle diameter along the cylinder is a local individual characteristic. By considering a coordinate system link with the axis of the associated cylinder, it is possible to follow the variation of these local individual characteristic values (see Figure 2).



Key

1 real feature

2 local characteristic values

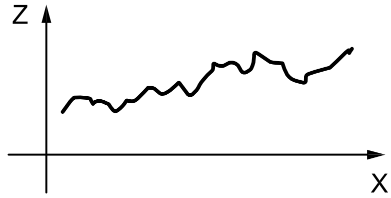
[a] Associated cylinder.

[b] Associated plane.

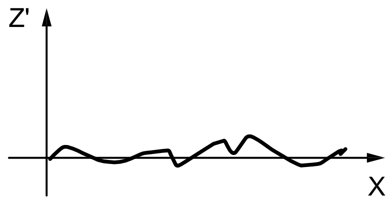
[c] Coordinate system.

Figure 2 — Example of curve of characteristic-values variation, based on minimum circumscribed circle diameter

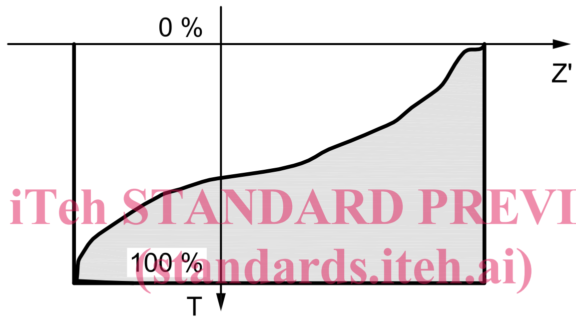
EXAMPLE 2 In the case of texture characteristics, it can be necessary to use several types of curve of characteristic-values variation or a transformation of it (see Figure 3).



a) Variation curve of situation characteristic between the non-ideal integral surface and a reference feature



b) Curve of characteristic-values variation corresponding to the transformation of curve a) by an application of a rotation with an objection function after application of a filter



c) Curve of ratios corresponding to the transformation of curve b) to define the ratio of material

Figure 3 — Examples of curves of characteristic-values variation

3.7.3.1
variation curve
characteristic variation represented in a coordinate system

NOTE 1 A variation curve can be obtained without transformation or by mathematical transformation. It can be qualified as direct or transformed.

NOTE 2 A variation curve can be filtered.

3.8
basic characteristic
basic geometrical characteristic
intrinsic characteristic or situation characteristic

NOTE 1 A basic characteristic does not include the definition of intermediate features obtained by operations.

NOTE 2 See Annex B.

3.8.1
intrinsic characteristic
characteristic of an ideal feature

[ISO 17450-1:2011, 3.14]

NOTE 1 A plane, a straight line and a point have no intrinsic characteristic.

EXAMPLE The diameter is the intrinsic characteristic of a cylinder. A torus has two intrinsic characteristics: the diameter of the generatrix and the diameter of the directrix. A cylinder and a torus are examples of features of size. The size of the feature of size of type cylinder is its diameter. The size of the feature of size of type torus is the diameter of the generatrix.

NOTE 2 See B.2.

3.8.2
situation characteristic
characteristic defining the relative location or orientation between two features

[ISO 17450-1:2011, 3.23]

NOTE 1 A situation characteristic is an orientation characteristic or a location characteristic.

NOTE 2 See B.3.

3.8.2.1
orientation characteristic
geometrical characteristic defining the related orientation between two ideal features

NOTE See B.3.2.

3.8.2.2
location characteristic
geometrical characteristic defining the related location between two features

NOTE A situation characteristic defines the related location between two ideal features (see B.3.2), between a feature portion and an ideal feature (see B.3.3), between a non-ideal feature and an ideal feature (see B.3.4), and between two non-ideal features (see B.3.5).

3.9
GPS characteristic
geometrical characteristic intended to be standardized corresponding to micro- or macro-geometry which may be quantified

NOTE See Clause 5.

3.9.1
input feature
GPS characteristic input feature
set of one or more features coming from the surface model or real surfaces of the workpiece which may be filtered, from which a GPS characteristic is defined

3.9.1.1
single characteristic
single individual characteristic
geometrical characteristic describing the micro- or macro-geometry of a feature taken from one workpiece

NOTE 1 The considered feature can be identified by a collection of several features, such as a feature constituted by two straight lines or a feature constituted by four parallel cylinders.

NOTE 2 See 5.2.1.

3.9.1.2
relationship individual characteristic
individual geometrical characteristic describing the geometrical situation (orientation, position) between several geometrical features

NOTE See 5.2.2.

