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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

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

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

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

ISO 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.

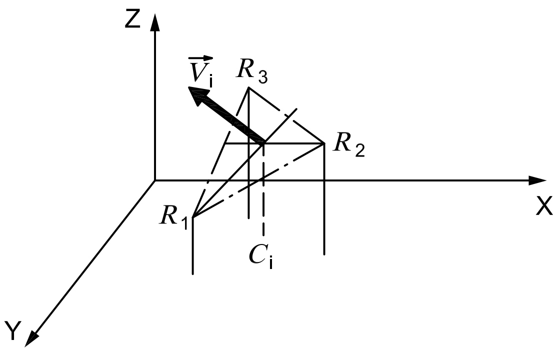
NOTE 4 For some statistical applications (like SPC), it can be necessary to define a “Target Value” (see ISO 7966 and ISO 3534-2).

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).

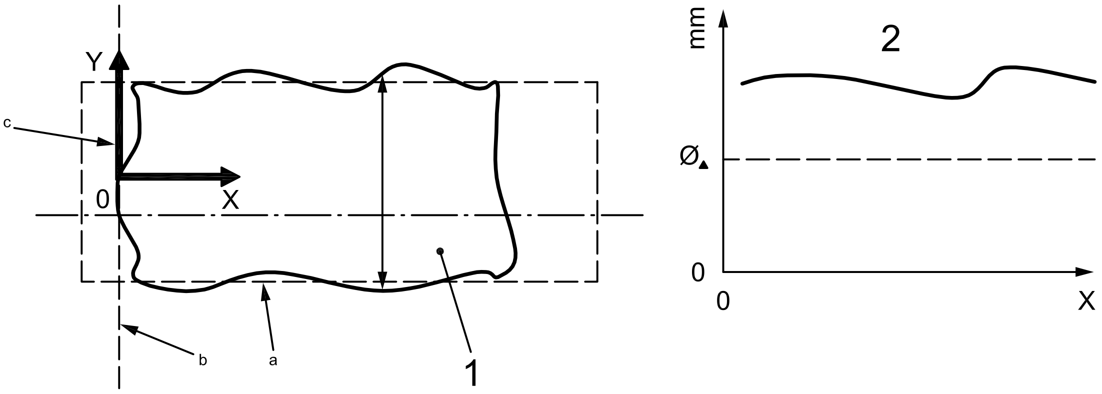
3.7.3
variation characteristic
set of local individual characteristic values recorded along a feature

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

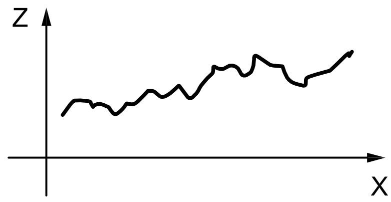
a Associated cylinder.

b Associated plane.

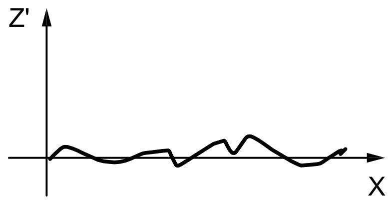
c Coordinate system.

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

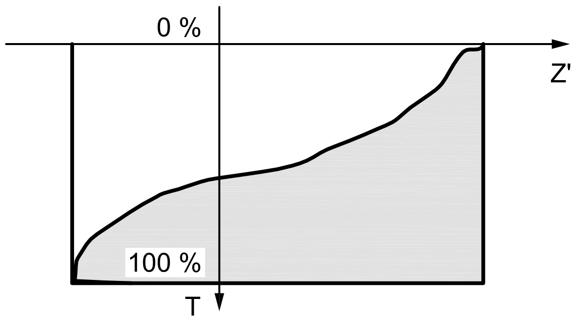
EXAMPLE 2 In the case of texture characteristics, it can be necessary to use several types of curve of characteristic-values variation or a transformation of it (see Figure 3).



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.

3.9.1.3
deviated feature
geometrical feature or variation curve considered in an intrinsic characteristic or which has the larger deviation among the two features considered in a situation characteristic

NOTE See 5.4.

3.9.1.4
reference feature
geometrical feature or variation curve which has the smaller deviation among the two features considered in a situation characteristic

NOTE See 5.4.

3.9.1.5
facing feature
ideal feature simulating the feature which a given feature on a workpiece is interfacing with by considering the assembly or some virtual geometry

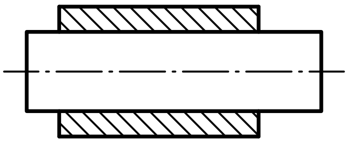
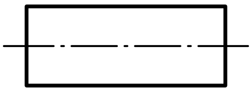
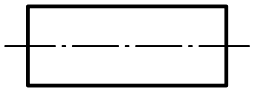
NOTE 1 A facing feature cannot be defined alone.

NOTE 2 The facing feature can have the same nominal geometry of the nominal integral feature (depending on the function). See Table 2.

NOTE 3 A facing feature can simulate the orientation or location of a workpiece, simulate a fitting, etc.

NOTE 4 It is sometimes necessary to consider the interface between the integral feature and its facing feature to precisely define the intrinsic characteristic or the relationship characteristic.

Table 2 — Examples of interfaces between an internal cylinder and different facing features

<table>
<tr><th>Assembly</th><th>Facing feature with the internal cylinder as considered workpiece</th><th>Interface</th></tr>
<tr><td>
Cylinder/Cylinder</td><td>
Cylinder</td><td>
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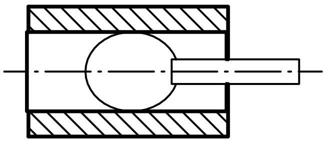
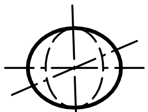
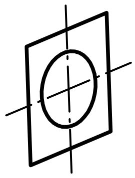
<tr><td>
Cylinder/Sphere</td><td>
Sphere</td><td rowspan="2">
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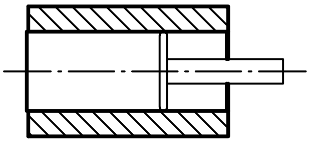
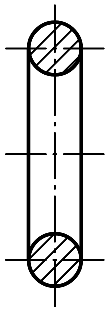
<tr><td>
Cylinder/Torus</td><td>
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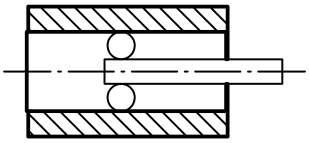
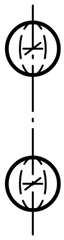
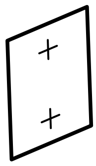
<tr><td>
Cylinder/Set of two spheres</td><td>
Set of two spheres</td><td>
Two points</td></tr>
</table>

3.9.2
independent characteristic
geometrical characteristic which has no influence on, nor is influenced by, any other geometrical characteristic

NOTE See 5.5.

3.9.2.1
independent form characteristic
GPS characteristic defining the deviation of form of a non-ideal feature (which may be a derived or integral feature) as a situation characteristic

NOTE 1 The reference feature is a substitute feature obtained from the deviated feature by an association.

NOTE 2 See 5.5.2.

3.9.2.2
independent size characteristic
GPS characteristic defining the size of a non-ideal feature (which may be a derived or integral feature) as an intrinsic characteristic

NOTE 1 The deviated feature is the reference feature of the independent form characteristic.

NOTE 2 See 5.5.3.

3.9.2.3
independent orientation characteristic
GPS characteristic defining the deviation of orientation between non-ideal features (which may be a derived or integral feature) as a situation characteristic

NOTE 1 The deviated features are the reference features of the independent form characteristics of each of the features.

NOTE 2 The reference features are ideal features obtained from the deviated features by an association with constraints of orientation.

NOTE 3 See 5.5.4.

3.9.2.4
independent location characteristic
GPS characteristic defining the deviation of location between non-ideal features (which may be a derived or integral feature) as a situation characteristic

NOTE 1 The deviated features are the reference features of the independent orientation characteristic.

NOTE 2 The reference features are ideal features obtained from the deviated features by an association with constraints of orientation and location.

NOTE 3 See 5.5.5.

3.9.2.5
complementary characteristic
set of independent characteristics related to form, size, orientation and location

NOTE See 5.5.

3.9.3
zone characteristic
GPS characteristic defining the deviation of non-ideal feature(s) [which may be a derived or integral feature(s)] as a situation characteristic of type maximum distance

NOTE See 5.6.

3.9.3.1
zone form characteristic
zone characteristic defining the deviation of form of a non-ideal feature (which may be a derived or integral feature)

NOTE 1 The deviated feature is the non-ideal feature itself or a feature obtained from it by filtration.

NOTE 2 The reference feature is a substitute feature obtained from the deviated feature by an association, with or without feature-size constraint.

NOTE 3 See 5.6.2.

3.9.3.2
zone orientation characteristic
zone characteristic defining the deviation of orientation of non-ideal features (which may be a derived or integral feature)

NOTE 1 The deviated features are the non-ideal features themselves or features obtained from them by filtration (smoothed features) or by association (substitute features).

NOTE 2 The reference features are features obtained from the deviated features by an association (substitute features) with constraints of orientation, with or without feature-size constraint.

NOTE 3 See 5.6.3.

3.9.3.3
zone location characteristic
zone characteristic defining the deviation of location of non-ideal features (which may be a derived or integral feature)

NOTE 1 The deviated features are the non-ideal features themselves or features obtained from them by filtration (smoothed features) or by association (substitute features).

NOTE 2 The reference features are features obtained from the deviated features by an association (substitute features) with constraints of orientation and location, with or without feature-size constraint.

NOTE 3 See 5.6.4.

3.9.4
gauge characteristic
GPS characteristic defining the deviation of integral or smoothed feature(s) as a basic characteristic, taking into account at least one candidate feature associated to the input features

NOTE See 5.7.

3.9.4.1
gauge size characteristic
GPS characteristic defining the size of a deviated feature, utilizing the relevant facing feature given the simulated interface of the non-ideal integral feature or smoothed feature

NOTE 1 In the majority of cases, the types of the facing feature and the integral feature are the same. Where this is the case, there is, nominally, no difference between the interface and the integral feature.

NOTE 2 For example, the gauge size characteristic integrates the notion of diameter of associated cylinders and local diameter.

NOTE 3 See 5.7.2.

3.9.4.2
gauge variation characteristic
GPS characteristic defining the deviation of integral or smoothed feature(s) as a situation characteristic between a reference feature and candidate feature(s) associated to the integral feature(s) with an objective of minimum or maximum of the situation characteristic

NOTE 1 The reference feature is relevant to the concept of datum.

NOTE 2 See 5.7.3.

3.9.4.3
gauge gap characteristic
GPS characteristic defining the deviation of integral or smoothed feature(s) as a situation characteristic between two orientations and/or locations of a candidate feature such that the situation characteristic is a maximum.

NOTE See 5.7.4.

3.9.4.4
floating contact
contact which permits tangential, normal and rotative related movements during regular functioning

NOTE See 5.8.2.

3.9.4.5
slipping contact
contact constrained by a mechanical action which permits only tangential related movement during regular functioning

NOTE See 5.8.2.

3.9.4.6
rolling contact
contact which permits only rotative related movements during regular functioning

NOTE See 5.8.2.

3.9.4.7
rolling/slipping contact
contact which permits tangential and rotative related movements during regular functioning

NOTE See 5.8.2.

3.9.4.8
fixed contact
contact constrained by a mechanical action and/or an induced friction which does not permit related movement during regular functioning

NOTE See 5.8.2.

3.9.4.9
configuration
particular positioning of the parts of an assembly without interference between the parts

NOTE See 5.8.3.

3.9.4.10
subset of configuration
configuration such that the features in fixed contact are in a given position

NOTE See 5.8.3.

3.9.5
texture characteristic
calculated characteristic on a curve of characteristic-values variation, which has been defined primarily on a portion of a non-ideal integral feature

NOTE 1 The curve of characteristic-values variation can represent the variation of the situation characteristic between a deviated feature and a reference feature or a transformation.

NOTE 2 The curve of characteristic-values variation can be multidimensional.

4 General presentation

4.1 General principles of the specifications

A GPS specification corresponds

a) to a requirement:

- on all the workpieces taken individually: individual specification,
- on the population of workpieces, taken collectively: population specification, or

b) to a compound requirement combining the two previous types of requirements.

In the case of a single specification, the condition shall be applied to any characteristic value.

This characteristic is a characteristic on one feature (for example, the form characteristic of a nominally planar surface) or between several features (for example, the orientation characteristic between two surfaces) (see ISO 22432).

NOTE This characteristic can be a global characteristic (for example, the diameter of a least-squares cylinder associated to a nominally cylindrical surface) or a function of a local characteristic (function of the two-point diameter of a nominally cylindrical surface).

In the case of population specification, the condition shall be applied on the population of characteristic values.

This population of characteristic values is obtained from a statistic (particular function) on the characteristic values observed on the population of workpieces. The individual characteristic observed on the workpiece shall be a global characteristic.

4.2 General principle of the characteristics

A geometrical characteristic corresponds to quantification or qualification of one or more constraints

- on one ideal or non-ideal feature (individual characteristic), or
- between one ideal or non-ideal feature and another ideal or non-ideal feature (relationship characteristic).

This constraint can be a size, surface texture, form, orientation or location constraint.

Since the characteristic is related to the real workpiece, all types of deviations from the nominal feature can exist.

The geometrical characteristic can be seen as the observation of one or more parameters of a feature:

- surface texture, form, size related to the same nominal feature itself [single (individual) characteristic];
- orientation, location of an ideal or non-ideal feature from one or more other ideal features (relationship characteristic).

The geometrical characteristic can permit the freedom parameters of a feature to be observed independently:

- surface texture/form freedom (1 parameter of shape freedom);
- size freedom (1 parameter of size freedom);
- angular freedom (3 degrees of rotation freedom);

— translation freedom (3 degrees of translation freedom).

These basic freedom parameters should be combined: i.e. a geometrical characteristic may consider independently the basic freedom parameters.

— Each nominal geometrical feature has a number of invariance degrees (NID) which cannot be constrained. The number of degrees of freedom, which can be constrained, is at a maximum equal to 6 minus the number of degrees of invariance of this nominal feature.

— Taking into account the real workpiece, or a surface model, on a real geometrical feature (non-nominal), 2 additional parameters appear (form and dimensional deviation).

As a result, a geometrical characteristic should be controlled by up to 8 minus the number of invariance degrees constraints.

The characteristics used in the field of the Geometrical Product Specification should be independent characteristics, zone characteristics and gauge characteristics, which are all subtypes of GPS characteristics (see Clause 6).

The GPS characteristics are all described from basic characteristics (see Clause 5).

5 Illustration of GPS characteristics

5.1 General

The GPS characteristics enable the definition of the deviations and the dimensions with regard to the ideal features. The deviations are called

— texture,

— form,

— orientation, and

— location.

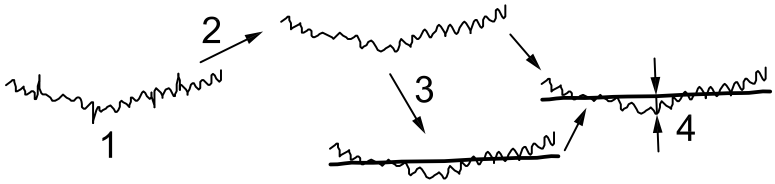
The texture and the form deviations are established from one non-ideal feature.

The size is an intrinsic characteristic established from one non-ideal feature.

The orientation and the location deviations are situation characteristics established from two non-ideal features.

NOTE A GPS characteristic on one or more input features generally requires the definition of other feature(s) obtained by operations and is expressed by a basic characteristic or by a function of basic characteristics on the feature(s).

EXAMPLE A form characteristic on a nominally planar surface is a GPS characteristic. To define this GPS characteristic, the specified surface could be filtered, and a plane associated according to a given criterion. Thus, the form characteristic is expressed as a basic characteristic, which is a situation characteristic between a non-ideal feature and an ideal feature: the maximum distance between the smoothed feature and the plane (see Figure 4).



Key

1 non-ideal feature
2 filtration
3 association
4 basic characteristic

Figure 4 — Example of definition of a GPS characteristic

5.2 Single and relationship characteristics

5.2.1 Single characteristic

A single (individual) characteristic describes the micro- or macro-geometry of one non-ideal feature. This corresponds to a nominal feature which can be

— a single feature such as a plane or a cylinder,

— a discontinuous feature such as a surface constituted of three portions of a cylinder (see Figure 5), or

— a feature obtained by a collection of several features such as planes (see Figure 6).

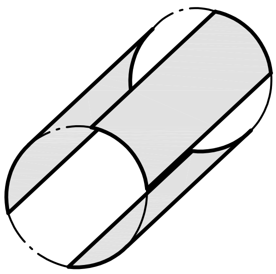


Figure 5 — Discontinuous feature constituted of three portions of a cylinder

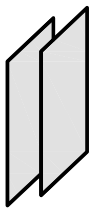


Figure 6 — Feature obtained by a collection of two planes

The basic characteristic integrates a texture, form and size characteristic.

EXAMPLE 1 Illustration of a local characteristic taken into account to define a texture characteristic of a nominally straight line (see Figure 7). The texture characteristic is calculated from the variation curve (local characteristic values) or a transformation of it.

EXAMPLE 2 Form characteristic of a nominally planar surface (see Figure 8).

EXAMPLE 3 Diameter of a nominally cylindrical surface (see Figure 9).

EXAMPLE 4 Angle of a surface obtained by the collection of two nominally planar surfaces (see Figure 10).

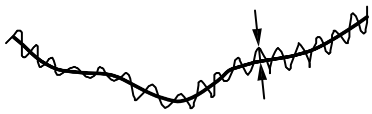


Figure 7 — Example of local deviation taken into account to define a texture characteristic of a nominally straight line

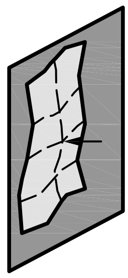


Figure 8 — Form characteristic of a nominally planar surface

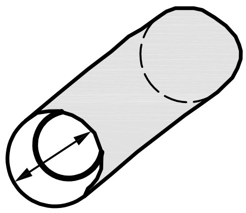


Figure 9 — Diameter of a nominally cylindrical surface

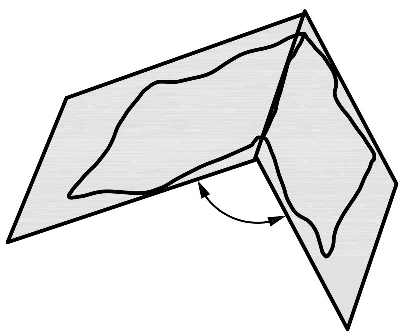


Figure 10 — Angle of a surface obtained by the collection of two nominally planar surfaces

5.2.2 Relationship characteristic

A relationship characteristic describes the micro- or macro-geometry of several non-ideal features. These features correspond to nominal features which can be

— a single feature such as a plane or a cylinder,

— a discontinuous feature such as a surface constituted of three portions of a cylinder, or

— a feature obtained by a collection of several features such as planes.

In a relationship characteristic, more than one feature shall be considered.

EXAMPLE 1 Perpendicularity of a nominally straight line with respect to another nominally straight line (see Figure 11).

EXAMPLE 2 Location of two nominally parallel straight lines (see Figure 12).

EXAMPLE 3 Orientation variation of a nominally cylindrical surface (see Figure 13).

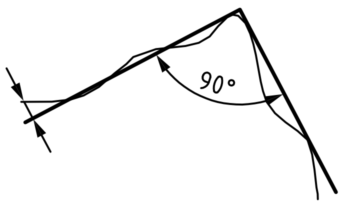
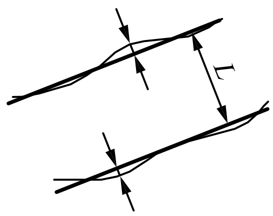


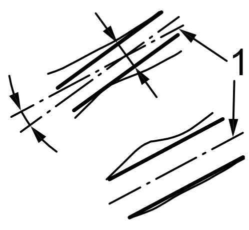
Figure 11 — Perpendicularity of a nominally straight line with respect to another nominally straight line



Key

L considered distance

Figure 12 — Location of two nominally parallel straight lines



Key

1 parallel

Figure 13 — Orientation variation of a nominally cylindrical surface

5.3 Local and global characteristics

Examples 1 and 2 give examples of local characteristics.

EXAMPLE 1 The distance between a point pair of a nominally circular line (see Figure 14).

EXAMPLE 2 The angle between two lines on two nominally planar surfaces (see Figure 15).

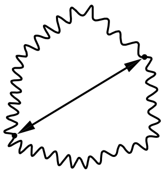


Figure 14 — Distance between a point pair of a nominally circular line

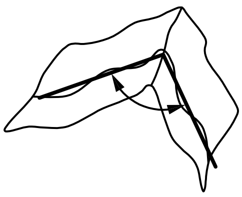


Figure 15 — Angle between two lines on two nominally planar surfaces

Examples 3 and 4 are examples of global characteristics.

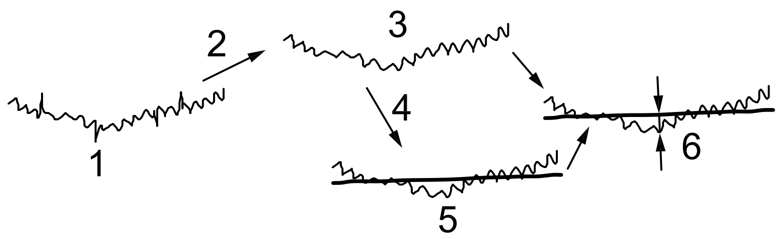
EXAMPLE 3 The average of the distances between the point pairs of a nominally circular line.

EXAMPLE 4 The maximum of the angles between line pairs on nominally planar surfaces.

5.4 Deviated and reference feature

The basic characteristic used to express a GPS characteristic controls features defined by operations. If the basic characteristic is an intrinsic characteristic, it controls a deviated feature. If the basic characteristic is a situation characteristic, the two features of the characteristic can generally be distinguished; in that case, one is called deviated feature and the other one is called reference feature. The reference feature is the feature which has smaller deviations with respect to the nominal model. A reference feature is obtained from a deviated feature by one or more feature operations.

EXAMPLE To define a form characteristic, the surface can be filtered, and a plane associated according to a given criterion. Thus, the form characteristic is expressed as a basic characteristic, which is the maximum distance between the smoothed feature and the plane (situation characteristic between a non-ideal feature and an ideal feature). The smoothed feature has larger deviations than the plane, so the smoothed feature is the deviated feature and the plane is the reference feature (see Figure 16).



Key

1 non-ideal feature

2 filtration

3 deviated feature

4 association

5 reference feature

6 basic characteristic

Figure 16 — Deviated and reference features

5.5 Independent characteristics

5.5.1 General

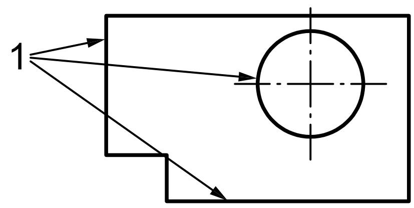
Two GPS characteristics are independent if the variation of one of them has no influence on the other one. A group of geometrical characteristics generates complementary characteristics if they enable the limitation of all the deviations of features.

A group of complementary and independent characteristics is formed by geometrical characteristics such as:

— the deviated feature of a characteristic is the reference feature of another characteristic;

— the reference feature of a characteristic (if there is one) is obtained from the deviated feature of the characteristic by an operation.

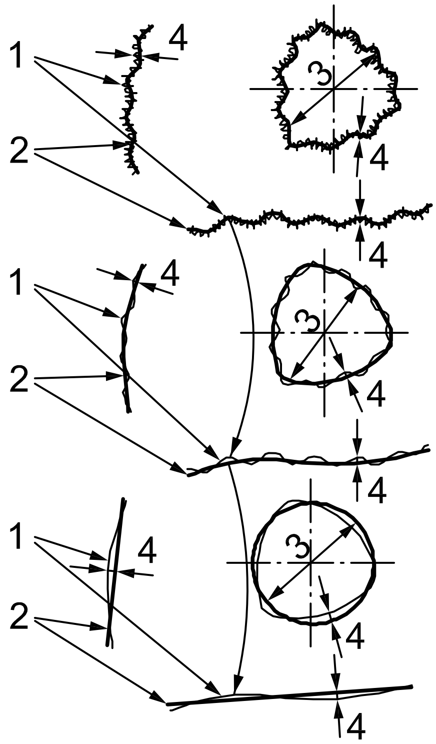
EXAMPLE The independent GPS characteristics of two nominally straight lines and of a nominally circular line (see Figures 17, 18 and 19).



Key

1 nominal features

Figure 17 — Nominal features



Key

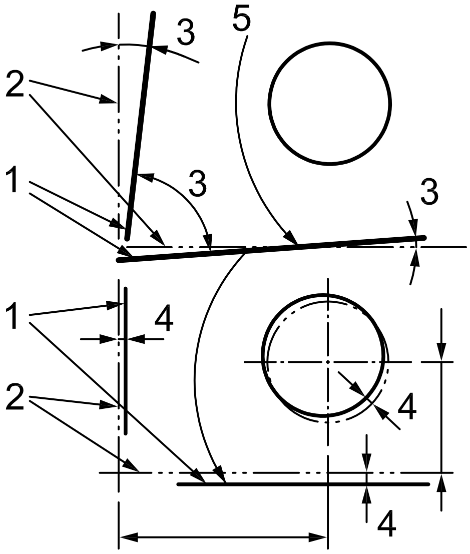
1 deviated features

2 reference features

3 size characteristic

4 form characteristics

Figure 18 — Individual independent characteristics



Key

1 deviated features

2 reference features

3 orientation characteristic

4 localization characteristic

5 reference features of the form characteristics

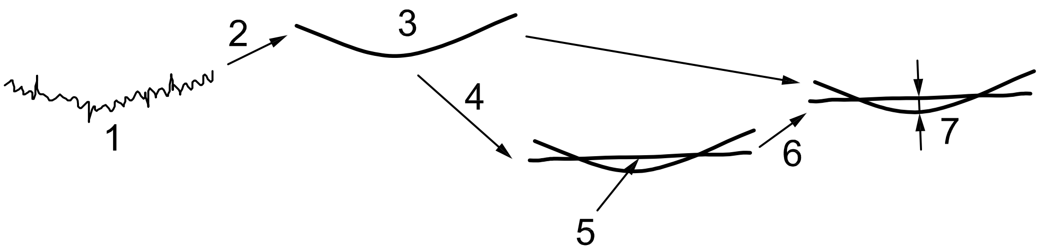
Figure 19 — Independent characteristics of relationship

The complementary of the characteristics is ensured by the fact that the deviated feature of one characteristic is identical to the reference feature of the characteristic of previous rank.

The independence of the characteristics is ensured by the fact that the reference feature of a characteristic is obtained from the deviated feature of this characteristic.

5.5.2 Independent form characteristic

Figure 20 illustrates the independent form characteristic.



Key

1 input feature

2 optional filtration

3 deviated feature

4 association

5 reference feature

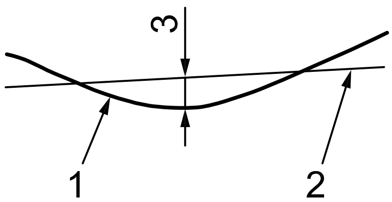
6 evaluation

7 form characteristic

Figure 20 — Independent form characteristic

The form characteristic is a geometrical characteristic defining the form deviation, but it can also include texture deviation.

The value of an independent form characteristic does not change if the non-ideal feature is transformed by a displacement. An independent form characteristic is a situation characteristic between non-ideal and ideal features: the reference feature and the deviated feature (see Figure 21).



Key

1 deviated feature filtered or not (non-ideal feature)

2 associated feature (ideal feature)

3 form characteristic

Figure 21 — Independent form characteristics of a nominally straight line

Different criteria of association could be chosen. The objective function can be, for example, the minmax, the least square, the minimum circumscribed, the maximum inscribed and the intrinsic characteristic can be constrained. Consequently, the form characteristic could take different values (see Figures 22 and 23).

Figure 22 — Independent form characteristic of a nominally straight line with different criteria of association of the corrected line

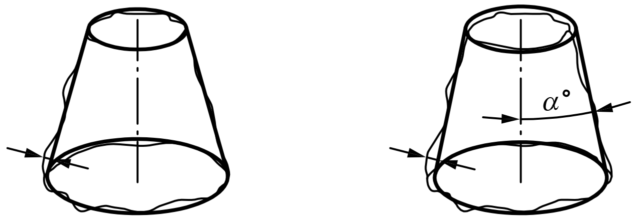
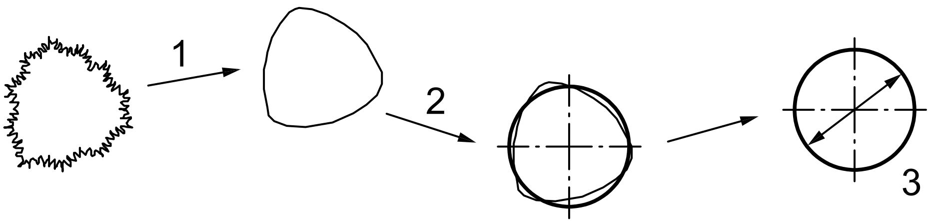


Figure 23 — Independent form characteristic of a cone with and without constraint on the apex angle

5.5.3 Independent size characteristic

Figure 24 shows an independent size characteristic.



Key

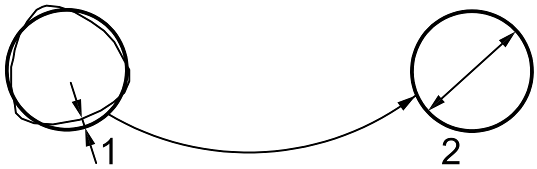
1 filtration

2 association

3 size characteristic

Figure 24 — Independent size characteristic

Form and size characteristics are independent and complementary if the reference feature of the form characteristic and the deviated feature of the size characteristic are identical (see Figure 25).



Key

1 form characteristic

2 size characteristic

Figure 25 — Independent and complementary form and size characteristics of a nominally circular line

The value of a size characteristic does not change if the non-ideal feature is transformed by a displacement.

The deviated feature is ideal, i.e. it has no form deviation (see Figure 26).

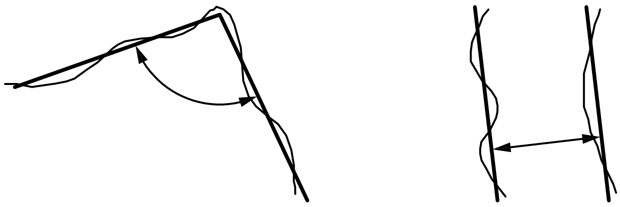
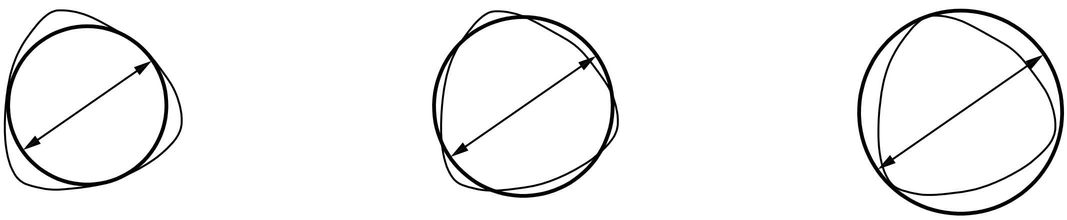


Figure 26 — Angular and linear size characteristics

The criteria of the association have an influence on the value of an independent size characteristic (see Figure 27).

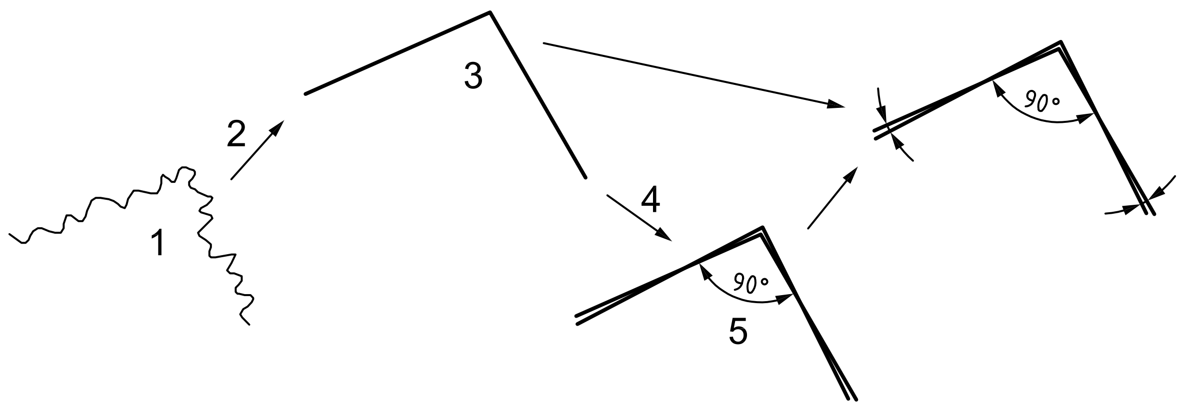


a) Maximum inscribed **b) Least-squares** **c) Minimum circumscribed**

Figure 27 — Independent size characteristic of a nominally circular line with different criteria of association

5.5.4 Independent orientation characteristic

Figure 28 shows an independent orientation characteristic.



Key

1 input features

2 filtration and association

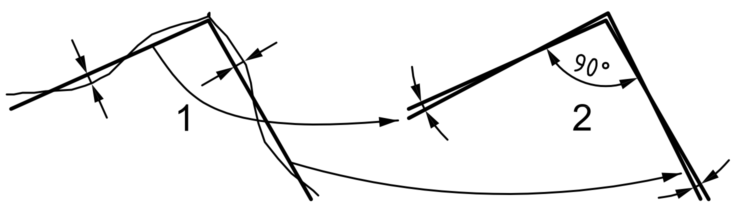
3 deviated features

4 association

5 reference features

Figure 28 — Independent orientation characteristic

Form and orientation characteristics are independent and complementary if the reference features of the form characteristics and the deviated features of the independent orientation characteristic are identical for every feature (see Figure 29).



Key

1 form characteristics

2 orientation characteristics

Figure 29 — Independent and complementary form and orientation characteristics of two nominally straight lines

An independent orientation characteristic is a relationship characteristic.

The value of an independent orientation characteristic does not change if the features are transformed by different translations.

The deviated and the reference features are ideal, i.e. they have no form deviation and the reference features have no orientation deviation.

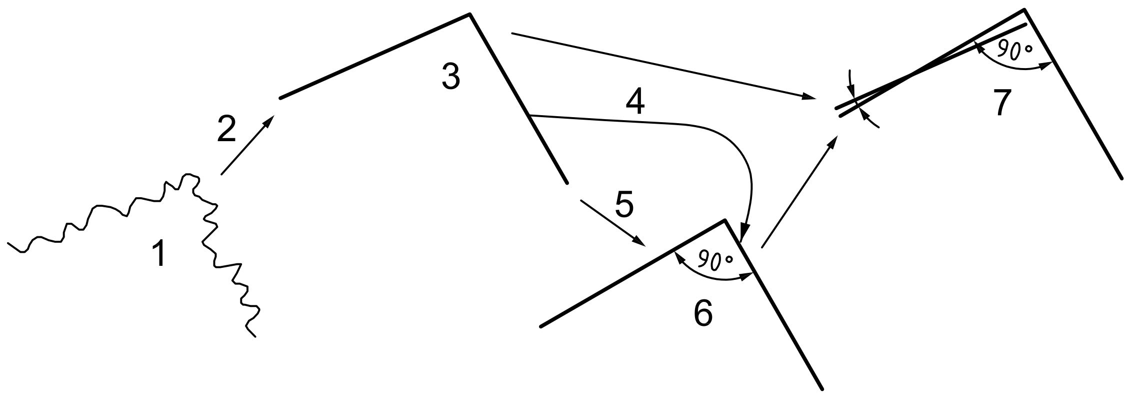
The criteria of association of the deviated and reference features have an influence on the value of an independent orientation characteristic.

An independent orientation characteristic may have a datum. In that case, a reference feature is identical to the corresponding deviated feature and consequently to the reference feature of the independent form characteristic (see Figure 30). The datum feature could be

— a single feature such as a plane or a cylinder,

— a discontinuous feature, such as a surface constituted of three portions of a cylinder, or

— a feature obtained by a collection of several features such as planes.



Key

1 input features

2 filtration and association

3 deviated features

4 datum features

5 association

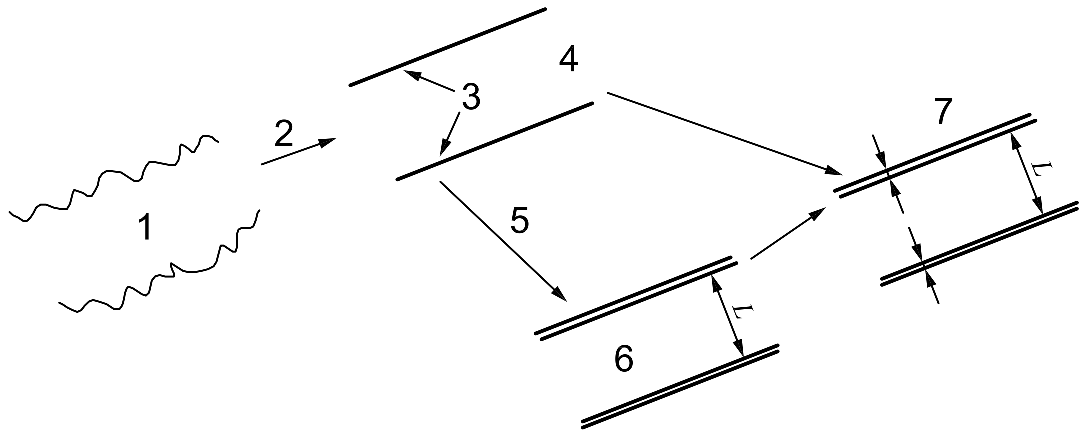
6 reference features

7 orientation characteristic

Figure 30 — Independent orientation characteristic with datum of two nominally straight lines

5.5.5 Independent location characteristic

Figure 31 shows an independent location characteristic.

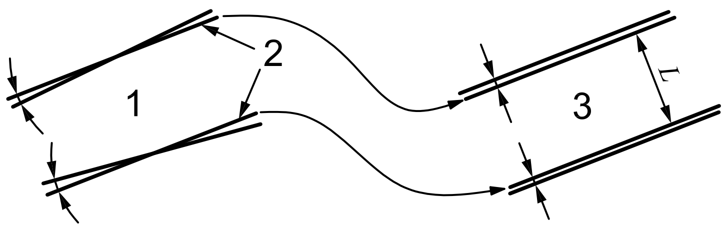


Key

1 input features
2 filtration and association
3 parallel
4 deviated features
5 association
6 reference features
7 location characteristic
L considered distance

Figure 31 — Independent location characteristic

An orientation and a location characteristic are independent and complementary if the reference features of the independent orientation characteristic and the deviated feature of the independent location characteristic are identical for every feature (see Figure 32).

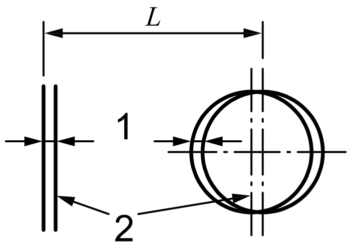


Key

1 orientation characteristic
2 parallel
3 location characteristic
L considered distance

Figure 32 — Independent and complementary orientation and location characteristics of two nominally straight lines

The independent location could be applied on a different type of feature, for example a plane and a cylinder (see Figure 33).



Key

1 location characteristic

2 parallel

L considered distance

Figure 33 — Independent location characteristic of a plane and a cylinder

An independent location characteristic is a relationship characteristic.

The deviated and the reference features are ideal, i.e. they have no form deviation and no orientation deviation and the reference features have no location deviation between each other.

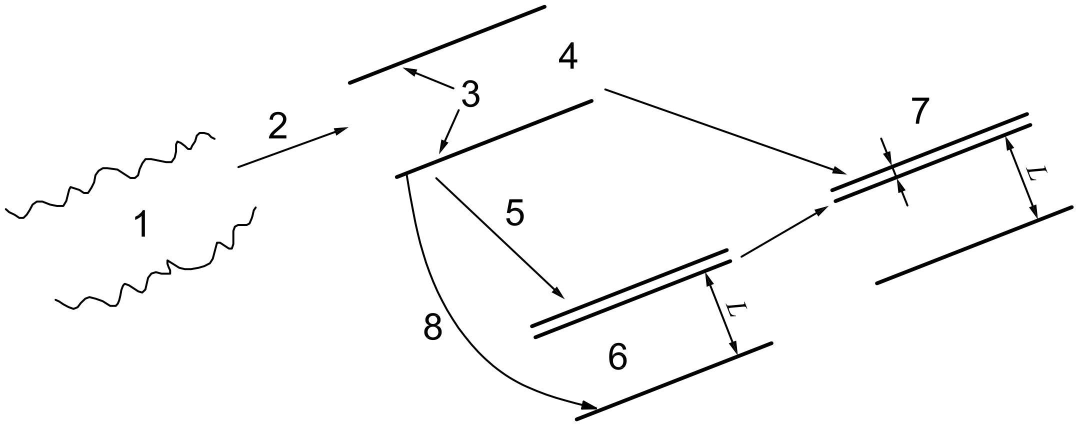
The criteria of association of the deviated and reference features have an influence on the value of an independent location characteristic.

An independent location characteristic may have a datum, in which case a reference feature is identical to the corresponding deviated feature and consequently to the reference feature of the independent orientation characteristic (see Figure 34). The datum feature could be

— a single feature such as a plane or a cylinder,

— a discontinuous feature such as a surface constituted of three portions of a cylinder, or

— a feature obtained by a collection of several features such as planes.



Key

1 input features
2 filtration and association
3 parallel
4 deviated features
5 association
6 reference features
7 location characteristic
8 datum
L considered distance

Figure 34 — Independent location characteristic with datum of two nominally straight lines

5.6 Zone characteristic

5.6.1 General

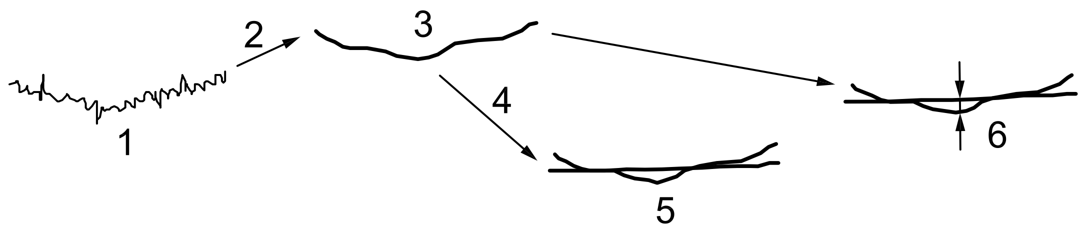
To define zone specifications, a type of characteristic associated to the zones shall be defined.

A weight could be applied to the distances according to the location of the points on the feature. These weights enable the consideration of zones with variable tolerances.

An offset could be applied to the feature or to the distances. This offset permits the consideration of non-symmetrical zones.

5.6.2 Zone form

Figure 35 shows a zone form characteristic.



Key

1 input features

2 filtration

3 deviated features

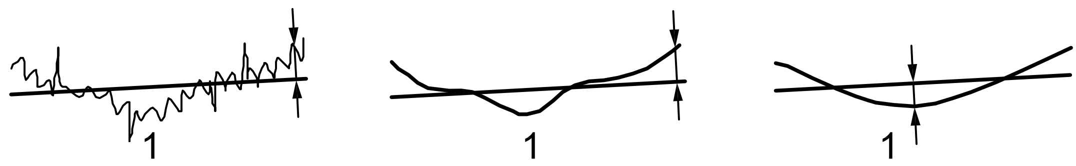
4 association

5 reference features

6 zone form characteristic

Figure 35 — Zone form characteristic

The zone form characteristic is a geometrical characteristic including form and texture deviation. The amount of texture in the zone form characteristic depends on the value of the nesting index of the filtration and on the type of filtration (see Figure 36).



Key

1 zone form characteristic

Figure 36 — Zone form characteristic showing the results of using different nesting index or filtration methods

A zone form characteristic is a single (individual) characteristic.

The value of a zone form characteristic does not change if the non-ideal feature is transformed by a displacement.

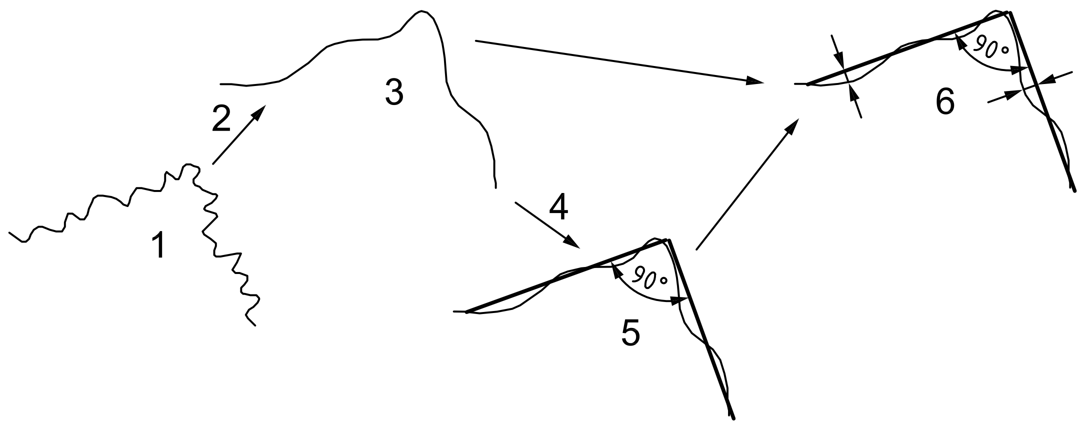
A zone form characteristic is a situation characteristic between non-ideal and ideal features.

The reference feature is ideal, i.e. it has no form deviation.

Different criteria of association could be chosen. The objective function can be, for example, the minmax, the least square, the minimum circumscribed, the maximum inscribed and the intrinsic characteristic can be constrained. Consequently, the zone form characteristic could take different values.

5.6.3 Zone orientation

Figure 37 shows a zone orientation characteristic.



Key

1 input features
2 filtration
3 deviated features
4 association
5 reference features
6 orientation characteristic

Figure 37 — Zone orientation characteristic

The zone orientation characteristic is a geometrical characteristic including independent orientation and partially independent form and texture. The amount of form and texture in the zone orientation characteristic depends on the types of the deviated features (see Figure 38).

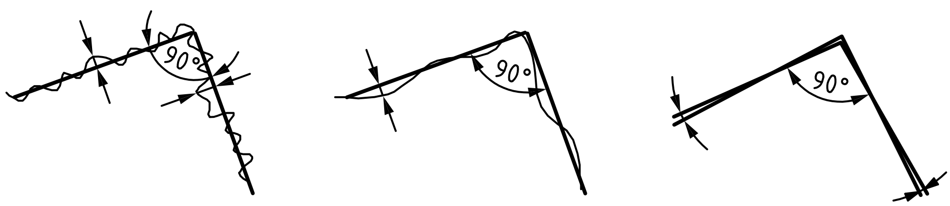


Figure 38 — Zone orientation characteristic of two nominally straight lines with different deviated features

Datum features may be used; these features are not affected by the basic characteristic (see Figure 39).

a) Without datum feature

b) With datum feature

Figure 39 — Zone orientation characteristic of two nominally straight lines

A zone orientation characteristic is a relationship characteristic.

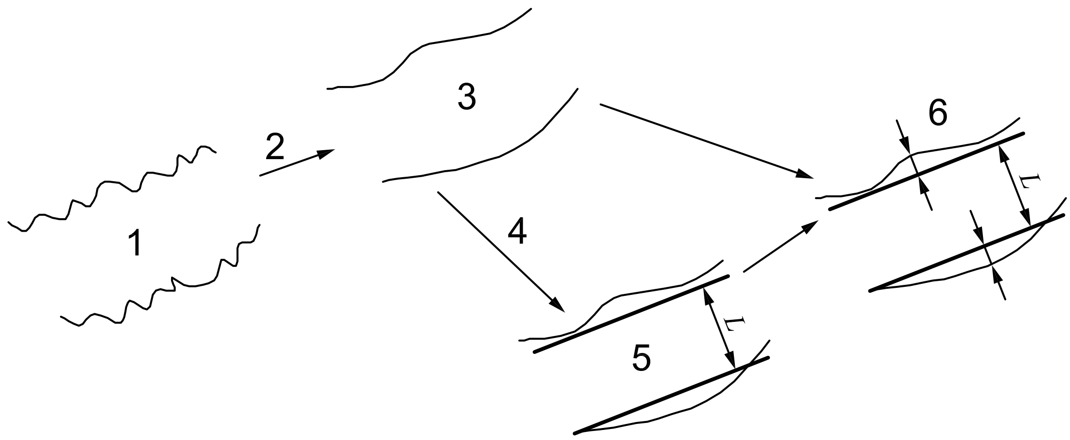
The value of a zone orientation characteristic does not change if the non-ideal features are transformed by translations.

The reference features have no form and no orientation deviations.

Different criteria of association could be chosen. The objective function can be, for example, the minmax, the least square, the minimum circumscribed, the maximum inscribed and the intrinsic characteristic can be constrained. Consequently, the zone orientation characteristic could take different values.

5.6.4 Zone location

Figure 40 illustrates a zone location characteristic.



Key

1 input features

2 filtration

3 deviated features

4 association

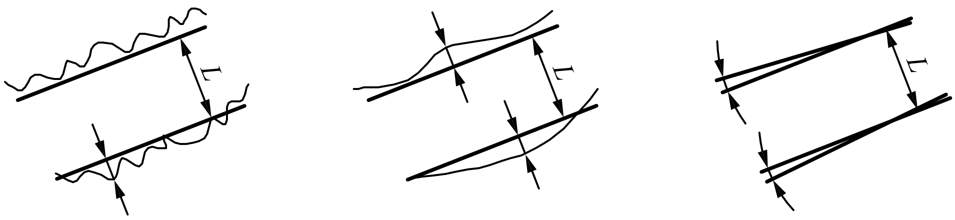
5 reference features

6 location characteristic

L considered distance

Figure 40 — Zone location characteristic

The zone location characteristic is a geometrical characteristic including independent location and partially independent orientation, form and texture. The amount of orientation, form and texture in the zone location characteristic depends on the type of the deviated features (see Figure 41).



Key

L considered distance

Figure 41 — Zone location characteristic of two nominally straight lines with different deviated features

Datum features can be used; these features are not affected by the basic characteristic (see Figure 42).

Key

L considered distance

Figure 42 — Zone location characteristic of two nominally straight lines with and without datum

A zone location characteristic is a relationship characteristic.

The reference features have no form, no orientation and no location deviations.

Different criteria of association could be chosen. The objective function can be, for example, the minmax, the least square, the minimum circumscribed, the maximum inscribed and the intrinsic characteristic can be constrained. Consequently, the zone location characteristic could take different values.

5.7 Gauge characteristic

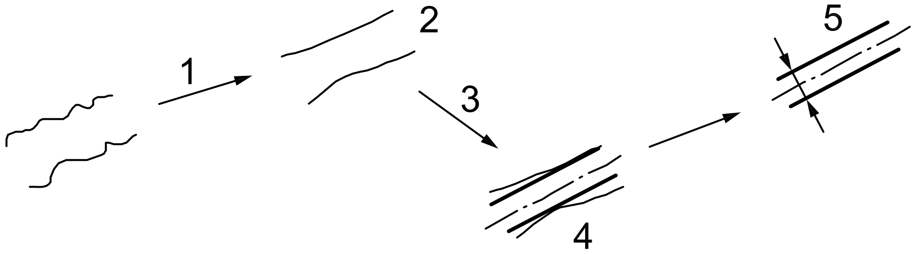
5.7.1 General

To better express some functions of a part, the deviation of candidate features is useful. The gauge characteristics are defined in 5.7.2 to 5.7.4.

5.7.2 Gauge size characteristic

Particularly for assembly, it is necessary to understand the maximum and minimum sizes of an ideal feature which can be assembled to a particular workpiece.

A gauge size characteristic can be applied to a single feature (see Figure 43).



Key

1 filtration

2 deviated feature

3 association

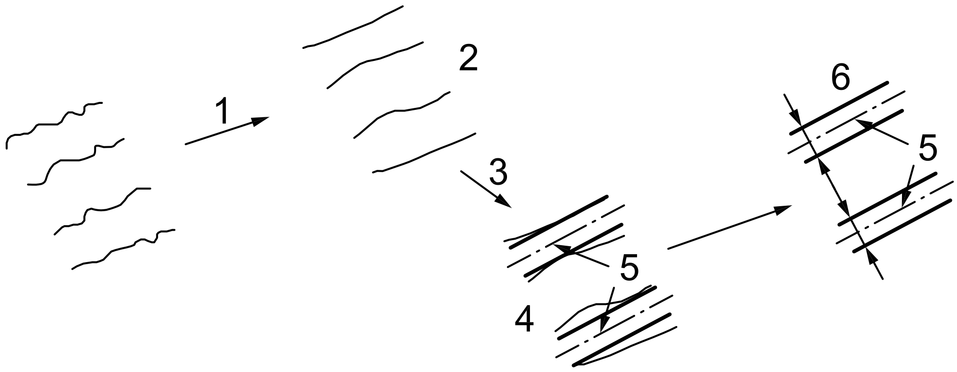
4 reference feature

5 gauge size characteristic

Figure 43 — Gauge size characteristic

The gauge size characteristic is a geometrical characteristic including independent size and partially independent form and texture when applied to a feature (see Figure 44). The amount of form and texture in the gauge size characteristic depends on the types of the deviated features. When applied to several features, it can also include independent location and orientation (see Figures 45 and 46).

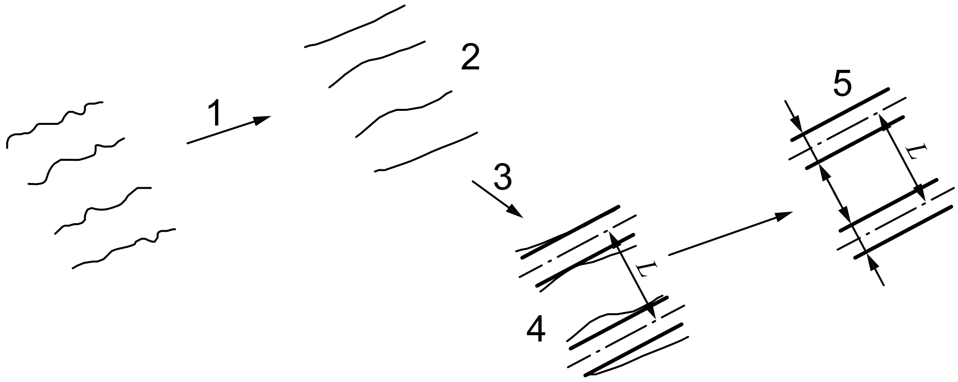
Figure 44 — Gauge size characteristic with different deviated features



Key

1	filtration	4	reference features
2	deviated features	5	parallel
3	association	6	gauge size characteristic

Figure 45 — Gauge size characteristic with constraints of orientation



Key

1 filtration

2 deviated features

3 association

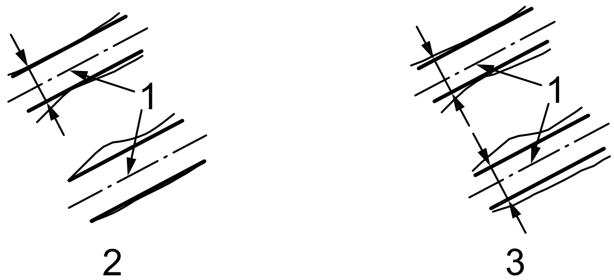
4 reference features

5 gauge size characteristic

L considered distance

Figure 46 — Gauge size characteristic with constraint of location

Datum features can be used; these features are not affected by the basic characteristic (see Figures 47 and 48).



Key

1 parallel

2 with datum feature

3 without datum feature

Figure 47 — Gauge size characteristic with constraint of orientation

a) With datum feature **b) Without datum feature**

Key

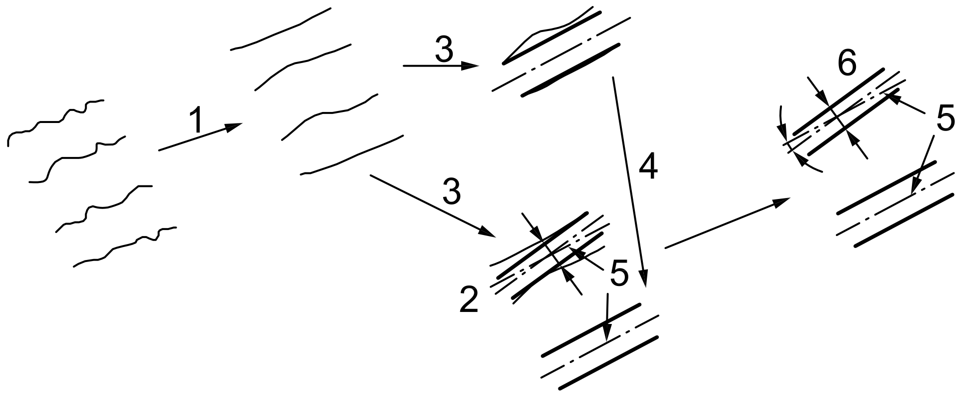
L considered distance

Figure 48 — Gauge size characteristic with constraint of location

5.7.3 Gauge variation characteristic

Gauge variation characteristics enable the definition of the possible variation of orientation and/or location of an ideal feature with respect to the nominal orientation or location (see Figure 49).

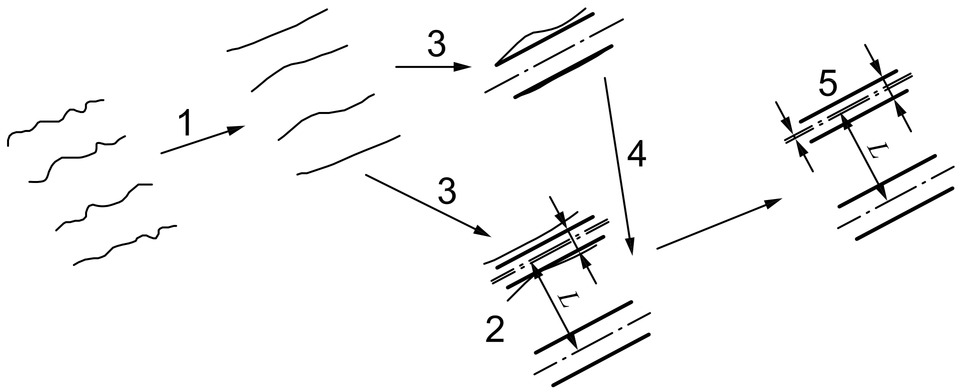
The gauge variation characteristic is a geometrical characteristic including independent location and/or orientation, independent size and partially independent form and texture. The amount of form and texture in the zone form characteristic depends on the type of the deviated features (see Figures 50 and 51).



Key

1 filtration
2 deviated features
3 association
4 datum features
5 parallel
6 gauge variation characteristic

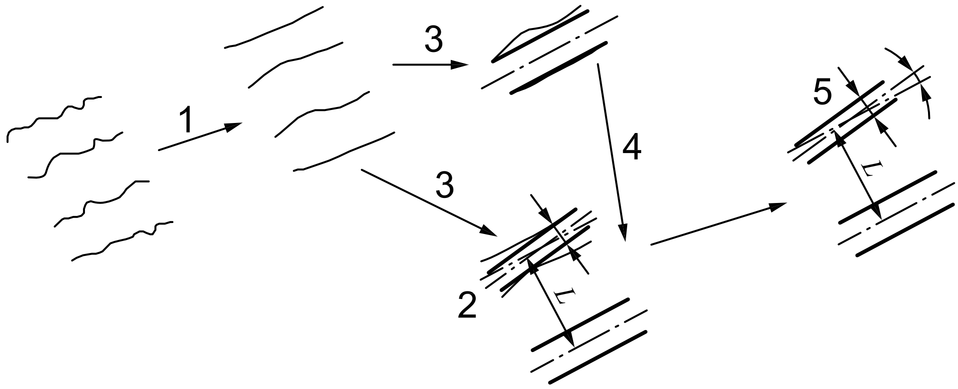
Figure 49 — Gauge variation characteristic with constraint of orientation



Key

1 filtration
2 deviated features
3 association
4 datum features
5 gauge variation characteristic
L considered distance

Figure 50 — Gauge variation characteristic with constraint of location



Key

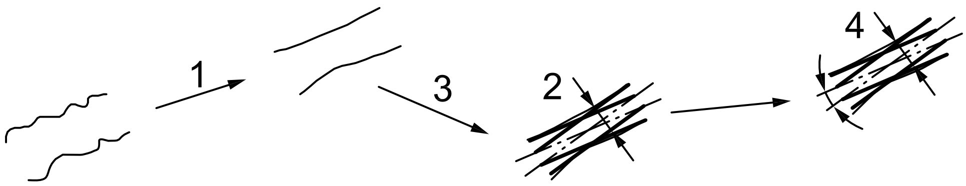
1 filtration
2 deviated features
3 association
4 datum features
5 gauge variation characteristic
L considered distance

Figure 51 — Gauge variation characteristic with constraint of location at a particular point

5.7.4 Gauge gap characteristic

Gauge gap characteristics enable the definition of possible movements of orientation and/or location of an ideal feature.

A gauge gap characteristic can be applied to a single feature (see Figure 52).



Key

1 filtration
2 deviated features
3 association
4 gauge gap characteristic

Figure 52 — Gauge gap characteristic

The situation characteristic could be an angle or a distance (see Figure 53).

Figure 53 — Gauge gap characteristics with distance and with angle

For a distance, the two positions of the candidate feature can be constrained in orientation (see Figure 54).

Figure 54 — Gauge gap characteristics with and without constraint of orientation

The gauge gap characteristic is a geometrical characteristic including independent size and partially independent form and texture when applied to a feature. The amount of form and texture in the zone form characteristic depends on the types of the deviated features. When applied to several features, it can also include independent location and orientation (see Figure 55).

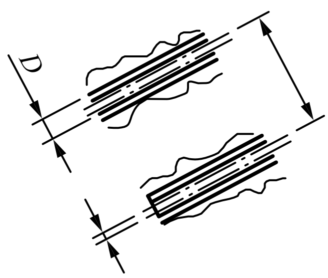


Figure 55 — Gauge gap characteristic with constraint of location

Datum features can be used; these features are not affected by the basic characteristic.

5.8 Assembly or sub-assembly characteristic

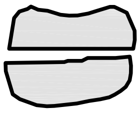
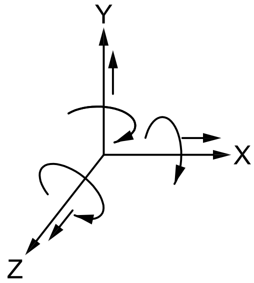
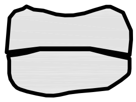
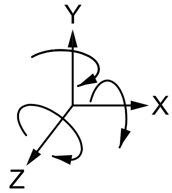
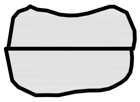
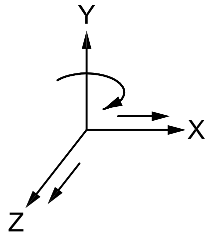
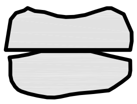
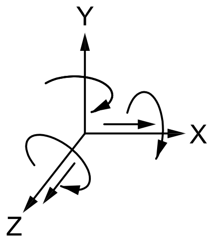
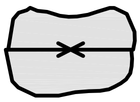
5.8.1 General

All the characteristics can be applied not only to isolated parts but also to assembly or sub-assembly. The geometrical representation of the assembly could be complete or partial. Many or all of the parts of the assembly could be replaced by a kinematics representation.

An assembly characteristic shall take account of the possible movements in the links between the parts. The movements depend on the degrees of freedom of the pairs, and the mechanical actions in the links. Two types of movements could be considered: tangential and normal to the feature movements.

5.8.2 Contact

According to the possible movements, five types of contact can be identified (see Figure 56).

Type of contact	Illustration	Possible remaining degree of freedom between two parts
Floating contact		
Rolling contact		
Slipping contact		
Rolling/slipping contact		
Fixed contact		None

Key

 translation along an axis

 rotation around an axis

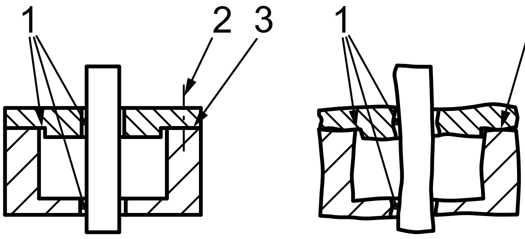
Figure 56 — Floating, rolling, slipping, rolling/slipping and fixed contacts

The motion between two parts can be composed of tangential translations, a normal translation and rotations.

The possible motions between the two parts describe the contact. They are linked to the degree of freedom of the relationship between the parts.

It is recommended that the characteristics of the mechanical actions be defined.

EXAMPLE An axis guide in a box with a cover. The cover has a plane pair and a bore-cylinder pair with the box. The plane pair is a fixed contact because the cover is secured by fasteners to the box. The contacts of the axis with the box and the cover are floating contacts (see Figure 57).



Key

1 floating contact

2 fasteners

3 fixed contact

Figure 57 — Floating and fixed contacts of an assembly

5.8.3 Configuration

Figure 58 shows different kinds of configurations.

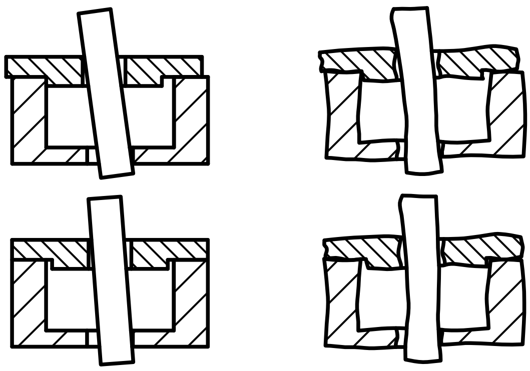
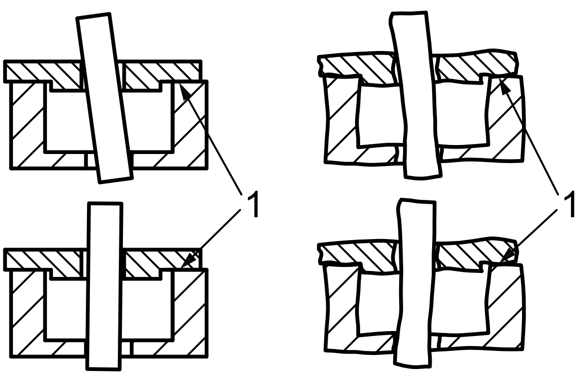


Figure 58 — Configurations

Figure 59 shows configurations of a fixed positioning.



Key

1 same fixed positioning

Figure 59 — Configurations of a fixed positioning

5.8.4 Independent characteristic

An independent characteristic applied on an assembly is equal either to the maximum or the minimum of the characteristic, considering all the configurations.

EXAMPLE An independent orientation characteristic of a nominally cylindrical surface and of a nominally planar surface. The nominally planar surface is considered as a datum. The independent orientation characteristic is determined for every configuration (see Figure 60). The characteristic on the assembly is, for instance, the maximum of the characteristics of all the configurations.

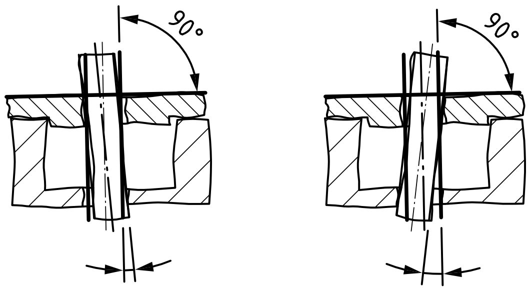


Figure 60 — Independent orientation characteristic for two configurations

5.8.5 Zone characteristic

A zone characteristic applied on an assembly is equal to the maximum of the characteristic considering all the configurations.

EXAMPLE A zone form characteristic of a nominally cylindrical surface. The zone form characteristic is determined for every configuration (see Figure 61). The characteristic on the assembly is the maximum of the characteristics of all the configurations.

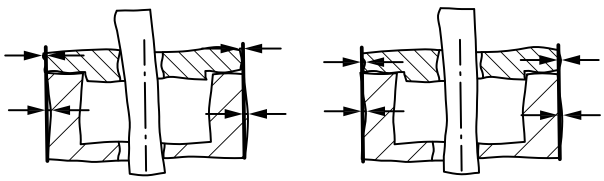


Figure 61 — Zone form characteristic for two configurations

5.8.6 Gauge characteristic

5.8.6.1 Gauge size characteristic

A gauge size characteristic applied on an assembly is equal either

— to the maximum of the characteristic considering all the configurations, or

— to the minimum of the characteristic considering all the configurations.

EXAMPLE A gauge size characteristic of two nominally cylindrical surfaces. One of the nominally cylindrical surfaces is considered as a datum. The gauge size characteristic is determined for every configuration (see Figure 62). The characteristic on the assembly is, for instance, the maximum of the characteristics of all the configurations.

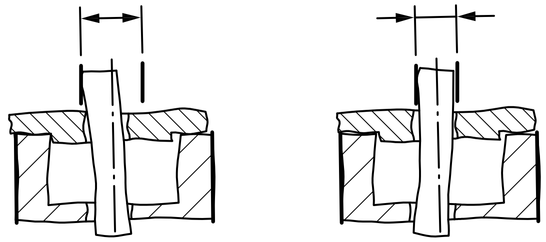


Figure 62 — Gauge size characteristic for two configurations

5.8.6.2 Gauge variation characteristic

A gauge variation characteristic applied on an assembly is equal to the maximum of the characteristic considering all the configurations.

EXAMPLE A gauge variation characteristic of two nominally cylindrical surfaces. One of the nominally cylindrical surfaces is considered as a datum. The gauge variation characteristic is determined for every configuration (see Figure 63). The characteristic on the assembly is the maximum of the characteristics of all the configurations.

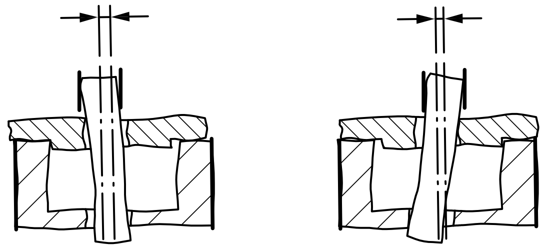
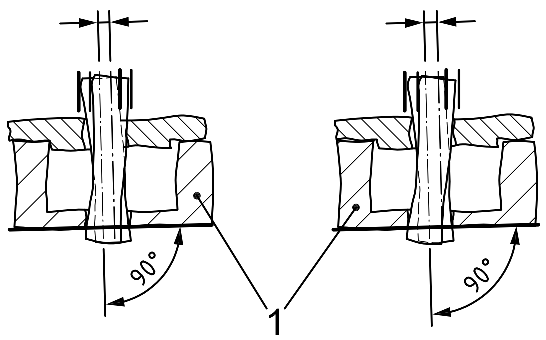


Figure 63 — Gauge variation characteristic for two configurations

5.8.6.3 Gauge gap characteristic

A gauge gap characteristic applied on a fixed positioning of an assembly is equal to the maximum of the basic characteristic between two configurations of the fixed positioning. A fixed part is considered as a datum part. The gauge gap characteristic applied on an assembly is either the maximum or the minimum of the characteristics applied to all the fixed positioning.

EXAMPLE A gauge gap characteristic of a nominally cylindrical surface and a nominally planar surface. The nominally planar surface is considered as a datum. The gauge gap characteristic is determined for every fixed position (see Figure 64). The characteristic on the assembly is, for instance, the maximum of the characteristics of all the fixed positions.



Key
1 fixed part

Figure 64 — Gauge gap characteristic for two fixed positions

6 Relations between terms related to characteristic

The relations between the different definitions given for characteristics are illustrated in Tables 3, 4 and 5.

Table 3 — Links between definitions

Point of view in relation with	Qualifier of the characteristic	In relation with	Comments
Determination	Individual (3.3.1)	Population level	
	Population (3.3.2)		
	Global (3.3.1.2)	Perception level	
	Local (3.3.1.1)		
	Single (elementary) (3.9.1.1)	Characteristic level	
	Combined (3.6)		
	Transformed (3.5.2)		
	Calculated (3.5)	Evaluation	Defining a value of a geometrical characteristic (3.7) or a variation characteristic (3.7.3)
	Direct (3.5.1)		
Concept: Basic characteristic (3.8)	Situation (3.8.2) Orientation (3.8.2.1) Location (3.8.2.2)	Type and subtype	Between a deviated feature (3.9.1.3) and a reference feature (3.9.1.4) Coming from one or more GPS characteristics (3.9) or variation curves (3.7.3.1)
	Intrinsic (3.8.1)		On a deviated feature (3.9.1.3) Coming from a GPS characteristic (3.9) or a variation curve (3.7.3.1)
Use in indication: GPS characteristic (3.9)	Independent (3.9.2) Form (3.9.2.1) Size (3.9.2.2) Orientation (3.9.2.3) Zone (3.9.3) Form (3.9.3.1) Orientation (3.9.3.2) Gauge (3.9.4) Size (3.9.4.1) Variation (3.9.4.2) Gap (3.9.4.3) Texture (3.9.5)		

Table 4 — Relation between the types of characteristics

Type of characteristic	Subtype of characteristic						
	Texture	**Form**	**Size**	**Orientation**	**Position**	**Variation**	**Gap**
Independent	Not applicable	Applicable — Variable intrinsic characteristic (size) for the reference feature	Applicable — Equal to the intrinsic characteristic (size) of the reference feature	Applicable	Applicable	Not applicable	Not applicable
Zone	Not applicable	Applicable — Variable intrinsic characteristic (size) for the reference feature	Applicable — Fixed intrinsic characteristic (size) for the reference feature	Applicable	Applicable	Not applicable	Not applicable
Texture	Applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Gauge	Not applicable	Not applicable	Applicable — Fixed intrinsic characteristic (size) for the reference feature	Not applicable	Not applicable	Applicable — Fixed intrinsic characteristic (size)	Applicable — Fixed intrinsic characteristic (size)

EXAMPLE To obtain an independent form characteristic (cylindricity for example), it is necessary to associate a reference feature with a variable intrinsic characteristic (cylinder with variable diameter).

Table 5 — Relation between individual characteristic and input feature

Characteristic	Input feature(s)	
Individual characteristic	Deviated feature	With or without reference feature

Annex A
(informative)

Overview diagrams

Figures A.1 to A.3 show the link between the workpiece and its specification.

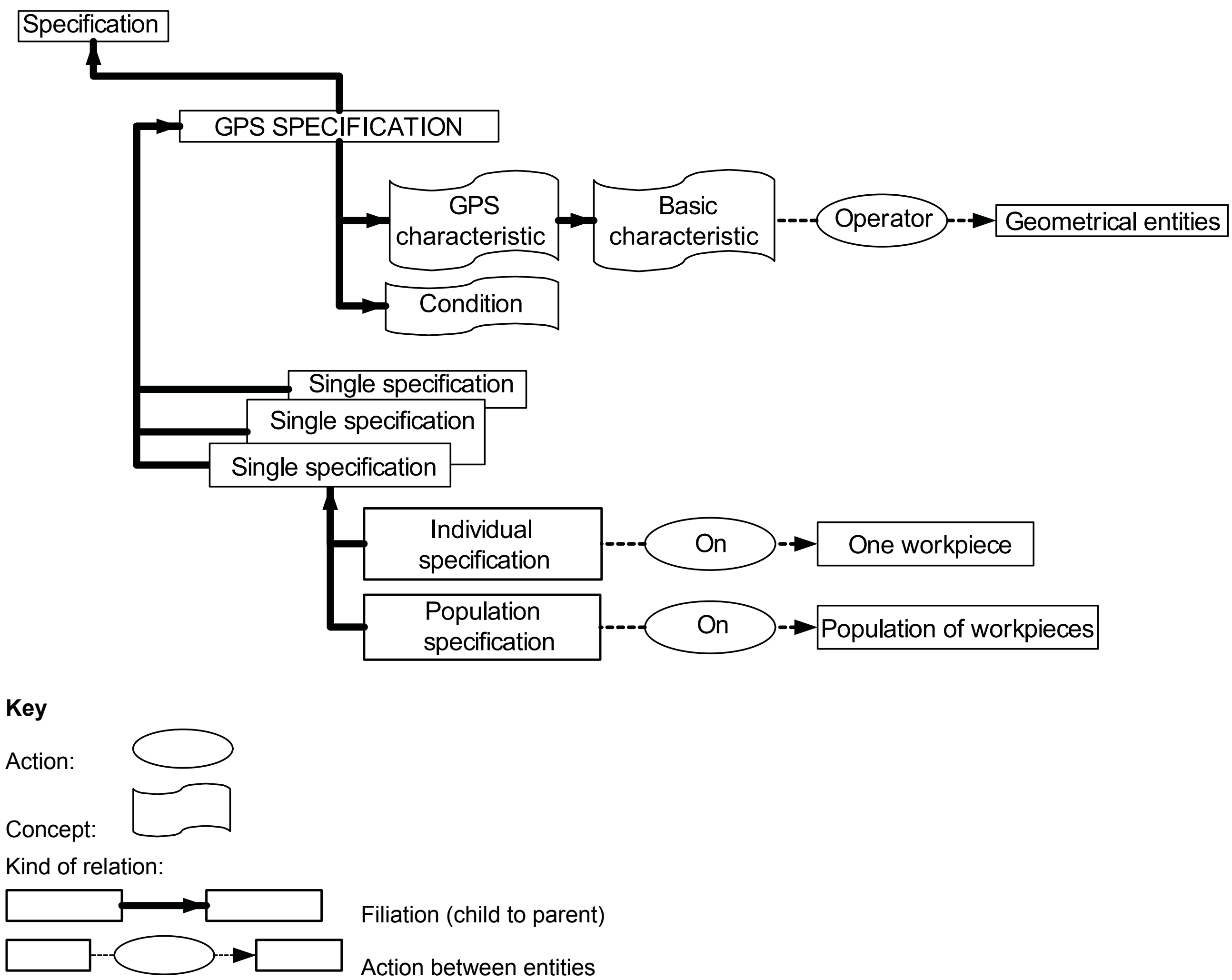


Figure A.1 — Specific overview diagram

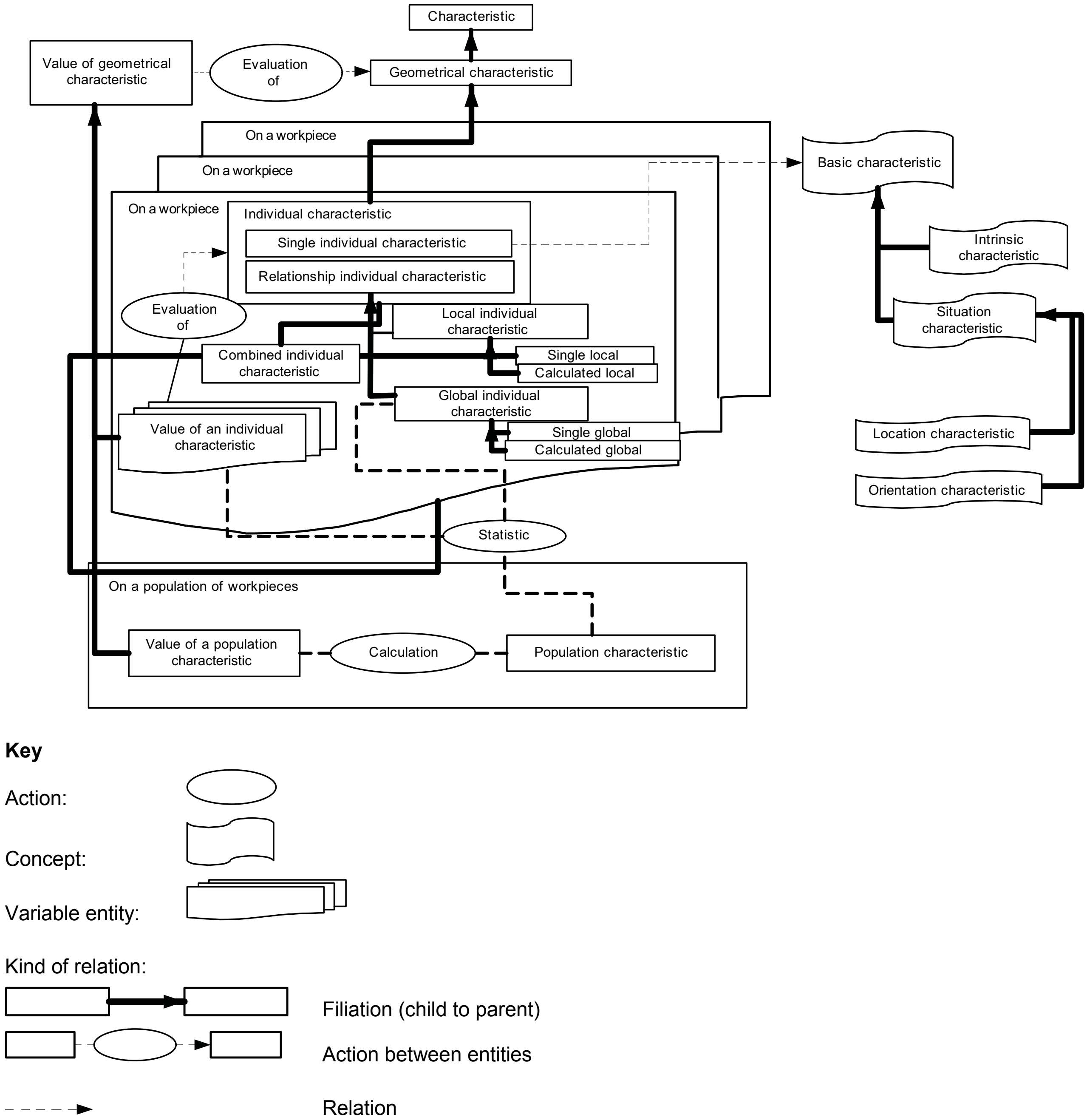
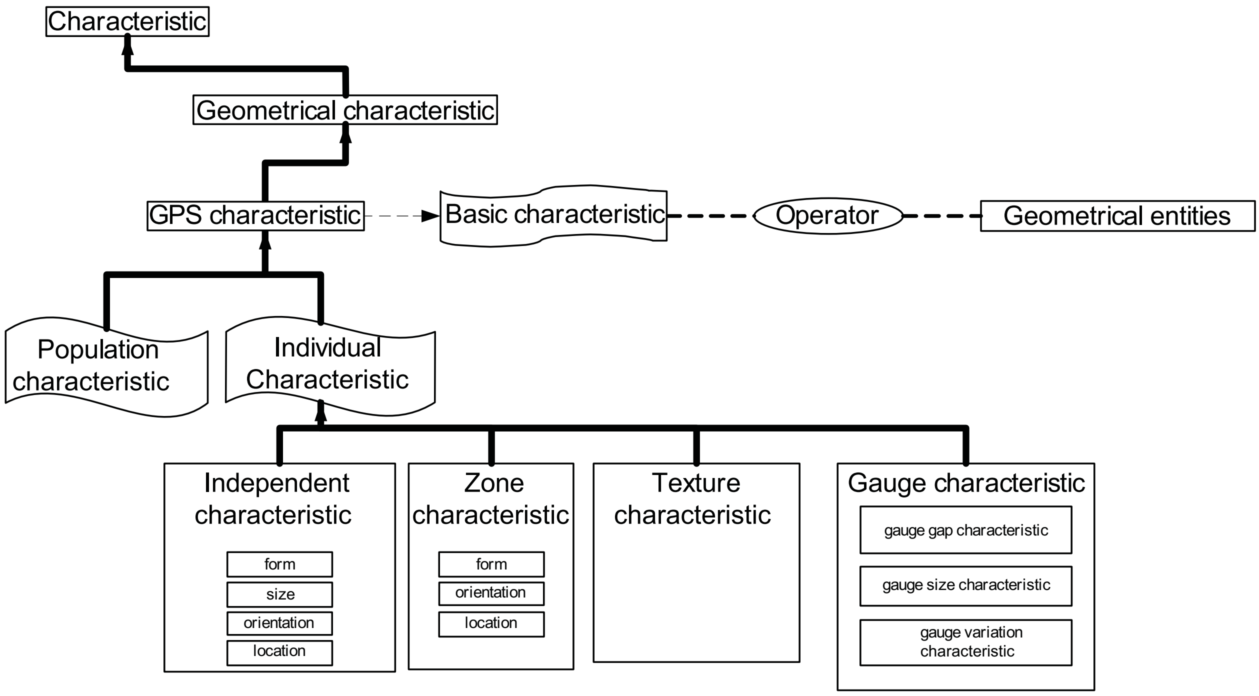


Figure A.2 — Geometrical characteristics



Key

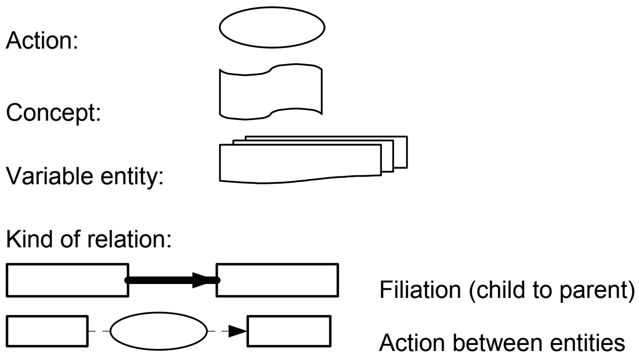


Figure A.3 — GPS characteristics

Annex B
(normative)

Basic (geometrical) characteristic

B.1 General

ISO 17450-1 gives general concepts on the intrinsic characteristic and situation characteristic, generally called basic characteristic.

This annex gives further details on intrinsic and situation characteristics.

Basic characteristics enable the definition of all the individual geometrical characteristics utilized in the GPS specifications.

B.2 Intrinsic characteristic

An intrinsic characteristic is a geometrical characteristic on an ideal feature which could be

— a single feature such as a nominally planar surface or a nominally cylindrical surface,

— a discontinuous feature such as a surface constituted of three portions of a nominally cylindrical surface, or

— a feature obtained by a collection of several features such as two nominally planar surfaces.

EXAMPLE 1 Radius of a circle (see Figure B.1).

EXAMPLE 2 Diameter of a cylinder (see Figure B.2).

EXAMPLE 3 Apex angle of a cone (see Figure B.3).

EXAMPLE 4 Angle of a collection of two straight lines (see Figure B.4).

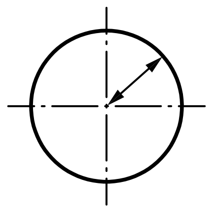


Figure B.1 — Radius of a circle

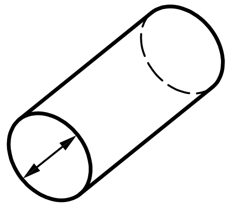


Figure B.2 — Diameter of a cylinder

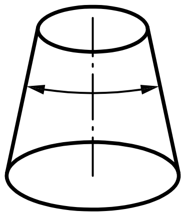


Figure B.3 — Apex angle of a cone

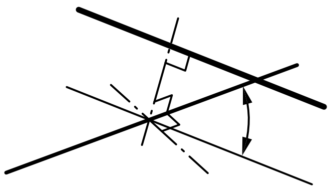


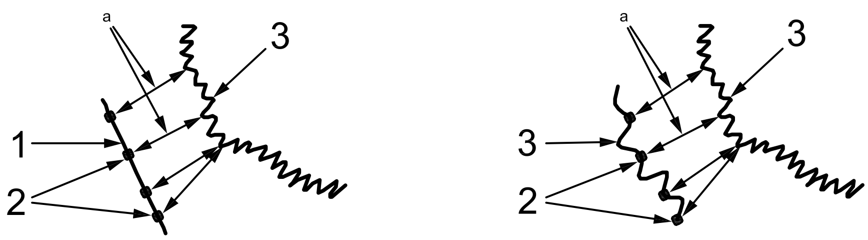
Figure B.4 — Angle of a collection of two straight lines

B.3 Situation characteristic

B.3.1 General

A situation characteristic is defined between two features.

The situation characteristics between two features are based on functions of the distances from the points of one feature to the other feature (see Figure B.5). As an example, it could be the average of the distances.



Key

1 ideal feature

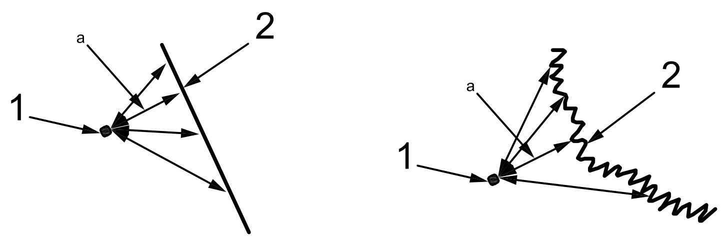
2 points

3 non-ideal feature

[a] Distances point/feature.

Figure B.5 — Distances between two features

The distance shall be the shortest distance between the two points (see Figure B.6).



Key

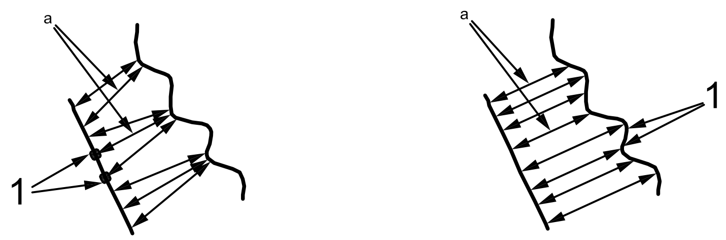
1 point

2 feature

a Minimum distance.

Figure B.6 — Distance between a point and a feature

NOTE The situation characteristic can change depending upon the order of feature consideration. This change can be particularly apparent in cases where the direction of the characteristic is changed by an orientation constraint (see Figure B.7)



Key

1 points

a Distances point/feature.

Figure B.7 — Effect of changing the order of feature consideration

The distance from a point to a feature is positive. In some cases, it is possible to define a signed distance, which could be negative or positive. The sign depends on the related position of the point with respect to the feature. In 3D space, a signed distance could be defined with respect to a surface. In a plane, a signed distance could be defined with respect to a planar line, where one side of the feature is defined as positive and the other as negative. By convention, the sign is related to the side of material (see Figure B.8).

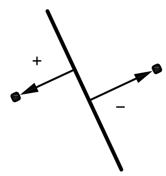
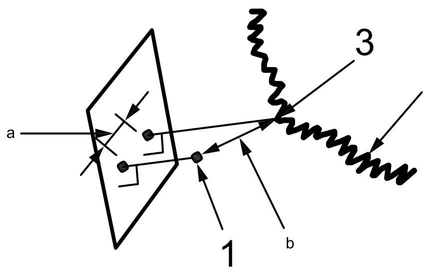


Figure B.8 — Signed distance from a point to a straight line (in a plane)

The distance from a point to a feature is generally considered in the three-dimensional space; nevertheless, in some cases, it is possible to define a projected distance. A projected distance can be defined in a plane or in a straight line (see Figure B.9). The projected distance is equal to the distance between the projection of the considered point and the projection of the nearest point of the feature (see Figure B.9).



Key

1 point

2 feature

3 nearest point

[a] Projected distance.

[b] Minimum distance.

Figure B.9 — Projected distances on a plane and on a straight line

B.3.2 Situation characteristic between ideal features

In the particular case of a situation characteristic between situation features, there are angles (orientation characteristics) and distances (location characteristics).

For an angle, the situation characteristic is commutative, i.e. the order in which the two features are considered, has no influence on the angle. The angles are as follows:

— angle between 2 straight lines (see Figure B.10);

— angle between a straight line and a plane (see Figure B.10);

— angle between two planes (see Figure B.10).

The angles are included between 0° and 90°. Angles between 0° and 180° could be defined between two straight lines or two planes. Angles between −90° and 90° could be defined between a straight line and a plane. These are called signed angles and they depend on the order and the direction of the situation features (a direction could be related to a straight line or a plane by a vector).

The projected angle with respect to a plane could be defined between 2 straight lines. The projected angle is equal to the angle between the projections of the straight lines on the plane of projection.

For a distance, the situation characteristic is defined as the minimum distance from the points of one feature to the other one. This characteristic is commutative. The distances are as follows:

— distance between two points (see Figure B.10);

— distance between a point and a straight line (distance according to the perpendicular to the straight line (see Figure B.10);

— distance between a point and a plane (distance according to the perpendicular to the plane, see Figure B.10);

— distance between two straight lines (distance according to the common perpendicular, see Figure B.10);

— distance between a straight line and a plane (see Figure B.10);

— distance between two planes (see Figure B.10);

Distances are positives. A sign (positive or negative) can be associated to the distance and, in this case, this one shall be called signed distance. Signed distances depend on the order and the direction of the situation features (a direction could be associated to a straight line or a plane by a vector).

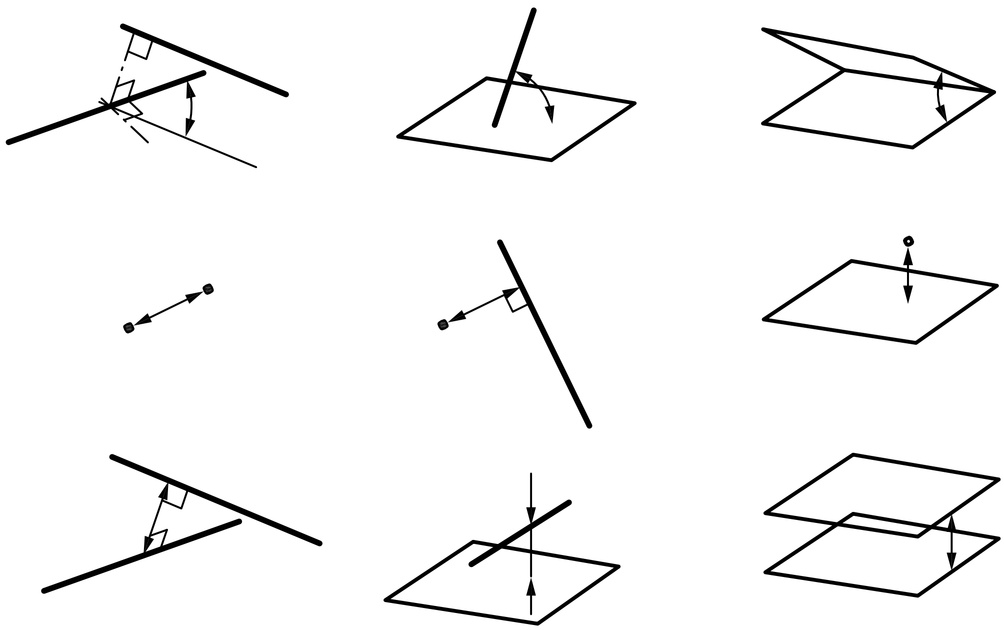


Figure B.10 — Angles and distances

Projected distances with respect to a plane or a straight line can be defined. A projected distance is equal to the distance between the projections of the nearest points of the two features. The projected distances are as follows:

— distance between two points;

— distance between a point and a straight line;

— distance between a point and a plane;

— distance between two straight lines;

— distance between a straight line and a plane;

— distance between two planes.

By convention, the situation characteristic between ideal features is a situation characteristic between situation features of the features.

However, where the situation characteristic between the surfaces or the lines is required, the situation characteristic between ideal features is defined as a function of the distances from the points of one of the ideal features to the other (see Figure B.11). The function can be the maximum distance, minimum distance, quadratic distance or another function.

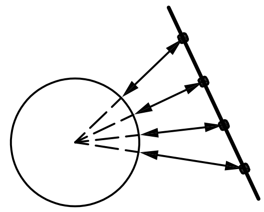
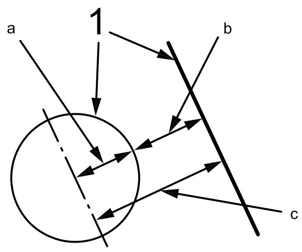


Figure B.11 — Distances from the points of a straight line to a circle

NOTE This function of distances could be expressed by intrinsic characteristics and situation characteristics between situation features, especially in the case of the minimum distance.

EXAMPLE The minimum distance from a straight line to a circle (which are coplanar) could be expressed as the difference between the distance from the straight line to the centre of the circle (situation characteristic between situation features) and the radius of the circle (intrinsic characteristic) (see Figure B12).



Key

1 ideal features

[a] Intrinsic characteristic radius.

[b] Minimum distance.

[c] Distance between the straight line and the centre of the circle.

Figure B.12 — Minimum distance

B.3.3 Situation characteristic between feature portion and ideal feature

The situation characteristic between the feature portion and the ideal feature is defined as a function of the distances from the points of the feature pointer to the ideal feature. The function should be the maximum distance, minimum distance, quadratic distance or another function.

EXAMPLE Maximum distance between a line segment and a straight line (see Figure B.13)

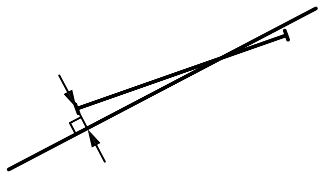


Figure B.13 — Maximum distance between a line segment and a straight line

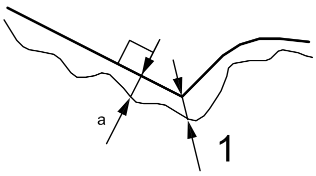
Distances are positives. A sign (positive or negative) can be associated to the distance and, in this case, this one shall be called signed distance. These are defined as functions of the signed distance from the points of the feature portion to the ideal feature. The sign depends on the related position of the point with respect to the feature.

The distances can be projected in a plane or in a straight line; they are called projected distances and are defined as functions of the projected distances from the points of the feature portion to the ideal one.

B.3.4 Situation characteristic between non-ideal and ideal features

The situation characteristic between non-ideal and ideal features is defined as a function of the distances from the points of the non-ideal feature to the ideal feature. The distance concerned corresponds to the normal distance, except if the involved point on the ideal feature is a singular point (which does not have a unique normal).

EXAMPLE 1 Distance of a point to an ideal profile including an angle (see Figure B.14).



Key

1 singular point

a Normal distance.

Figure B.14 — Normal distance and singular point with no normal distance

This characteristic is not commutative. The function can be the maximum distance, minimum distance, quadratic distance or another function.

EXAMPLE 2 Maximum distance between a nominally straight line and a straight line (see Figure B.15).

EXAMPLE 3 Maximum distance between a nominally circular line and a circle (see Figure B.15).

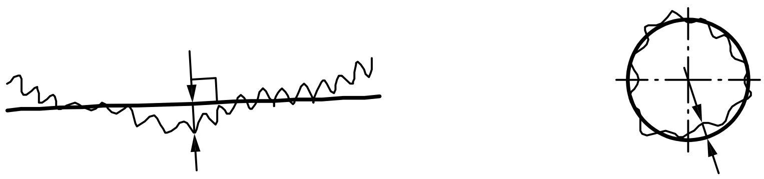


Figure B.15 — Maximum distance between a nominally straight line and a straight line and maximum distance between a nominally circular line and a circle

Distances are positives. A sign (positive or negative) can be associated to the distance and, in this case, this one shall be called signed distance. These are defined as functions of the signed distance from the points of the non-ideal feature to the ideal feature. The sign depends on the related position of the point with respect to the feature.

The distances can be projected in a plane or in a straight line and are called projected distances, which are defined as functions of the projected distances from the points of the non-ideal feature to the ideal feature.

B.3.5 Situation characteristic between non-ideal features

The situation characteristic between non-ideal features is defined as a function of the distances from the points of one of the features to the other. This characteristic is not commutative. The function can be the maximum distance, minimum distance, quadratic distance or another function.

Generally, one of the features is obtained from the other one by a filtration. In this case, the situation characteristic is a function of the distances from the points of the most filtered feature to the other one. In some cases, it is possible to consider the distances along with a particular direction. This direction is normal to a feature which is obtained by an association.

EXAMPLE 1 Maximum distance between two nominally straight lines [see Figure B.16 a)].

EXAMPLE 2 Minimum distance between two nominally straight lines [see Figure B.16 b)].

a) Maximum distance

b) Minimum distance

Figure B.16 — Maximum and minimum distances between two nominally straight lines

Distances are positives. A sign (positive or negative) can be associated to the distance and, in this case, this one shall be called signed distance. These are defined as functions of the signed distance from the points of one of the features to the other. The sign depends on the related position of the point with respect to the feature.

The distances can be projected in a plane or in a straight line and are called projected distances, which are defined as functions of the projected distances from the points of one of the features to the other.

Annex C
(informative)

Relation to the GPS matrix model

C.1 General

For full details concerning the GPS matrix model, see ISO/TR 14638.

C.2 Information about this International Standard and its use

This International Standard defines general terms and types for geometrical characteristics of specifications.

C.3 Position in the GPS matrix model

This International Standard is a global GPS standard that influences all the chain links of the chains of standards in the general GPS matrix, as graphically illustrated in Figure C.1.

Fundamental GPS standards

Global GPS standards

General GPS matrix						
Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
Size	X	X	X	X	X	X
Distance	X	X	X	X	X	X
Radius	X	X	X	X	X	X
Angle	X	X	X	X	X	X
Form of line independent of datum	X	X	X	X	X	X
Form of line dependent on datum	X	X	X	X	X	X
Form of surface independent of datum	X	X	X	X	X	X
Form of surface dependent on datum	X	X	X	X	X	X
Orientation	X	X	X	X	X	X
Location	X	X	X	X	X	X
Circular run-out	X	X	X	X	X	X
Total run-out	X	X	X	X	X	X
Datums	X	X	X	X	X	X
Roughness profile	X	X	X	X	X	X
Waviness profile	X	X	X	X	X	X
Primary profile	X	X	X	X	X	X
Surface imperfections	X	X	X	X	X	X
Edges	X	X	X	X	X	X

Figure C.1 — Position in the GPS matrix model

C.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Figure C.1.

Bibliography

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[2] ISO 7966:1993, *Acceptance control charts*

[3] ISO 9000:2005, *Quality management systems — Fundamentals and vocabulary*

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[5] ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (GUM:1995)

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