TECHNICAL SPECIFICATION

ISO/TS 17450-1

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Geometrical product specifications (GPS) — General concepts —

Part 1: Model for geometrical specification and verification

Spécification géométrique des produits (GPS) — Concepts généraux —
Partie 1: Modèle pour la spécification et la vérification géométriques

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Foreword

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

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

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

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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/TS 17450-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO/TS 17450 consists of the following parts, under the general title *Geometrical product specifications (GPS) — General concepts*:

— *Part 1: Model for geometrical specification and verification*

— *Part 2: Basic tenets, specifications, operators and uncertainties*

Introduction

This part of ISO/TS 17450 is a Geometrical Product Specification (GPS) document and is to be regarded as a global GPS document (see ISO/TR 14638). It influences all chain links of the chains of standards.

For more detailed information on the relationship of this part of ISO/TS 17450 to other standards and to the GPS matrix model, see annex E.

In a market environment of increased globalization, the exchange of technical product information is of high importance and the need to express unambiguously the geometry of mechanical workpieces of vital urgency. Consequently, codification associated with the macro- and micro-geometry of workpiece specifications must be unambiguous and complete if the functional geometrical variation of parts is to be limited; in addition, the language ought to be applicable to CAX systems.

The aim of ISO/TC 213 is to provide the tools for a global and “top-down” approach to GPS. These tools are the basis of new standards for a common language for geometrical definition, able to be used by design (assemblies and individual workpieces), manufacturing and inspection, including for description of the measurement procedure, regardless of the media (e.g. paper drawing, numerical drawing or exchange file) used. These tools are based on the characteristics of features, as well as on the constraints between the features and on feature operations, used for the creation of different geometrical features.

Geometrical product specifications (GPS) — General concepts —

Part 1:
Model for geometrical specification and verification

1 Scope

This part of ISO/TS 17450 provides a model for geometrical specification and verification and defines the corresponding concepts. It also explains the mathematical basis of the concepts associated with the model.

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 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

International Vocabulary of Basic and General Terms in Metrology (VIM), BIPM, IFCC, IEC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993

3 Terms and definitions

For the purposes of the present document, the terms and definitions given in ISO 14660-1 and VIM, and the following apply.

3.1
associated feature
ideal feature established from a non-ideal surface model (skin model) or from a real surface through an association operation

NOTE The relationship between this term and ISO 14660-1 is given in Figure 1.

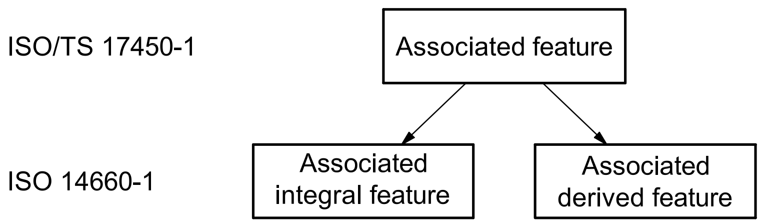


Figure 1 — Relationships of the term associated feature

3.2
association
operation used to fit ideal feature(s) to non-ideal feature(s) according to a criterion

NOTE See 8.1.5.

3.3
bounded feature
feature contained within a sphere of finite radius

3.4
characteristic
single property of one or more feature(s) expressed in linear or angular units

NOTE See annex D.

3.5
collection
operation used to identify more than one feature together, in accordance with the function of the workpiece

NOTE See 8.1.6.

3.6
construction
operation used to build ideal feature(s) from other ideal features, within constraints

NOTE See 8.1.7.

3.7
deviation
difference between the value of a characteristic obtained from the non-ideal surface model (skin model) and the corresponding nominal value

3.8
evaluation
operation used to identify either the value of a characteristic, or its nominal value and its limit(s)

NOTE See 8.2.

3.9
extraction
operation used to identify specific points from a non-ideal feature

NOTE See 8.1.3.

3.10
feature
geometric feature
point, line or surface

[ISO 14660-1]

3.11
feature operation
specific tool required for obtaining features

3.12
filtration
operation used to create a non-ideal feature by reducing the level of information of a non-ideal feature

NOTE See 8.1.4.

3.13
ideal feature
feature defined by a parametrized equation

NOTE The expression of the parametrized equation depends on the type of ideal feature and on the intrinsic characteristics.

3.14
intrinsic characteristic
characteristic of an ideal feature

NOTE 1 See 7.2.

NOTE 2 Ideal features have only dimensional characteristics as intrinsic characteristics.

NOTE 3 The intrinsic characteristics are the parameters of the parametrized equation of the ideal feature.

3.15
invariance class
a group of ideal features defined by the same invariance degree

3.16
invariance degree of an ideal feature
displacement(s) of the ideal feature for which the feature is kept identical in the space

NOTE It corresponds to the degree of freedom used in kinematics.

3.17
nominal feature
ideal feature independent of the non-ideal surface model (skin model)

NOTE The relationship between this term and ISO 14660-1 is given in Figure 2.

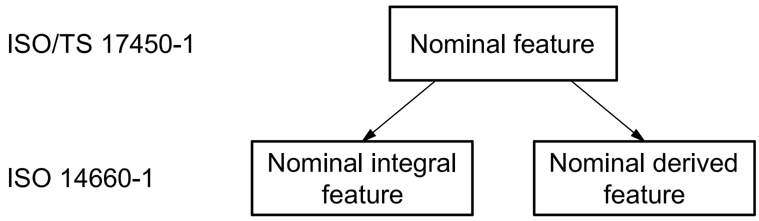


Figure 2 — Relationships of the term nominal feature

3.18
nominal model
model of the workpiece of perfect shape defined by the designer (design intent)

3.19
non-ideal feature
imperfect feature fully dependent on the non-ideal surface model (skin model)

3.20
operation
specific tool required to obtain features or values of characteristics, their nominal value and their limit(s)

3.21
partition
operation used to identify bounded feature(s) from non-ideal feature(s) or from ideal feature(s)

NOTE See 8.1.2

3.22
real surface of a workpiece
set of features which physically exist and separate the entire workpiece from the surrounding medium

[ISO 14660-1]

3.23
situation characteristic
characteristic defining the relative location or orientation between two features

3.24
situation characteristic between ideal features
characteristic defining the relative location or orientation between two situation features

3.25
situation characteristic between non-ideal and ideal features
characteristic defining the relative location between a non-ideal feature and an ideal feature

3.26
situation feature
feature of type point, straight line, plane or helix, which allows the location and/or orientation of a feature to be defined

3.27
non-ideal surface model (of a workpiece)
skin model (of a workpiece)
model of the physical interface of the workpiece with its environment

NOTE See clause 5.

3.28
specification
expression of permissible limits on a characteristic

3.29
specification by dimension
specification that limits the permissible value of an intrinsic characteristic or of a situation characteristic between ideal features

3.30
specification by zone
specification that limits the permissible variation of a non-ideal feature inside a space limited by an ideal feature or by ideal features

3.31
type (of ideal feature)
name given for a set of shapes of an ideal feature

NOTE 1 See Tables 2 and 3.

NOTE 2 From a type of ideal feature, a particular feature can be defined by giving value(s) to intrinsic characteristic(s).

NOTE 3 The type defines the parametrized equation of the ideal feature.

3.32
unbounded feature
feature that cannot be contained within a sphere of finite radius

3.33
variation
phenomenon whereby the value of a characteristic is not constant within one individual feature or within a set of workpieces

4 Application and future prospects

4.1 The model proposed in this part of ISO/TS 17450 is aimed at

a) expressing the fundamental concepts on which the geometrical specification of workpieces can be based, with a global approach including all the geometrical tools (e.g. operations) needed in GPS, and

b) providing a mathematization of the concepts (see annex B), in order to facilitate standardization inputs to

— software designers for CAD-systems,

— software designers for computing algorithms in metrology, and

— standards makers on STEP (computerized exchange of product data between CAD-systems).

4.2 This part of ISO/TS 17450 is not intended to be used directly as a standard way to specify the geometry of a workpiece, but should serve as a basis for revising and completing the existing standards according to a unified and systematic approach, in order to

a) provide a non-ambiguous GPS language, to be used and understood by people involved in design, manufacturing and inspection, and

b) identify correctly features, characteristics, and rules, thereby providing the capacity to

— propose default definitions, for example, definition of a least square surface,

— propose rules for expressing non-default definitions (special definitions),

— propose a simplified symbology,

— develop consistent rules for deviation assessment and measurement methods — the proposed tools allow the definition, without any ambiguity, of the quantity to be evaluated for each characteristic and also allow the explicit description of the measurement sequence — and

— use statistical tools — as each characteristic is defined without any ambiguity, it is possible to consider it as deterministic or statistical (e.g. statistical process control or statistical tolerance functional analysis).

5 General

The geometrical specification is the design step where the field of permissible deviations of a set of characteristics of a workpiece is stated, accommodating the required functional performance of the workpiece (functional need). It will also define a level of quality in conformance with manufacturing processes, the limits permissible for manufacturing, and the definition of the conformity of the workpiece (see Figure 3).

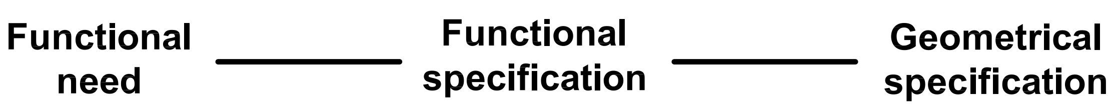


Figure 3 — Relationship between functional needs and geometrical specification

The designer first defines a “workpiece” of perfect form with shape and dimensions that fit the functions of the mechanism. This “workpiece” of perfect form is called the nominal model (see Figure 4).

This first step establishes a representation of the workpiece with only nominal values that is impossible to produce or inspect (each manufacturing or measuring process has its own variability or uncertainty).

The real surface of the workpiece, which is the physical interface of the workpiece with its environment, is imperfect geometry; it is impossible to completely capture the dimensional variation of the real surface of the workpiece in order to completely understand the complete extent of all variation.

From the nominal geometry, the designer imagines a model of this real surface, which represents the variations that could be expected on the real surface of the workpiece. This model representing the imperfect geometry of the workpiece is called the non-ideal surface model (skin model) (see Figure 5).

The non-ideal surface model (skin model) is used to simulate variations of the surface at a conceptual level. On this model the designer will be able to optimize the maximum permissible limit values for which the function is downgraded but still ensured. These maximum permissible limit values define the tolerances of each characteristic of the workpiece.

NOTE This document does not include a methodology to evaluate how close the geometrical specification is to the functional specifications.

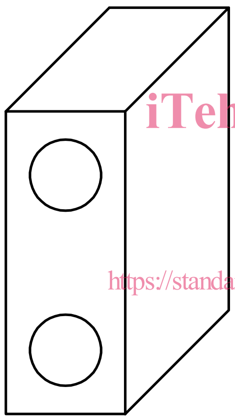


Figure 4 — Nominal model

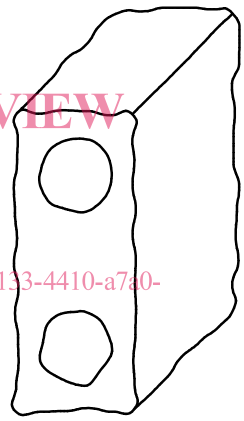


Figure 5 — Non-ideal surface model (skin model)

Verification is the manufacturing step at which a metrologist determines whether the real surface of a workpiece conforms to the field of permissible deviations that have been specified.

The definition of this geometrical deviation will be used to adjust the manufacturing process.

The metrologist begins by reading the specification, taking into account the non-ideal surface model (skin model), in order to know the specified characteristics. From the real surface of the workpiece, the metrologist defines the individual steps of the verification plan, depending on the measuring equipment.

Conformance is then determined by comparing the specified characteristics with the result of measurement (see Figure 6).

Geometrical specification ——— **Quantity (to be measured)** ——— **Result of measurement**

Figure 6 — Relationship between geometrical specification and result of measurement

6 Features

6.1 General

According to the definition of a feature, its nature is point, line or surface.

Two kinds of features can be distinguished:

a) ideal features (see 6.2);

b) non-ideal features (see 6.3).

6.2 Ideal features

6.2.1 Ideal features are defined by their type and by their intrinsic characteristics.

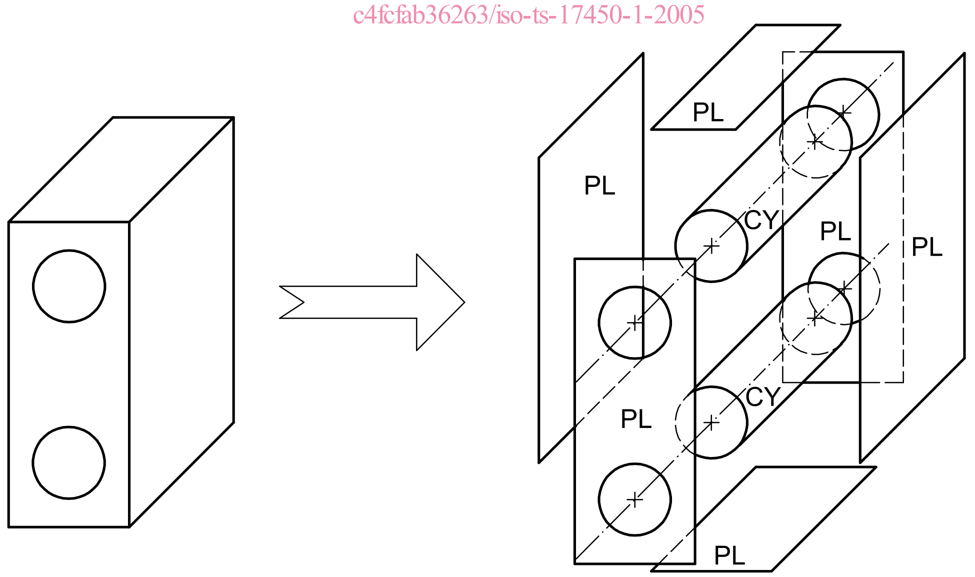
A feature is generally called by its type, for example, straight line, plane, cylinder, cone, sphere or torus.

Characteristics are defined in clause 7. A characteristic is, for example, the diameter of a cylinder, a distance between a plane and the centre point of a sphere, or the angle between the axis of a cylinder and a plane.

6.2.2 Ideal features used to define the nominal model are called nominal features. They are independent of the non-ideal surface model (skin model).

Ideal features, the characteristics of which are dependent on the non-ideal surface model (skin model), are called associated features.

For instance, the nominal model shown in Figure 7 is built with several ideal features of types plane and cylinder. The location and orientation between the features are given by situation characteristics, and the diameters of the cylinders are given by intrinsic characteristics (see clause 7).



a) Nominal model

b) Ideal features of types plane (PL) and cylinder (CY) constituting the nominal model

Figure 7 — Building the nominal model

6.2.3 Ideal features can be unbounded or bounded by ideal boundaries (e.g. nominal features are bounded, associated features are bounded or unbounded).

6.2.4 All ideal features belong to one of the seven invariance classes defined in Table 1.

Table 1 — Table of invariance classes

Invariance class[a]	Invariance degree[b]
complex	None
prismatic	1 translation along a straight line
revolute	1 rotation around a straight line
helical	1 translation along and 1 rotation combined around a straight line
cylindrical	1 translation along and 1 rotation around a straight line
planar	1 rotation around a straight line and 2 translations in a plane perpendicular to the straight line
spherical	3 rotations around a point

[a] As defined in 3.15.
[b] As defined in 3.16.

EXAMPLE 1 A cylinder is invariant either by translation along its axis or by rotation around its axis; it belongs to the cylindrical invariance class.

EXAMPLE 2 A cone is invariant by rotation around its axis; it belongs to the revolute invariance class.

EXAMPLE 3 A prism with elliptical section is invariant by a translation along a straight line; it belongs to the invariance class prismatic.

6.2.5 For each ideal feature, one or more situation features can be defined: a situation feature is an ideal feature, which is a point, a straight line, a plane, or a helix, from which the location or orientation of a feature can be defined with characteristics. Examples of situation features are given in Table 2.

Table 2 — Examples of situation features of ideal features

Invariance class	Type	Examples of situation features
complex	elliptic curve hyperbolic paraboloid ...	ellipse plane, symmetry planes symmetry planes, tangent point ...
prismatic	prism with an elliptic basis ...	symmetry planes, axis
revolute	circle cone torus ...	the plane containing the circle, the circle centre the symmetry axis, apex the plane perpendicular to the torus axis, the torus centre ...
helical	helical line helical surface with a basis of involute to a circle ...	helix helix ...
cylindrical	straight line cylinder	the straight line [a] the symmetry axis [a]
planar	plane	the plane
spherical	point sphere	the point [a] the centre [a]

[a] No alternative situation feature can be chosen, because the result would be a different invariance class for the considered feature.

6.3 Non-ideal features

Non-ideal features are fully dependent of the non-ideal surface model (skin model). They can be

— the non-ideal surface model (skin model) itself (see Figure 5),

— part of the non-ideal surface model (skin model) (features called partition features) (see Figure 11),

— the derived partition features [features not included in the non-ideal surface model (skin model) but created by operation (see clause 8) from part of the non-ideal surface model (skin model)] (see Figure 8), or

— the intersection between the “non-ideal surface model (skin model)” and an ideal feature.

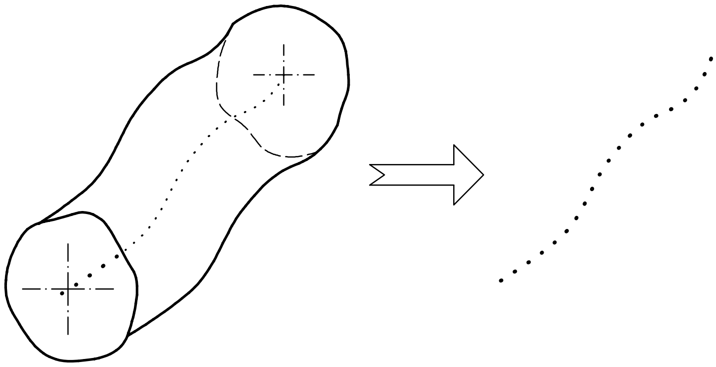


Figure 8 — Derived partition feature

Non-ideal features are bounded and are composed of an infinite or finite set of points.

7 Characteristics

7.1 General

Characteristics are defined either

— on ideal features and called intrinsic characteristics (see B.3.1), or

— between ideal features and called situation characteristics (see B.3.2), or

— between ideal and non-ideal features and also called situation characteristics (see B.3.3).

7.2 Intrinsic characteristics of ideal features

The intrinsic characteristics of an ideal feature are specific to the type of the feature itself. Examples of intrinsic characteristics are given in Table 3.