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Geometrical product specifications (GPS) — General concepts —

Part 2:
Basic tenets, specifications, operators, uncertainties and ambiguities

Spécification géométrique des produits (GPS) — Concepts généraux — Partie 2: Principes de base, spécifications, opérateurs, incertitudes et ambiguïtés

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Foreword

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

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

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

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

ISO 17450-2 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This first edition of ISO 17450-2 cancels and replaces ISO/TS 17450-2:2002, which has been technically revised. It also incorporates ISO/TS 17450-2/Cor.1:2004.

ISO 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, uncertainties and ambiguities*

Introduction

This part of ISO 17450 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 in all chains of standards in the general GPS matrix.

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise indicated.

For more detailed information on the relationship of this part of ISO 17450 to other standards and to the GPS matrix model, see Annex C.

This part of ISO 17450 covers several fundamental issues common to all the GPS standards developed by ISO/TC 213 and, by presenting GPS's basic tenets and specification and verification processes, explains some of the underlying ideas and indicates the starting point for the standards developed by this technical committee.

It is pointed out that these ideas — and, for that matter, all the other ideas and concepts applied by ISO/TC 213 — are subject to development and refinement, as the TC's recognition and understanding of them further evolves during its ongoing standards work.

Geometrical product specifications (GPS) — General concepts —

Part 2:
Basic tenets, specifications, operators, uncertainties and ambiguities

1 Scope

This part of ISO 17450 defines terms related to specifications, operators (and operations) and uncertainties used in geometrical product specifications (GPS) standards. It presents the basic tenets of the GPS philosophy while discussing the impact of uncertainty on those tenets, and examines the processes of specification and verification as they apply to GPS.

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 14253-2:2011, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

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

ISO 14978:2006, *Geometrical product specifications (GPS) — General concepts and requirements for GPS measuring equipment*

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

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

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14253-2, ISO 14660-1, ISO 14978, ISO 17450-1, ISO/IEC Guide 98-3, ISO/IEC Guide 99 and the following apply. See Figure A.1 for a concept diagram giving an overview of the relationships between these terms; it is recommended that this figure be consulted first.

3.1 Terms related to operations

3.1.1

specification operation

operation formulated using mathematical expressions, geometrical expressions or algorithms, or a combination of these, defining part of the specification

NOTE 1 Specification operations are used as part of a **specification operator** (3.2.3), in order to define a GPS requirement for a work-piece (product or component).

NOTE 2 A specification operation is a theoretical concept.

EXAMPLE 1 Association of a minimum circumscribed cylinder in the specification of the diameter of a shaft.

EXAMPLE 2 Filtration by a Gaussian filter in the specification of a surface texture requirement.

3.1.2

default specification operation

specification operation (3.1.1) which is applied to a **basic GPS specification** (3.4.4) in the absence of any additional information or modifier

NOTE 1 The default specification operation may be a global default (ISO default), company default or drawing default specification operation.

NOTE 2 The default specification operation depends on the context in which the default specification operator is applied.

EXAMPLE 1 Evaluation of a two-point diameter in the specification of the diameter of a shaft using the default indication ∅30 ± 0,1.

EXAMPLE 2 Filtration by a Gaussian filter (default filter) with the default cut-off length given in ISO 4288 in the specification of *Ra* for a surface.

3.1.3

special specification operation

specification operation (3.1.1) which is applied to a **basic GPS specification** (3.4.4) to change or modify a default specification operation (3.1.2) for this basic GPS specification with additional information or one or more modifiers

EXAMPLE 1 The association of a minimum circumscribed cylinder in the specification of the diameter of a shaft, when the modifier symbol, Ⓔ, for envelope requirement, is used (see ISO 14405-1).

EXAMPLE 2 The filtration by a Gaussian filter (default filter) with a special cut-off length of 2,5 mm in the specification of *Ra* for a surface, when the appropriate indication is used to override the default rules in ISO 4288.

3.1.4

actual specification operation

specification operation (3.1.1) which is indicated implicitly (in the case of a *default specification operation*) or explicitly (in the case of a *special specification operation*) in a GPS requirement indicated in the technical product documentation under consideration

NOTE An actual specification operation can be:

— indicated implicitly by an ISO **basic GPS specification** (3.4.4), or;

— indicated explicitly by a **GPS specification element** (3.4.1), or;

— omitted when the specification operator is not complete.

EXAMPLE 1 Evaluation of a two-point default diameter in an actual specification operation, such as when the specification ∅30 ± 0,1 is used (see ISO 14405-1).

EXAMPLE 2 Filtration by a Gaussian filter (default filter) with a special cut-off length of 2,5 mm, and the calculation of a surface texture requirement using the *Ra* algorithm, are two actual specification operations, when the specification indicates *Ra* 1,5 with a 2,5 mm filter.

3.1.5
verification operation
operation which is implemented in the form of a measurement, or by means of a measurement apparatus, or a combination of these, which corresponds to an **actual specification operation** (3.1.4)

NOTE 1 Verification operations are used in the geometrical field of mechanical engineering to verify a product to the corresponding **specification operation** (3.1.1).

NOTE 2 A verification operation is used to verify the requirements of a **specification operation** (3.1.1).

EXAMPLE 1 Evaluation of a two-point diameter when verifying the diameter of a shaft — using a micrometer, for instance.

EXAMPLE 2 Extraction of data points from a surface for surface finish verification using a nominal stylus tip radius of 2 µm and a sample spacing of 0,5 µm.

3.1.6
perfect verification operation
verification operation (3.1.5) which implements an ideal method of verifying an **actual specification operation** (3.1.4) with no intentional deviation from its requirements

NOTE 1 Although the perfect verification operation implements an ideal method for verifying the specification operation, and the method itself will introduce no measurement uncertainty; contributions to measurement uncertainty may still arise from other sources, such as deficiencies, e.g. deviations of metrological characteristics, in the apparatus used.

NOTE 2 The purpose of calibration is generally to evaluate the magnitude of those measurement uncertainty components originating from the measuring equipment.

EXAMPLE Extraction of data points from a surface using a nominal stylus tip radius of 2 µm and a sample spacing of 0,5 µm during the verification of the surface finish, when this is the extraction operation indicated in the specification.

3.1.7
simplified verification operation
verification operation (3.1.5) with intentional deviations from the corresponding **actual specification operation** (3.1.4)

NOTE These intentional deviations cause measurement uncertainty contributions in addition to the measurement uncertainty contributions from the metrological characteristic deviation(s) in the implementation of the operation.

EXAMPLE The association of a two-point diameter in the verification of the size of a shaft — using a micrometer, for instance — when the specification indicates that the minimum circumscribed cylinder association is to be used.

3.1.8
actual verification operation
verification operation (3.1.5) used in the actual measurement process

3.2 Terms related to operators

3.2.1
operator
ordered set of operations

3.2.2
functional operator
operator (3.2.1) with perfect correlation to the intended function of the workpiece/feature

NOTE 1 While a functional operator in most cases cannot formally be expressed as an ordered set of well-defined operations, it can conceptually be thought of as a set of **specification operation**(s) (3.1.1) or **verification operation**(s) (3.1.5) that would exactly describe the functional requirements of the workpiece.

NOTE 2 The functional operator is an idealized concept used, for comparison purposes only, to evaluate how well a **specification operator** (3.2.3) or **verification operator** (3.2.9) expresses the functional requirements.

EXAMPLE Ability of a shaft to run in a hole with a seal for 2 000 h without leaking.

3.2.3
specification operator
set of one or more **specification operation**(s) (3.1.1) applied in a specified order

NOTE 1 The specification operator is the result of the full interpretation of the combination of the **GPS specification**(s) (3.4.3) indicated in the technical product documentation according to ISO GPS standards.

NOTE 2 A specification operator can be incomplete and could, in such a case, introduce **ambiguity of specification** (3.3.2).

NOTE 3 A specification operator is intended to define, for example, a specific possible "diameter" in a cylinder (two-point diameter, minimum circumscribed circle diameter, maximum inscribed circle diameter, least squares circle diameter, etc.), and not the generic concept "diameter".

NOTE 4 The difference between the specification operator and the **functional operator** (3.2.2) causes **ambiguity of the description of the function** (3.3.3).

EXAMPLE If the specification for a shaft were ∅30 h7 (see ISO 286-1 and ISO 14405-1), then the specification operators for the upper and lower limits would be

— partition from the skin model of the non-ideal cylindrical surface;

— association of an ideal feature of type cylinder with the least squares criteria of association;

— construction of straight lines perpendicular to and intersecting the axis of the associated cylinder;

— extraction of two points for each straight line, where the line intersects the non-ideal cylindrical surface;

and

— evaluation of the distance between each set of two points, the largest distance being compared to the upper limit and the smallest distance to the lower limit.

3.2.4
complete specification operator
specification operator (3.2.3) based on an ordered and complete set of fully defined **specification operation**(s) (3.1.1)

NOTE A complete specification operator is unambiguous and therefore has no **ambiguity of specification** (3.3.2).

EXAMPLE 1 Specification of local diameter, defining how any distance between two opposite points is defined.

EXAMPLE 2 See the example in 3.2.3.

3.2.5
incomplete specification operator
specification operator (3.2.3) with one or more **specification operation**(s) (3.1.1) either missing, incompletely defined or unordered, or any combination of these

NOTE 1 An incomplete specification operator is ambiguous and therefore introduces **ambiguity of specification** (3.3.2).

NOTE 2 In order to establish the corresponding **verification operator** (3.2.9), when an incomplete specification operator is given, it is necessary to complete it by adding missing operations or missing parts of operation, or by ordering the operations in the incomplete specification operator. See also **method uncertainty** (3.3.4).

EXAMPLE The specification of the step dimension 30 ± 0,1, which does not specify the association to be used.

3.2.6
default specification operator
specification operator (3.2.3) which is applied to a **basic GPS specification** (3.4.4) in the absence of any additional information or modifiers

NOTE 1 The default specification operator can be:

— an ISO default specification operator defined by ISO standards, or;

— a national default specification operator defined by national standards, or;

— a company default specification operator defined by company standards/documents, or;

— a drawing default specification operator defined on the drawing according to one of the above (see Annex B).

NOTE 2 A default specification operator can be either a **complete specification operator** (3.2.4) or an **incomplete specification operator** (3.2.5).

EXAMPLE In accordance with ISO standards, the specification of *Ra* 1,5 indicates:

— partition from the skin model of a non-ideal surface;

— partition of non-ideal lines from this non-ideal surface in multiple places;

— extraction using the evaluation length and sample spacing given by the rules given in ISO 4288;

— filtration using a Gaussian filter with a cut-off wavelength and stylus tip radius given in ISO 4288;

and

— evaluation of *Ra* value as defined in ISO 4287 and ISO 4288 (16 % rule).

Since each of these operations is a default specification operation, and as they are used in the default order, the **specification operator** (3.2.3) is a default specification operator.

3.2.7
special specification operator
specification operator (3.2.3) which is required when a **special GPS specification** (3.4.5) is used, including one or more **special specification operations** (3.1.3).

NOTE 1 The special specification operator is defined by a **GPS specification** (3.4.3).

NOTE 2 A special specification operator may be a **complete specification operator** (3.2.4) or an **incomplete specification operator** (3.2.5).

NOTE 3 A special specification operator can be established from a default operator by modifying one or more operations.

EXAMPLE 1 The specification for a shaft of ∅30 ± 0,1 Ⓔ is a special specification operator, because one of the **specification operations** (3.1.1), the association of the minimum circumscribed cylinder, is not a **default specification operation** (3.1.2).

EXAMPLE 2 The specification of *Ra* 1,5 using a 2,5 mm filter for a surface is a special specification operator, because one of the **specification operations** (3.1.1), the cut-off length used in the filtration, is not a **default specification operation** (3.1.2).

3.2.8
actual specification operator
specification operator (3.2.3) derived from an actual specification given in the technical product documentation

NOTE 1 The standard or standards in accordance with which the actual specification operator is to be interpreted are identified explicitly or implicitly.

NOTE 2 An actual specification operator can be either a **complete specification operator** (3.2.4) or an **incomplete specification operator** (3.2.5).

NOTE 3 An actual specification operator can be either a **special specification operator** (3.2.7) or a **default specification operator** (3.2.6).

3.2.9
verification operator
ordered set of **verification operation**(s) (3.1.5)

NOTE 1 The verification operator is the metrological emulation of a **specification operator** (3.2.3) and is the basis for the measurement procedure.

NOTE 2 A verification operator might not correspond perfectly to the specification operator. In this case, the differences between the two result in a **method uncertainty** (3.3.4), which is part of the measurement uncertainty.