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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

Reference number
ISO 17450-2:2012(E)

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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.

EXAMPLE For an ISO basic specification for a local diameter, the implementation of the measurement with a micrometer gives a type of verification operator.

3.2.10
perfect verification operator

verification operator (3.2.9) based on a complete set of **perfect verification operation**(s) (3.1.6) performed in the prescribed order

NOTE 1 The only measurement uncertainty contributions from a perfect verification operator are from metrological characteristic deviation(s) (see ISO 14978) in the implementation of the operator.

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

EXAMPLE In accordance with ISO standards, the verification of the specification *Ra* 1,5 is

— partition (choice) of the required surface from the actual workpiece,

— partition of non-ideal lines by the physical positioning of the measuring instrument in multiple places,

— extraction of data from the surface with an instrument in accordance with the requirements of ISO 3274, using the evaluation length given in ISO 4288,

— filtration of data using a Gaussian filter with a cut-off wavelength determined by the rules in ISO 4288 and the corresponding stylus tip radius and sample spacing,

— filtration of data using a Gaussian filter with a cut-off wavelength determined by the rules in ISO 4288,

— use of the stylus tip radius and sample spacing given by the rules 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 perfect verification operation and they are performed in the order prescribed in the specification, this verification operator is a perfect verification operator.

3.2.11
simplified verification operator

verification operator (3.2.9) including one or more **simplified verification operation**(s) (3.1.7), or deviations from the prescribed order of operations, or a combination of these

NOTE 1 The **simplified verification operation**(s) (3.1.7), deviations in the order of operations, or both, cause measurement uncertainty contributions additional to those from the metrological characteristic deviation(s) in the implementation of the operator.

NOTE 2 The magnitude of these uncertainty contributions is also dependent on the geometrical characteristics (deviations of form and angularity) of the actual workpiece.

EXAMPLE 1 Applying ISO standards, the verification of the upper limit of the diameter of a shaft with the specification ⌀ 30 ± 0,1 Ⓔ using a two-point diameter evaluation — for instance, by measuring the shaft with a micrometer — is a simplified verification operator, because the specification indicates the diameter of the minimum circumscribed cylinder of a shaft.

EXAMPLE 2 In accordance with ISO standards, a simplified verification operator for the specification *Ra* 1,5 would be

— partition (choice) of the required surface from the actual workpiece,

— partition of non-ideal lines by the physical positioning of the measuring instrument in multiple places,

— extraction of data from the surface with an instrument using a skid (this instrument being, however, not in accordance with ISO 3274), using the evaluation length given in ISO 4288,

— filtration of data using a Gaussian filter with a cut-off wavelength determined by the rules in ISO 4288 and the corresponding stylus tip radius and sample spacing, and

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

Since not all of these operations are **perfect verification operation**(s) (3.1.6), this verification operator is a simplified verification operator, the reason being that the use of a surface-texture measuring instrument with a skid is not the extraction operation prescribed in the specification.

3.2.12
actual verification operator
ordered set of **actual verification operation**(s) (3.1.8)

NOTE 1 The actual verification operator may be different to the required **perfect verification operator** (3.2.10). The divergence between the perfect verification operator and the chosen actual verification operator is the measurement uncertainty [sum of **method uncertainty** (3.3.4) and **implementation uncertainty** (3.3.5)], see 3.3.5, Note 1.

NOTE 2 When the actual specification operator is incomplete then see 3.2.5 Note 2 and 3.3.5 Note 1.

3.3 Terms related to uncertainty

3.3.1
uncertainty
parameter, associated with a stated value or a relationship, that characterizes the dispersion of the values that could reasonably be attributed to the stated value or relation

NOTE 1 A stated value in the GPS field may be a measurement result or a specification limit.

NOTE 2 A relationship in the GPS field is normally the difference between the values yielded by two different **operator**(s) (3.2.1) for the same feature, e.g. a **specification operator** (3.2.3) and an **actual verification operator** (3.2.12).

NOTE 3 A relationship in the GPS field can also be the difference between the value yielded by, for example, a specification operator and a value that correlates to the function of the feature/feature [the **functional operator** (3.2.2)].

NOTE 4 Uncertainty [measurement uncertainty, **ambiguity of specification** (3.3.2), **ambiguity of the description of the function** (3.3.3), etc.] quantified in ISO GPS is always in the meaning of expanded uncertainty according to ISO 14253-2 and ISO/IEC Guide 98-3.

3.3.2
ambiguity of specification
uncertainty (3.3.1) inherent in an **actual specification operator** (3.2.8) when applied to a real feature

NOTE 1 Ambiguity of specification is of the same nature as measurement uncertainty and may — if relevant — be part of an uncertainty budget.

NOTE 2 The ambiguity of specification quantifies the ambiguity in the **specification operator** (3.2.3).

NOTE 3 Ambiguity of specification is a property related to the **actual specification operator** (3.2.8).

NOTE 4 The magnitude of the ambiguity of specification is also dependent on the expected or actual variation of the geometrical characteristics (deviations of form and angularity) of workpieces.

EXAMPLE The ambiguity of specification in a step dimension 30 ± 0,1, which does not specify which association shall be used, is obtained from the range of values that can be obtained with different association criteria.

3.3.3
ambiguity of the description of the function
uncertainty (3.3.1) arising from the difference between the **actual specification operator** (3.2.8) and the **functional operator** (3.2.2) that defines the intended function of the workpiece, expressed in the terms and units of the actual specification operator

NOTE 1 Ambiguity of the description of the function is, if possible, expressed in numbers and units comparable to the specification given.

NOTE 2 Ambiguity of the description of the function is usually not related to a single **GPS specification** (3.4.3). Usually it takes a number of single GPS specifications to simulate a function (e.g. size, form and surface texture for the same feature of the workpiece).

EXAMPLE Where the **functional operator** (3.2.2) for a shaft is the shaft's ability to run in a hole with a seal for 2 000 h without leaking, and the **specification operator** (3.2.3) is ⌀30 h7 for the size of the shaft and Ra 1,5 using a 2,5 mm filter for the surface texture of the shaft, then the ambiguity of the description of the function is derived from this specification's ability to ensure that

— a shaft complying with the specification will run for 2 000 h without leaking, and

— a shaft that does not comply with the specification will not run for 2 000 hours without leaking.

3.3.4
method uncertainty

uncertainty (3.3.1) arising from the differences between the **actual specification operator** (3.2.8), and the **actual verification operator** (3.2.12), disregarding the metrological characteristic deviation(s) of the actual verification operator

NOTE 1 When an **incomplete specification operator** (3.2.5) is given as the actual specification operator, it is necessary to define a **complete specification operator** (3.2.4), without conflicting with the incomplete actual specification operator, by adding operations or parts of operations missing in the incomplete specification operator in order to establish the corresponding **perfect verification operator** (3.2.10). Based on the knowledge of this perfect verification operator, the actual verification operator is chosen. The divergence between the perfect verification operator and the chosen actual verification operator is the measurement uncertainty [sum of the method uncertainty and the **implementation uncertainty** (3.3.5)].

NOTE 2 The magnitude of the method uncertainty value indicates the level of divergence of the chosen **actual verification operator** (3.2.12) from the **perfect verification operator** (3.2.10).

NOTE 3 Even with perfect measuring equipment, it is impossible to reduce the measurement uncertainty below the method uncertainty.

EXAMPLE If the specification for a shaft indicates ⌀30 ± 0,1 Ⓔ and a perfect micrometer (i.e. no scale error and perfectly flat and parallel anvils) is used to verify the upper limit of the specification, then the method uncertainty is derived from the difference between the value obtained by the micrometer and the values obtained by measuring the diameter of the minimum circumscribed cylinder with a perfect instrument.

3.3.5
implementation uncertainty

uncertainty (3.3.1) arising from the divergence of the metrological characteristics of the **actual verification operator** (3.2.12) from the ideal metrological characteristics defined by the **perfect verification operator** (3.2.10)

NOTE 1 The purpose of calibration is generally to evaluate the magnitude of the part (implementation uncertainty) of the measurement uncertainty originating from the measuring equipment.

NOTE 2 Other effects (e.g. environmental), not directly related to the measuring equipment, may also contribute to the implementation uncertainty.

EXAMPLE If the specification for a shaft indicates ⌀30 ± 0,1 Ⓔ and a micrometer is used to verify the specification, then the implementation uncertainty is derived from the imperfections in the spindle of the micrometer, as well as the flatness and parallelism of its anvils, regardless of whether it is the upper limit (specified as the diameter of the minimum circumscribed cylinder) or the lower limit (specified as the smallest two point diameter) that is being verified.

3.3.6
total uncertainty

sum (in the sense of the word according to ISO/IEC Guide 98-3) of the **ambiguity of the description of the function** (3.3.3), the **ambiguity of specification** (3.3.2) and the measurement uncertainty

NOTE 1 The magnitude of the total uncertainty indicates the level of divergence of the **actual verification operator** (3.2.12) from the **functional operator** (3.2.2).

NOTE 2 The total uncertainty describes the ability to determine the functional performance based on measurement and is not predictable and not easily quantifiable.

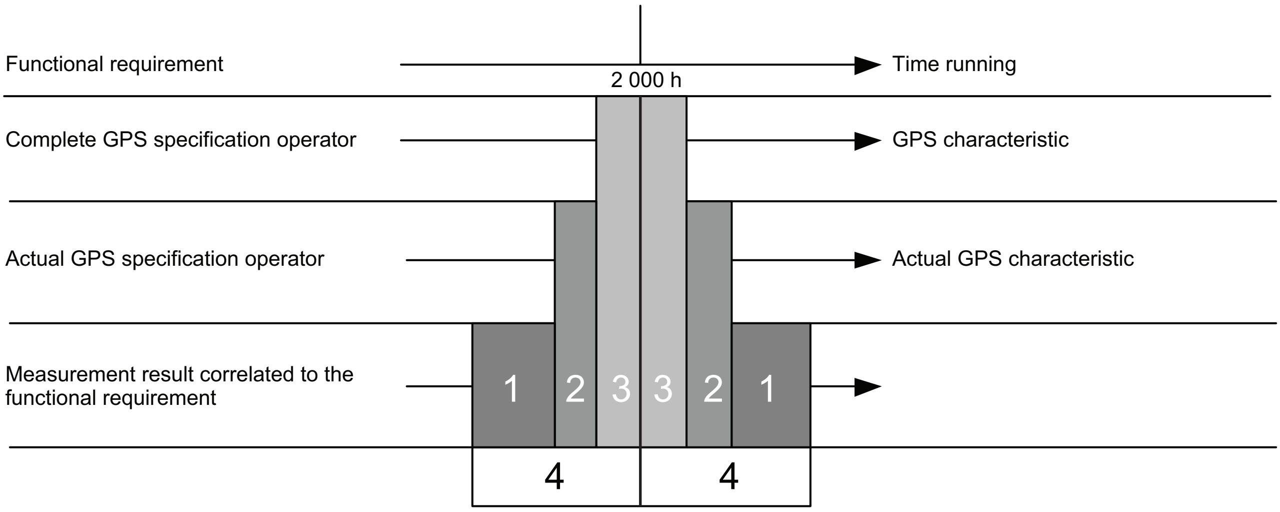
NOTE 3 The total uncertainty, the specification ambiguity and the ambiguity of the description of the function are not predictable and quantifiable.

EXAMPLE 1 If the functional operator for a shaft is the ability of the shaft to run in a hole with a seal for 2 000 h without leaking, and the **specification operator** (3.2.3) is ⌀30 h7 for the size of the shaft and *Ra* 1,5 with a 2,5 mm filter for the surface texture of the shaft, then the total uncertainty is derived from the ability to determine, based on measurements with, for instance, a surface texture instrument and a micrometer, whether

— a shaft measured found to be in compliance with the specification will run for 2 000 h without leaking, and

— if a shaft measured not to be found in compliance with the specification will not run for 2 000 h without leaking.

EXAMPLE 2 Compliance of the workpiece with the functional requirement:



Key

1 measurement uncertainty

2 specification ambiguity

3 ambiguity of description of the function

4 total uncertainty

3.4 Terms related to specifications

3.4.1
GPS specification element
standardized graphical symbol or indication included in GPS specification referring to an ordered set of one or more **specification operation**(s) (3.1.1)

NOTE 1 GPS specification elements are used in technical product documentation.

NOTE 2 Not all GPS characteristics have a full and sufficient list of GPS specification elements defined in the existing standards.

EXAMPLE In the surface texture specification: the symbology for USL, LSL, filter type, λ_S, λ_C, profile, parameter, number of sampling lengths, acceptance criteria, parameter value, manufacturing process, orientation of lay.

3.4.2
specification modifier
GPS specification element (3.4.1) that changes the default definition of the **basic GPS specification** (3.4.4), when applied

NOTE Specification modifiers may be defined by International Standards, national standards or by company standards/documents.

3.4.3
GPS specification
set of **GPS specification elements** (3.4.1) which, together, control a **specification operator** (3.2.3)

NOTE 1 A GPS specification can be expressed with or without **specification modifier(s)** (3.4.2).

NOTE 2 A GPS specification does not necessarily include a full and sufficient set of GPS specification elements.

3.4.4
basic GPS specification

shortest form for expressing a **GPS specification** (3.4.3) in technical product documentation using **default specification options** (3.1.2)

NOTE 1 The basic GPS specification can include

— an ISO default specification operator specified by ISO standards, or

— a national default specification operator specified by national standards, or

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

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

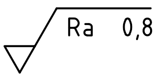
NOTE 2 When standardized by International Standards, basic GPS specifications are referred to as ISO basic GPS specifications. When defined by national or company standards, a similar specific reference is needed.

NOTE 3 A basic GPS specification is expressed without the application of **specification modifier**(s) (3.4.2).

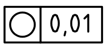
NOTE 4 When the ISO basic GPS specification is used, the **default specification operator** (3.2.6) applies.

EXAMPLE 1 ⌀30h7, ⌀38 ±0,1

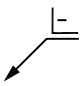
EXAMPLE 2



EXAMPLE 3



EXAMPLE 4



3.4.5
special GPS specification

GPS specification (3.4.3) expressed in technical product documentation, with the application of one or more **specification modifier**(s) (3.4.2)

NOTE In a special GPS specification, one or more **default specification operation**(s) (3.1.2) are overridden by a **special specification operation** (3.1.3) according to the indicated **GPS specification element**(s) (3.4.1).

3.4.6
actual GPS specification

GPS specification (3.4.3) defining a characteristic in the technical product documentation at hand

NOTE The actual specification can be a **basic GPS specification** (3.4.4) or a **special GPS specification** (3.4.5).

4 Basic tenets

The foundation of the GPS philosophy can be expressed in the four basic GPS tenets, A, B, C and D.

A It is possible to significantly control the functionality of a workpiece or feature using one or more GPS specifications in the technical product documentation.

NOTE 1 There can be good or bad correlation between the workpiece or feature functionality and the GPS specifications used. In other words, the ambiguity of the description of the function, for an intended functionality, can be either small or large.

B A GPS specification for a GPS characteristic shall be stated in the technical product documentation. The workpiece or feature is to be considered acceptable/good when the specification is fulfilled. Only that which is explicitly required in the technical product documentation shall be taken into account. The actual GPS specification stated in the technical product documentation defines the measurand.

NOTE 2 A GPS specification in the technical product documentation could be perfect/complete or imperfect/incomplete. In other words, the ambiguity of specification can be anything from zero to very large.

C Realization of a GPS specification shall be considered as independent of the GPS specification itself.

NOTE 3 A GPS specification is realized in a verification operator. The GPS specification does not dictate which verification operators are acceptable. The acceptability of a verification operator is evaluated using the measuring uncertainty and, in some cases, the ambiguity of specification.

D Standard GPS rules and definitions for verification define theoretically perfect means for proving the conformance or non-conformance of a workpiece/feature to a GPS specification (see ISO 14253-1). However, verification is always accomplished imperfectly.

NOTE 4 Because verification involves the realization of the GPS specification in actual measuring equipment, which can never be made perfect, verification will always include implementation uncertainty.

5 Impact of uncertainty on basic tenets

5.1 Impact of ambiguity of the description of the function and ambiguity of specification

A set of GPS specifications is complete when all intended functionalities of the workpiece are controlled with GPS characteristics. In many cases, the set of GPS specifications may be incomplete because some functionalities are defined imperfectly or not at all. Hence, there may be a good or bad correlation between the functionalities and the GPS specifications used.

Ambiguity of the description of the function refers to the case of imperfect control, while ambiguity of specification implies absence of control. For example, a GPS specification with a small ambiguity in the description of the function and a small ambiguity of specification would completely describe and control geometric characteristics that tightly control the intended functionality. See Table 1 for a summary of the combinations that can result for these two uncertainties.

Table 1 — Combination of ambiguity of the description of the function and ambiguity of specification

	Small ambiguity of specification	Large ambiguity of specification
Small ambiguity of the description of the function	Describes and controls geometric characteristics that tightly control the intended functionality.	Geometric characteristics are described and controlled to achieve portions of the intended function but specification is incomplete.
Large ambiguity of the description of the function	Describes all geometric characteristics but does not tightly control intended functionality.	Neither describes nor controls geometry required for intended functionality.

5.2 Impact of method and implementation uncertainties

Additionally, measurement uncertainty, which consists of method and implementation uncertainties, results from each practical (and imperfect) implementation of a GPS verification method. When the implemented procedure faithfully mimics the theoretically exact definition, there is small measurement uncertainty.

NOTE A measurement with low measurement uncertainty is of little value when ambiguity of the description of the function (3.3.3) or ambiguity of specification (3.3.2), or both, is large.

Table 2 summarizes the combinations that can result for the method and implementation uncertainties.

Table 2 — Combination of method and implementation uncertainties

	Small implementation uncertainty	Large implementation uncertainty
Small method uncertainty	The measuring process closely follows the specification and is implemented with few deviations from ideal metrological characteristics.	The measuring process closely follows the specification, but is implemented with significant deviations from ideal metrological characteristics.
Large method uncertainty	The measuring process does not follow the specification very tightly, but it is implemented with few deviations from ideal metrological characteristics.	The measuring process does not follow the specification very tightly and it is implemented with significant deviations from ideal metrological characteristics.
NOTE It is impossible to tell *a priori* whether large method uncertainty and small implementation uncertainty or small method uncertainty and large implementation uncertainty will result in a higher overall measurement uncertainty. Small method uncertainty and large implementation uncertainty will generally appear as having a higher measurement uncertainty, as the implementation uncertainty is typically more visible than the method uncertainty.		

NOTE For the purposes of this part of ISO 17450, measurement uncertainty is equal to the sum (in the sense of the word according to ISO/IEC Guide 98-3) of the **method uncertainty** (3.3.4) and the **implementation uncertainty** (3.3.5).

EXAMPLE The measurement uncertainty for the verification of the upper limit of the specification ⌀30 ± 0,1 Ⓔ for a shaft, when the verification is performed by measuring the shaft with a micrometer, is derived from the difference between the value obtained by the micrometer (taking into account the imperfections in the micrometer's spindle — implementation uncertainty components — as well as the flatness and parallelism of its anvils) and the value obtained by measuring the diameter of the minimum circumscribed cylinder with a perfect instrument (method uncertainty contribution).

6 Specification process

The specification process is the first process to take place in the definition of a product or a system. Its purpose is the translation of design intent into a requirement or requirements for specific GPS characteristics. The specification process is the responsibility of the designer, and comprises the following steps:

a) feature functionality — the desired design intent of the GPS specification;

b) GPS specification — consisting of a number of GPS specification elements;

c) GPS specification elements — each of which controls one or more specification operations;

d) specification operations — organized in ordered sets to form a specification operator;

e) specification operator — correlates to a greater or lesser extent to the intended feature functionality, and defines the GPS characteristics of the specification (measurand used in verification).

7 Verification process

The verification process takes place after the specification process. Its purpose is the verification on the real workpiece of the feature characteristic defined by the specification operator in the actual GPS specification. This is done by implementation of the actual specification operator in an actual verification operator. The verification process is the responsibility of the metrologist, and comprises the following steps:

a) actual specification operator — can be broken down into an ordered set of actual specification operations and defines the measurand;

b) actual specification operations — each approximated by actual verification operations;

c) actual verification operations — grouped in an ordered set to form the actual verification operator;

d) actual verification operator — identical to the actual measurement process;

e) measured value — compared to the GPS specification.

Annex A
(informative)

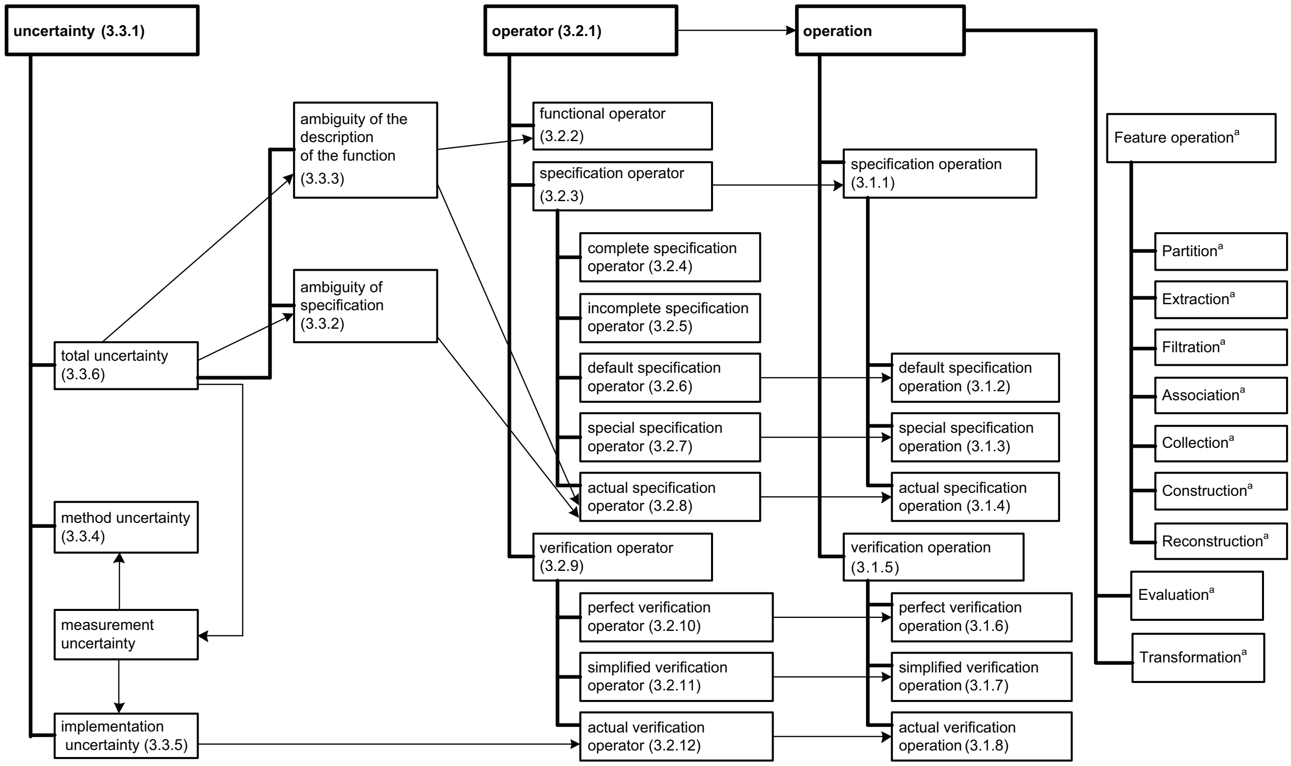
Concept diagram

The concept diagram shown in Figure A.1 illustrates the three top level concepts:

— uncertainty;

— operator;

— operation.



a See ISO 17450-1.

NOTE Thick, solid lines in the directions down and to the right connect high-level general concepts to specific subconcepts. Thinner lines with arrow heads point from one concept to another or others used in the first concept's definition.

Figure A.1 — Concept diagram for operations, operators and uncertainties

Annex B
(informative)

Drawing indications

Figure B.1 shows the possible rules applicable to GPS indications on a drawing, Figure B.2 the complete and incomplete specifications and Figure B.3 the relationship between the terms related to specifications. If the default operator deviates from the ISO default operator (e.g. company default), it is indicated on the drawing.

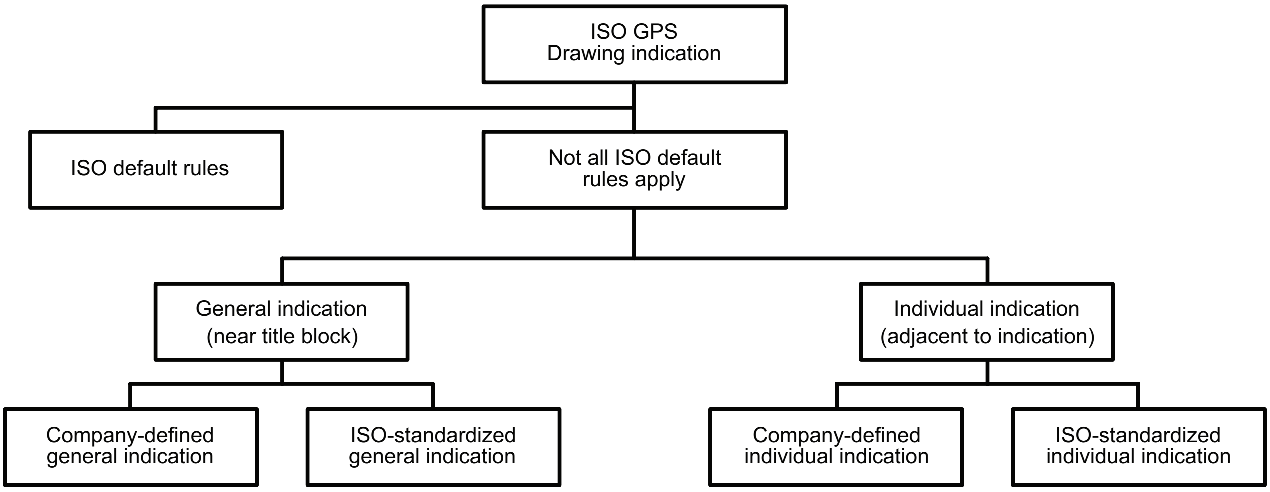


Figure B.1 — GPS indications on drawing — Possible applicable rules

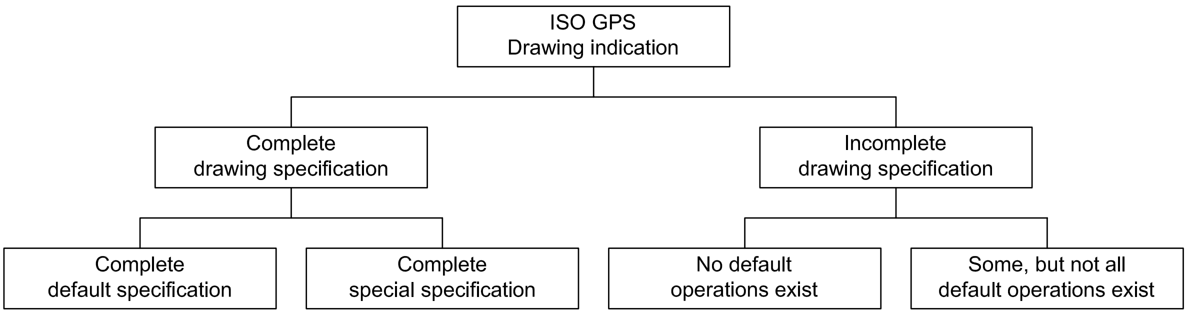


Figure B.2 — Complete and incomplete specifications

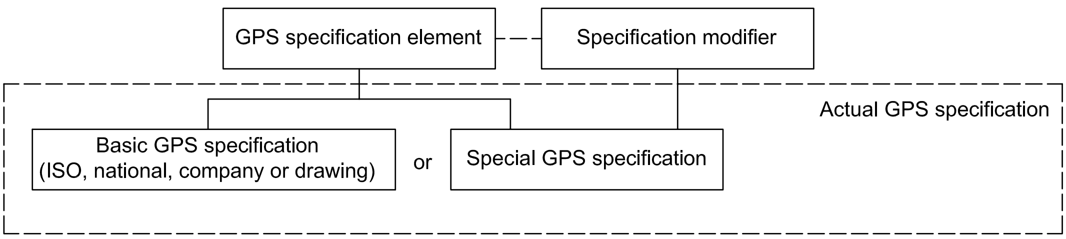


Figure B.3 — GPS specifications

Annex C
(informative)

Relationship to the GPS matrix model

C.1 General

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

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.

C.2 Information about this part of ISO 17450 and its use

This part of ISO 17450 is a basis for standards covering geometrical specification and verification.

C.3 Position in the GPS matrix model

This part of ISO 17450 is a global GPS standard, which influences all the chain links of all the chains of standards, as graphically illustrated in Figure C.1.

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

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

[1] ISO 286-1, *Geometrical product specification (GPS) — ISO code system for tolerance on linear size — Part 1: Bases of tolerances, deviations and fits*

[2] ISO 3274, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

[3] ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

[4] ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

[5] ISO 8015, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

[6] ISO 14253-1, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications*,

[7] ISO 14405-1, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 1: Linear sizes*

[8] ISO/TR 14638, *Geometrical product specification (GPS) — Masterplan*

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