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Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules

Spécification géométrique des produits (GPS) — Principes fondamentaux — Concepts, principes et règles

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 8015 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This second edition cancels and replaces the first edition (ISO 8015:1985), which has been technically revised.

Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a fundamental GPS standard (see ISO/TR 14638). It influences all other standards in the GPS matrix system, i.e. all global, general and supplementary standards, as well as any other kind of document in the GPS matrix system.

For more detailed information of the relation of this International Standard to other standards and the GPS matrix model, see Annex A.

This International Standard covers a number of fundamental principles that apply to all GPS standards and technical product documentation that is based on the GPS matrix system. Until this current version of this International Standard was published, these principles were implied, but not formulated explicitly.

This International Standard also covers the indication of ISO default specification operators and particularly the indication of non-default specification operators, either by direct indication or by the use of company-specific or drawing-specific defaults.

For the purpose of this International Standard, a concept is considered as an abstract idea, a principle is considered as a standardized truth based on concepts upon which rules are based, and a rule is considered as a standardized procedure (for action).

Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules

1 Scope

This International Standard specifies fundamental concepts, principles and rules valid for the creation, interpretation and application of all other International Standards, Technical Specifications and Technical Reports concerning dimensional and geometrical product specifications (GPS) and verification.

This International Standard applies to the interpretation of GPS indications on all types of drawings.

For the purposes of this International Standard, the term “drawing” is to be interpreted in the broadest possible sense, encompassing the total package of documentation specifying the workpiece.

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

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

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — 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 17450-1, ISO 17450-2, ISO/IEC Guide 98-3, ISO/IEC Guide 99 and the following apply.

3.1
ISO GPS system
GPS system
geometrical product specification and verification system developed in ISO by ISO/TC 213

1) To be published. (Revision of ISO/TS 17450-1:2005)

2) To be published. (Revision of ISO/TS 17450-2:2002)

3.2
default GPS specification
GPS specification in which the specification operator is defined by standards or regulations

NOTE Where defined, default specifications are usually recognizable by the introductory wording: "*unless otherwise specified...*".

3.3
ISO default GPS specification
default GPS specification defined by ISO standards

3.4
altered default GPS specification
default GPS specification defined by other means

3.5
ISO default GPS specification operator
specification operator containing only default specification operations in the default order and defined by ISO standards

4 Fundamental assumptions for the reading of specifications on drawings

4.1 General

The following assumptions regarding the interpretation of tolerance limits are the basis for the overall rules of the GPS system.

General and individual specifications written on the drawing shall always be respected and are linked by default to the assumptions given in 4.2 to 4.4.

4.2 Functional limits

It is assumed for interpretation that the functional limits are based on an exhaustive investigation done by experiment or theory, or a combination of both, so the functional limits are known with no uncertainty.

4.3 Tolerance limits

It is assumed for interpretation that the tolerance limits are identical to the functional limits.

4.4 Workpiece functional level

It is assumed for interpretation that the workpiece functions 100 % within the tolerance limits and 0 % outside the tolerance limits.

5 Fundamental principles

5.1 Invocation principle

Once a portion of the ISO GPS system is invoked in a mechanical engineering product documentation, the entire ISO GPS system is invoked, unless otherwise indicated on the documentation, e.g. by reference to a relevant document.

"Unless otherwise indicated on the documentation" means e.g. that if it is indicated on the documentation that it has been prepared in accordance with a regional, national or company standard, then that standard and not the ISO GPS system shall be used to interpret those elements of the specification that are covered by that standard.

"Tolerancing ISO 8015" can optionally be indicated in or near the title block for information, but is not required to invoke the ISO GPS system.

NOTE 1 The most common way to invoke the ISO GPS system is to use one or more GPS specifications in a drawing.

NOTE 2 The ISO GPS system is defined in the International Standards published by ISO/TC 213. See also ISO/TR 14638.

NOTE 3 That "the entire ISO GPS system is invoked" means that e.g. fundamental and global GPS standards apply and consequently that e.g. the reference temperature given in ISO 1 and the decision rules given in ISO 14253-1 apply unless otherwise indicated. The purpose of the invocation principle is to provide the formal traceability for these GPS standards and rules.

5.2 Principle of GPS standard hierarchy

The ISO GPS system is defined in a hierarchy of standards that includes the following types of standards in the given order:

— fundamental GPS standards;

— global GPS standards;

— general GPS standards;

— complementary GPS standards.

The rules given in standards at a higher level in the hierarchy apply in all cases unless rules in standards at lower levels in the hierarchy specifically give other rules.

The rules given in fundamental GPS standards, e.g. this International Standard, apply in all cases, unless the rules in a specific standard at a lower level give other rules that apply within its scope.

The rules given in global GPS standards, e.g. ISO 1, apply in all cases, unless the rules in a specific general or complementary GPS standard give other rules that apply within its scope.

All rules given in fundamental and global GPS standards apply in addition to the rules specifically given in general GPS standards, e.g. ISO 1101, except in the cases where the rules in the general GPS standard are explicitly different from the rules given in fundamental and global GPS standards and unless the rules in a specific complementary GPS standard give other rules that apply within its scope.

All rules given in fundamental, global and general GPS standards apply in addition to the rules specifically given in complementary GPS standards, e.g. ISO 2768-1, except in the cases where the rules in the complementary GPS standard are explicitly different from the rules given in fundamental, global and general GPS standards.

5.3 Definitive drawing principle

The drawing is definitive. All specifications shall be indicated on the drawing using GPS symbology (with or without specification modifiers), associated default rules or special rules and references to related documentation, e.g. regional, national or company standards. Consequently, requirements not specified on the drawing cannot be enforced.

A drawing may include specifications relating to several stages of completion of the product. In this case, it shall be indicated which stage each indication refers to, unless it is the final stage.

As part of the ISO GPS system, this International Standard and the principles and rules defined in it apply to all product specifications where the ISO GPS system is invoked (see 5.1), even though it is not explicitly referenced in the drawing.

NOTE As stated in the Scope, for the purposes of this International Standard, the term "drawing" is to be interpreted in the broadest possible sense, encompassing the total package of documentation specifying the workpiece.

5.4 Feature principle

A workpiece shall be considered as made up of a number of features limited by natural boundaries. By default, every GPS specification for a feature or relation between features applies to the entire feature or features; and each GPS specification applies only to one feature or one relation between features.

This default can only be overridden by explicit indications on the drawing.

NOTE 1 The natural boundaries between features are in most cases edges where an abrupt change in the surface normal occurs. However, this is not always the case. Consider a workpiece that consists of a cylindrical feature between two hemispherical features of the same diameter. In this case, there is no abrupt change in the surface normal at the natural boundaries between the features.

NOTE 2 There are indications available to specify that a requirement does not apply to the entire feature, e.g. when a part of a feature is indicated with a long-dashed dotted wide line or when the ACS (any cross-section) indication is used.

NOTE 3 There are indications available to specify that a requirement applies to more than one feature, e.g. when the CZ (common tolerance zone) indication is used.

NOTE 4 Unless otherwise specified, a general GPS specification is considered a set of GPS specifications. Each GPS specification in the set only applies to one characteristic of a feature or a relationship between features (see also 5.12).

5.5 Independency principle

By default, every GPS specification for a feature or relation between features shall be fulfilled independent of other specifications except when it is stated in a standard or by special indication (e.g. Ⓜ modifiers according to ISO 2692, CZ according to ISO 1101 or Ⓔ modifiers according to ISO 14405-1) as part of the actual specification.

5.6 Decimal principle

Non-indicated decimals of nominal values and tolerance values are zeros. This principle applies to drawings as well as GPS standards.

EXAMPLE 1 ± 0,2 is the same as ± 0,200 000 ...

EXAMPLE 2 10 is the same as 10,000 000 ...

5.7 Default principle

A complete specification operator can be indicated by using ISO basic GPS specifications. The ISO basic GPS specification indicates that the requirement is based on the default specification operator.

NOTE 1 ISO GPS standards define the ISO default GPS specification operator for each ISO basic GPS specification. It is not directly visible in the drawing.

EXAMPLE The dimensional specification “∅30 H6” implies that the default specification operator (local size) according to ISO 14405-1 applies.

NOTE 2 Special GPS specifications can be indicated in technical product documentation by the use of modifiers or shorthand notations, or both. These modifiers or shorthand notations, or both, are visible in the drawing.

NOTE 3 Modifiers are used to change the specification operator when the default specification operator does not apply.

NOTE 4 Default GPS specifications can be changed by using drawing-specific default GPS specifications or company-specific default GPS specifications. Both of these are indicated in the drawing either directly, or through the reference to a document, e.g. a regional, national or company standard (see 6.3).

5.8 Reference condition principle

By default, all GPS specifications apply at reference conditions. These include the standard reference temperature of 20 °C defined in ISO 1 and that the workpiece shall be free of contaminants. Any additional or other conditions that apply, e.g. humidity conditions, shall be defined in the drawing.

5.9 Rigid workpiece principle

By default, a workpiece shall be considered as having infinite stiffness and all GPS specifications apply in the free state, undeformed by any external forces including the force of gravity. Any additional or other conditions that apply to the workpiece shall be defined in the drawing; see, for example, ISO 10579.

5.10 Duality principle

5.10.1 Operator concept

Specifications for workpiece features in GPS standards are formulated as specification operators. A specification operator is a set of prescribed operations in a prescribed order.

This concept allows for flexibility in specifications. The set of operations in a specification can be designed to emulate specific functional requirements, thus limiting or eliminating any ambiguity of the description of the function in the specification.

A complete specification operator defines the measurand for the specification in all significant details. This eliminates ambiguity of the specification.

The verification operator is the physical implementation of the specification operator. It may have exactly the same operations in the same order, in which case the method uncertainty is zero, or it may have different operations or perform the operations in a different order, in which case the method uncertainty is not zero.

The verification operator is not specified in the drawing. Rather, it is decided during verification to be sufficiently close to the specification operator to keep the method uncertainty at an acceptable level.

5.10.2 Duality principle statement

The duality principle states that:

1) a GPS specification defines a GPS specification operator independent of any measurement procedure or measurement equipment, and;

2) the GPS specification operator is realized in a verification operator which is independent of the GPS specification itself, but is intended to mirror the GPS specification operator.

The GPS specification does not dictate which verification operators are acceptable. The acceptability of a verification operator is evaluated using the measurement uncertainty and any ambiguity of the specification.

5.11 Functional control principle

Each workpiece function is expressed by a functional operator and can be simulated by a set of specification operators, which again defines a set of measurands and the associated tolerances for these measurands.

The specification of a workpiece is complete when all intended functions of the workpiece are described and controlled with GPS specifications. In most cases, the specification will be incomplete because some functions are described/controlled imperfectly or not at all. Hence, there may be a good or bad correlation between the function and the set of GPS specifications used.

Any lack of correlation between the functional requirements and the requirements of the GPS specifications results in ambiguity of the description of the function.

5.12 General specification principle

General GPS specifications apply individually to each characteristic for each feature and to each characteristic for each relationship between features for which no individual GPS specification of the same type has been indicated. General GPS specifications are considered as a set of specifications unless otherwise specified and apply to each characteristic for each feature and to each characteristic for each relationship between features individually.

If no general GPS specifications are indicated in or near the title block, then only the individual GPS specifications indicated in the technical product documentation apply.

If more than one general GPS specification is indicated in or near the title block and these specifications are contradictory, they shall be supplemented with an explanation to make it clear to which characteristics each general GPS specification applies to avoid ambiguities in the specification.

In the case of contradictory general GPS specifications, i.e. two or more general GPS specifications for the same characteristic, the general rules for ambiguity of the specification only require compliance with one general GPS specification, i.e. the most permissive one.

NOTE 1 An individual GPS specification can be more or less restrictive than the general GPS specification indicated in the drawing.

NOTE 2 For example, ISO 1302, ISO 2768 and ISO 13715 provide tools for indicating general tolerances.

5.13 Responsibility principle

Given the duality principle and the functional control principle, it is necessary to describe the closeness of a specification operator to the functional operator and the closeness of a verification operator to a specification operator. The ambiguity of the description of the function and the ambiguity of the specification together describe the closeness of the specification operator to the functional operator. These ambiguities are the responsibility of the designer. The measurement uncertainty quantifies the closeness of the verification operator to the specification operator. Unless otherwise stated, the measurement uncertainty is the responsibility of the party who is providing proof of conformance or non-conformance with a specification; see ISO 14253-1.

6 Rules for indication of default specification operators

6.1 General

Default GPS specifications are generally used to simplify the tolerancing on technical drawings. A default specification operator can be specified in one of two ways, by indicating either a general ISO default GPS specification, or a general altered default GPS specification.

6.2 General ISO default GPS specification

When the

— ISO basic GPS specification according to ISO 1101, ISO 1302, ISO 5459, etc., is the actual specification for any geometrical characteristic on the drawing, and

— no general altered default GPS specification is indicated in or near the title block,

then the ISO default specification operator is the one required by the current ISO standard defining the default specification operator in question. The ISO standard defining the default specification operator in question is always the latest version available at the time of the preparation of the drawing. If reference to previous versions of that ISO standard is required, it shall be unambiguously stated.

NOTE Currently, ISO GPS standards do not provide defaults for all specification operations in all specification operators. Consequently, many ISO default specification operators are not complete.

6.3 Altered default GPS specification

An altered default specification operator shall be defined in a relevant document.

The altered default specification operator shall be thorough, unambiguous and completely defined in order to be regarded as a complete specification operator.

The altered default specification operator shall be indicated on the drawing in or near the title block. The indication shall as a minimum include the following when non-ISO GPS standards are applied:

— the word “Tolerancing” or “Tolerancing ISO 8015”;

— the symbol (AD);

— complete identification of the relevant document and other necessary information (e.g. date of issue).

NOTE AD stands for “Altered Default”.

If more than one altered default specification operator is used in a drawing, each (AD) symbol shall be followed by a number.

Some ISO standards provide means to alter the ISO default, e.g. Size ISO 14405 GG.

(AD) is only used when non-ISO GPS standards are applied.

Tolerancing ISO 8015 (AD) – ABC12345:2010

Symbol

Complete identification of the relevant document and other necessary information

See also the example in Figure 1.

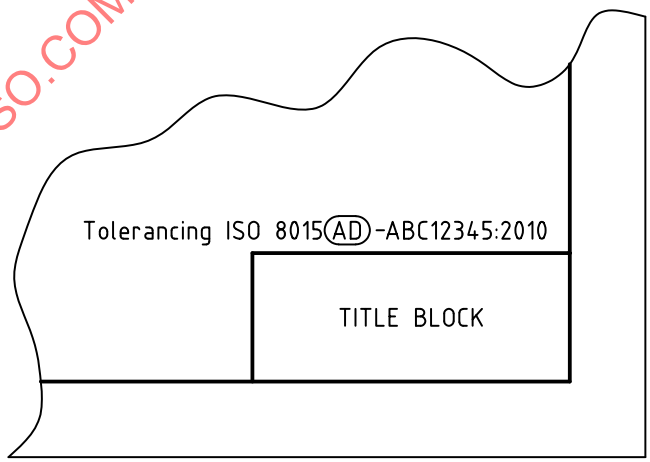

Figure 1 — Indication of an altered default specification operator

7 Rules for indication of special specification operators

7.1 General

Special specification operators for any geometrical characteristic shall be indicated by adding complementary information (requirements) to the ISO basic specification. The added complementary information changes the operations in the defined default specification operator.

NOTE 1 This type of added complementary information (requirement) is defined as a specification modifier (see ISO 17450-2:—, 3.5.2).

Operations not having complementary requirements assigned in the indicated special specification operator remain as defined by the default specification according to the ISO basic specification.

NOTE 2 Currently, ISO GPS standards do not provide defaults for all specification operations in all specification operators. Consequently, many ISO basic specifications are not complete.

The technique described in 7.2 shall be applied for indication of special specification operators for both

— features toleranced individually in accordance with ISO 1101, ISO 1302, ISO 5459, etc., and

— drawing unique default specifications.

7.2 Added complementary information (requirements) to the ISO basic specification

Added complementary information (requirements) to the ISO basic specification may change the default operations of ISO basic specification where needed. Examples of this information are

a) association rule,

b) filter type,

c) transmission band,

d) stylus tip, and

e) extraction strategy.

When changing any of these default operations to the specific need of the design, the ISO basic specification shall be modified as follows:

— in the case of an ISO 1101 specification, by adding information to the second compartment of the tolerance indicator;

— in the case of an ISO 1302 specification, by adding information in areas a-e of the complete graphical symbol for surface texture;

— in the case of an ISO 14405-1 specification, by adding modifiers to the tolerance indication.

See the respective International Standards for details.

NOTE Currently, ISO GPS standards do not define all the necessary specification modifiers.

8 Rules for statements in parentheses

Statements given in parentheses are only for information and do not constitute an integral part of the specification/requirement.