TECHNICAL SPECIFICATION

ISO/TS 14253-4

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Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 4:
Background on functional limits and specification limits in decision rules

Spécification géométrique des produits (GPS) — Vérification par la mesure des pièces et des équipements de mesure —

Partie 4: Informations de base sur les limites fonctionnelles et les limites de spécification dans les règles de décision

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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 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order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn.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 14253-4 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO 14253 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment*:

— *Part 1: Decision rules for proving conformance or non-conformance with specifications*

— *Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

— *Part 3: Guidelines for achieving agreements on measurement uncertainty statements*

— *Part 4: Background on functional limits and specification limits in decision rules* [Technical Specification]

Introduction

This part of ISO 14253 is a geometrical product specifications (GPS) standard and is to be regarded as a global GPS standard (see ISO/TR 14638). It influences the chain links 3, 4, 5 and 6 of all chains of general GPS standards.

For more detailed information on the relation of this part of ISO 14253 to other standards and the GPS matrix model, see Annex A.

The decision rules given in ISO 14253-1, which apply unless otherwise specified, are designed to ensure that workpieces and measuring equipment are within the specification and that disputes over whether workpieces and measuring equipment are within the specification can be avoided.

In order for the decision rules to work as designed, it is important to first give proof of conformance. In other words, the user/buyer of the product in question should always require the manufacturer/supplier/seller of the product to provide proof of conformance with the product.

If subsequent incoming inspection proves nonconformance, uncertainty budgets can be examined according to ISO 14253-3 for mutual assurance of their validity. If it is concluded that both uncertainty budgets are valid, the only conclusion is that one or the other or both measurement results are unrepresentative for the measurement process in question.

If, for some reason, the user of the product does not want the supplier to provide the first proof, but instead relies on incoming inspection, the user should reduce the functional limits by the measurement uncertainty of the incoming inspection to arrive at the contractual specification limits that are communicated to, and negotiated and agreed with, the supplier.

A separate problem is that of the reseller, who purchases product from a manufacturer and resells it to the user. The decision rules given in ISO 14253-1 will function correctly if the reseller requires the manufacturer of the product to provide proof of conformance and subsequently provides that proof to the user. If the reseller for some reason decides to prove conformance to the user independently, there will be cases where neither conformance nor nonconformance can be proven, so the reseller can neither return nor resell the product based on the original specification. Consequently, this approach is not recommended.

The decision rules in ISO 14253-1 are also based on a number of assumptions. When these assumptions are not true, these decision rules may not be economically optimal. This part of ISO 14253 outlines these assumptions and discusses why they are the theoretically ideal assumptions.

For workpieces, only the creator of the specification (the designer) can be expected to know whether the assumptions are true. Therefore, any deviations from the ISO 14253-1 decision rules can only be initiated and documented by the specification owner.

For measuring equipment, a specification may be based on a standard, written unilaterally by the manufacturer or purchaser of the equipment or written in cooperation between the manufacturer and the purchaser of the equipment. If the specification is based on an ISO standard, and the standard does not indicate other decision rules, the rules of ISO 14253-1 apply. In other cases, the decision rules can only be documented by the specification author(s).

It must be recognized that the decision rules, whether they are given implicitly or explicitly, are part of the specification.

It must further be recognized that the issues involved in choosing the optimal set of decision rules are complicated and that it is unrealistic to expect that simple rules can suit every circumstance. Parties should ensure access to competent technical resources before deviating from the ISO 14253-1 decision rules.

In this case, the specification owner must explicitly recognize that decision rules other than those defined in ISO 14253-1 apply, and that documentation of this policy needs to be prepared and be made available to trading partners (customers and/or suppliers) and be referenced in the technical product documentation.

Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 4: Background on functional limits and specification limits in decision rules

1 Scope

This part of ISO 14253 outlines the main assumptions behind the theoretically ideal decision rules established in ISO 14253-1. It discusses why these rules have to be the default rules and what considerations should be taken into account before applying different decision rules.

This part of ISO 14253 applies to all specifications defined in general GPS standards (see ISO/TR 14638), i.e. standards prepared by ISO/TC 213, including

— workpiece specifications (usually given as specification limits), and

— measuring equipment specifications (usually given as maximum permissible errors).

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 14253-1:1998, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications*

3 Definitions

3.1
reverse engineering
design process that consists in analysing the shape, dimensions and function of a finished part or prototype and using this information to produce a similar product

3.2
product functional level
how well the product functions overall

3.3
product attribute functional level
how well the product functions with regard to a particular attribute

NOTE The overall product functional level depends on the product attribute functional levels for all the product attributes.

3.4
workpiece functional level
how well a product made up of the workpiece in question and a set of acceptable workpieces functions overall

3.5
workpiece characteristic functional level
how well a product made up of the workpiece in question and a set of acceptable workpieces functions with regard to the attributes influenced by the characteristic in question

NOTE The overall workpiece functional level depends on the workpiece characteristic functional levels for all the workpiece characteristics.

3.6
functional level of metrological characteristic
how well a measuring equipment with the metrological characteristic in question and a set of acceptable metrological characteristics functions with regard to the attributes influenced by the characteristic in question

3.7
functional deterioration curve
graphical representation of the relationship between the product (attribute) functional level and the value of a geometrical characteristic, a combination of geometrical characteristics or a metrological characteristic

NOTE In general, the translation from product attribute functional level to derived functional limits for geometrical characteristics or metrological characteristics is not perfect. Correlation uncertainty (see ISO/TS 17450-2) quantifies this imperfection.

4 Relationship between functional limits and specification limits

4.1 General

The management policy for determining specification limits (the specification limit operator) determines the relationship between the functional limits and the specification limits that are specified on the drawing.

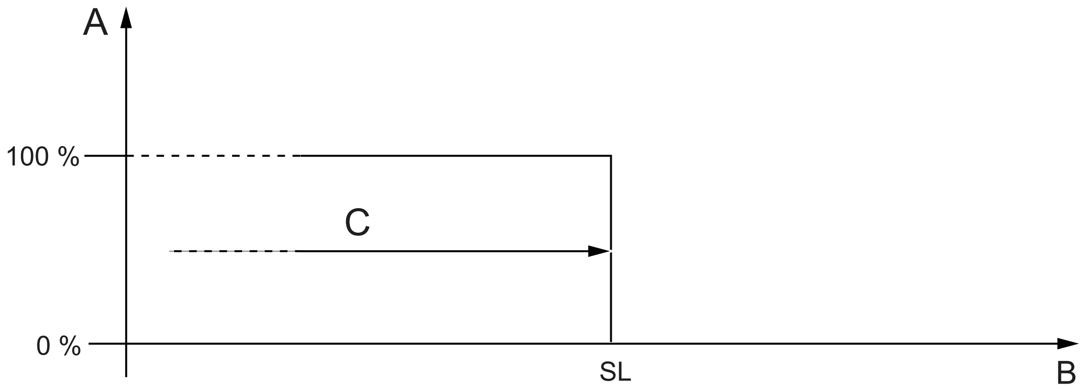
In many cases, several workpieces and several features and characteristics of those features on each workpiece contribute to a given function.

Choosing the right characteristics of the right features for the specification is crucial for ensuring that the specification is functionally relevant. It is the responsibility of the specification creator to select the functionally relevant characteristics for the specification.

Most functions depend on a one-sided specification limit. For example, the ability of a shaft to fit into a given hole depends on its diameter not being too large. There is no lower limit on the range of diameters that can fit into the hole. The lower limit of the specification for the diameter of such a shaft serves an entirely different function, e.g. that the shaft may not fit too loosely, the interface may not leak, or the shaft may not be too weak.

4.2 The one-sided case

The theoretically ideal assumption that is used for defining fundamental rules in GPS, including the decision rules defined in ISO 14253-1, is that the specification limits are equal to the functional limits and that the function of the workpiece is 100 % when the specification limit is not exceeded and 0 % when it is exceeded (see Figure 1).



Key

A workpiece characteristic functional level

B characteristic value

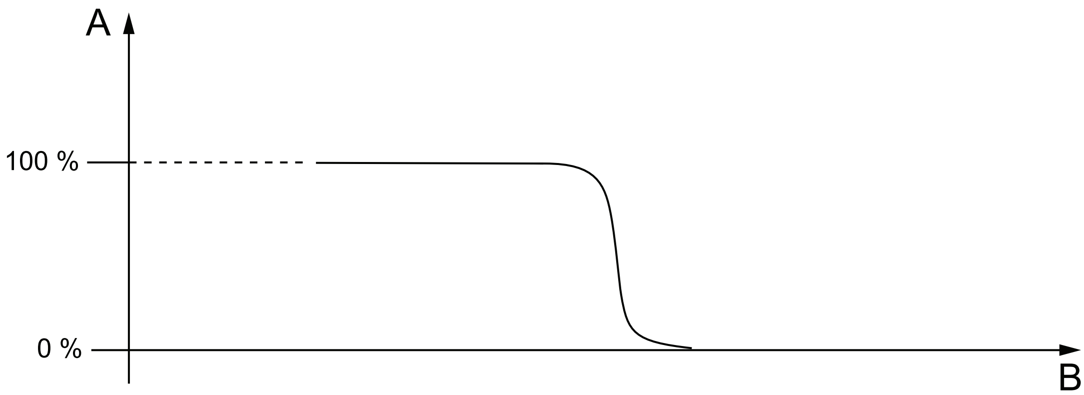
C workpiece conforms

SL specification limit

NOTE For an upper specification limit, the workpiece function is 100 % (full functionality) when the specified characteristic value is below the specification limit (SL) and 0 % when the specified characteristic value is above the specification limit (SL). The situation is similar, but reversed, for a lower specification limit.

Figure 1 — One-sided case with specification limit equal to functional limit

The workpiece functional level deterioration curve generally has a different shape from that shown in Figure 1 (see Figure 2). This functional level curve may represent the diameter of a shaft whose function it is to fit into a hole. As the diameter becomes too large, the functional level deteriorates rapidly because the shaft no longer fits into the hole.



Key

A workpiece characteristic functional level

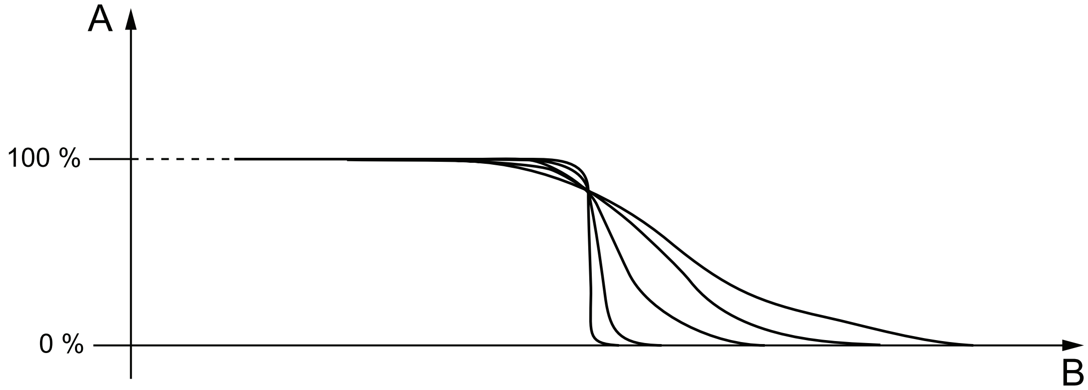
B characteristic value

NOTE 1 The abore is an example of an upper functional limit where the workpiece function deteriorates gradually as the specified characteristic value is increased beyond the range where it is 100 %. The situation is similar, but reversed, for a lower specification limit.

NOTE 2 The “tail” can either represent the situation where a press fit still allows assembly with a perfect counterpart, or the situation where variation in the counterpart still allows assembly, as the function of fit is dependent on the difference between the two sizes rather than on the one size only.

Figure 2 — One-sided case with deteriorating functional level of workpiece

The functional level deterioration curve has different shapes and deteriorate at different rates for different functions (see Figure 3).



Key

A workpiece characteristic functional level

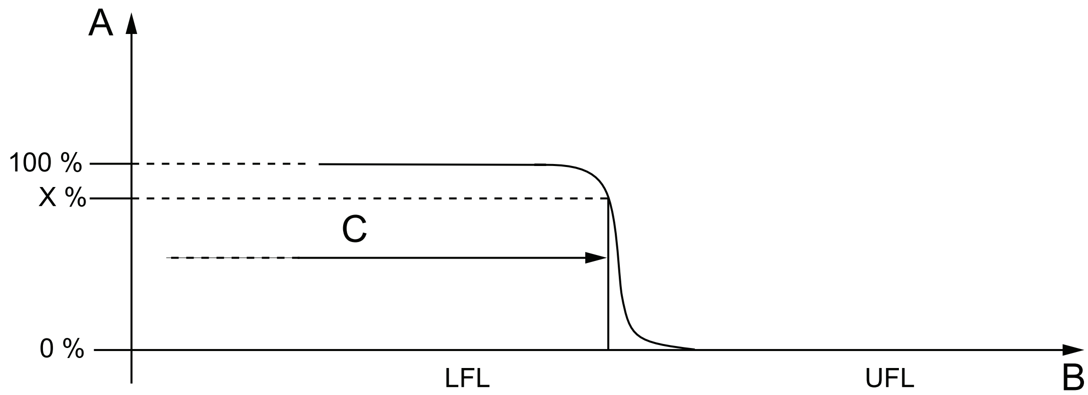
B characteristic value

NOTE For different functions, the workpiece function degrades gradually at different rates as the specified characteristic value is increased beyond the range where it is 100 %.

Figure 3 — One-sided case with different deteriorating functional levels of workpiece

In the cases shown in Figures 2 and 3, it is necessary to define a minimum acceptable functional level before functional limits can be considered meaningful (see Figure 4).

An example of this situation is the vibration of a turbine shaft. Vibration is caused by imbalances in the turbine due to, for example, straightness deviations in the axis of the turbine shaft, roundness deviations of the turbine shaft and variation in the weight of the fan blades. As the vibration level increases, the noise increases and the life of the turbine decreases. The design criteria for the turbine include a requirement for minimum life. It is impossible to manufacture a turbine with no vibration and the manufacturing cost generally goes up as tolerances are reduced to limit vibration, so the design is based on an acceptable level of vibration that leads to an acceptable life span. This acceptable level of vibration defines the X % workpiece functional level in Figure 4. Specifications for the workpieces that make up the turbine can be derived from this minimum acceptable functional level.



Key

A workpiece characteristic functional level

B characteristic value

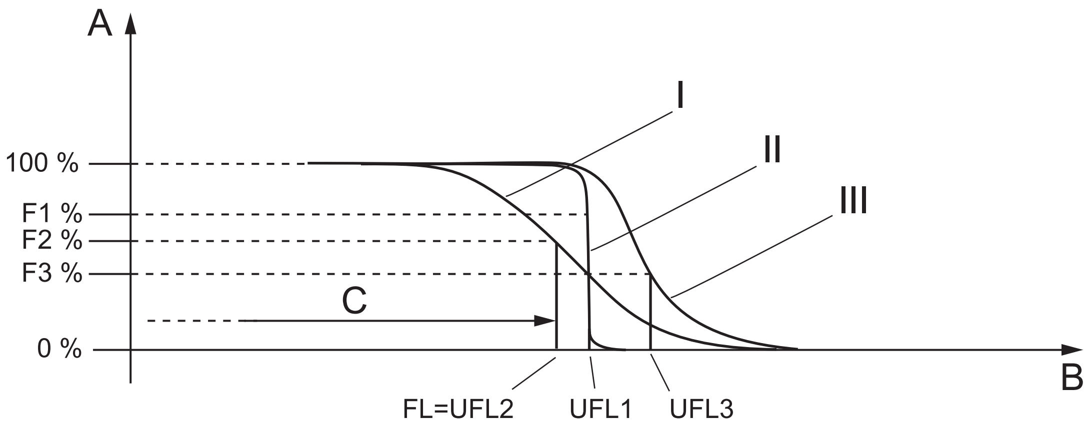
C workpiece conforms

LFL lower functional limit

UFL upper functional limit

NOTE A minimum functional level of X % is determined and the functional limit is determined as the point where the function degrades beyond this value.

Figure 4 — One-sided case with defined minimum acceptable functional level



Key

A workpiece characteristic functional level
B characteristic value
C workpiece conforms
I function 1
II function 2
III function 3
FL functional limit
UFL upper functional limit

Figure 5 — A characteristic value determines the functional level for three functions

Figure 5 shows the situation where one characteristic value determines the functional level for three functions. Each function has a minimum acceptable functional level F1, F2 or F3. These minimum acceptable functional levels each determine an upper functional limit for the characteristic value UFL1, UFL2 or UFL3. The functional limit (FL) is the most restrictive of these upper functional limits, in this case UFL2.

Once the functional limit (FL) is determined as in Figure 4 or Figure 5, the specification limit (SL) may, optionally, be placed before the functional limit as in Figure 6. In principle, it could also be placed after the functional limit, but it is hard to find a case where it would be meaningful to do this on purpose.

In many cases, companies have a (written or unwritten) management policy that dictates the relationship between specification limits and functional limits.