TECHNICAL REPORT

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

Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces

Spécification géométrique des produits (GPS) — Vérification par la mesure des pièces et des équipements de mesure —
Partie 6: Règles de décision générales pour l'acceptation ou le rejet d'instruments et de pièces

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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 exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 14253-6 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* [Technical Specification]

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

— *Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces* [Technical Report]

The following part is under preparation:

— *Part 5: Uncertainty in testing indicating measuring instruments*

Introduction

This part of ISO 14253 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences the measurement, measurement equipment and calibration chain links of the chains of standards in the general GPS matrix.

The ISO/GPS Masterplan given in ISO 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 relation of this part of ISO 14253 to other standards and to the GPS matrix model, see Annex A.

This document is based on the ISO 14253-1 concept of a decision rule, and expands the terminology beyond the default rule (stringent acceptance with a 100 % expanded uncertainty guard band) to allow the communication of other possible rules that can be adapted for different industrial needs.

This document follows the guidance provided in ISO/IEC Guide 98-4. Decision rules determine where the gauging limits are set and do not affect the workpiece tolerance; they address the (always present) uncertainty in measurement and explicitly state how this uncertainty will impact acceptance or rejection decisions.

The selection of the decision rule typically involves the designer, who can provide information on the function relative to the dimensional specification, the metrologist, who can provide information on the accuracy of the dimensional measurements, and management, who can provide information on the economic consequences of various acceptance or rejection scenarios.

The selection of a decision rule is only one element of a manufacturing effort, other activities that also affect the number or conforming (or nonconforming) workpieces include the specification of tolerances, the selection of the manufacturing process, and the selection of the measurement process; all of these issues are interconnected and should be considered together.

Both parties (the manufacturer and the customer) should discuss and agree on the decision rule as it affects the economics of the product.

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

Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces

1 Scope

This part of ISO 14253 expands the scope of decision rules to industrial situations where the default rule of ISO 14253-1 might not be economically optimal.

NOTE 1 ISO 14253-1 provides a default decision rule having a very high probability that a measured value resulting in product acceptance also yields a product with the corresponding measurand conforming to specifications.

NOTE 2 Changing the decision rule from the default case to a more task-specific case requires agreement between the two parties.

This part of ISO 14253 does not address how to determine the cost of correct decisions (accepting conforming workpieces or rejecting nonconforming workpieces) or incorrect decisions (rejecting conforming workpieces or accepting nonconforming workpieces) as this is a business concern. However, the terminology and requirements to communicate and implement the particular decision rules desired by an organization are provided along with examples to guide the reader.

NOTE 3 The decision rules in this part of ISO 14253 pertain to a single metrological characteristic under consideration. Unless otherwise stated, all probability distributions discussed in this document are Gaussian and centrally located and the cost functions are simple step functions; however, the principles of this document can be applied to any probability distribution function or cost function.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

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

ISO 17450-2:2012, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

ISO 21747:2006, *Statistical methods — Process performance and capability statistics for measured quality characteristics*

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 purpose of this International document, the terms and definitions given in ISO 14253-1, ISO 14978, ISO 17450-2, ISO/IEC Guide 98-3, ISO/IEC Guide 99 and the following apply.

3.1
acceptance limit
upper or lower bound of permissible measured quantity values

NOTE 1 For workpieces, the acceptance limits are often called the gauging limits.

NOTE 2 In the case of a simple-acceptance decision rule, the acceptance limits equal the specification limits.

3.2
acceptance zone
acceptance interval
interval of permissible measured quantity values

NOTE 1 Unless otherwise stated in the specification, the acceptance limits belong to the acceptance interval.

NOTE 2 In ISO 14253-1, the stringent acceptance zone defined by the default decision rule is (loosely speaking) called the conformance zone because of the high probability that a measurement result in this zone corresponds to a conforming product.

NOTE 3 A measured value that is in the acceptance zone does not necessarily correspond to a (truly) conforming characteristic due to measurement uncertainty.

3.3
binary decision rule
decision rule with only two possible outcomes, either acceptance or rejection

3.4
conforming
having the quality that its true value lies within or on the boundary of the tolerance zone or specification zone

NOTE In this part of ISO 14253, it is assumed that the true value of the measurand is essentially unique.

3.5
consumer's risk
probability that a particular accepted item is nonconforming

NOTE In ISO/IEC Guide 98-4, this is called "specific consumer's risk".

3.6
decision rule
documented rule that describes how measurement uncertainty will be allocated with regard to accepting or rejecting a product according to its specification and the result of a measurement

3.7
guard band
interval between a tolerance limit and a corresponding acceptance limit

NOTE In this part of ISO 14253, the term "tolerance limit" is synonymous with "specification limit".

3.8
measurement capability index
C_m
tolerance divided by a multiple of the standard measurement uncertainty associated with the measured value of a property of an item

NOTE 1 In this part of ISO 14253, the multiple is taken to be 4; hence, in the case of measuring a characteristic for conformance to a two-sided tolerance zone of width T, $C_m = T/4u_m$, where u_m is the standard uncertainty associated with the measurement of the characteristic.

NOTE 2 In this part of ISO 14253, the term “tolerance limit” is synonymous with “specification limit”.

3.9
nonconforming
having the quality that its true value lies outside the boundary of the tolerance zone or specification zone

NOTE In this part of ISO 14253, it is assumed that the true value of the measurand is essentially unique.

3.10
process distribution
probability distribution characterizing reasonable belief in values of a characteristic resulting from a manufacturing process

NOTE The form of this distribution can be inferred from a frequency distribution (usually displayed in a histogram) of measured characteristics from a large sample of items.

3.11
process capability index
C_p
index describing process capability in relation to a specified tolerance

NOTE 1 This definition is specific to this part of ISO 14253 and is a special case of the more general definition given in ISO 21747.

NOTE 2 In this part of ISO 14253, the process distribution is centred in the middle of the tolerance (i.e. specification) zone, and the index is the ratio of the zone width to 6 standard deviations of the production distribution.

3.12
producer’s risk
probability that a particular rejected item is conforming

NOTE In ISO/IEC Guide 98-4, this is called “specific producer’s risk”.

3.13
relaxed acceptance
situation when the acceptance zone is increased, and partially outside, the specification limit by the amount of a guard band

NOTE 1 Relaxed acceptance should be used with caution as it increases the size of the acceptance zone and hence decreases the probability that an accepted product is a conforming product.

NOTE 2 Relaxed acceptance and stringent rejection occur together in a binary decision rule.

NOTE 3 The magnitude (in mm) of the relaxed guard band should be specified instead of % U to avoid poor metrology (large U) increasing the number of acceptable workpieces.

NOTE 4 See Figure 2 as an example of relaxed acceptance.

3.14
relaxed rejection
situation when the rejection zone is increased, and partially inside, the specification limit by the amount of a guard band

NOTE 1 Relaxed rejection increases the size of the rejection zone and hence decreases the probability that a rejected product is a nonconforming product.

NOTE 2 Stringent acceptance and relaxed rejection occur together in a binary decision rule.

NOTE 3 See Figure 1 as an example of relaxed rejection.

3.15
rejection zone
rejection interval
interval of non-permissible measured quantity values

NOTE In ISO 14253-1, the stringent rejection zone defined by the default decision rule is (loosely speaking) called the nonconformance zone because of the high probability that a measurement result in this zone corresponds to a nonconforming product.

3.16
simple acceptance
acceptance criterion where the specification zone equals the acceptance zone

NOTE A common binary decision rule combines simple acceptance with simple rejection.

3.17
simple rejection
rejection criterion rule where the rejection zone equals everything outside of the specification zone

NOTE A common binary decision rule combines simple acceptance with simple rejection.

3.18
stringent acceptance
guarded acceptance
situation when the acceptance zone is decreased, and completely inside, the specification limit by the amount of a guard band

NOTE 1 Stringent acceptance decreases the size of the acceptance zone and hence increases the probability that an accepted product is a conforming product.

NOTE 2 Stringent acceptance and relaxed rejection occur together in a binary decision rule.

NOTE 3 The default rule ISO 14253-1 is an example of stringent acceptance with a 100 % U guard band.

NOTE 4 See Figure 1 as an example of stringent acceptance.

3.19
stringent rejection
situation when the rejection zone is decreased, and completely outside, the specification limit by the amount of a guard band

NOTE 1 Stringent rejection decreases the size of the rejection zone and hence increases the probability that a rejected product is a nonconforming product.

NOTE 2 Relaxed acceptance and stringent rejection occur together in a binary decision rule.

NOTE 3 See Figure 2 as an example of stringent rejection.

3.20
transition zone
range of values of a characteristic that is neither in the acceptance zone nor rejection zone

NOTE 1 There may be more than one transition zone; each should be separately labelled.

NOTE 2 A binary decision rule does not have a transition zone.

3.21
uncertainty interval
<of a measurement> interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

NOTE 1 The width of the uncertainty interval is typically twice the expanded uncertainty.

NOTE 2 The uncertainty interval is also known as the coverage interval [ISO/IEC Guide 99:2007, 2.36].

NOTE 3 The uncertainty interval for the mean of repeated measurements may decrease with increasing numbers of measurements.

4 General

ISO 14253-1 raised the awareness of the metrology community to the importance of uncertainty in decision rules for the acceptance and rejection decisions of products. This part of ISO 14253 expands the scope of applications to include cases where the default rule of ISO 14253-1 might not be the optimal choice. The procedure and terminology follow that of recent developments in risk analysis.

While the ISO 14253-1 default rule provides a high probability that an accepted product actually conforms to specifications, in some less critical applications, the economic optimal decision rule may be less stringent. For example, consider a workpiece production distribution where the true values of the measurand form a Gaussian distribution such that six standard deviations of the distribution lie within the specification zone (C_p = 1). Then using the ISO 14253-1 default rule with a measurement system having a measurement capability index of four (C_m = 4) will have only a 0,000 02 probability of accepting a nonconforming product. Hence, in this case, using the ISO 14253-1 default rule yields an acceptance decision that almost certainly results in accepting a conforming product.

In contrast, if a simple-acceptance decision rule is used in this example, which allows acceptance up to (and including) the specification limits, then there is a 0,000 74 probability of accepting a nonconforming product – a factor of more than 30 times as large as the default case. In safety-critical situations or situations with very high consequences for defective products, the ISO 14253-1 default rule is often economically justified as it provides very high assurance that an accepted product is actually conforming and hence reduces costly mistakes. The price of this high assurance is that a significant fraction of conforming products will not be accepted; in the above example, the ISO 14253-1 default rule rejects 3,3 % of conforming production, in contrast to rejecting 0,3 % of conforming product for the simple acceptance rule.

For less critical products where the economic cost of accepting a nonconforming product is less significant, a decision rule that accepts more product may be economically optimal. This is often cost driven because the requirement of accepting a low number of nonconforming products usually necessitates rejecting many times as many conforming products. The factors associated with the cost of accepting a nonconforming product are many; they include replacement of the product, increased warranty costs, company reputational damage, and potential legal actions (lawsuits). In particular, where safety-critical factors might result in the injury or loss of human life, such an outcome may be very expensive and justify the costs associated with unintentionally rejecting conforming products to increase the probability that the products that are accepted are conforming. The financial risk of accepting a nonconforming product in this situation is usually calculated as the sum of all expected (probability × cost) value outcomes; for a case involving human safety, the costs may be very high. Ultimately, the choice of the decision rule is a business decision that is based on all of the relevant costs associated with the product. Additionally, it should be clear (but beyond the scope of this part of ISO 14253) that many other factors can be optimized. In particular, changing the manufacturing or the measurement process may be more economical than