TECHNICAL SPECIFICATION

ISO/TS 14253-2

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Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

Part 2:
Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification

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

Partie 2: Guide pour l'estimation de l'incertitude dans les mesures GPS, dans l'étalonnage des équipements de mesure et dans la vérification des produits

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 734 10 79
E-mail copyright@iso.ch
Web www.iso.ch

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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 3.

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 normative 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 every three years with a view to deciding whether it can be transformed into an International Standard.

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

ISO/TS 14253-2 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 specification*

— *Part 2: Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification* [Technical Specification]

— *Part 3: Procedures for evaluating the integrity of uncertainty in measurement values*

Annexes A to D of this Technical Specification are for information only.

Introduction

This Technical Specification is a global GPS technical report (see ISO/TR 14638:1995). This global GPS Technical Report influences chain link 4, 5 and 6 in all chains of standards.

For more detailed information of the relation of this report to other standards and the GPS matrix model, see annex D.

This Technical Specification is developed to support ISO 14253-1. This Technical Specification establishes a simplified, iterative procedure of the concept and the way to evaluate and determine uncertainty (standard uncertainty and expanded uncertainty) of measurement, and the recommendations of the format to document and report the uncertainty of measurement information as given in *"Guide to the expression of uncertainty in measurement"* (GUM). In most cases only very limited resources are necessary to estimate uncertainty of measurement by this simplified, iterative procedure, but the procedure may lead to a slight overestimation of the uncertainty of measurement. If a more accurate estimation of the uncertainty of measurement is needed, the more elaborated procedures of the GUM must be applied.

This simplified, iterative procedure of the GUM methods is intended for GPS measurements, but may be used in other areas of industrial (applied) metrology.

Uncertainty of measurement and the concept of handling uncertainty of measurement being of importance to all the technical functions in a company, this Technical Specification relates to e.g. management function, design and development function, manufacture function, quality assurance function, metrology function, etc.

This Technical Specification is of special importance in relation to ISO 9000 quality assurance systems, where it is a requirement that the uncertainty of measurement is known [e.g. 4.11.1, 4.11.2 a) and 4.11.2 b) of ISO 9001:1994].

In this Technical Specification the uncertainty of the result of a process of calibration and a process of measurement is handled in the same way:

— calibration is treated as "measurement of metrological characteristics of a measuring equipment or a measurement standard";

— measurement is treated as "measurement of geometrical characteristics of a workpiece".

Therefore, in most cases no distinction is made in the text between measurement and calibration. The term "measurement" is used as a synonym for both.

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

Part 2:
Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification

1 Scope

This Technical Specification gives guidance on the implementation of the concept of *"Guide to the estimation of uncertainty in measurement"* (in short, GUM) to be applied in industry for the calibration of (measurement) standards and measuring equipment in the field of GPS and the measurement of workpiece GPS-characteristics. The aim is to promote full information on how to achieve uncertainty statements and provide the basis for international comparison of results of measurements and their uncertainties (relationship between purchaser and supplier).

This Technical Specification is intended to support ISO 14253-1. This Technical Specification and ISO 14253-1 are beneficial to all technical functions in a company in the interpretation of GPS specifications (i.e. tolerances of workpiece characteristics and values of maximum permissible errors (MPE) for metrological characteristics of measuring equipment).

This Technical Specification introduces the Procedure for Uncertainty MAnagement (PUMA), which is a practical, iterative procedure based on the GUM for estimating uncertainty of measurement without changing the basic concepts of the GUM and is intended to be used generally for estimating uncertainty of measurement and giving statements of uncertainty for:

— single results of measurement;

— comparison of two or more results of measurement;

— comparison of results of measurement — from one or more workpieces or pieces of measurement equipment — with given specifications [i.e. maximum permissible errors (MPE) for a metrological characteristic of a measurement instrument or measurement standard, and tolerance limits for a workpiece characteristic, etc.], for proving conformance or non-conformance with the specification.

The iterative method is based basically on an upper bound strategy, i.e. overestimation of the uncertainty at all levels, but the iterations control the amount of overestimation. Intentional overestimation — and not under-estimation — is necessary to prevent wrong decisions based on measurement results. The amount of overestimation shall be controlled by economical evaluation of the situation.

The iterative method is a tool to maximize profit and minimize cost in the metrological activities of a company. The iterative method/procedure is economically self-adjusting and is also a tool to change/reduce existing uncertainty in measurement with the aim of reducing cost in metrology (manufacture). The iterative method makes it possible to compromise between risk, effort and cost in uncertainty estimation and budgeting.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Technical Specification. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this Technical Specification are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1:1975, *Standard reference temperature for industrial length measurements*.

ISO 4288:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*.

ISO 9001:1994, *Quality systems — Model for quality systems in design, development, production, installation and servicing*.

ISO 9004-1:1994, *Quality management and quality system elements — Part 1: Guidelines*.

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

ISO 14253-3:—[1)], *Geometrical Product Specification (GPS) — Inspection by measurement of workpieces and measuring instruments — Part 3: Procedures for evaluating the integrity of uncertainty of measurement values.*

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

Guide to the expression of uncertainty in measurement (GUM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1st edition, 1995.

International Vocabulary of Basic and General Terms in Metrology (VIM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993.

3 Terms and definitions

For the purposes of this Technical Specification, the terms and definitions given in ISO 14253-1, ISO 14660-1, VIM, GUM and the following apply.

3.1
black box model for uncertainty estimation
method of/model for uncertainty estimation in which the output value of a measurement is obtained in the same unit as the input (stimuli), rather than by measurement of other quantities functionally related to the measurand

NOTE 1 In the black box model — in this Technical Specification — the uncertainty components are assumed additive, the influence quantities is transformed to the unit of the measurand and the sensitivity coefficients are equal to 1.

NOTE 2 In many cases a complex method of measurement may be looked upon as one simple black box with stimulus in and result out from the black box. When a black box is opened, it may turn out to contain several "smaller" black boxes and/or several transparent boxes.

NOTE 3 The method of uncertainty estimation remains a black box method even if it is necessary to make supplementary measurements to determine the values of influence quantities in order to make corresponding corrections.

1) To be published.