TECHNICAL SPECIFICATION

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Geometrical Product Specifications (GPS) — Coordinate measuring machines (CMM): Technique for determining the uncertainty of measurement —

Part 4:
Evaluating task-specific measurement uncertainty using simulation

Spécification géométrique des produits (GPS) — Machines à mesurer tridimensionnelles (MMT): Technique pour la détermination de l'incertitude de mesure —

Partie 4: Évaluation de l'incertitude de mesure spécifique d'une tâche à l'aide de simulations

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Contents

Page

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 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 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order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn.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 15530-4 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification.*

ISO/TS 15530 consists of the following parts, under the general title *Geometrical Product Specifications (GPS) — Coordinate measuring machines (CMM): Technique for determining the uncertainty of measurement*:

- *Part 3: Use of calibrated workpieces or standards* [Technical Specification]
- *Part 4: Evaluating task-specific measurement uncertainty using simulation* [Technical Specification]

The following part is under preparation:

- *Part 2: Use of multiple measurements strategies in calibration artefacts* [Technical Specification]

The following part is planned:

- *Part 1: Overview and general issues*

Introduction

This part of ISO 15530 is a Geometrical Product Specification (GPS) Technical Specification and is to be regarded as a general GPS document (see ISO/TR 14638). It influences the chain link 6 of the chain of standards on size, distance, radius, angle, form, orientation, location, run-out and datums.

For more detailed information of the relation of this part of ISO 15530 to the GPS matrix model, see Annex H.

For coordinate measuring machines (CMMs) used to inspect tolerances according to ISO 14253-1, the task-specific uncertainties of measurement are taken into account when tests for conformity/non-conformity are carried out. While knowledge of the uncertainty of measurement is important, up to the present, there have been only a few procedures that allow the task-specific uncertainty of measurement to be stated.

For simple measuring devices, this uncertainty can be evaluated by an uncertainty budget according to the recommendations of the *Guide to the expression of uncertainty in measurement (GUM)*. However, in the case of a CMM, the formulation of a classical uncertainty budget is impractical for the majority of the measurement tasks due to the complexity of the measuring process.

Alternate methods that are consistent with the GUM can be used to determine the task-specific uncertainty of coordinate measurements. One such method that evaluates the uncertainty by numerical simulation of the measuring process allowing for uncertainty influences is described in this part of ISO 15530.

To allow CMM users to easily create uncertainty statements, CMM suppliers and other third party companies have developed uncertainty evaluating software (UES). UES is based on a computer-aided mathematical model of the measuring process. In this model, the measuring process is represented from the measurand to the measurement result, taking important influence quantities into account.

In the simulation, these influences are varied within their possible or assumed range of values (described by probability distributions), and the measuring process is repeatedly simulated, using possible combinations of the influence quantities. The uncertainty is determined from the variation of the final result.

This procedure is compatible with the fundamental principles of the internationally valid *Guide to the expression of uncertainty in measurement (GUM)*. The details of the UES are often hidden in compiled computer code making it difficult for the user to assess the reliability of the calculated uncertainty statements. This part of ISO 15530 sets forth terminology and testing procedures for both the UES supplier and the CMM user to communicate and quantify the capabilities of UES.

This part of ISO 15530 begins by considering the declaration of influence quantities. The declarations identify which influence quantities, along with their ranges of values, the UES can account for in its uncertainty evaluation. For example, some UES can include the effects of using multiple styli during a CMM measurement, while others cannot.

Similarly, some UES can include the effects of spatial temperature gradients or variations of temperature over time, while others cannot. The purpose of the declaration section is to clearly identify to the CMM user what influence quantities, and their ranges of values, the UES will consider in its uncertainty evaluation.

This will allow the user to be able to make informed decisions. Purchasing a UES product with limited capabilities that do not include some influence quantities present during the CMM measurements requires the CMM user to independently evaluate these unaccounted-for influence quantities and combine them appropriately with those that are evaluated by the UES in order to produce a GUM compliant uncertainty statement.

This part of ISO 15530 then goes on to identify four possible methods of testing, recognizing that no single method is comprehensive in a practical sense. For each method, a description is given along with its considerations, advantages and disadvantages. A descriptive example is also included for each method.

Geometrical Product Specifications (GPS) — Coordinate measuring machines (CMM): Technique for determining the uncertainty of measurement —

Part 4:
Evaluating task-specific measurement uncertainty using simulation

1 Scope

This part of ISO 15530 specifies requirements (for the manufacturer and the user) for the application of (simulation-based) uncertainty evaluating software (UES) to measurements made with CMMs, and gives informative descriptions of simulation techniques used for evaluating task-specific measurement uncertainty.

Furthermore, it describes testing methods for such simulation software, along with advantages and disadvantages of various testing methods.

Finally, it describes various testing procedures for the evaluation of task specific uncertainty determination by simulation for specific measurement tasks carried out on CMMs, taking into account the measuring device, the environment, the measurement strategy and the object. This document describes the general procedures without restricting the possibilities of the technical realization. Guidelines for verification and evaluation of the simulation package are included.

The document is not aimed at defining new parameters for the general evaluation of the accuracy of CMM measurements.

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 10360-1:2000, *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 1: Vocabulary*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

Guide to the expression of uncertainty in measurement (GUM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1st edition, 1993, corrected and reprinted in 1995

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 10360-1, VIM and GUM apply.