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Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 2:
CMMs used for measuring size

Spécification géométrique des produits (GPS) — Essais de réception et de vérification périodique des machines à mesurer tridimensionnelles (MMT) —

Partie 2 : MMT utilisées pour les mesures de tailles

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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.

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 part of ISO 10360 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10360-2 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 10360-2:1994), which has been technically revised and whose title has changed.

ISO 10360 consists of the following parts, under the general title *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM)*:

— *Part 1: Vocabulary*

— *Part 2: CMMs used for measuring size*

— *Part 3: CMMs with the axis of a rotary table as the fourth axis*

— *Part 4: CMMs used in scanning measuring mode*

— *Part 5: CMMs using multiple-stylus probing systems*

— *Part 6: Estimation of errors in computing Gaussian associated features*

Annexes A and B of this part of ISO 10360 are for information only.

Introduction

This part of ISO 10360 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences link 5 of the chains 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 10360 to other standards and the GPS matrix model see annex B.

The tests of this part of ISO 10360 have two different technical objectives, which are to test

— the error of indication for size measurement, and

— the probing error,

of which the more important is the test for the error of indication for size measurement. The benefit of this test is that the measured result has a direct traceability to the unit length, the metre, and that it gives knowledge on how the CMM will perform when similar measurement relative to the unit length is performed.

The other test is intended to assess the 3D-probing error as a supplement to the test for the error of indication for size measurement, which only involves the probing system in two dimensions. Because it is not possible to completely isolate the probing errors from other sources of machine error, some measurement errors, of both static and dynamic origin, inherent in the other parts of the CMM measuring system, will affect the results of measurement in this test.

Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 2:
CMMs used for measuring size

1 Scope

This part of ISO 10360 specifies the acceptance test for verifying that the performance of a CMM used for measuring size is as stated by the manufacturer. It also specifies the reverification test which enables the user to periodically reverify the performance of a CMM used for measuring size.

The acceptance and reverification tests of

— probing error, and

— error of indication for size measurement,

given in this part of ISO 10360, are applicable only to CMMs using contacting probing systems of any type operating in the discrete-point probing mode.

This International Standard specifies

— performance requirements that can be assigned by the manufacturer or the user of the CMM,

— the manner of execution of the acceptance and reverification tests to demonstrate the stated requirements,

— rules for proving conformance, and

— applications for which the acceptance and reverification tests can be used.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10360. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10360 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 3650:1998, *Geometrical Product Specifications (GPS) — Length standards — Gauge blocks*

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

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 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

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

3 Terms and definitions

For the purposes of this part of ISO 10360, the terms and definitions given in ISO 10360-1, ISO 14253-1, ISO 14660-1 and VIM apply.

4 Requirements for metrological characteristics

4.1 Error of indication for size measurements

The error of indication of a CMM for size measurement, E, shall not exceed the maximum permissible error, MPE_E, as stated by:

— the manufacturer, in the case of acceptance tests;

— the user, in the case of reverification tests.

The error of indication of a CMM for size measurement, E, and the maximum permissible error of indication of a CMM for size measurement, MPE_E, are expressed in micrometres.

4.2 Probing error

The probing error, P, shall not exceed the maximum permissible probing error, MPE_P, as stated by:

— the manufacturer, in the case of acceptance tests;

— the user, in the case of reverification tests.

The probing error, P, and the maximum permissible probing error, MPE_P, are expressed in micrometres.

4.3 Environmental conditions

Limits to be respected for permissible environmental conditions such as temperature conditions, air humidity and vibration at the site of installation that influence the measurements shall be specified by:

— the manufacturer, in the case of acceptance tests;

— the user, in the case of reverification tests.

In both cases, the user is free to choose the conditions within the specified limits.

4.4 Probing system

The limits of the probing system configuration (stylus, stylus extensions, stylus orientation, weight of stylus system etc.) to which the stated value or values of MPE_E apply shall be specified by:

— the manufacturer, in the case of acceptance tests;

— the user, in case of reverification tests.

In both cases, the user is free to choose the way in which the components of the probing system are configured within the specified limits.

The form deviation of the stylus tip will influence the measurement results and shall be taken into account when proving conformance or non-conformance with specification.

4.5 Operating conditions

The CMM shall be operated using the procedures given in the manufacturer's operating manual when conducting the tests given in clause 5.

Specific areas in the manufacturer's manual to be adhered to are, for example,

a) machine start-up/warm-up cycles,

b) stylus system configuration,

c) cleaning procedures for stylus tip and reference sphere, and

d) probing system qualification.

The stylus tip and the reference sphere should be cleaned before the probing system qualification in order to eliminate any residual film that might affect the measuring or test result.

5 Acceptance test and reverification test

5.1 General

In the following:

— acceptance tests are executed according to the manufacturer's specifications and procedures;

— reverification tests are executed according to the user's specifications and the manufacturer's procedures.

5.2 Probing error

5.2.1 Principle

The principle of the assessment method for the probing error is to establish whether the CMM is capable of measuring within the stated maximum permissible probing error, MPE_P, by determining the range of distances of the measured points from the centre of the Gaussian associated sphere.

5.2.2 Measuring equipment

5.2.2.1 Test sphere, with nominal diameter of no less than 10 mm and no greater than 50 mm.

The reference sphere supplied with the CMM for probing system qualification purposes shall not be used for this test.

The form of the test sphere shall be calibrated, since the form deviation influences the test result, and shall be taken into account when proving conformance or non-conformance with the specification.

The test sphere shall be placed at a location other than that of the reference sphere used for the probing system qualification.

5.2.3 Procedure

5.2.3.1 The user is free to choose the orientation of the stylus and the location of the mounting of the test sphere within the specified limits.

It is recommended that the orientation of the stylus not be parallel to any CMM axis.

NOTE The choice of orientation of the stylus and the location of the mounting of the test sphere may significantly affect the test result.

5.2.3.2 Set up and qualify the probing system in accordance with the manufacturer's normal procedures (see 4.4 and 4.5).

5.2.3.3 Position the test sphere in accordance with 5.2.2. The test sphere should be mounted rigidly to minimize errors due to bending.

5.2.3.4 Measure and record 25 points. The points shall be approximately evenly distributed over at least a hemisphere of the test sphere. Their position shall be at the discretion of the user and, if not specified, the following probing pattern is recommended (see Figure 1):

— one point on the pole (defined by the direction of the stylus shaft) of the test sphere;

— four points (equally spaced) 22,5° below the pole;

— eight points (equally spaced) 45° below the pole and rotated 22,5° relative to the previous group;

— four points (equally spaced) 67,5° below the pole and rotated 22,5° relative to the previous group;

— eight points (equally spaced) 90° below the pole (i.e. on the equator) and rotated 22,5° relative to the previous group.

5.2.4 Derivation of test results

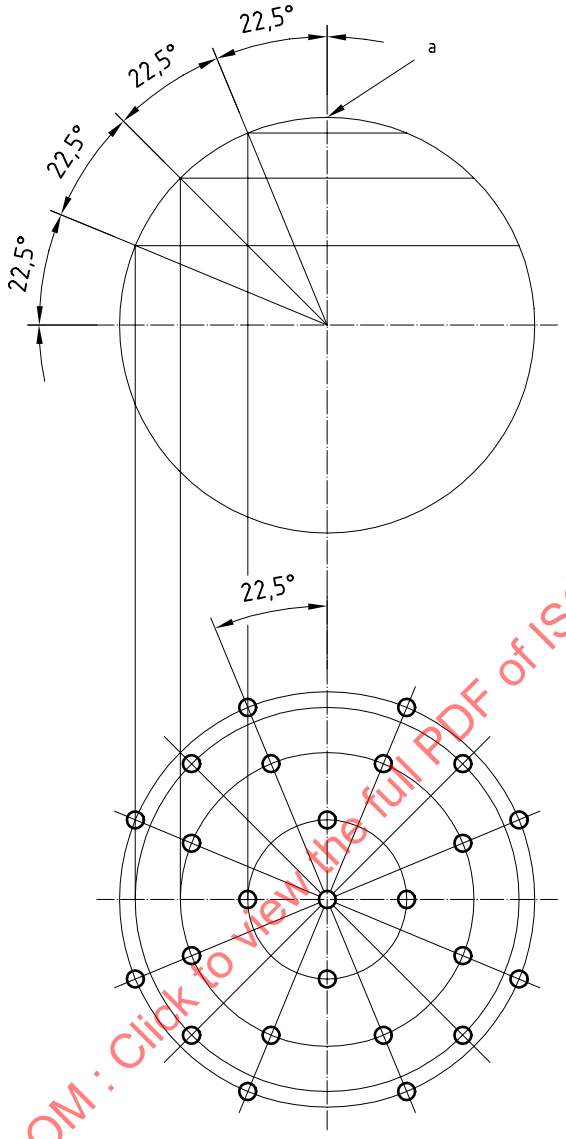
Using all 25 measurements, compute the Gaussian associated sphere. For each of the 25 measurements, calculate the Gaussian radial distance, R.

Calculate the probing error, P, as the range of the 25 Gaussian radial distances, $R_{max} - R_{min}$.

5.3 Size

5.3.1 Principle

The principle of the assessment method for size is to establish whether the CMM is capable of measuring within the stated maximum permissible error of indication of a CMM for size measurement, MPE_E. The assessment shall be performed by comparison of the calibrated values with the indicated values of five different material standards of size, each of a different length. The five different material standards of size shall be placed in seven different locations or orientations or both, in the measuring volume of the CMM, and measured three times, for a total of 105 measurements.



a Pole

Figure 1 — Target contact points

5.3.2 Measuring equipment

5.3.2.1 **Material standard of size**, (either a step gauge or a series of gauge blocks conforming to ISO 3650 are strongly recommended), with the longest size being at least 66 % of the longest spatial diagonal of the measuring volume of the CMM, and the shortest size being less than 30 mm.

The length of each material standard of size shall be calibrated and the calibration uncertainty shall be taken into account when proving conformance or non-conformance of the CMM with the specification.

5.3.3 Procedure

5.3.3.1 The user is free to choose the seven different locations and orientations of the five different material standards of size within the specified limits.

NOTE The choice of locations and orientations may significantly affect the test result.

5.3.3.2 Set up and qualify the probing system in accordance with the manufacturer's normal procedures (see 4.4 and 4.5).

5.3.3.3 Repeat the following for all seven different locations and orientations.

Measure each of the five material standards of size in any of the seven different locations and orientations three times, making external or internal bi-directional measurements only. Measure one point only at each end of the material standard of size for each size measurement.

Supplementary measurements are required for alignment purposes. It is recommended that the alignment method used be consistent with the procedures used during calibration.

The uncertainties due to the alignment method shall be taken into account when proving conformance or non-conformance with the specification.

5.3.4 Derivation of test results

For all 105 measurements, calculate each error of indication for size measurement, E, by calculating the difference between the indicated value and a true value of each material standard of size.

The indicated value of a particular measurement (of a particular material standard of size in a particular location and orientation) may be corrected to account for systematic errors if the CMM has accessory devices for correcting systematic instrument errors or software for this purpose. Manual correction of the result obtained from the computer output to take account of temperature or other corrections shall not be allowed when the environmental conditions recommended by the manufacturer apply.

A true value of the material measure is taken as the calibrated size between the measuring faces of the material standard of size. This value should be temperature corrected only if this facility is normally available in the software of the CMM under test.

Plot all the errors (values of E) on a diagram, as indicated on Figure 12, 13 or 14 of ISO 10360-1:2000, which matches the expressed form of MPE_E.

6 Compliance with specifications

6.1 Acceptance test

The performance of the CMM used for measuring size is verified if

— the error of indication of a CMM for size measurements, E, is not greater than the maximum permissible error of indication of a CMM for size measurements, MPE_E, as specified by the manufacturer and taking into account the uncertainty of measurement according to ISO 14253-1, and

— the probing error, P, is not greater than the maximum permissible probing error, MPE_P, as specified by the manufacturer and taking into account the uncertainty of measurement according to ISO 14253-1.

A maximum of five of the 35 size measurements (in accordance with 5.3.1, five material standards of size in seven different locations or orientations or both) may have one of three replicate values of the errors of indication of a CMM for size measurement outside the conformance zone. Each such size measurement that is out of the conformance zone (according to ISO 14253-1) shall be re-measured 10 times at the relevant location and orientation.

If all the values of the errors of indication of a CMM for size measurement from the 10 repeated measurements are within the conformance zone (see ISO 14253-1), then the performance of the CMM is verified.

6.2 Reverification test

The performance of the CMM used for measuring size is considered to have been verified if

— the error of indication of a CMM for size measurements, E, is not greater than the maximum permissible error of indication of a CMM for size measurements, MPE_E, as specified by the user and taking into account the uncertainty of measurement according to ISO 14253-1, and

— the probing error, P, is not greater than the maximum permissible probing error, MPE_P, as specified by the user and taking into account the uncertainty of measurement according to ISO 14253-1.

A maximum of five of the 35 size measurements (in accordance with 5.3.1, five material standards of size in seven different locations or orientations or both) may have one of three replicate values of the errors of indication of a CMM for size measurement outside the conformance zone. Each such size measurement that is out of the conformance zone (according to ISO 14253-1) shall be re-measured 10 times at the relevant location and orientation.

If all the values of the errors of indication of a CMM for size measurement from the 10 repeated measurements are within the conformance zone (see ISO 14253-1), then the performance of the CMM is considered to have been verified.

7 Applications

7.1 Acceptance test

In a contractual situation between a supplier and a customer such as that described in a

— purchasing contract,

— maintenance contract,

— repair contract,

— renovation contract, or

— upgrading contract etc.,

the acceptance test specified in this part of ISO 10360 may be used as a test for verifying the performance of the CMM used for measuring size in accordance with the specification for the two stated maximum permissible errors, MPE_E and MPE_P, as agreed upon by the supplier and the customer.

The supplier is permitted to specify detailed limitations applicable for MPE_E and MPE_P. If no such specification is given, MPE_E and MPE_P apply for any location and orientation in the measuring volume of the CMM.

7.2 Reverification test

In an organization's internal quality assurance system, the performance verification described in this part of ISO 10360 can be used as a reverification test to verify the performance of the CMM used for measuring size in accordance with the specification for the two maximum permissible errors, MPE_E and MPE_P as stated by the customer.

The customer is permitted to state the values of, and to specify detailed limitation applicable to, MPE_E and MPE_P.

7.3 Interim check

In an organization's internal quality assurance system, a reduced performance verification may be used periodically to demonstrate the probability that the CMM conforms with specified requirements regarding the two maximum permissible errors, MPE_E and MPE_P.

The extent of the performance verification as described in this part of ISO 10360 may be reduced by the number of measurements, the location and the orientation being performed (see annex A).