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Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 2: CMMs used for measuring linear dimensions

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

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Partie 2: MMT utilisées pour les mesures de dimensions linéaires

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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.

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 10360-2 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

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This third edition cancels and replaces the second edition (ISO 10360-2:2001), which has been technically revised.

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

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— *Part 1: Vocabulary*

— *Part 2: CMMs used for measuring linear dimensions*

— *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 single and multiple stylus contacting probing systems*

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

— *Part 7: CMMs equipped with imaging probing systems*

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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 F.

The tests of this part of ISO 10360 have three technical objectives:

1) to test the error of indication of a calibrated test length using a probing system without any ram axis stylus tip offset;

2) to test the error of indication of a calibrated test length using a probing system with a specified ram axis stylus tip offset; and

3) to test the repeatability of measuring a calibrated test length.

The benefits of these tests are that the measured result has a direct traceability to the unit length, the metre, and that it gives information on how the CMM will perform on similar length measurements.

Clause 3 of this part of ISO 10360 contains definitions that supersede similar definitions in ISO 10360-1:2000.

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The revised definitions are required to avoid an ambiguity that would otherwise have been introduced with this issue of ISO 10360-2. Also, definition 3.6 supersedes effectively an identical definition in ISO 10360-1:2000 because the symbols used have been revised and expanded for clarification.

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Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) —

Part 2:
CMMs used for measuring linear dimensions

1 Scope

This part of ISO 10360 specifies the acceptance tests for verifying the performance of a coordinate measuring machine (CMM) used for measuring linear dimensions as stated by the manufacturer. It also specifies the reverification tests that enable the user to periodically reverify the performance of the CMM.

The acceptance and reverification tests given in this part of ISO 10360 are applicable only to Cartesian CMMs using contacting probing systems of any type operating in the discrete-point probing mode.

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This part of ISO 10360 does not explicitly apply to:

— non-Cartesian CMMs; however, parties may apply this part of ISO 10360 to non-Cartesian CMMs by mutual agreement;

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— CMMs using optical probing; however, parties may apply this approach to optical CMMs by mutual agreement.

This part of ISO 10360 specifies performance requirements that can be assigned by the manufacturer or the user of a 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 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 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*

ISO/TS 23165:2006, *Geometrical product specifications (GPS) — Guidelines for the evaluation of coordinate measuring machine (CMM) test uncertainty*

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

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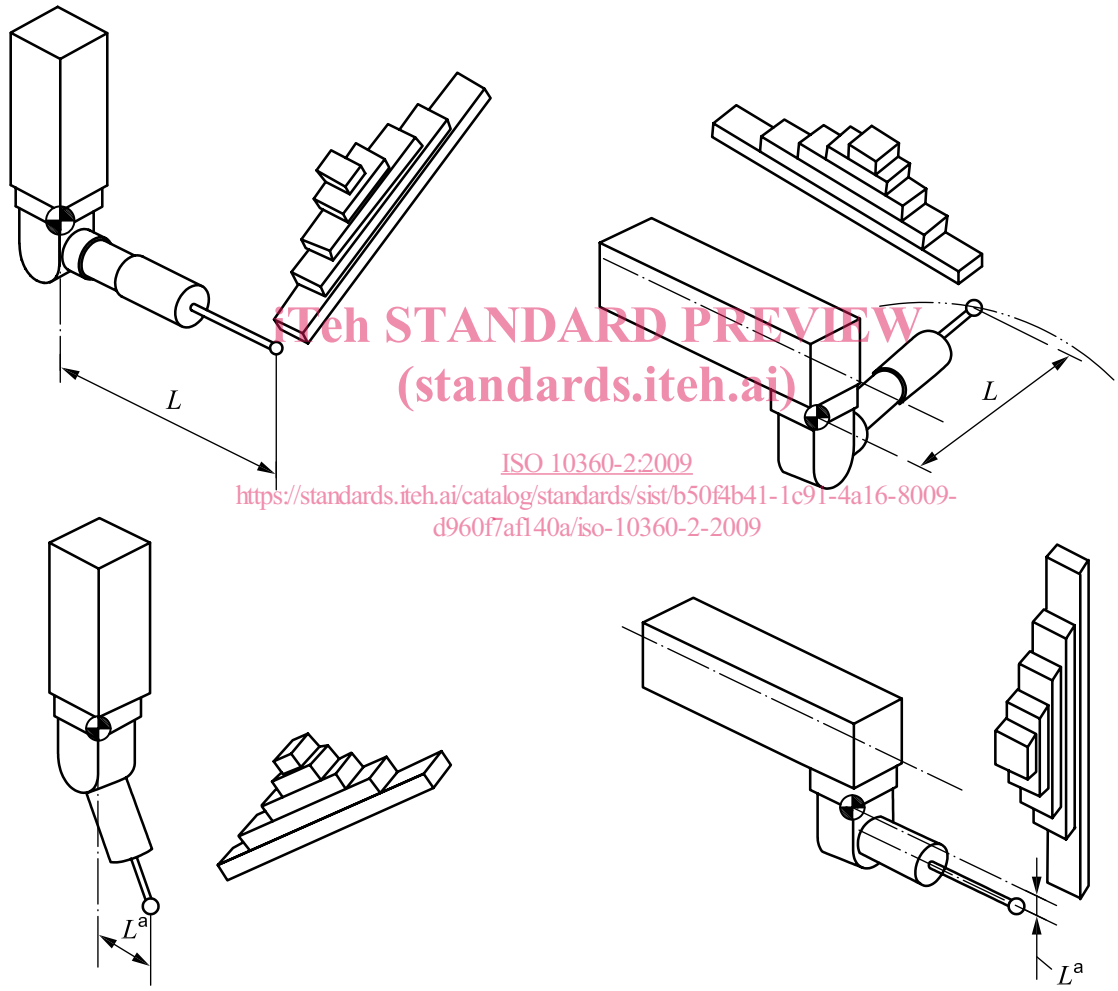
3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10360-1, ISO 14253-1, ISO 14660-1, ISO/TS 23165, ISO/IEC Guide 99 and the following apply.

3.1
ram axis stylus tip offset
L
distance (orthogonal to the ram axis) between the stylus tip and a reference point

NOTE 1 The reference point is defined by the manufacturer. If no manufacturer-defined reference point is known, the user chooses a reference point close to the probe system mount.

NOTE 2 The reference point is usually in or near the probe system.



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[a] $L \approx 0$.

Figure 1 — Examples of the ram axis stylus tip offset in the case of an articulated probing system

3.2
coefficient of thermal expansion
CTE
α
linear thermal expansion coefficient of a material at 20 °C

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3.3
normal CTE material
material with a CTE between 8 × 10^{-6}/°C and 13 × 10^{-6}/°C

3.4
length measurement error
E_L
error of indication when measuring a calibrated test length using a CMM with a ram axis stylus tip offset of L, using a single probing point (or equivalent) at each end of the calibrated test length

NOTE 1 In this part of ISO 10360, L = 0 mm and L = 150 mm (default values) are specified.

NOTE 2 See Annex B for the requirements of point sampling strategies.

3.5
repeatability range of the length measurement error
R_0
range (largest minus smallest) of three repeated length measurement errors measured by a CMM with zero ram axis stylus tip offset

3.6
maximum permissible error of length measurement
$E_{L, MPE}$
extreme value of the length measurement error, E_L, permitted by specifications

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NOTE 1 In this part of ISO 10360, L = 0 mm and L = 150 mm (default values) are specified.

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NOTE 2 A maximum permissible error (MPE) as opposed to a maximum permissible limit (MPL) specification is used when the test measurements determine errors; hence, testing an MPE specification requires the use of calibrated artefacts.

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NOTE 3 The MPE may be expressed using any of the methods shown in Figure 12, Figure 13 and Figure 14 of ISO 10360-1:2000.

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3.7
maximum permissible limit of the repeatability range
$R_{0, MPL}$
extreme value of the repeatability range of the length measurement error, R_0, permitted by specifications

NOTE 1 A maximum permissible limit (MPL) as opposed to a maximum permissible error (MPE) specification is used when the test measurements are not errors; hence, testing an MPL specification does not require the use of calibrated artefacts.

NOTE 2 The MPL may be expressed using any of the methods shown in Figure 12, Figure 13 and Figure 14 of ISO 10360-1:2000.

3.8
dual ram CMM
CMM composed of two independent rams and a method for reporting the coordinate measurements from both rams in a single coordinate system

NOTE 1 The two rams usually share part of their measuring range, but this is not required.

NOTE 2 The method for establishing a single coordinate system may require an alignment procedure.

NOTE 3 A dual ram CMM may report the results of each ram in separate coordinate systems; see **simplex operating mode** (3.9).

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3.9
simplex operating mode
method of using a dual ram CMM in which the two rams are treated as separate measuring systems

NOTE In the simplex operating mode, the coordinate measurements from the two rams are not reported in a single coordinate system.

3.10
duplex operating mode
method of using a dual ram CMM in which the coordinate measurements from the two rams are reported in a single coordinate system

4 Symbols

For the purpose of this document, the symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Meaning
E_{L}	Length measurement error
R_0	Repeatability range of the length measurement error
$E_{\mathrm{L,\,MPE}}$	Maximum permissible error of length measurement
$R_{0,\,\mathrm{MPL}}$	Maximum permissible limit of the repeatability range

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NOTE See Clause 9 with respect to the indications of these symbols in product documentation, drawings, data sheets, etc.

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5 Environmental and metrological requirements

5.1 Environmental conditions

Limits 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 environmental conditions under which the ISO 10360-2 testing will be performed within the specified limits (as supplied in the data sheet of the manufacturer; see ISO 10360-1, Amendment 1).

The user is responsible for providing the environment enclosing the CMM, as specified by the manufacturer in the data sheet.

If the environment does not meet the specifications, then verification of the maximum permissible errors, $E_{0,\,\mathrm{MPE}}$, $E_{\mathrm{L,\,MPE}}$, and maximum permissible limit, $R_{0,\,\mathrm{MPL}}$, cannot be required.

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5.2 Operating conditions

The CMM shall be operated using the procedures given in the manufacturer's operating manual when conducting the tests given in Clause 6.

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;

d) probing system qualification;

e) thermal stability of the probing system before calibration;

f) weight of stylus system and/or probing system;

g) location, type, number of thermal sensors.

5.3 Length measurement error, E_L

The length measurement errors (E_L values) shall not exceed the maximum permissible error of length measurement, $E_{L,\,MPE}$, as stated by:

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— the manufacturer, in the case of acceptance tests;

— the user, in the case of reverification tests.

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The length measurement errors (E_L values) and the maximum permissible error of length measurement, $E_{L,\,MPE}$, are expressed in micrometres.

NOTE The default values of L are 0 mm and 150 mm; hence, $E_L = E_0$ and $E_L = E_{150}$.

5.4 Repeatability range of the length measurement error, R_0

The repeatability range of the length measurement errors (R_0 values) shall not exceed the maximum permissible limit of the repeatability range, $R_{0,\,MPL}$, as stated by:

— the manufacturer, in the case of acceptance tests;

— the user, in the case of reverification tests.

The repeatability range of the length measurement error (R_0 values) and the maximum permissible limit of the repeatability range, $R_{0,\,MPL}$, are expressed in micrometres.

5.5 Workpiece loading effects

The length measurement error with $L = 0$ (or minimum required for clearance), E_0, shall not exceed the maximum permissible error, $E_{0,\,MPE}$, as stated by the manufacturer when the CMM is loaded with up to the maximum workpiece mass for which the CMM performance is rated. Testing of the length measurement error, E_0, may be conducted under any workpiece load (from zero up to the rated maximum workpiece load), selected by the user subject to the following conditions:

— the physical volume of the load supplied for testing shall lie within the measuring volume of the CMM and the load shall be free-standing;

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— the manufacturer may specify a limit on the maximum load per unit area (kg/m^2) on the CMM support (i.e. table) surface and/or on individual point loads (kg/cm^2); for point loads, the load at any specific contact point shall be no greater than twice the load of any other contact point;

— unless otherwise specified by the manufacturer, the load shall be located approximately centrally and approximately symmetrically at the centre of the CMM table.

The user and manufacturer should arrange for the availability of the load.

The user and the manufacturer should discuss the loading of the CMM table since access to measurement positions may be impaired by the load.

6 Acceptance tests and reverification tests

6.1 General

6.1.1 Acceptance tests are executed according to the manufacturer's specifications and procedures that are in compliance with this part of ISO 10360. In particular, unless the user supplies the calibrated test length (subject to the restrictions of ISO/TS 23165), the manufacturer may choose the artefact representing the calibrated test length from those described in Annex B and Annex D.

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

Issues associated with dual ram CMMs are discussed in 6.6.

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6.1.2 This part of ISO 10360 does not explicitly apply to CMMs using optical probing; however, if, by mutual agreement, the parties apply this approach to optical CMMs, then additional issues, such as the following, should be considered:

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— in the case of two dimensional sensors (no ram movement), an index 2D may be used for indication, e.g. $E_{0\text{-}2D}$;

— in the case of two dimensional systems, the number and location of the measurement positions may be reduced;

— specifications for the magnification and illumination;

— artefact issues such as material and surface finish that affect the test results;

— bidirectional probing may or may not be possible depending on the artefact and probing system (see Annex B).

6.2 Principle

The principle of the assessment method is to use a calibrated test length, traceable to the metre, to establish whether the CMM is capable of measuring within the stated maximum permissible error of length measurement for a CMM with a specified ram axis stylus tip offset (both 0 and 150), $E_{0,\,MPE}$ and $E_{150,\,MPE}$, and within the stated maximum permissible limit for the repeatability range, $R_{0,\,MPL}$.

The assessment shall be performed by comparison of the indicated values of five different calibrated test lengths, each measured three times, relative to their calibrated values. The indicated values are calculated by point-to-point length measurements projected onto the alignment direction (see also Annex C).

Each of the three repeated measurements is to be arranged in the following manner: if one end of the calibrated test length is labelled “A” and the other end “B”, then the measurement sequence is either A_1 B_1, A_2 B_2, A_3 B_3 or A_1 B_1, B_2 A_2, A_3 B_3. Other sequences such as A_1 A_2 A_3, B_1 B_2 B_3 are not permitted. Each of the three repeated measurements shall have its own unique measured points. That is, in general, B_1, B_2 and

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