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Geometrical product specification (GPS) — Coordinate measuring machines (CMM): Testing the performance of CMMs using single-stylus contacting probing systems

Spécification géométrique des produits (GPS) — Machines à mesurer tridimensionnelles (MMT): Essai de performance des MMT utilisant des systèmes de palpage à stylet simple

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Foreword

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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.

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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/PAS 12868 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

Introduction

This Publicly Available Specification specifies the acceptance and reverification tests for coordinate measuring machine (CMM) probing error. These tests are similar to those provided for a single-stylus contacting probing system in ISO 10360-2:2001. As the revised version of ISO 10360-2 (ISO 10360-2:2009) does not include these tests, similar tests are being temporarily provided in this Publicly Available Specification. When ISO 10360-5:2000 is revised, it will include tests for a single-stylus contacting probing system.

Geometrical product specification (GPS) — Coordinate measuring machines (CMM): Testing the performance of CMMs using single-stylus contacting probing systems

1 Scope

This Publicly Available Specification specifies the acceptance and reverification tests for CMM probing error. It is applicable only to Cartesian CMMs using a single-stylus contacting probing system, discrete-point probing mode, and a spherical or hemispherical stylus.

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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
single-stylus form error
P_{FTU}
error of indication within which the range of radii can be determined by a least-squares fit of points measured on a spherical material standard of size, the measurements being taken with a single stylus on the test sphere located anywhere in the measuring volume by a CMM using the discrete-point probing mode

See Figure 15 in ISO 10360-1:2000.

NOTE 1 The character "P" in P_{FTU} indicates that the error is related primarily to the probing-system performance. The character "F" indicates form; the character "T" indicates a tactile probe, and the character "U" indicates use of a single (unique) stylus.

NOTE 2 P_{FTU} is identical to the parameter P in ISO 10360-2:2001.

3.2
single-stylus size error
P_{STU}
error of indication representing the error in the diameter of a least-squares fit of points measured on a spherical material standard of size, the measurements being taken with a single stylus on the test sphere located anywhere in the measuring volume by a CMM using the discrete-point probing mode

NOTE 1 The character "P" in P_{STU} indicates that the error is related primarily to the probing-system performance. The character "S" indicates size; the character "T" indicates a tactile probe, and the character "U" indicates use of a single (unique) stylus.

NOTE 2 P_{STU} is only an informative value used in ISO 10360-2:2001, Annex A.

3.3
maximum permissible single-stylus form error
$P_{FTU, MPE}$
extreme value of the single-stylus form error, P_{FTU}, permitted by specifications, regulations, etc. for a CMM

See Figure 15 in ISO 10360-1:2000.

NOTE $P_{FTU, MPE}$ may be specified by probe tip offset length or stylus system.

4 Symbols

For the purpose of this Publicly Available Specification, the symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Meaning
P_{FTU}	single-stylus form error
P_{STU}	single-stylus size error
$P_{FTU, MPE}$	maximum permissible single-stylus form error

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

5 Requirements for metrological characteristics

5.1 Single-stylus form error

The single-stylus form error, P_{FTU}, shall not exceed the maximum permissible single-stylus form error, $P_{FTU, MPE}$, as stated by

— the manufacturer, in the case of acceptance tests, or

— the user, in the case of reverification tests.

The single-stylus form error, P_{FTU}, and the maximum permissible single-stylus form error, $P_{FTU, MPE}$, are expressed in micrometres.

5.2 Probing system

The limits of the probing-system configuration (stylus, stylus extensions, stylus orientation, weight of stylus system, etc.) to which the stated value of $P_{\mathrm{FTU,\ MPE}}$ applies shall be stated by

— the manufacturer, in the case of acceptance tests, or

— the user, in the 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 specifications.

Use of a stylus relevant to a typical workpiece measuring task is recommended.

NOTE An articulating probing system used at a single angular position, with a single stylus, is deemed to be a single-stylus probing system.

5.3 Stylus

Any stylus used in the testing specified in Clause 6 shall be one approved by the CMM manufacturer for use with the CMM, i.e. made of the same material, of the same stylus-shaft diameter and nominal length, and having the same stylus-tip quality. However, it is recognised that the exact stylus lengths used for test procedures might not be available; therefore, a stylus-length variation of 6 mm or 10 % of the nominal length, whichever is the greater, may be used.

5.4 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, or

— the user, in the case of reverification tests.

In both cases, the user is free to choose the environmental conditions under which the ISO 10360-5 testing will be performed within the specified limits (the specified limits are given in the manufacturer's data sheet).

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 none of the maximum permissible errors in this Publicly Available Specification can be required to be verified.

5.5 Operating conditions

For the testing specified in Clause 6, the CMM shall be operated using the procedures given in the manufacturer's operating manual. Specific areas of the manufacturer's operating manual to be adhered to include

a) machine start up/warm up cycles,

b) stylus system configuration and assembly,

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

d) probing-system qualification, and

e) when specified by the manufacturer, the position of the reference sphere.

The stylus tip, the reference sphere and the test sphere shall be cleaned before the probing-system qualification to eliminate residual film which might affect the measuring or test results.

Ensuring approximate thermal equilibrium of the probing system before and during the probing-system qualification is critical to the test.

6 Acceptance test and reverification test for single-stylus form error

6.1 General

In the following subclauses,

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

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

6.2 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 single-stylus form error, $P_{\mathrm{FTU,\ MPE}}$, by determining the range of distances of the measured points from the centre of the Gaussian associated sphere.

6.3 Measuring equipment

The test sphere shall have a 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 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.

6.4 Procedure

6.4.1 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.

6.4.2 Set up and qualify the probing system in accordance with the manufacturer's normal procedures (see 5.2 and 5.3).

6.4.3 Position the test sphere in accordance with 6.3. The test sphere should be mounted rigidly to minimize errors due to bending.

6.4.4 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):

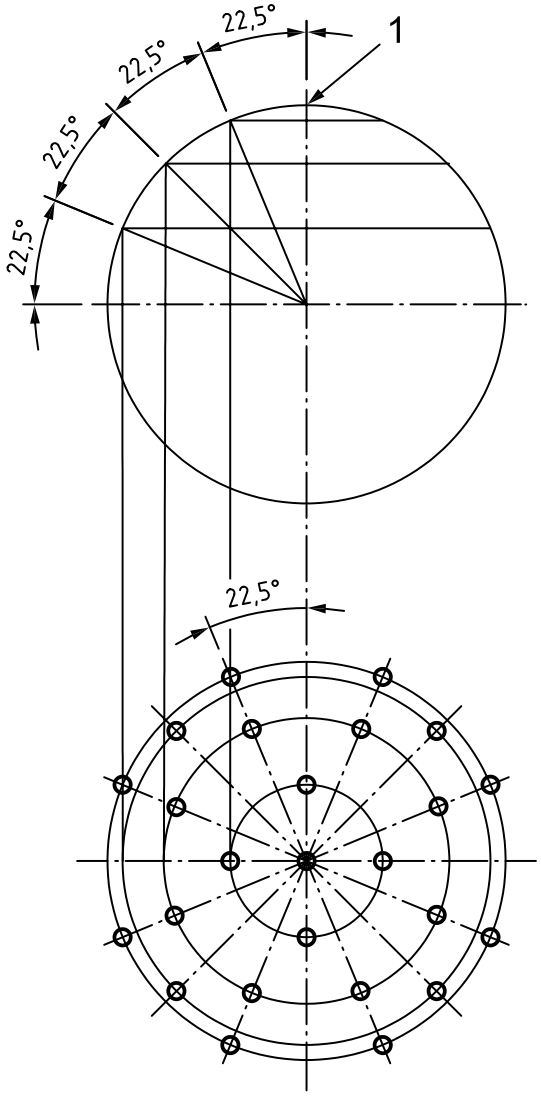
— one point on the pole (defined by the direction of the stylus shaft) of the test sphere;

— 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.



Key

1 pole

Figure 1 — Target contact points

6.5 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 single-stylus form error, P_{FTU}, as the range of the 25 Gaussian radial distances, R_{max} to R_{min}.

If needed, calculate the single-stylus size error, P_{STU}, as the radius of the Gaussian associated sphere minus the calibrated radius of the sphere.

7 Compliance with specifications

7.1 Acceptance test

The single-stylus probing performance is verified if the single-stylus form error, P_{FTU}, is not greater than the maximum permissible single-stylus form error, $P_{FTU,\ MPE}$, as specified *by the manufacturer* and taking into account the uncertainty of measurement according to ISO 14253-1.

7.2 Reverification test

The single-stylus probing performance is verified if the single-stylus form error, P_{FTU}, is not greater than the maximum permissible single-stylus form error, $P_{FTU,\ MPE}$, as specified *by the user* and taking into account the uncertainty of measurement according to ISO 14253-1.

8 Applications

8.1 Acceptance tests

In a contractual situation between a supplier and a customer such as that described in a purchasing, maintenance, repair, renovation or upgrade contract, the acceptance tests described in this Publicly Available Specification may be used to verify the single-stylus probing performance in accordance with the specified maximum permissible errors agreed on by the supplier and the customer.

8.2 Reverification tests

The reverification tests given in this document can be used in an organization's internal quality assurance system for verification of the single-stylus probing performance in accordance with the specified appropriate maximum permissible errors as stated by the user with all possible and detailed limitations applied.

8.3 Interim checks

In an organization's internal quality assurance system, reduced reverification tests can be used periodically to demonstrate the probability that the CMM conforms to the requirements for maximum permissible errors specified in 7.1.

The extent of the interim checks for multiple stylus systems specified in this Publicly Available Specification may be reduced in respect of the number of actual measuring points being assessed.

It is recommended that the probing system be checked regularly, and checked after any incident which could have significantly affected the probing performance.

9 Indication in product documentation and data sheets

The symbols of Clause 4 are not well suited for use in product documentation, drawings, data sheets, etc. Table 2 gives the corresponding indications also allowed for.

Table 2 — Symbols and corresponding indication in product documentation, drawings, data sheets, etc.

Symbol used in this document	Corresponding indication
P_{FTU}	$PFTU$
P_{STU}	$PSTU$
$P_{FTU,\ MPE}$	MPE($PFTU$)

Annex A
(informative)

Relation to the GPS matrix model

A.1 General

For full details about the GPS matrix model, see ISO/TR 14638.

A.2 Information about this PAS and its use

This Publicly Available Specification specifies the acceptance and reverification tests for coordinate-measuring-machine (CMM) probing error. These tests are similar to those provided for a single-stylus contacting probing system in ISO 10360-2:2001. As the revised version of ISO 10360-2 (ISO 10360-2:2009) does not include these tests, similar tests are being temporarily provided in this Publicly Available Specification. When ISO 10360-5:2000 is revised, it will include tests for a single-stylus contacting probing system.

A.3 Position in the GPS matrix model

This Publicly Available Specification is a general GPS standard, which influences chain link 5 of the chains of standards on size, distance, radius, angle, form, orientation, location, run-out and datums in the general GPS matrix, as graphically illustrated in Figure A.1.

Fundamental GPS standards

Global GPS standards						
General GPS standards						
Chain link number	**1**	**2**	**3**	**4**	**5**	**6**
Size					**X**	
Distance					**X**	
Radius					**X**	
Angle					**X**	
Form of line independent of datum					**X**	
Form of line dependent of datum					**X**	
Form of surface independent of datum					**X**	
Form of surface dependent of datum					**X**	
Orientation					**X**	
Location					**X**	
Circular run-out					**X**	
Total run-out					**X**	
Datums					**X**	
Roughness profile						
Waviness profile						
Primary profile						
Surface imperfections						
Edges						

Figure A.1 — Position in the GPS matrix model

A.4 Related standards

The related standards are those of the chains of standards indicated in Figure A.1.

Bibliography

[1] ISO/TR 14638:1995, *Geometrical product specification (GPS) — Masterplan*

[2] ISO 10360-2:2001, *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 2: CMMs used for measuring size*

[3] ISO 10360-5:2000, *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 5: CMMs using multiple-stylus probing systems*

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

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

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

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