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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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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently, **JIS B 7440-2:2003** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

JIS B 7440 series consists of the following 9 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 linear dimensions

Part 3: CMM's 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 (under preparation)

Part 8: CMMs with optical distance sensors (under preparation)

Part 9: CMMs with multiple probing systems (under preparation)

Geometrical product specifications (GPS)— Acceptance and reverification tests for coordinate measuring machines (CMM)— Part 2: CMMs used for measuring linear dimensions

Introduction

This Japanese Industrial Standard has been prepared based on the third edition of **ISO 10360-2** published in 2009 without any modifications of the technical contents.

The portions with continuous sidelines or dotted underlines are the matters not given in the corresponding International Standard.

This Standard 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 Standard to other standards and the GPS matrix model, see Annex E.

The tests of this Standard have three technical objectives:

- to test the error of indication of a calibrated test length¹⁾ using a probing system without any ram axis stylus tip offset;
- to test the error of indication of a calibrated test length using a probing system with a specified ram axis stylus tip offset; and
- to test the repeatability of measuring a calibrated test length.

Note ¹⁾ For the measure to represent a calibrated test length, see Annex B.

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.

JIS B 7440-5 describes checking the probing system, hence prior to beginning the testing described in this Standard, it is recommended to perform the single- or multiple-stylus probing system test, as appropriate, described in **JIS B 7440-5**, to ensure that the probing system is operating within specifications.

Clause 3 of this Standard contains definitions that supersede similar definitions in **JIS B 7440-1**.

The revised definitions are required to avoid an ambiguity that would otherwise have been introduced with this Standard. Also, definition 3.6 supersedes effectively an identical definition in **JIS B 7440-1** because the symbols used have been revised and expanded for clarification.

1 Scope

This Standard 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 Standard are applicable only to Cartesian CMMs using contacting probing systems of any type operating in the discrete-point probing mode.

This Standard does not explicitly apply to:

- non-Cartesian CMMs; however, parties may apply this Standard to non-Cartesian CMMs by mutual agreement;
- CMMs using optical probing; however, parties may apply this approach to optical CMMs by mutual agreement.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows:

ISO 10360-2:2009 *Geometrical product specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 2: CMMs used for measuring linear dimensions (IDT)*

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent editions (including amendments) shall be applied.

JIS B 0641-1 *Geometrical Product Specifications (GPS)—Inspection by measurement of workpieces and measuring equipment—Part 1: Decision rules for proving conformance or nonconformance with specifications*

NOTE : Corresponding International Standard: 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 (IDT)*

JIS B 0672-1 *Geometrical Product Specifications (GPS)—Geometrical features—Part 1: General terms and definitions*

NOTE : Corresponding International Standard: ISO 14660-1:1999 *Geometrical Product Specifications (GPS)—Geometrical features—Part 1: General terms and definitions (IDT)*

JIS B 7440-1 *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 1: Vocabulary*

NOTE : Corresponding International Standard: ISO 10360-1:2000 *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 1: Vocabulary* (IDT)

JIS B 7440-5 *Geometrical product specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 5: CMMs using single and multiple stylus contacting probing systems*

NOTE : Corresponding International Standard: ISO 10360-5:2010 *Geometrical product specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 5: CMMs using single and multiple stylus contacting probing systems* (IDT)

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)*

NOTE : Above Guide is publicly-available as **TS Z 0032**.

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS B 7440-1**, **JIS B 0641-1**, **JIS B 0672-1**, **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.

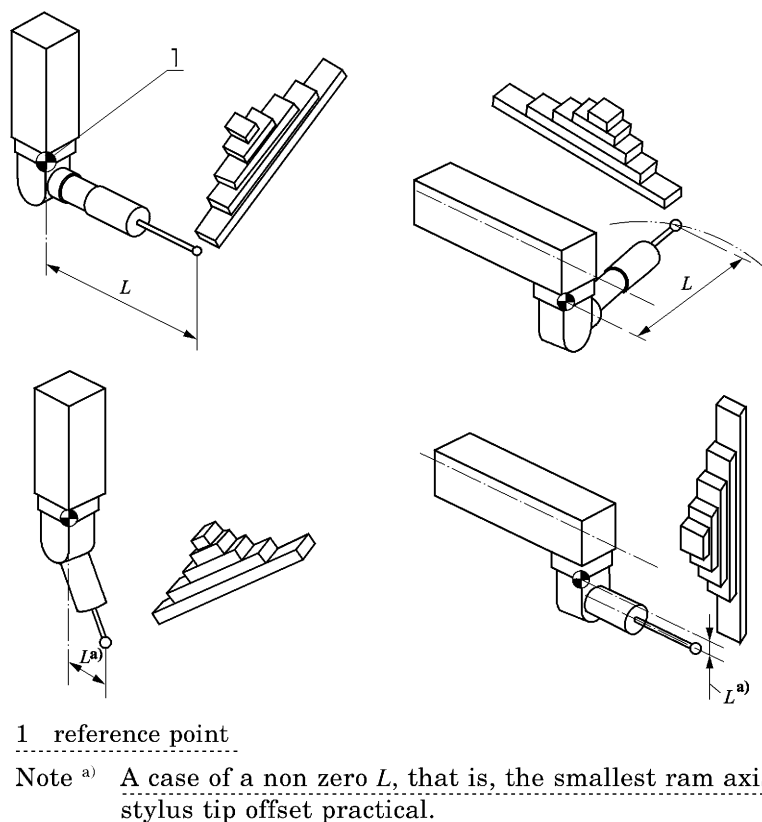


Figure 1 Examples of the ram axis stylus tip offset in the case of an articulated probing system

3.2 coefficient of thermal expansion, CTE, α

linear thermal expansion coefficient of a material at 20 °C

3.3 normal CTE material

material with a CTE between $8 \times 10^{-6}/^{\circ}\text{C}$ and $13 \times 10^{-6}/^{\circ}\text{C}$

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 Standard, $L = 0$ 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, $E_{L, \text{MPE}}$

extreme value of the length measurement error, E_L , permitted by specifications

- NOTE 1 In this Standard, $L = 0$ mm and $L = 150$ mm (default values) are specified.
- 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 artefacts²⁾.
- NOTE 3 The MPE may be expressed using any of the methods shown in figure 12, figure 13 and figure 14 of **JIS B 7440-1**.
- Note ²⁾ Artefact means a measure to represent a calibrated test length. See Annex B.

3.7 maximum permissible limit of the repeatability range, $R_{0, \text{MPL}}$

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 **JIS B 7440-1**.

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).

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 Standard, 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
$E_{L, \text{MPE}}$	Maximum permissible error of length measurement
$R_{0, \text{MPL}}$	Maximum permissible limit of the repeatability range

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

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 tests of this Standard will be performed within the specified limits (as supplied in the data sheet of the manufacturer; see **ISO 10360-1, Cor. 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, $E_{0, \text{MPE}}$, $E_{L, \text{MPE}}$, and maximum permissible limit, $R_{0, \text{MPL}}$, cannot be required.

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, $E_{L, \text{MPE}}$, as stated by:

- the manufacturer, in the case of acceptance tests;
- the user, in the case of reverification tests.

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;
- 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 the 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 Standard. 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.

6.1.2 This Standard 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:

- in the case of two dimensional sensors (no ram movement), an index 2D may be used for indication, e.g. E_{0-2D} ;
- 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_1B_1 , A_2B_2 , A_3B_3 or A_1B_1 , B_2A_2 , A_3B_3 . Other sequences such as $A_1A_2A_3$, $B_1B_2B_3$ 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 B_3 shall be different actual points of the same target point B. Once the measurement sequence for a test length has begun, no additional probing points shall be measured other than those required to measure its length; for instance, no alignment points are permitted between the measurement of A_1 and B_3 .

For CMMs without workpiece thermal expansion compensation, the uncorrected differential thermal expansion between the CMM and the calibrated test length can produce a significant error; hence this Standard also requires the disclosure of the test length CTE.

For CMMs with workpiece thermal expansion compensation, this thermally induced error is greatly reduced. For these CMMs, a significant portion of the residual thermal error is due to the uncertainty in the test length's CTE (i.e. resulting in imperfect thermal expansion correction); hence this Standard requires the disclosure of the uncertainty in the CTE of the test length.