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**Acceptance and reverification tests
for coordinate measuring machines
(CMM) with non-contacting probing
systems**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

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Acceptance and reverification tests for coordinate measuring machines (CMM) with non-contacting probing systems

1 Scope

This Japanese Industrial Standard specifies the acceptance test and the reverification test for coordinate measuring machines (CMM) with non-contacting probing systems capable of obtaining the form of an object as the three-dimensional coordinate of multipoint group.

The CMM shall be equipped with a projector for projection of a pattern-texture on the surface of object for measurement, an optical sensor with laser beam irradiation system, etc. and other non-contacting probing system technology (see Annex A) in addition to an image sensor (such as CCD camera). There are such concrete examples of the optical sensor as a laser slit scanning, stripe projection, spot light projection and moiré method. Also, this Standard is applicable to both CMMs with or without moving system. Further, this Standard is applicable to the assessment of measurement results obtained by merging of measuring data from CMM without moving system using a marker, software, etc.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below 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*
- JIS B 0672-1 *Geometrical Product Specifications (GPS)—Geometrical features—Part 1: General terms and definitions*
- JIS B 7440-1 *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 1: Vocabulary*

3 Terms and definitions

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

3.1 error of spherical form measurement P_{FS}

range of the distance from the centre determined by the approximation of measured points on the test sphere according to the least-square method to each measured point in the CMM with non-contacting probing systems

NOTE : The error of spherical form measurement P_{FS} corresponds to the probing error P defined in **JIS B 7440-1**.

3.2 error of diameter measurement P_S

difference between the diameter determined by the approximation of measured points on the test sphere according to the least-square method and its calibrated value in the CMM with non-contacting probing systems

3.3 error of flat form measurement P_{FF}

distance between two planes parallel to the plane determined by the least-square method of points measured on the test plane in the CMM with non-contacting probing systems, by which all measured points are sandwiched

3.4 error of sphere-spacing measurement E_S

difference between the measured value of distance between centres of two balls of test ball-bar and its calibrated value in the CMM with non-contacting probing systems

3.5 error of indication of a CMM for size measurement E

error of indication when the size of the material standard of size is measured in the CMM with non-contacting probing systems

NOTE : The error of indication of a CMM for size measurement E corresponds to the error of indication of a CMM specified in **JIS B 7440-1**.

3.6 maximum permissible error

extreme value of each error permitted by specifications, regulations, etc. for the CMM with non-contacting probing systems

Maximum permissible errors include the following.

- a) maximum permissible error of spherical form measurement $P_{FS,MPE}$
- b) maximum permissible error of diameter measurement $P_{S,MPE}$
- c) maximum permissible error of flat form measurement $P_{FF,MPE}$
- d) maximum permissible error of sphere-spacing measurement $E_{S,MPE}$
- e) maximum permissible error of indication of a CMM for size measurement E_{MPE}

3.7 merging of measurement data

merging of plural measurement results by using marker, software, etc.

4 Requirements for metrological characteristics

4.1 Error of spherical form measurement

The error of spherical form measurement P_{FS} shall not exceed the maximum permissible error of spherical form measurement $P_{FS,MPE}$ which is designated by the manufacturer in the case of acceptance test and by the user in the case of reverification test. The manufacturer or the user may set the maximum permissible error of spherical form measurement $P_{FS,MPE}$ smaller only for the limited measuring space. In addition, the method for obtaining three-dimensional coordinate values on the surface of object and test conditions shall be listed in the report.

The error of spherical form measurement P_{FS} and the maximum permissible error of spherical form measurement $P_{FS,MPE}$ are expressed in micrometres.

4.2 Error of diameter measurement

The error of diameter measurement P_S shall not exceed the maximum permissible error of diameter measurement $P_{S,MPE}$ which is designated by the manufacturer in the case of acceptance test and by the user in the case of reverification test. The manufacturer or the user may set the maximum permissible error of diameter measurement $P_{S,MPE}$ smaller only for the limited measuring space. In addition, the method for obtaining three-dimensional coordinate values on the surface of object and test conditions shall be listed in the report.

The error of diameter measurement P_S and the maximum permissible error of diameter measurement $P_{S,MPE}$ are expressed in micrometres.

4.3 Error of flat form measurement

The error of flat form measurement P_{FF} shall not exceed the maximum permissible error of flat form measurement $P_{FF,MPE}$ which is designated by the manufacturer in the case of acceptance test and by the user in the case of reverification test. The manufacturer or the user may set the maximum permissible error of flat form measurement $P_{FF,MPE}$ smaller only for the limited measuring space. In addition, the method for obtaining three-dimensional coordinate values on the surface of object and test conditions shall be listed in the report.

The error of flat form measurement P_{FF} and the maximum permissible error of flat form measurement $P_{FF,MPE}$ are expressed in micrometres.

4.4 Error of sphere-spacing measurement

The error of sphere-spacing measurement E_S shall not exceed the maximum permissible error of sphere-spacing measurement $E_{S,MPE}$ which is designated by the manufacturer in the case of acceptance test and by the user in the case of reverification test. The manufacturer or the user may set the maximum permissible error of sphere-spacing measurement $E_{S,MPE}$ smaller only for the limited measuring space. In addition, the method for obtaining three-dimensional coordinate values on the surface of object and test conditions shall be listed in the report.

The error of sphere-spacing measurement E_S and the maximum permissible error of sphere-spacing measurement $E_{S,MPE}$ are expressed in micrometres.

4.5 Error of indication of a CMM for size measurement

The error of indication of a CMM for size measurement E shall not exceed the maximum permissible error of indication of a CMM for size measurement E_{MPE} which is designated by the manufacturer in the case of acceptance test and by the user in the case of reverification test. The manufacturer or the user may set the maximum permissible error of indication of a CMM for size measurement E_{MPE} smaller only for the limited measuring space. In addition, the method for obtaining three-dimensional coordinate values on the surface of object and test conditions shall be listed in the report.

The execution of this test is arbitrary upon the agreement between the parties concerned with delivery.

The error of indication of a CMM for size measurement E and the maximum permissible error of indication of a CMM for size measurement E_{MPE} are expressed in micrometres.

4.6 Environmental conditions

Limits for permissible environmental conditions such as temperature conditions, humidity, vibration and state of disturbing light at the installation site that influence the measurements shall be designated by the manufacturer in the case of acceptance test and the user in the case of reverification test. In both cases, the user may choose the conditions freely within the permissible limits.

5 Acceptance test and reverification test

5.1 General

The acceptance test shall be executed according to the manufacturer's specifications and procedures, and the reverification test shall be executed according to the user's specifications and the manufacturer's procedures. Examples are as follows.

- a) Switching on the CMM with non-contacting probing systems and preparing for the measurement.
- b) Fixing the material standard. The material standard shall be mounted rigidly to avoid influences of bending.
- c) Setting of parameters, etc. for measurement.

The manufacturer shall provide necessary information. Confirmation shall be executed on the conformance with the environmental and operational conditions designated by the manufacturer during the test.

The assessment in the acceptance test and the reverification test shall be classified by the case "with merging of measurement data" and "without merging of measurement data". Which assessment to be executed depends on the function of the CMM. If the CMM has the function capable of both measuring assessments, both assessments shall be executed.

Measured points which are clearly identified as the noise caused by disturbance may be removed manually upon the agreement between the parties concerned with delivery.

Filtering of the measured points is permissible within the range which is defined as the test conditions or where the apparatus is ordinarily used. The filtering method shall be reported to the user. If necessary, when the user requires another filtering, the manufacturer shall also assess on this (see Annex B).

Other removal or interpolation of the measured points than the filtering may be executed upon the agreement between the parties concerned with delivery.

In the case of the CMM with temperature correction function, the temperature correction may be executed. In the case of the CMM without temperature correction function, manual correction is not allowed.

5.2 Error of spherical form measurement and error of diameter measurement

5.2.1 General

The error of spherical form measurement P_{FS} and the error of diameter measurement P_S shall be regarded as the measurement error in the small measuring volume

of the whole system of the CMM with non-contacting probing systems. The error of spherical form measurement P_{FS} shall be the assessment of the variation range of three-dimensional coordinate values on the surface of object. The error of diameter measurement P_S assesses the effect of the surface characteristics of the test sphere and the size measurement characteristics in the small measuring volume.

5.2.2 Instrument for assessment

A test sphere shall be used as the instrument for assessment (see Annex C). The test sphere shall be made of appropriate materials such as ceramics, steel and aluminium and be a sphere having optically homogeneous diffusing surface, and should have the diameter of size by 2 % to 20 % of the diagonal length of the measuring range of the CMM to be used. The diameter of sphere used shall be listed in the report. Because the values of the error of spherical form measurement P_{FS} and the error of diameter measurement P_S are different according to the optical characteristics, the material and the optical characteristics of the surface of the test sphere shall be listed in the report. In the case where the manufacturer has not designated the material and the optical characteristics of the surface of the test sphere, the user may select them arbitrarily. In addition, the diameter and circularity of the test sphere shall be calibrated, and the uncertainty of calibration shall be taken into account for the conformance with the specification.

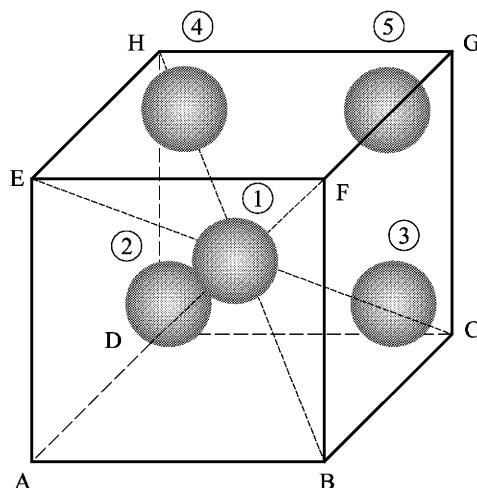
5.2.3 Assessment method

5.2.3.1 Case without merging of measurement data

The assessment of the error of spherical form measurement P_{FS} and the error of diameter measurement P_S shall be executed by measuring the test sphere at arbitrary positions within the measuring volume of the CMM. At this time, measurement shall be executed at any five different positions. For example, the neighbour of the centre and each apex of the measuring volume is recommended (see figure 1). The total number of points where coordinate values on the surface of the test sphere are taken shall be 25 or more but no limit for the maximum number.

5.2.3.2 Case with merging of measurement data

Measurement shall be similar to 5.2.3.1, but the error of spherical form measurement P_{FS} and the error of diameter measurement P_S shall be calculated by locating a test sphere at one position and moving an optical sensor to two or more different positions.



NOTE : Test sphere shall be located at neighbour of centre (①) and each apex (② to ⑤) in measuring range.

Figure 1 Location and orientation of test sphere

5.2.4 Obtaining method of test result

At each measuring position, the error of spherical form measurement P_{FS} and the error of diameter measurement P_S shall be calculated as follows.

- Error of spherical form measurement P_{FS}** After calculating the central coordinate of the least-square sphere from the measured points to be used for assessment, the distance from centre of least-square sphere R to respective measured point used for the calculation of least-square sphere shall be calculated. The range from the distance from centre of least-square sphere R ($R_{\max} - R_{\min}$) shall be calculated, and this shall be taken as the error of spherical form measurement P_{FS} .
- Error of diameter measurement P_S** The value of the diameter D_{mea} of the least-square sphere shall be calculated from the measured points to be used for assessment. The difference ($D_{\text{mea}} - D_{\text{cal}}$) between the calibrated value of the diameter of the test sphere D_{cal} and the value obtained by the measurement D_{mea} shall be calculated, and this shall be taken as the error of diameter measurement P_S .

5.3 Error of flat form measurement P_{FF}

5.3.1 General

The error of flat form measurement P_{FF} is determined so that the test plane is measured and the distance between two planes parallel to the plane determined by the least-square method of points measured on the test plane, by which all measurement points are sandwiched. This measurement shall be executed in the entire measuring range for the testing of CMM.

5.3.2 Instrument for assessment

A test plane shall be used as the instrument for assessment (see Annex C). The test plane shall be made of appropriate materials such as ceramics, steel and aluminium, and be a rectangular plane having optically homogeneous diffusing surface. The width, length, material and optical characteristics of the surface of the test plane shall be listed

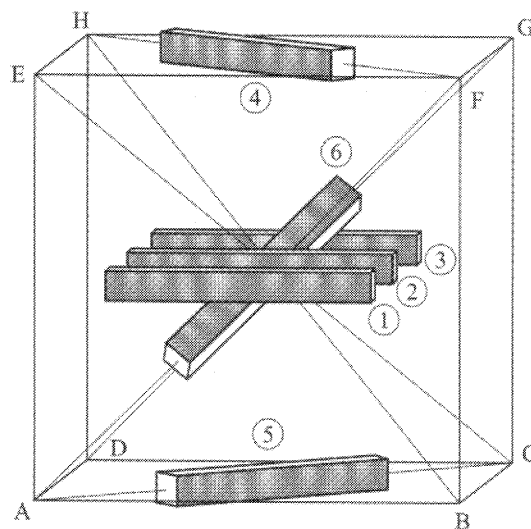
in the report. The surface roughness of the test plane shall be less than 10 % of the maximum permissible error of flat form measurement $P_{FF,MPE}$. In the case where the manufacturer has not designated the material and the optical characteristics of the surface of the test plane, the user may select them arbitrarily. The width and length of the test plane shall be at least 5 % and 66 % of the maximum measurable length of each side in the measuring range of the CMM to be used, respectively.

The test plane shall be calibrated, and the uncertainty of calibration shall be taken into account for the conformance with the specification.

5.3.3 Assessment method

5.3.3.1 Case without merging of measurement data

The error of flat form measurement P_{FF} shall be assessed by measuring the test plane at six positions and six orientations in the entire measuring range of CMM. The following locations are recommended (see figure 2). The total number of points where coordinate values on the surface of the test plane are taken shall be 25 or more but no limit for the maximum number.



NOTE 1 Located at front (①), centre (②) and rear (③) in the measuring range.

NOTE 2 Plane to be measured is located parallel to diagonal line F-H (④) and A-C (⑤).

NOTE 3 Plane to be measured is located at one of the space diagonal [for example A-G (⑥)].

Figure 2 Location and orientation of test plane

In the case where the length of the test plane to be used is less than 66 % of the maximum measurable length of each side of the measuring range, the test plane shall be moved along each direction without change in orientation, and measurement shall be executed several times within the range whose length is at least 66 % of the length of each side (see figure 3).