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**Geometrical Product Specifications
(GPS)—Acceptance and reverification
tests for coordinate measuring
machines (CMM)—Part 6 : Estimation
of errors in computing Gaussian
associated features**

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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 according to the proposal of establishing a Japanese Industrial Standard from Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **ISO 10360-6 : 2001 Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 6 : Estimation of errors in computing Gaussian associated features** for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS B 7440 consists of the following 6 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

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Geometrical Product Specifications (GPS)— Acceptance and reverification tests for coordinate measuring machines (CMM)— Part 6 : Estimation of errors in computing Gaussian associated features

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **ISO 10360-6** *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 6 : Estimation of errors in computing Gaussian associated features* published in 2001 without modifying the technical contents.

This Standard is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see **TR B 0007**). 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 B.

Coordinate measurement technology is widely used in industrial metrology to assess features of a workpiece. A common requirement is to fit an associated feature to a data set consisting of coordinate measurements of a real feature. This fitting is carried out by software.

Software for calculating an associated feature provides values of parameters of the associated feature that are descriptive of the size, shape, location and orientation of the feature. These parameters are useful for the purpose of carrying out calculations involving the feature, often in conjunction with other associated features and other information, and in determining the extent to which a workpiece satisfies dimensional and positional specifications.

The reliability of information about features that is determined from associated features is influenced by the quality of the software for computing these features.

The tests defined in this Standard are concerned with assessing the correctness of the parameters of computed associated features as measured by a coordinate measuring machine (CMM) or other coordinate measuring system. Although different criteria may be used to compute associated features (for example, by minimizing the Euclidean or Chebyshev norm of residuals), this test is applicable for software designed for unconstrained Gaussian (least-squares) features.

In the case of reverification tests of CMMs, the software test of this Standard usually does not provide new or different information in comparison with that obtained by an acceptance test, since software is supposed to be stable over time. However, a reverification test of the software may be useful following possible corruption or alteration of the software under test.

For software already in existence, the evaluation of the performance may not be obtained only by fulfilling the requirements of this Standard. However, such cases do not necessarily exclude the ability of the software to perform correct computation of measurements.

This Standard is applicable to software submitted for test in respect of the values it provides for the parameters of an associated feature. The test procedure is based on applying the software under test to reference data sets, and comparing the results obtained with reference results.

1 Scope This Standard specifies a method for testing software used for computing associated features from coordinate measurements. The features of concern are the line (in two and three dimensions), the plane, the circle (in two and three dimensions), the sphere, the cylinder, the cone and the torus.

One or more separate tests are required for each feature claimed to be covered by the software.

The test is of the software alone and therefore independent of the coordinate measuring system.

NOTE : If the result of the test indicates that the performance values for linear size parameters of the associated feature are significant compared with the error of indication of a CMM for size measurement (see **JIS B 7440-2**), as provided by the CMM manufacturer, the software is inadequate for application on that measuring system. However, small performance values, obtained as a result of this test, do not provide complete assurance that the software is totally suitable for computing associated features.

This Standard is concerned with complete features and non-extremely partial features; however, the test for complete features and that for partial features are separate, and software may be submitted for either or both tests.

Cones with very large apex angles are not covered by the test.

NOTES 1 Associated cones with very large angles are unusual in practice and the software for their stable computation is not widely available.

2 The International Standard corresponding to this Standard is as follows.

In addition, 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**.

ISO 10360-6 : 2001 *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 6 : Estimation of errors in computing Gaussian associated features (IDT)*

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect or the year of publication is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect or the year of publication apply only to the most recent edition (including amendments).

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 : **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* is identical with the said standard.

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

NOTE : **ISO 14660-1 : 1999** *Geometrical Product Specifications (GPS)—Geometrical features—Part 1 : General terms and definitions* is identical with the said standard.

JIS B 0672-2 *Geometrical Product Specifications (GPS)—Geometrical features—Part 2 : Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

NOTE : **ISO 14660-2 : 1999** *Geometrical Product Specifications (GPS)—Geometrical features—Part 2 : Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature* is identical with the said standard.

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

NOTE : **ISO 10360-1 : 2000** *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 1 : Vocabulary* is identical with the said standard.

JIS B 7440-2 *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 2 : CMMs used for measuring size*

NOTE : **ISO 10360-2 : 2001** *Geometrical Product Specifications (GPS)—Acceptance and reverification tests for coordinate measuring machines (CMM)—Part 2 : CMMs used for measuring size* is identical with the said standard.

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

3 Terms and definitions For the purposes of this Standard, the terms and definitions given in **JIS B 0672-1**, **JIS B 0672-2**, **JIS B 7440-1** and VIM apply.

4 Basic requirements The following basic requirements shall be met by the software supplier.

- a) The software under test shall have an unambiguous and unique identification (e.g. a release number).

Improper applications of the test result to other versions of the software under test are forbidden. The testing body is allowed to satisfy the request by an owner

of (a license of) the software under test and its test certificate to re-run the test based on the reference data sets identified by the release number reported in the test certificate.

- b) The software under test shall provide a means of
- 1) direct input of a reference data set and output of test parameter values to adequate numerical precision (see clause 8), bypassing the measurement and software correction parts of the system, and
 - 2) inputting 2D coordinates to the software under test for computing 2D associated features (line and circle in two dimensions); if this is not available, it is tolerated to add a dummy null z coordinate to each point in the reference data sets, thus projecting the feature onto the xy coordinate plane.

NOTE : The input and output procedures associated with some measuring systems may be limited in terms of the numerical precision of the values transmitted. This limitation may disadvantage the software under test in terms of the test results obtained.

- c) The method of input to, and output from the processor is to be agreed with the testing body.

NOTE : It may be convenient to use a standard computer-readable medium in a standard format.

- d) Corresponding to each feature for which the software under test is to be tested, a statement of the parametrization of the feature used by the software under test shall be provided.

NOTE : Reference parametrizations are given in table 3.

- e) Corresponding to each feature for which the software under test is to be tested and to the test type (see table 2), a statement of the maximum permissible errors, MPE_q , of the relevant parameter classes (location, orientation, size or angle) (see 9.3) shall be provided.

5 Reference data sets and reference parameter values

5.1 General The reference data sets and the corresponding reference parameter values used for the purposes of testing the software under test shall be generated according to the procedure specified in annex A. The reference data sets are designed to simulate a range of sizes, shapes, locations, orientations and sampling of features. They are also designed to simulate typical CMM errors of measurement, including probing errors, and feature form deviations.

The reference data sets and the reference parameter values generated according to annex A shall not be used for verification of any other software under test (see annex A.1).

5.2 Initial estimates of parameter values Software under test may require that a subset of the points input to the software (usually the first ones in the set) has a predefined sampling pattern. This subset is used to determine the initial estimates of the parameter values. When this requirement is written in the operating instructions of the software under test, and upon request of the software supplier, the testing

body shall generate additional points consistent with the predefined sampling pattern. These additional points form the subset added to the data as generated according to annex A to form a reference data set. These circumstances shall be noted on the test certificate [see clause 11 k) 5)].

NOTE 1 The software under test typically employs iterative methods of calculation for determining the values of the parameters of the associated feature. For this purpose, identification of a subset of points may be required, from which initial estimates of these values can be computed.

NOTE 2 A Gaussian associated cylinder can be used for purposes of illustration: the first six points in a reference data set could be identified as a subset for initial-estimation purposes. For instance, the line joining the centres of the circles defined by the first three points and the second three points could be used as an approximation to the axis of the associated cylinder, and the radii of these circles could be used as approximations to the radius of the associated cylinder.

NOTE 3 Software under test which does not require initial estimates of the parameter values is more robust, being self-contained, and does not impose an operating procedure for measuring real features.

6 Test parameter values and converted test parameter values Since different software suppliers may use different parametrizations, for the purposes of the test, the test parameter values produced by the software under test shall be modified, if necessary, by applying a conversion rule to produce converted test parameter values. The converted test parameter values so derived correspond to the same parametrization as the reference parameter values and can meaningfully be compared with them.

For this purpose, the software supplier shall provide full details of the test parametrization.

When necessary, the testing body shall implement and apply the appropriate conversion rule.

It is recommended that the software supplier provide test parameter values to adequate numerical resolution (see clause 8), in order that uncertainty may not be unnecessarily added in producing converted test parameter values.

Software under test may fail to produce results for some reference data sets.

NOTE : Failure to produce results may be due to, for example:

- a) the software under test indicating that the data set cannot be processed because it is beyond its domain of application (e.g. it contains too many data points or the data points are unsuitably distributed), or
- b) lack of convergence of an iterative algorithm, or
- c) a fatal error that has arisen during execution of the software (e.g. a floating-point overflow or an attempt to take the square root of a negative number).