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Specifikacija geometrijskih veličin izdelka (GPS) - Preskusi za sprejemljivost in ponovno overjanje koordinatnih merilnih strojev (KMS) - 13. del: Optični 3D CMS (ISO/DIS 10360-13:2020)

Geometrical product specifications (GPS) - Acceptance and reverification tests for coordinate measuring systems (CMS) - Part 13: Optical 3D CMS (ISO/DIS 10360-13:2020)

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Spécification géométrique des produits (GPS) - Essais de réception et de vérification périodique des systèmes à mesurer tridimensionnels (SMT) - Partie 13: SMT optique 3D (ISO/DIS 10360-13:2020)

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Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) —

Part 13: **Optical 3D CMS**

Spécification géométrique des produits (GPS) — Essais de réception et de vérification périodique des systèmes à mesurer tridimensionnels (SMT) —

Partie 13: SMT optique 3D

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

It is a new part of the ISO 10360 series.

A list of all parts in the ISO 10360 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document 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 document to other standards and the GPS matrix model see Annex G.

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise indicated.

This document has two technical objectives:

1. to test the error of indication when measuring a calibrated test length across the global measuring volume of the CMS, and

2. to test the errors of indication within a locally intended measuring volume.

These two correspond to:

a) the test performed for a probing system and a moving carrier of the probing system in combination as described in ISO 10360-2, -7, -8, -10, and 11, and

b) the test performed dominantly for the probing system as described in ISO 10360-5, -7, -8, -9, -10, and -11.

The benefits of these tests are that the measured result has a direct traceability to the unit of length, the metre, and that it gives information on how the CMM (Coordinate Measuring Machine) or the CMS (Coordinate Measuring System) will perform on similar length measurements.

In close reliance on ISO 10360-2 and ISO 10360-5 for CMS equipped with contact probing systems, as well as on ISO 10360-8 for CMS with optical distance sensors, this part of ISO 10360 specifies the acceptance and reverification tests for verifying the performance of optical 3D coordinate measuring systems. The testing methodology of these three parts of ISO 10360 is designed to be identical wherever technically possible.

Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) —

Part 13:
Optical 3D CMS

1 Scope

This document specifies the acceptance tests for verifying the performance of an optical CMS (Coordinate Measuring System) when measuring lengths as stated by the manufacturer. It also specifies the reverification tests that enable the user to periodically reverify the performance of the optical 3D CMS.

An optical 3D CMS that this standard intends to specify is a contactless area measuring sensor delivering 3D data in several individual single views by an optical measuring principle and transforming it into a common coordinate system. Typical optical measuring principles are pattern projection, fringe projection, and project-and-sweep a scanned line, or similar, delivering single views without assistance of external information related to position and orientation of the objects to be scanned relative to the CMS. Typical registration principles are based on a best fitting of commonly captured position information across at least two different single views, either or both by using reference targets or surface features of the objects to be scanned.

This standard applies to verification of the measuring performance of CMSs in case the surface characteristics (e.g. glossiness, colour) of the object to be scanned are restricted and within a cooperative range.

This standard does not explicitly apply to other types of CMSs, including those standardized by the other parts of ISO 10360 or other standards. In the list below, a metrological moving carrier is a mover equipped with scales measuring the position and/or orientation of the probing system, to be used as essential information for the determination of the measurement result.

- tactile CMMs (Cartesian metrological moving carrier): ISO 10360-2,
- imaging CMMs (Cartesian metrological moving carrier): ISO 10360-7,
- CMMs equipped with optical distance sensors (Cartesian metrological moving carrier): ISO 10360-8,
- laser trackers: ISO 10360-10,
- X-ray CTs: ISO 10360-11,
- articulated arm CMMs (anthropomorphic metrological moving carrier): ISO 10360-12,
- measuring instruments intended to measure surface characteristics: ISO 25178,
- optical microscopes,
- hand-held laser line(s) scanners.

Parties may apply this part of 10360 to the above or other type CMSs by mutual agreement.

This part of ISO 10360 specifies:

— performance requirements that can be assigned by the manufacturer or the user of the CMS,

— the manner of execution of the acceptance and reverification tests to demonstrate the stated requirements,

— rules for verifying conformance, and

— applications for which the acceptance and reverification tests can be used.

Note 1 Annex E describes possible limitations with regard to less cooperative surface characteristics, e.g. colour, glossiness and roughness, and provides a suggested test that may give CMS users an idea of how representative the maximum permissible error would be when measuring their specific industrial part.

Note 2 The optical 3D CMS can be moved and positioned by a manually or automated moving unit. The position and/or orientation can be used as additional information for the registration.

Note 3 The acceptance and reverification tests are designed to mimic real but simple measurements occurring in practice, subject to the rated operating conditions and the testing procedures. The user is advised to consider the influence of additional or omitted conditions and/or procedural steps when applying the test results according to this standard to predict the performance of an actual CMS.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 10360-2:2009, *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 2: CMMs used for measuring linear dimensions*

ISO 10360-5, *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) — Part 5: Coordinate measuring machines (CMMs) using single and multiple stylus contacting probing systems using discrete point and/or scanning measuring mode*

ISO 10360-8, *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) — Part 8: CMMs with optical distance sensors*

ISO 14253-1, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for verifying conformity or nonconformity with specifications*

ISO 14253-5, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 5: Uncertainty in verification testing of indicating measuring instruments*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10360-1, ISO 14253-1, VIM and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
optical 3D coordinate measurement system (CMS)
measuring system performing measurements of spatial coordinates exclusively by optical sensors

3.2
sensor measurement volume
volume in which the sensor in still motion can measure, fulfilling the specifications provided by the manufacturer according to this standard

3.3
registration
transformation(s) of coordinate systems that brings single-view coordinates into a unified coordinate system

Note 1 to entry: to entry: A transformation is realized e.g. by linear homogeneous transformation or rigid rototranslation in the other word, consisting either or both of rigid body translation and/or rigid body rotation.

Note 2 to entry: to entry: Each single-view holds its own coordinate system and requires a transformation to the unified coordinate system.

Note 3 to entry: to entry: The registration is invertible. The inverse registration is performed by applying the inverse transformation.

Note 4 to entry: to entry: In a registration, the transformation parameters are derived first, and then the transformations occur. The latter may occur either immediately or significantly after the former.

Note 5 to entry: to entry: A registration may or may not require a person to operate the CMS.

3.4
fusion
operation that merges two or more sets of measured coordinates into a unified set of measured coordinates

Note 1 to entry: to entry: Fusions are performed to improve the measurement, e.g. to reduce the dispersion and the mismatch of single views.

Note 2 to entry: to entry: Fusion are typically irreversible (not invertible).

Note 3 to entry: to entry: A fusion may include any number of elementary operations in combination and/or in sequence, such as coordinate transformation, averaging, outlier rejection, decimation, convolution, filtration.

Note 4 to entry: to entry: The fusion may occur either immediately or significantly after the registration.

3.5
concatenated measurement volume
volume of measurement of the CMS obtained by movement of the sensor and registration fulfilling the specifications provided by the manufacturer according to this standard.

As a default, the longest length fully inside the concatenated measurement volume shall be no shorter than twice the longest length fully inside the sensor measurement volume.

Note 1 to entry: The concatenated measurement volume can be given by design of a measuring cabin or a dimension of a typical workpiece to be measured.

3.6
single-view measurement
measurement of spatial coordinates done with an optical sensor in the still motion relative to the workpiece

Note 1 to entry: Single-view measurement is performed with no movement of the carrier, registration nor fusion.

3.7
multiple-view measurement
measurement of spatial coordinates through registration and fusion of multiple single-view measurements in different locations and orientations of the optical sensor relative to the workpiece

3.8
probing form dispersion error
$\boldsymbol{P}_{\textbf{Form.Sph.}\boldsymbol{i}:\boldsymbol{j}:\textbf{O3D}}$
smallest width of a spherical shell that encompasses a percentile of all measured data

Note 1 to entry: The symbol "P" in $P_{\text{Form.Sph.}i:j:\text{O3D}}$ indicates that the error is associated with the probing system performance, the qualifier "Form.Sph" indicates that it is associated with the probing dispersion error when measuring a sphere, and the qualifier "O3D" indicates that it is associated with an optical 3D CMS. The qualifier "i" identifies the percentile of probing points selected for the evaluation: either "D95%" denoting 95 % of the population or "All" denoting the whole population, i.e. 100 %. The qualifier "j" identifies the measuring conditions of the CMS: "SMV.SV" denotes single-view measurement while "SMV.MV" multiple-view measurement; the measurement is performed within the sensor measurement volume ("SMV") in either case. Possible examples of such symbol are $P_{\text{Form.Sph.D95\%:SMV.SV:O3D}}$ or $P_{\text{Form.Sph.All:SMV.MV:O3D}}$.

Note 2 to entry: 5 % of the measured data is eliminated to determine $P_{\text{Form.Sph.D95\%:}j\text{:O3D}}$. Outliers that might be present in the measurement data may be eliminated by this operation.

Note 3 to entry: It could be beneficial to evaluate probing errors from point cloud both from "95%" population and "All" population. A difference in these two test results may reveal influences of smoothing filters or equivalent functions potentially pre-installed as an integral part of the CMS or the associated software, which is not always transparently visible for users of the CMS.

3.9
probing size error
$\boldsymbol{P}_{\textbf{Size.Sph.}\boldsymbol{i}:\boldsymbol{j}:\textbf{O3D}}$
error of indication when measuring a calibrated diameter of a test sphere as associated by least-squares to a percentile of all measured data

difference between the diameter of a measured test sphere as associated by least-squares to a range indicated by a percentile of all measured data, and its calibrated value

Note 1 to entry: The symbol "P" in $P_{\text{Size.Sph.}i:j:\text{O3D}}$ indicates that the error is associated with the probing system performance, the qualifier "Size.Sph" indicates that it is associated with the probing size error of a sphere and the qualifier "O3D" indicates that it is associated with the optical 3D CMS. The qualifier "i" identifies the percentile of probing points selected for the evaluation: either from "D95%" denoting 95 % of the population or "All" denoting the whole population, i.e. 100 %. The qualifier "j" identifies the measuring conditions of the CMS. "SMV.SV" denotes single-view measurement while "SMV.MV" multiple-view measurement; the measurement is performed within the sensor measurement volume ("SMV") in either case. Possible examples of such symbol are $P_{\text{Size.Sph.D95\%:SMV.SV:O3D}}$ or $P_{\text{Size.Sph.All:SMV.MV:O3D}}$.

Note 2 to entry: The probing size error is determined by the errors of the sensors (caused by e.g. noise, digitization, image distortion, optical interaction with the surface of the material standard, calibration, faulty algorithms) and of the positioning system.

3.10
distortion error
$\boldsymbol{D}_{\textbf{CC:}\boldsymbol{j}:\textbf{O3D}}$
error of indication when measuring a calibrated centre-to-centre distance within the sensor measurement volume either by single-view measurement operation or multiple-view measurement operation

Note 1 to entry: The symbol "D" indicates that the error is associated with the geometrical deformation of the sensor, the qualifier "CC" indicates that the error of indication is of a centre-to-centre distance, and the qualifier "O3D" indicates that it is associated with optical 3D CMS. The qualifier "j" identifies the measuring conditions of the CMS: "SMV.SV" denotes single-view measurement while "SMV.MV" multiple-view measurement operation; the measurement is performed within the sensor measurement volume ("SMV") in either case. Possible examples of such symbol are $D_{\text{CC:SMV.SV:O3D}}$ or $D_{\text{CC:SMV.MV:O3D}}$.

3.11
flat form distortion error
$D_{\mathrm{Form.Pla.}i:j\mathrm{:O3D}}$
smallest distance between two parallel planes that encompass a percentile of all data measured on the test flat

Note 1 to entry: The symbol "*D*" indicates that the error is associated with the geometrical deformation of the sensor, the qualifier "Form.Pla" indicates that it is associated with the form error of a plane, and the qualifier "O3D" indicates that it is associated with the optical 3D CMS. The qualifier "*i*" identifies the percentile of probing points selected for the evaluation: either "D95%" denoting 95 % of the population or "All" denoting the whole population, i.e. 100 %. The qualifier "*j*" identifies the measuring conditions of the CMS: "SMV.SV" denotes single-view measurement while "SMV.MV" multiple-view measurement. The measurement is performed within the sensor measurement volume ("SMV") in either case. Possible examples of such symbol are $D_{\mathrm{Form.Pla.D95\%:SMV.SV:O3D}}$ or $D_{\mathrm{Form.Pla.All:SMV.MV:O3D}}$.

3.12
volumetric length measurement error in concatenated measurement volume
$E_{\mathrm{Vol:CMV.MV:O3D}}$
error of indication when measuring a calibrated test length within the concatenated measurement volume by multiple-view measurement

Note 1 to entry: The symbol "*E*" indicates that the error of indication is of a length in space, the qualifier "Vol" indicates that local probing errors are not of interest (volumetric geometry errors of the CMS), the qualifier "CMV.MV" denotes multiple-view measurement within the concatenated measurement volume, and the qualifier "O3D" indicates that it is associated with optical 3D CMS.

Note 2 to entry: The multiple-view measurement is to reveal the volumetric length measurement error in the concatenated measurement volume.

Note 3 to entry: A calibrated test length may typically be calibrated by the centre-to-centre distance of a sphere standard. See Annex B for detail.

3.13
maximum permissible probing form dispersion error
$P_{\mathrm{Form.Sph.}i:j\mathrm{:O3D,MPE}}$
extreme value of $P_{\mathrm{Form.Sph.}i:j\mathrm{:O3D}}$ permitted by specifications as maximum permissible error

3.14
maximum permissible probing size error
$P_{\mathrm{Size.Sph.}i:j\mathrm{:O3D,MPE}}$
extreme value of $P_{\mathrm{Size.Sph.}i:j\mathrm{:O3D}}$ permitted by specifications as maximum permissible error

3.15
maximum permissible distortion error
$D_{\mathrm{CC:}j\mathrm{:O3D,MPE}}$
extreme value of $D_{\mathrm{CC:}j\mathrm{:O3D}}$ permitted by specifications as maximum permissible error

3.16
maximum permissible flat form distortion error
$D_{\mathrm{Form.Pla.}i:j\mathrm{:O3D,MPE}}$
extreme value of $D_{\mathrm{Form.Pla.}i:j\mathrm{:O3D}}$ permitted by specifications as maximum permissible error

3.17
maximum permissible volumetric length measurement error in concatenated measurement volume
$E_{\mathrm{Vol:CMV.MV:O3D,MPE}}$
extreme value of $E_{\mathrm{Vol:CMV.MV:O3D}}$ permitted by specifications as maximum permissible error

3.18
bi-directional length measurement error in concatenated measurement volume

$E_{\mathrm{Bi:CMV.MV:O3D}}$

bi-directional error of indication when measuring a calibrated test length within the concatenated measurement volume by multiple-view measurement

Note 1 to entry: See Annex A for details on the optional characteristics.

Note 2 to entry: The symbol "*E*" indicates that the error is of a length in space, the qualifier "Bi" indicates that the local probing errors are included (bi-directional probing), the qualifier "CMV.MV" denotes multiple-view measurement within the concatenated measurement volume and the qualifier "O3D" indicates that it is associated with optical 3D CMS.

Note 3 to entry: The multiple-view measurement is to reveal the volumetric length measurement error in the concatenated measurement volume.

3.19
maximum permissible bi-directional length measurement error

$E_{\mathrm{Bi:CMV.MV:O3D,MPE}}$

extreme value of $E_{\mathrm{Bi:CMV.MV:O3D}}$ permitted by specifications as maximum permissible error

4 Symbols

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

Table 1 — Symbols

Symbol	Meaning
$P_{\mathrm{Form.Sph.}i:j\mathrm{:O3D}}$	probing form dispersion error
$P_{\mathrm{Size.Sph.}i:j\mathrm{:O3D}}$	probing size error
$D_{\mathrm{CC:}j\mathrm{:O3D}}$	distortion error
$D_{\mathrm{Form.Pla.}i:j\mathrm{:O3D}}$	flat form distortion error
$E_{\mathrm{Vol:CMV.MV:O3D}}$	volumetric length measurement error in concatenated measurement volume
$E_{\mathrm{Bi:CMV.MV:O3D}}$	bi-directional length measurement error in concatenated measurement volume
$P_{\mathrm{Form.Sph.}i:j\mathrm{:O3D,MPE}}$	maximum permissible probing form dispersion error
$P_{\mathrm{Size.Sph.}i:j\mathrm{:O3D,MPE}}$	maximum permissible probing size error
$D_{\mathrm{CC:}j\mathrm{:O3D,MPE}}$	maximum permissible distortion error
$D_{\mathrm{Form.Pla.}i:j\mathrm{:O3D,MPE}}$	maximum permissible flat form distortion error
$E_{\mathrm{Vol:CMV.MV:O3D,MPE}}$	maximum permissible volumetric length measurement error in concatenated measurement volume
$E_{\mathrm{Bi:CMV.MV:O3D,MPE}}$	maximum permissible bi-directional length measurement error in concatenated measurement volume
D95%	95 % percentile of the population
All	whole population (i.e. 100 % percentile)
SMV.SV	single-view measurement within the sensor measurement volume
SMV.MV	multiple-view measurement within the sensor measurement volume
CMV.MV	multiple-view measurement within the concatenated measurement volume

5 Rated operating conditions

5.1 Environmental conditions

Limits for permissible environmental conditions (such as temperature conditions, air humidity, vibration and ambient lighting at the site of installation that influences 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 testing will be performed within the manufacturer's specified limits given in the CMS data sheet.

The user is responsible for providing the environment enclosing the CMS as specified by the manufacturer in the data sheet. If the environment does not meet the specifications, then the maximum permissible errors cannot be required to be verified.

5.2 Operating conditions

5.2.1 General

For all the tests described in this document, the Optical 3D CMS shall be operated compliant with the rated operating conditions and the default settings stated by the manufacturer.

In case any of the conditions and settings are not specified, the user is free to choose.

The manufacturer may specify extra specifications for special operating conditions and settings at its discretion.

Specific areas in the manufacturer's manual to be adhered to include:

1. machine start-up/warm-up cycles,
2. probing system qualification,
3. achievement of thermal stability of the CMS,
4. location, type, number of thermal sensors in the case these are at least partially applicable,
5. software filters,
6. surface characteristics of the material standards such as colour, roughness, glossiness, light scattering characteristics, and
7. default procedures and settings for data registration and data fusion.

NOTE The CMS qualification may include a number of adjustment and parameter setting, such as those related to the geometry in a sub-system assembly, the illumination, the optical sensing, and the numerical filtration.

5.2.2 Material and surface characteristic of material standards

The material used for the material standards shall be stated by the manufacturer. Different materials have different optical characteristics such as reflection factor, optical penetration depth (volume scattering), colour, scattering characteristics, etc., which may influence the test values. The roughness of the material standard shall be negligibly smaller than the maximum permissible error of the length test. Where the manufacturer chooses not to specify the material and surface of the material standard, the user is free to choose.