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

Part 10: Laser trackers for measuring point-to-point distances

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

Partie 10: Laser de poursuite pour mesurer les distances de point à point

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO 10360 consists of the following 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: CMMs 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 of Gaussian associated features*

— *Part 7: CMMs equipped with imaging probing systems*

ISO 10360 also consists of the following parts, under the general title *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS)*:

— *Part 8: CMMs with optical distance sensors*

— *Part 9: CMMs with multiple probing systems*

— *Part 10: Laser trackers for measuring point-to-point distances*

The following part is under preparation:

— *Part 12: Articulated-arm CMMs*

Computed tomography is to form the subject of a future part 11

Introduction

This part of ISO 10360 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences link F of the chains of standards on size, distance, radius, angle, form, orientation, location, and run-out.

The ISO/GPS matrix model given in ISO 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 part of ISO 10360 and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this part of ISO 10360, unless otherwise indicated.

More detailed information on the relation of this part of ISO 10360 to other standards and the GPS matrix model can be found in Annex I.

The objective of this part of ISO 10360 is to provide a well-defined testing procedure for a) laser tracker manufacturers to specify performance by maximum permissible errors (MPEs), and b) to allow testing of these specifications using calibrated, traceable test lengths, test spheres, and flats. 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 laser tracker will perform on similar length measurements.

This part of ISO 10360 is ***distinct*** from that of ISO 10360-2, which is for coordinate measuring machines (CMMs) equipped with contact probing systems, in that the orientation of the test lengths reflect the different instrument geometry and error sources within the instrument.

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

Part 10:
Laser trackers for measuring point-to-point distances

1 Scope

This part of ISO 10360 specifies the acceptance tests for verifying the performance of a laser tracker by measuring calibrated test lengths, test spheres and flats according to the specifications of the manufacturer. It also specifies the reverification tests that enable the user to periodically reverify the performance of the laser tracker. The acceptance and reverification tests given in this part of ISO 10360 are applicable only to laser trackers utilizing a retro-reflector as a probing system. Laser trackers that use interferometry (IFM), absolute distance meter (ADM) measurement, or both can be verified using this part of ISO 10360. This part of ISO 10360 can also be used to specify and verify the relevant performance tests of other spherical coordinate measurement systems that use cooperative targets, such as "laser radar" systems.

NOTE Systems, such as laser radar systems, which do not track the target, will not be tested for probing performance.

This part of ISO 10360 does not explicitly apply to measuring systems that do not use a spherical coordinate system (i.e. two orthogonal rotary axes having a common intersection point with a third linear axis in the radial direction). However, the parties can apply this part of ISO 10360 to such systems by mutual agreement.

This part of ISO 10360 specifies

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

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

— rules for proving conformance, and

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10360-8:2013, *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) — Part 8: CMMs with optical distance sensors*

ISO 10360-9:2013, *Geometrical product specifications (GPS) — Acceptance and reverification tests for coordinate measuring systems (CMS) — Part 9: CMMs with multiple probing systems*

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

3 Terms and definitions

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

3.1
laser tracker
coordinate measuring system in which a cooperative target is followed with a laser beam and its location determined in terms of a distance (range) and two angles

Note 1 to entry: The two angles are referred to as azimuth, θ (rotation about a vertical axis – the standing axis of the laser tracker) and elevation, φ (angle above a horizontal plane – perpendicular to the standing axis).

3.2
interferometric measurement mode
IFM mode
measurement method that uses a laser displacement interferometer integrated in a *laser tracker* (3.1) to determine distance (range) to a target

Note 1 to entry: Displacement interferometers can only determine differences in distance, and therefore require a reference distance (e.g. home position).

3.3
absolute distance measurement mode
ADM mode
measurement method that uses time of flight instrumentation integrated in a *laser tracker* (3.1) to determine the distance (range) to a target

Note 1 to entry: Time of flight instrumentation may include a variety of modulation methods to calculate the distance to the target.

3.4
retroreflector
passive device designed to reflect light back parallel to the incident direction over a range of incident angles

Note 1 to entry: Typical retroreflectors are the cat's-eye, the cube corner, and spheres of special material.

Note 2 to entry: Retroreflectors are cooperative targets.

Note 3 to entry: For certain systems, e.g. laser radar, the retroreflector might be a cooperative target such as a polished sphere.

3.5
spherically mounted retroreflector
SMR
retroreflector (3.4) that is mounted in a spherical housing

Note 1 to entry: In the case of an open-air cube corner, the vertex is typically adjusted to be coincident with the sphere centre.

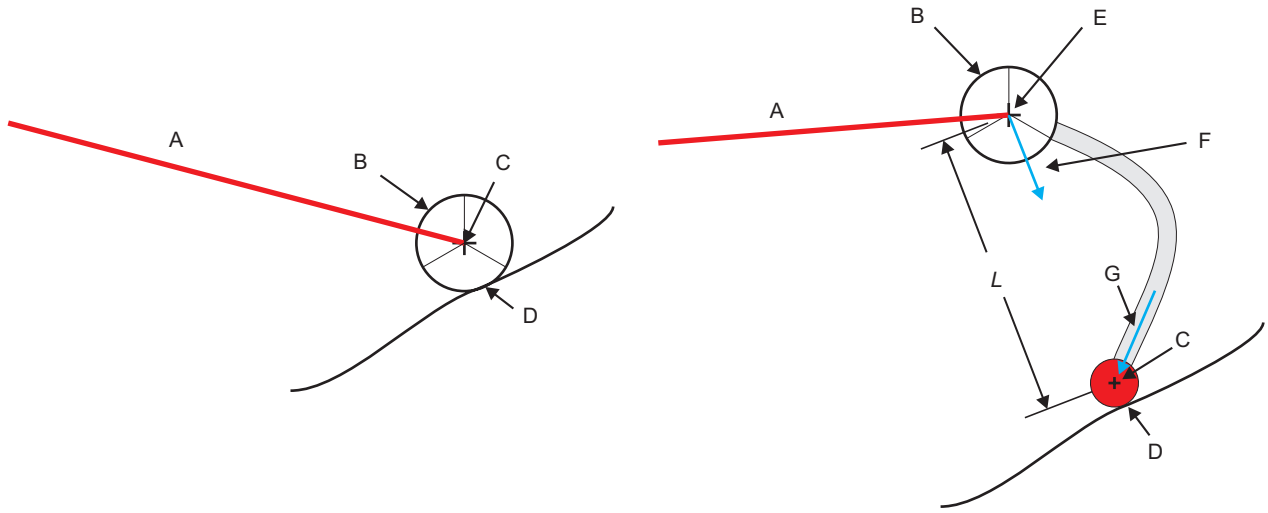
Note 2 to entry: The tests in this part of ISO 10360 are typically executed with a spherically mounted retroreflector.

Note 3 to entry: See Figure 1.

3.6
stylus and retroreflector combination
SRC
probing system that determines the measurement point utilizing a probe stylus to contact the workpiece, a *retroreflector* (3.4) to determine the base location of the probe, and other means to find the stylus orientation unit vector

Note 1 to entry: The datum for the stylus tip offset (L) is the centre of the retroreflector.

Note 2 to entry: See Figure 1.



a) SMR **b) SRC**

Key

A laser beam
B retroreflector
C measurement point
D contact point
E base location
F stylus orientation unit vector
G normal probing direction vector
L stylus tip offset

Figure 1 — Representation of SMR vs. SRC

3.7
optical distance sensor and retroreflector combination
ODR
probing system that determines the measurement point utilizing an optical distance sensor to measure the workpiece, a *retroreflector* (3.4) to determine the base location of the optical distance sensor, and other means to find the orientation of the optical distance sensor

3.8
target nest
nest
device designed to repeatably locate an SMR

3.9
length measurement error
$E_{\text{Uni:L:LT}}$
$E_{\text{Bi:L:LT}}$
error of indication when performing a unidirectional ($E_{\text{Uni:L:LT}}$) or bidirectional ($E_{\text{Bi:L:LT}}$) point-to-point distance measurement of a calibrated test length using a laser tracker with a stylus tip offset of L

Note 1 to entry: $E_{\text{Uni:0:LT}}$ and $E_{\text{Bi:0:LT}}$ (used frequently in this part of ISO 10360) correspond to the common case of no stylus tip offset, as the retroreflector optical centre coincides with the physical centre of the probing system for spherically mounted retroreflectors.

3.10
normal CTE material
material with a coefficient of thermal expansion (CTE) between 8×10^{-6}/ °C and 13×10^{-6}/ °C

[SOURCE: ISO 10360-2:2009]

Note 1 to entry: Some documents may express CTE in units 1/K, which is equivalent to 1/ °C.

3.11
probing form error
$P_{\text{Form.Sph.1x25::SMR.LT}}$
error of indication within which the range of Gaussian radial distances can be determined by a least-squares fit of 25 points measured by a *laser tracker* (3.1) on a spherical material standard of size

Note 1 to entry: Only one least-squares fit is performed, and each point is evaluated for its distance (radius) from this fitted centre.

3.12
probing size error
$P_{\text{Size.Sph.1x25::SMR.LT}}$
error of indication of the diameter of a spherical material standard of size as determined by a least-squares fit of 25 points measured with a *laser tracker* (3.1)

3.13
location error
two-face error
plunge and reverse error
$L_{\text{Dia.2x1:P\&R:LT}}$
the distance, perpendicular to the beam path, between two measurements of a stationary *retroreflector* (3.4), where the second measurement is taken with the *laser tracker* (3.1) azimuth axis at approximately 180° from the first measurement and the laser tracker elevation angle is approximately the same

Note 1 to entry: This combination of axis rotations is known as a *two face*, or *plunge and reverse*, test.

Note 2 to entry: The laser tracker base is fixed during this test.

3.14
maximum permissible error of length measurement
$E_{\text{Uni:L:LT,MPE}}$
$E_{\text{Bi:L:LT,MPE}}$
extreme value of the length measurement error, $E_{\text{Bi:L:LT}}$ or $E_{\text{Uni:L:LT}}$, permitted by specifications

Note 1 to entry: $E_{\text{Bi:0:LT,MPE}}$ and $E_{\text{Uni:0:LT,MPE}}$ are used throughout this part of ISO 10360.

3.15
maximum permissible error of probing form
$P_{\text{Form.Sph.1x25::SMR.LT,MPE}}$
extreme value of the *probing form error* (3.11), $P_{\text{Form.Sph.1x25::SMR.LT}}$, permitted by specifications

3.16
maximum permissible error of probing size
$P_{\text{Size.Sph.1x25::SMR.LT,MPE}}$
extreme value of the *probing size error* (3.12), $P_{\text{Size.Sph.1x25::SMR.LT}}$, permitted by specifications

3.17
maximum permissible error of location
$L_{\text{Dia.2x1:P\&R:LT,MPE}}$
extreme value of the location error, $L_{\text{Dia.2x1:P\&R:LT}}$, permitted by specifications

3.18
rated operating condition
operating condition that must be fulfilled, according to specification, during measurement in order that a measuring instrument or measuring system performs as designed

Note 1 to entry: Rated operating conditions generally specify intervals of values for a quantity being measured and for any influence quantity.

Note 2 to entry: Within this part of ISO 10360, the term “as designed” in the definition means “as specified by MPEs”.

Note 3 to entry: When the rated operating conditions are not met in a test according to this part of ISO 10360, neither conformance nor non-conformance to specifications can be determined.

[SOURCE: ISO/IEC Guide 99:2007, 4.9 — modified.]

4 Symbols

For the purposes of this part of ISO 10360, the symbols in Table 1 apply.

Table 1 — Symbols of specification quantities

Symbol	Meaning
$E_{Uni:L:LT}$ $E_{Bi:L:LT}$	Length measurement error (Uni- or Bi-directional lengths) where L is the stylus tip offset
$P_{Form.Sph.1\times25::SMR.LT}$ $P_{Form.Sph.1\times25::SRC.LT}$ $P_{Form.Sph.1\times25::ODR.LT}$	Probing form error for SMR, SRC or ODR operation mode
$P_{Size.Sph.1\times25::SMR.LT}$ $P_{Size.Sph.1\times25::SRC.LT}$ $P_{Size.Sph.1\times25::ODR.LT}$	Probing size error for SMR, SRC or ODR operation mode
$L_{Dia.2\times1:P\&R:LT}$	Location error (from two face tests)
$E_{Uni:L:LT,MPE}$ $E_{Bi:L:LT,MPE}$	Maximum permissible error of length measurement where L is the stylus tip offset
$P_{Form.Sph.1\times25::SMR.LT,MPE}$	Maximum permissible error of probing form
$P_{Size.Sph.1\times25::SMR.LT,MPE}$	Maximum permissible error of probing size
$L_{Dia.2\times1:P\&R:LT,MPE}$	Maximum permissible error of location (from two face tests)
	Accessory sensor testing – SRC
Symbol	**Meaning**
$P_{Form.Sph.1\times25::SRC.LT}$	Probing form error for SRC
$P_{Size.Sph.1\times25::SRC.LT}$	Probing size error for SRC
$P_{Dia.15\times1::SRC.LT}$	Orientation error for SRC
$P_{Form.Sph.1\times25::SRC.LT,MPE}$	Maximum permissible error of probing form for SRC
$P_{Size.Sph.1\times25::SRC.LT,MPE}$	Maximum permissible error of probing size for SRC
$P_{Dia.15\times1::SRC.LT,MPE}$	Maximum permissible error of orientation for SRC
	Accessory sensor testing – ODR
Symbol	**Meaning**
$P_{Form.Sph.1\times25::ODR.LT}$	Probing form error for ODR (25 points)
$P_{Form.Sph.D95\%::ODR.LT}$	Probing form error for ODR (95 % of the points)
$P_{Size.Sph.1\times25::ODR.LT}$	Probing size error for ODR (25 points)