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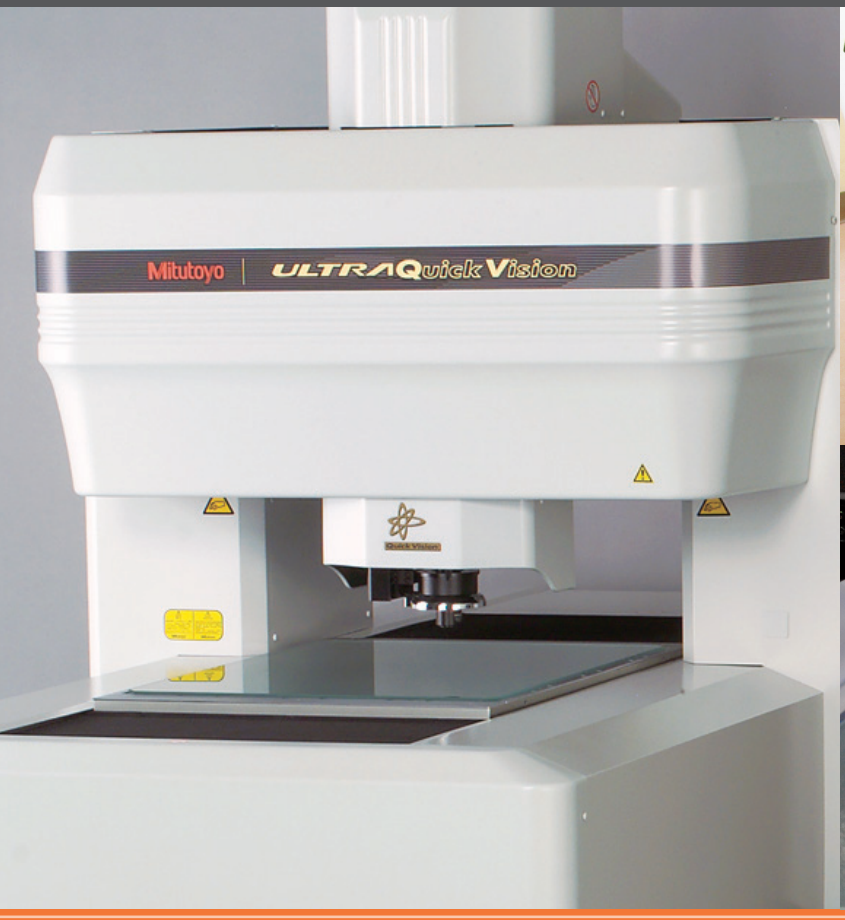
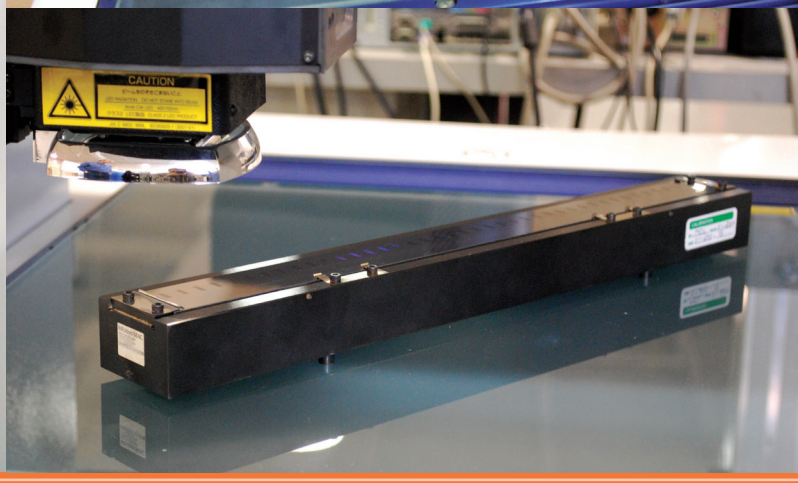
TESTING VISION CMMS AND THE INTERNATIONAL STANDARD, ISO 10360-7

A TECHNICAL PRESENTATION FROM THE LEADING MANUFACTURER OF METROLOGY INSTRUMENTS

EDUCATION





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About this Presentation

ISO 10360-7:2011 is the first international standard to address the calibration and testing of non-contacting coordinate measuring machines (CMMs) equipped with any type of imaging probing system, such as video or vision measuring instruments. This technical presentation provides an overview of this standard along with some insight into the options available in the standard. This presentation also explains how the tests in this standard can be used for the most modern three-dimensional measuring systems while still providing testing methods to meet the needs of older systems.

Whatever your challenges are, Mitutoyo supports you from start to finish.

Mitutoyo is not only a manufacturer of top-quality measuring products but one that also offers qualified support for the lifetime of the equipment, backed by comprehensive services that ensure your staff can make the very best use of the investment.

Apart from the basics of calibration and repair, Mitutoyo offers product and metrology training, as well as IT support for the sophisticated software used in modern measuring technology. We can also design, build, test and deliver measuring solutions and even, if deemed cost-effective, take your critical measurement challenges in-house on a sub-contract basis.

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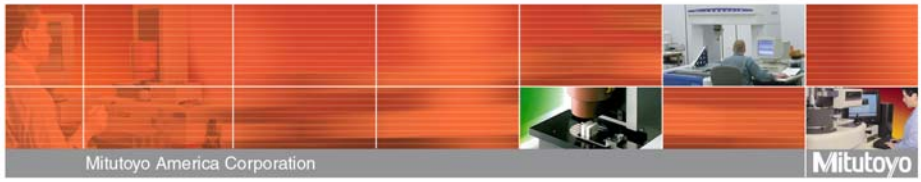
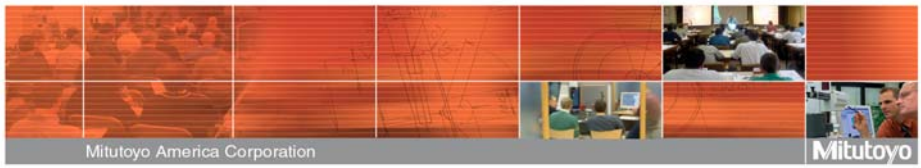


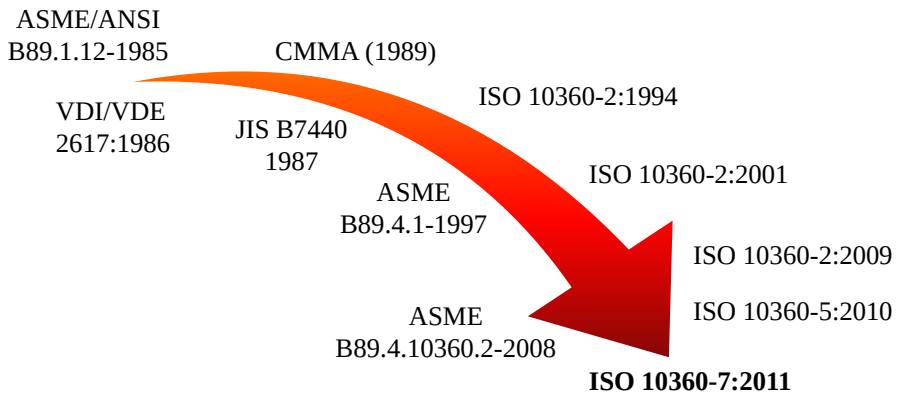
The International Standard for Specifying and Testing CMMs with Imaging Probing Systems

New ISO 10360-7:2011

- Full title of new international standard:
  - ISO 10360-7:2011, Geometrical product specifications (GPS) – Acceptance and reverification tests for coordinate measuring machines (CMM) – Part 7: CMMs equipped with imaging probing systems.
- Developed by the international standards organization (ISO):
  - Technical committee 213, working group 10 on CMMs
  - Task force leader: Dr. Jim Salsbury, Mitutoyo America
  - Publication date: June 1, 2011



Evolution of CMM Performance Testing Standards



The new ISO 10360-7 applies well-developed contact probe CMM testing methods to a "CMM equipped with an imaging probing system"

Summary of ISO 10360 CMM Standards

- ISO 10360-1:2000 Terminology.
- ISO 10360-2:2009 Length tests, E (contact probing systems).
- ISO 10360-3:2000 Rotary table tests.
- ISO 10360-4:2000 Contact scanning tests.
- ISO 10360-5:2010 Contact probing tests, P.
- ISO 10360-6:2001 Software testing.
- ISO 10360-7:2011 CMMs with imaging probing systems.
- ISO 10360-8:2013 CMMs with optical distance sensors
- ISO 10360-9:2013 CMMs with multiple probing systems
- ISO/FDIS 10360-10 Laser trackers (under development)
- ISO/DIS 10360-12 Articulated arm CMMs (under development)

Background of ISO 10360-7 Approach

- Directive for ISO 10360-7 was to apply well-known CMM testing ideas to vision based CMMs.
- Since 1994, the fundamental test for CMMs (with contact probes) has been the 3D length test, currently known as E_0 in ISO 10360-2.
- The E_0 test is run in 7 positions including parallel to the machine axes and volumetrically (3D).
- It was recognized early in the development process that the testing in 10360-7 would have some variations from ISO 10360-2.

Spatial diagonal testing required in ISO 10360-2

For further details on ISO 10360-2, see Mitutoyo America presentation on CMM Testing.

Two Optional Approaches in ISO 10360-7:2011

- Composite Approach
  - Single 3D specification
  - Useful when comparing to contact probe CMMs
  - Does the user need or want a 3D specification?
  - Challenges in testing
- Component Approach
  - Based on historical best industrial practices
  - Preserve legacy of specifications
  - XY plane linears
  - Z axis linear and squareness

For either approach, there is also an important new “Probing Test” plus two optional tests when measuring only in the field of view.

The manufacturer should choose the specification method. The two approaches are considered equally valid in ISO 10360-7.

Summary of ISO 10360-7 Specifications/Symbols

- Component Approach:
  - XY plane: E_{UXY} or E_{BXY}
  - Z axis: E_{UZ} or E_{BZ}
  - Squareness: E_{SQ}
- Probing test: P_{F2D}
- Optional 2D field of view tests:
  - Length: E_{UV} or E_{BV}
  - Probing: P_{FV2D}

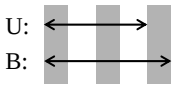
- Composite Approach:
  - 3D testing: E_U or E_B
  - Repeatability: R_U or R_B

Manufacturer specifications are listed as maximum permissible errors (MPE), for example:
- $E_{UXY, MPE} = 0.5 + 2L/1000$ µm
- $E_{SQ, MPE} = 2.5$ µm

The B and U in E_B, E_{UXY}, etc., refer to the type of artifact (unidirectional or bidirectional)

Unidirectional versus Bidirectional

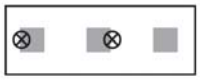
- Standard allows for either unidirectional (U) or bidirectional (B) artifacts.
- Unidirectional: pitch
- Bidirectional: width



- Standard does not recommend U or B, and the choice is at the discretion of the manufacturer.

- Bidirectional examples:

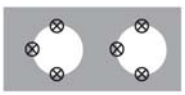

Linescale/gage block: width


Linescale: opposing direction edges


Circle/sphere: size

- Unidirectional examples:


Linescale: pitch


Circles: center to center

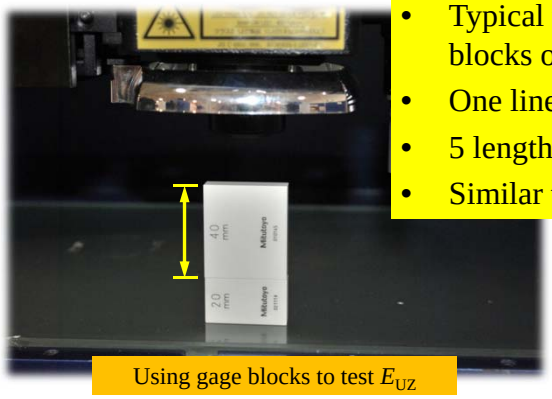
ISO 10360-7 2-D length test: E_{UXY} and E_{BXY}

- Typical test artifact: linescale.
- Four measurement lines parallel to XY plane.
- 5 lengths, 3 repeats, 60 values.
- Combination of historical specifications E_{1XY} and E_{2XY}

Testing E_{UXY}

The test artifact is measured in four positions. The default positions are parallel to X, parallel to Y, and the two XY planar diagonals. The linescale above is set to test one of the diagonal positions.

ISO 10360-7 1-D length test: E_{UZ} (or E_{BZ})



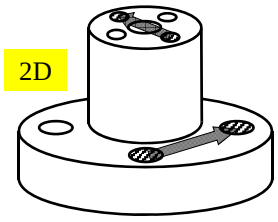
Using gage blocks to test E_{UZ}

- Typical test artifact: gage blocks or stair step gage.
- One line parallel to Z axis.
- 5 lengths, 3 repeats, 15 values.
- Similar to historical E_{1Z}

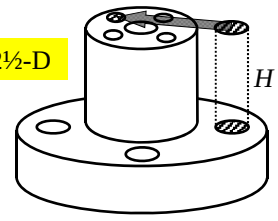
A stair step gage to test E_{UZ}

Z-axis Straightness/Squareness to XY Plane, E_{SQ}

- True 3D measurements are less common on vision CMMs.
- Many measurements, however, involve some motion of the Z-axis. 3D geometry errors can easily create errors in what seems to be a 2D measurement. This is sometimes called a 2½-D measurement.

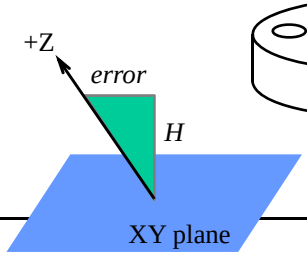


2D

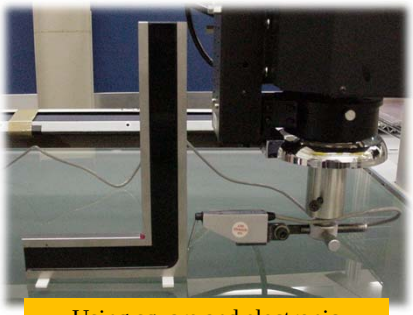


2½-D

If 3D volumetric length tests are not being done, then the squareness test is critical.



ISO 10360-7 Squareness Test: E_{SQ}



Using square and electronic indicator to test E_{SQ} in XZ plane

- Typical test artifact: precision square.
- Test squareness in two positions: XZ and YZ planes.
- Similar to historical squareness or perpendicularity specifications (which were usually not readily available).
- The test may require the use of some type of indicator or electronic gage.

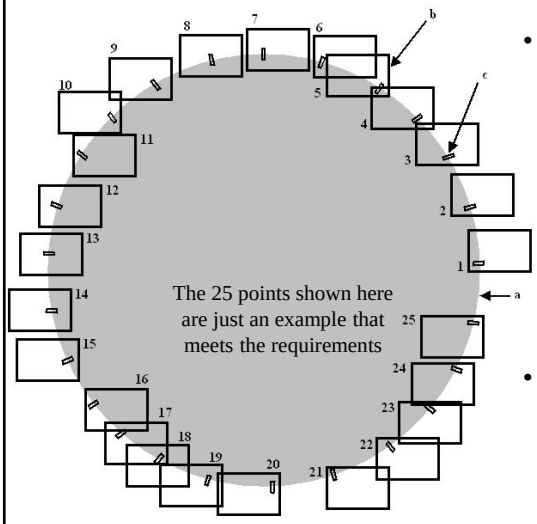
ISO 10360-7 3D composite length test: E_U or E_B

- E_B test is equal to E_0 test for contact probe CMMs.
  - Useful for comparison between CMMs with different probing systems.
- E_B or E_U requires 3D test using the vision probe.
  - Infrequently used today.
  - Requires measuring an inclined linescale.

Testing one of the four spatial diagonals using inclined linescale

The composite approach, with a single 3D specification, is generally applicable if the primary use of the equipment is for 3D measurements.

ISO 10360-7 Probing Test: P_{F2D}



- The new P_{F2D} test looks at the overall measuring system including the probing system.
  - Hardware, e.g. optics.
  - Setup, e.g. camera alignment.
  - Software, e.g. edge detection.
  - Test requires machine motion.
  - Tests complete measuring system over smaller range.
- The P_{F2D} test measures form (roundness) on one large circular artifact.
  - Measure 25 points across the field of view (FOV) of the measuring system.

Notice that the 25 points are in different positions in the FOV

Test Artifact for Checking P_{F2D}

- Need accurate (round) 2D circular artifact.
- Not readily available in the market at sufficient accuracy.
- Limited laboratories have the ability to perform calibration of the roundness.

Mitutoyo developed a special glass chart and calibration method to meet the needs of ISO 10360-7.

Test	Historical Specifications	New Specifications	
		Parameter	ISO Standard
Length parallel to X or Y axis	E_{1XY} or U_{1XY}	$E_{UXY,MPE}$ or $E_{BXY,MPE}$	ISO 10360-7
Length diagonals in XY plane	E_{2XY} or U_{2XY}		
Length parallel to Z axis	E_{1Z} or U_{1Z}	$E_{UZ,MPE}$	ISO 10360-7
Squareness of Z to XY	Unpublished specifications	$E_{SQ,MPE}$	ISO 10360-7
Volumetric (composite)	Nothing	$E_{U,MPE}$ or $E_{B,MPE}$	ISO 10360-7
Probe test, vision probe	Nothing	$P_{F2D,MPE}$	ISO 10360-7
Volumetric with touch probe (multi-sensor CMM)	Not used	$E_{0,MPE}$	ISO 10360-2
Probe test, touch probe (multi-sensor CMM)	Not used	$P_{FTU,MPE}$	ISO 10360-5

Thank You

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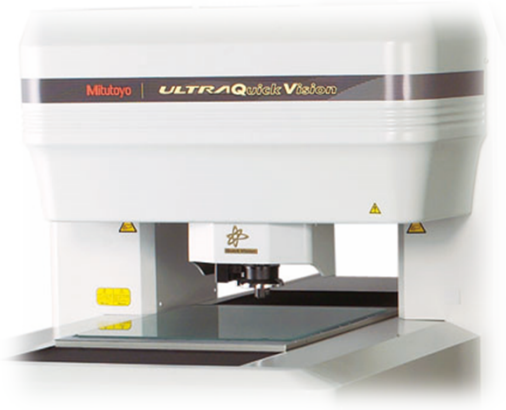

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