Verifying the dimensional performance of XCT systems with metrology capability

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13th July 2017

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NPL Event hosted by Warwick

Thanks to WMG Innovative Solutions for hosting

δXCT

2017

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National Physical Laboratory

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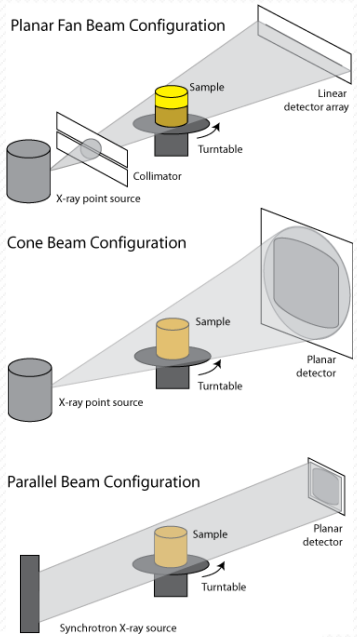
XCT for 3D coordinate measurement

Which kit to buy? How to compare? How to verify?

What about Interim checks after purchase/service?



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ISO verification~ XCT development

- Demonstrating traceability to national standards.
- Estimating the accuracy of measurements
  - Providing confidence
  - Assuring reliability in the measurements.
- The ISO 10360 series of standards, can check MPE supporting
  - Acceptance;
  - Re-verification tests;
  - Interim checks.

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Applications of a standard

- Acceptance testing

Used in a contractual situation between a manufacturer and a user such as when **purchasing, maintenance, repair**, renovation or upgrade contract,

- Reverification testing

The reverification tests given in this part can be used in an organization's **internal quality assurance system** for verification of the performances of the probing and the length measurement.

- Interim checking

In an organization's internal quality assurance system, reduced reverification tests can be used periodically to **demonstrate the probability** that the CMS conforms to the requirements for maximum permissible errors.

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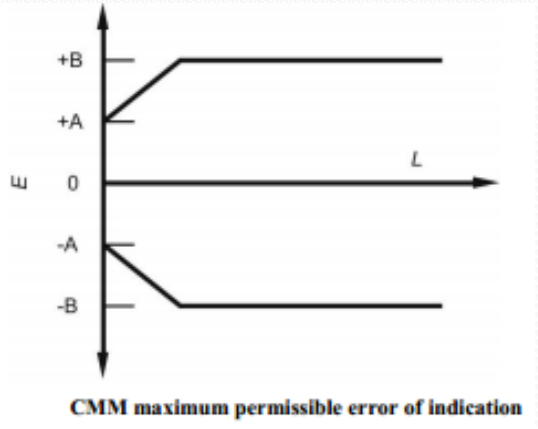
Maximum permissible error

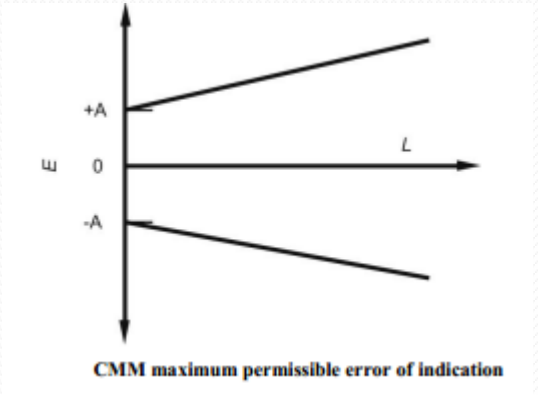
- The term $E_{(MPE, L)}$ can specify the length measuring accuracy of a CMS /Metrology XCT system.
- MPE, can be stated in at least three different ways.

Some ways of expressing MPE

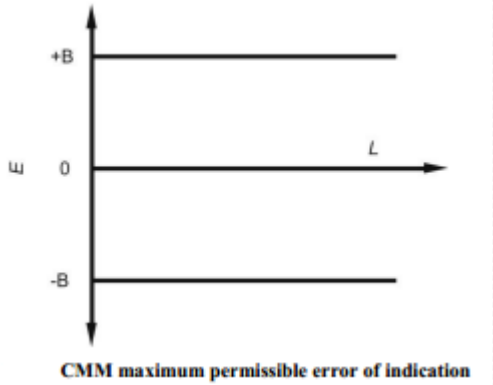
Case a



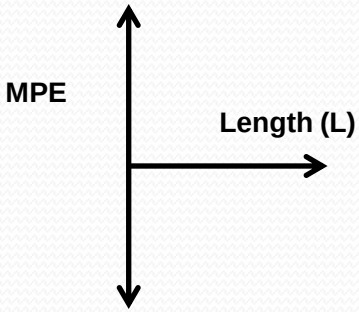
Case b



Case c



Ref: D.Flack



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XCT performance specifications 5 examples ref: Internet 10/7/17

- **Example A)** SYSTEM CAPABILITIES~ Geometric Magnification: >2000x; Overall **Maximum System Resolution**: <500 nm
- **Example B)** **Maximum Permissable Error** MPE (perhaps they mean permissible?). MPE, no air conditioning required CT Sensor: P: 9,5 µm, E: (9.5+L/75) µm, MPE for advanced laboratory conditions CT Sensor: P: 6,5 µm, E: (6.5+L/75) µm;
- **Example C)** **Absolute accuracy** 9 + L/50 µm;
- **Example D)** **Resolution:** 3.5 - 6 µm; **Accuracy:** Down to 2.9 µm + L/100 Sphere center point error;
- **Example E)** **Precise metrology** MPE_{SD} = 8 µm + L/75, measured as a deviation of sphere distance.

To help confusion, examples do not use BIPM's VIM / ISO recommended language & nobody states the units of L?... I guess its Metres, or Microns?

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Geometrical Product Specifications (GPS) – Acceptance and re-verification tests for CMM / CMS

- ISO 10360-1: 2000 — Part 1, (of nominally 12}: Vocabulary.
- International standard ISO 10360-1 defines a co-ordinate measuring machine (CMM) as a measuring system with the means to move a probing system and with capability to determine spatial coordinates on a workpiece surface.
- You may well ask

What is a probe? what is a workpiece etc? in fact what is a CMM or CMS?

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ISO 10360 Part 11 currently under development for XCT by ISO213 committee.

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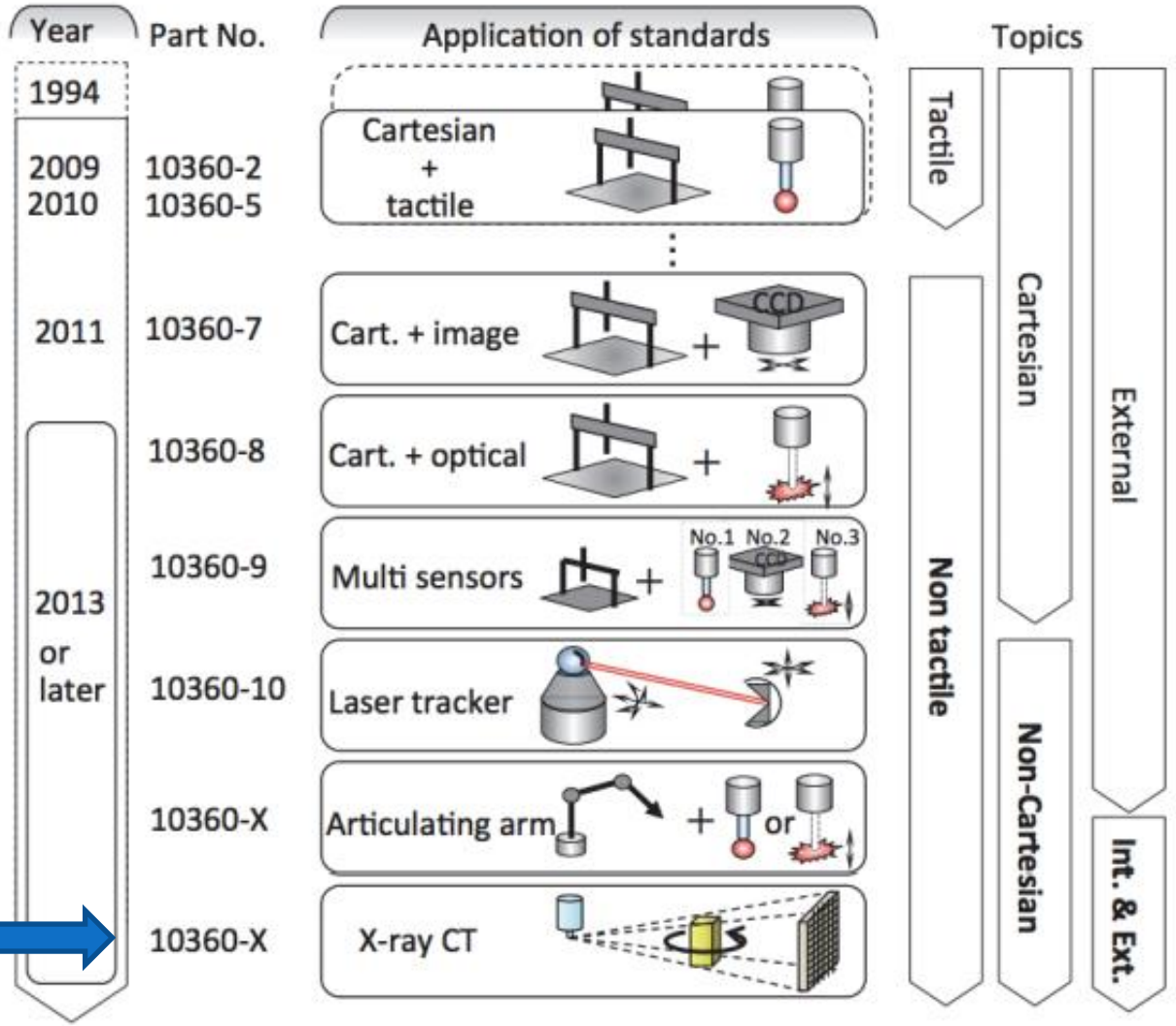
Development Summary ~ISO 10360

(Toshiyuki Takatsuji , Makoto Abe , Hiroyuki Fujimoto NMIJ iCT Conference 2014)



AA Part 12
Published 2016

Unofficial ~CD
Draft XCT
Part 11 at 3/2017

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The purpose of ISO 10360 XCT

- Intention: To achieve comparability with the characteristics of coordinate measuring systems with tactile and with optical sensors.
- Dedicated to measurements which are predominantly based on the attenuation contrast when penetrating physical matter.
- Define metrological characteristics and methods for testing XCT with a single sensor which are dedicated to dimensional measurements of workpieces.
- Excludes: medical imaging, medical dimensional measurements and as well non-destructive (material) defect analyses.

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ISO 10360 Part-11 XCT is a written document

Consisting of **procedures**, along with some recommended physical test **artefacts**, that can be used to **verify the performance** of both **OEM** and custom **XCT dimensional** measuring systems.

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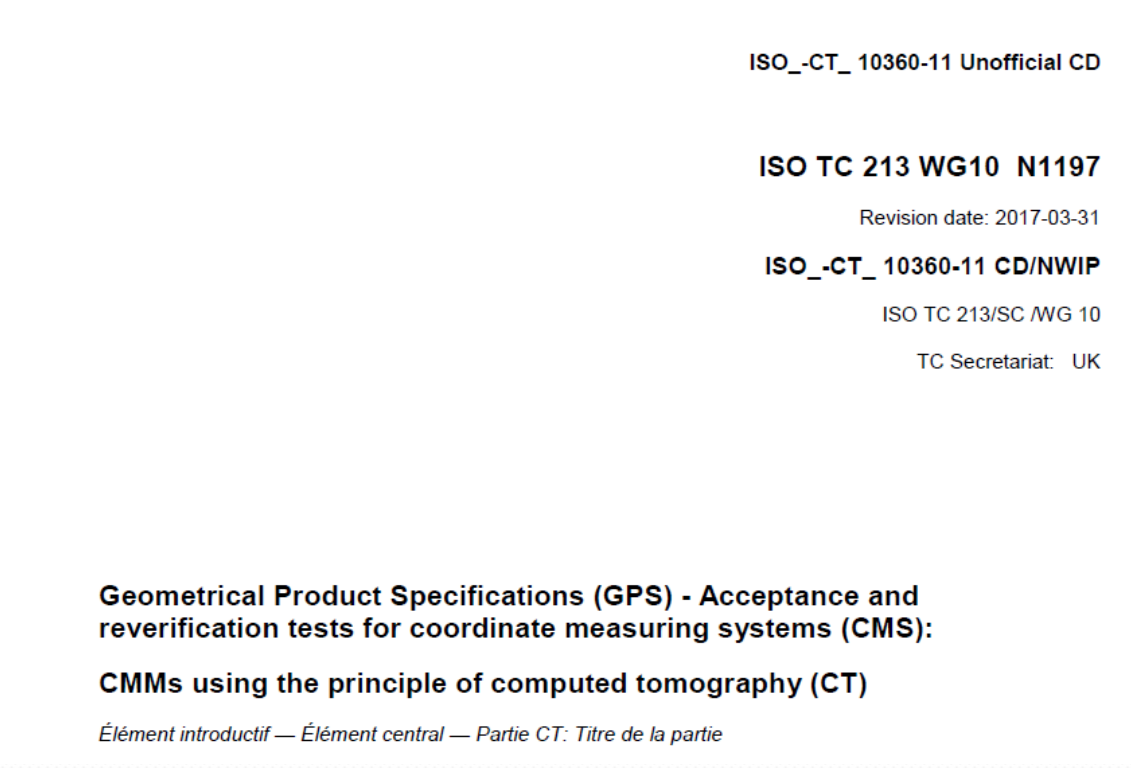
ISO 10360-11 Current state.

Unofficial ‘CD’ committee draft @ 31.3.2017



ISO_-CT_ 10360-11 Unofficial CD

ISO TC 213 WG10 N1197

Revision date: 2017-03-31

ISO_-CT_ 10360-11 CD/NWIP

ISO TC 213/SC /WG 10

TC Secretariat: UK

Geometrical Product Specifications (GPS) - Acceptance and reverification tests for coordinate measuring systems (CMS):

CMMs using the principle of computed tomography (CT)

Élément introductif — Élément central — Partie CT: Titre de la partie

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ISO-10360 Part 11 XCT.

Considerations being debated.

- Length Error~ bi-directional /unidirectional
- Probing Errors
- Operating conditions: Environment, warm up cycles, thermal stability, software used.
- Workpiece loading effects
- Measurement Volume & where in Volume?
- Measurement time
- Mono (or Multi-material)
- Materials: Considering~ Plastics; Aluminium; Steel
- How compatibility with the rest of ISO10360 parts

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ISO XCT Task force members @ July 2017

members (Some main players)

National Institute of Advanced Industrial Science and Technology

National Metrology Institute of Japan

ZEISS

PTB

Nikon

HEXAGON METROLOGY

NORTH STAR IMAGING, INC.

NSI

An ITW Company

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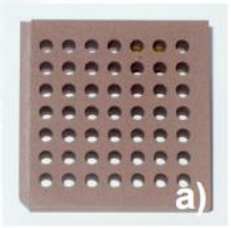
Example test samples Material Influence

Length measurement error *E* testing

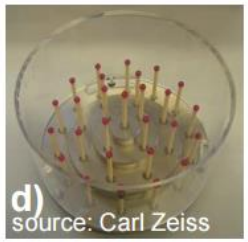
- **MPE_{Em} including material influence**; examples, implicit with internal features
  - a: hole plate
  - b: "calotte" plate
  - c: "calotte" cube



Under discussion:

Test with hole plate sufficient to show material influence?

- **MPE_{Ez} negligible material influence**
  - d: multiple sphere standards (stylus or probe forest)
  - e: stylus star



Additional measure-ments for material influence testing required (e.g. step cylinder)

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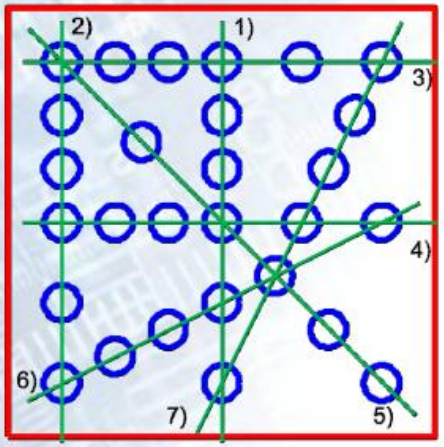
Hole plate design Material influence

New design of hole plate with 28 holes



Advantage of new design:
7 lengths measured in one setting

Size considerations for aluminum (low magnification case)

X-ray tube voltage in kV	Dimensions of square-shaped hole plate in mm			
	Side	Thickness	Diameter of holes	Material
90	18.0	3.0	1.5	Al
130	30.0	5.0	2.5	
225	48.0	8.0	4.0	
450	66.0	11.0	5.5	
600	77.0	13.0	6.0	

Size considerations for steel (high magnification case)

X-ray tube voltage in kV	Dimensions of square-shaped hole plate in mm			
	Side	Thickness	Diameter of holes	Material
90	6.0	1.0	0.5	Fe
130				
225				
450				ZrO_2
600				WC

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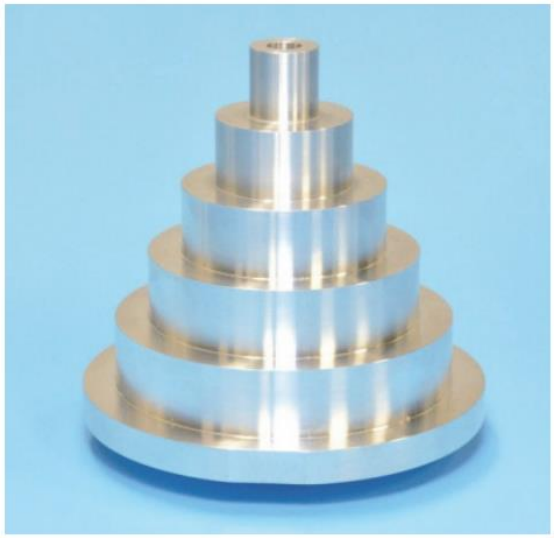
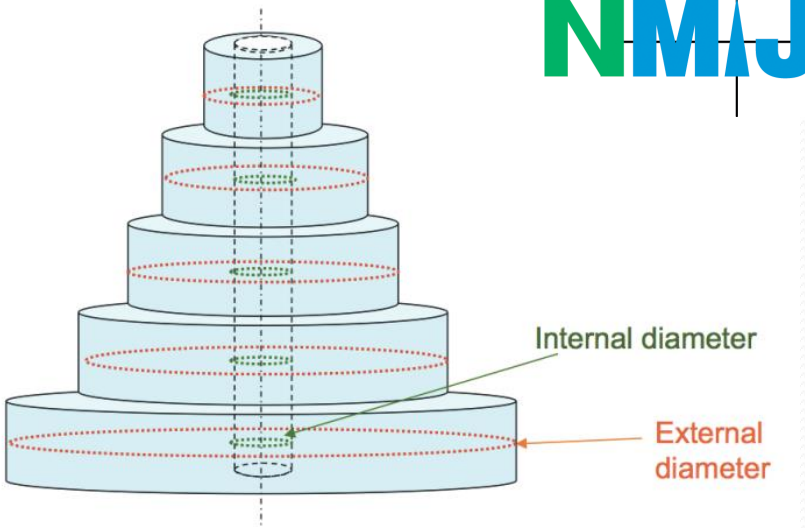
Step cylinder gauge used for assessing internal measurement capability of dimensional X-ray CT. (max dia 60mm)

(Toshiyuki Takatsuji , Makoto Abe , Hiroyuki Fujimoto NMIJ iCT Conference 2014)





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Moving forwards

- Development of draft ISO XCT document continues under joint German & Japanese chairmanship, with wide selection of international input.
- UK industry strongly encouraged to, review drafts, comment on drafts and input ideas into ISO via, the correct process, namely via BSI ~ not a wish list, but technically supported proposals.
- BSI TDW4 meets four times a year.
- BSI's XCT standards user group, meet a few times per year or as required~ you are very welcome to join.

Contact me for more information~ BSI's XCT panel chair

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