Measurement Assurance Best Practices for MTE Calibration
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Abstract
High risk technology, such as advanced space launch systems, require that measurement assurance best practices be applied to the calibration of measuring and test equipment (MTE) and end-item testing. Pursuant to this, it is important to establish that MTE calibration procedures and results support end-item testing requirements. MTE are often initially selected based on manufacturer specified performance capabilities and affordability. The key question is which MTE performance specifications should be calibrated and to what accuracy?

Emphasis is given to calibration support of MTE used for end-item acceptance or conformance testing because this is demonstrably the most important level of the calibration support hierarchy. The role of calibration in the validation and verification of MTE performance capabilities is discussed. Best practices for assuring measurement quality and reliability during MTE calibration are presented and illustrated.

Outline
Overview (slide 1)
- Motivation
- Test and Calibration Support Sequence
- Measurement Reliability
- Important Requirements
- Current Obstacles and Barriers
- Recommended Best Practices

Motivation (slide 2)
- Companies and government agencies that maintain ISO 9001 or AS9100 quality management systems must also maintain an effective measurement and testing program.
- ISO 10012:2003
    - Provides quality assurance requirements for the metrological confirmation of MTE.
    - The confirmation process must ensure that specified performance characteristics comply with the requirements of the MTEôs intended use.
- ANSI/NCSLI Z540.3-2006
    - Establishes the technical requirements for the calibration of MTE

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- The accuracy and reliability of the MTE must be in accordance with identified preformance requirements.

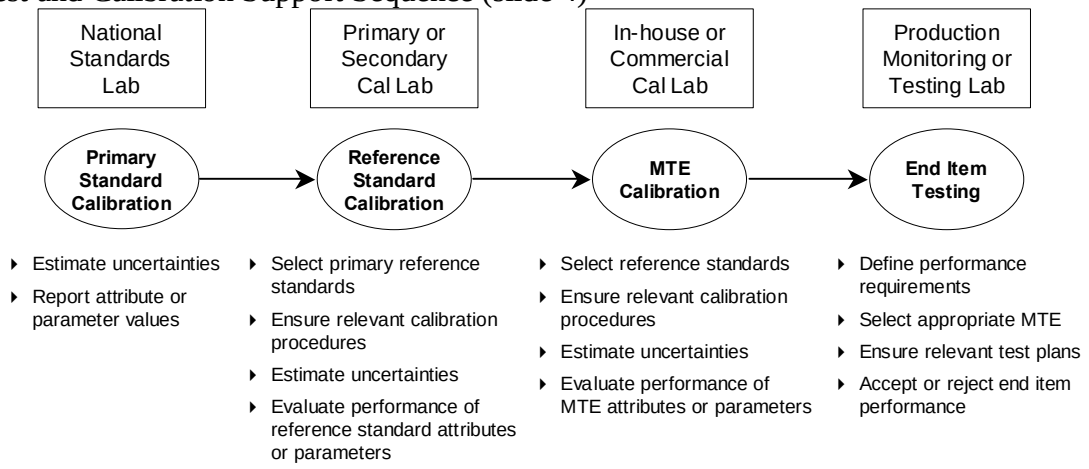
Motivation (slide 3)

- Most importantly, it makes economic sense that MTE be calibrated to meet end use requirements so that
  - There is a high probability that the MTE is in-tolerance during use.
  - Product retesting, recall or expensive corrective actions are minimized.
  - Calibration and metrology support services are aligned with real-world MTE applications such as

Concept studies
Research and development
Design and production

Operations and logistics
End item testing
End item performance monitoring

Test and Calibration Support Sequence (slide 4)



Measurement Reliability (slide 5)

- The probability that an MTE attribute or parameter is in conformance with specifications.
- Alternatively, the probability that a measurement result corresponds to a ñtrue valueò that lies within specified tolerance limits.
- A function of measurement uncertainty and tolerance limits.
- Related to successful performance.

Important Requirements (slide 6)

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- The MTE must be capable of accurately measuring the relevant end item attributes.
- The MTE must perform reliably under maximum predicted operationing conditions.
- The MTE calibration program must qualify, verify and validate performance throughout its life cycle.

Common Obstacles and Barriers (slide 7)

- MTE are often selected and purchased without consideration of the associated calibration and support costs.
- MTE users donôt see calibration as a value added process because they are unaware that their MTE attributes and parameters can drift or shift out of tolerance due to
    - extensive use or abuse
    - exposure to environmental extremes
    - shock and vibration during transport
    - improper handling or storage

Common Obstacles and Barriers (slide 8)

- Lack of communication between end users and metrology personnel regarding
    - MTE performance requirements
    - Development of relevant calibration procedures
    - Establishment of a periodic calibration schedule

Recommended Best Practices (slide 9)
MTE users

- Ensure that MTE specifications are consistent with performance requirements for intended use.
- Work with metrology personnel to develop and conduct a comprehensive acceptance testing plan to establish suitability of MTE performance during use.
- Conduct life cycle testing, if needed, to enable establish long-term MTE behavior and performance.
- Work with metrology personnel to establish calibration requirements
    - calibrate to manufacturer specs or special tolerances
    - calibration under maximum predicted operational environments
    - recalibrate after long storage
    - calibrate in-house or at commercial lab
    - accredited certificate of calibration
- Analyze and report uncertainty of measurement results

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Recommended Best Practices (slide 10)
Calibration Personnel

- Become familiar with MTE operation in end-use environment.
- Select appropriate reference standards and related calibration equipment.
- Work with end user to develop appropriate calibration procedures.
    - Sufficient tests points over range
    - Repeat measurements at select points
    - Reproducability, hysteresis
    - Environmental conditions
- Analyze and report uncertainty of calibration results.
- Establish calibration interval to control uncertainty growth.

Resources (slide 11)

- NCSLI RP-3-2007
    - Provides information on the development, validation, and maintenance of MTE calibration procedures.
    - Addresses the requirements of calibration procedures described in ANSI/NSCLI Z540.3 and ISO/IEC 17025.
- NCSLI RP-5-XXXX
    - Provides guidance for obtaining, interpreting and applying manufacturer specifications to assess MTE performance.
    - Presents recommended practices for the verification of MTE conformance to specification, including acceptance testing, periodic calibration, and other methods.

Resources (slide 12)

- NCSLI RP-1-1996, RP-12-2008, RP-18-2008
    - Analytical methods for establishing calibration intervals; estimating measurement uncertainty; and estimating and evaluating measurement decision risk.
- ASTM & ISA
    - Standards, specifications and procedures for testing various instruments and transducers.
- GIDEP (Government Industry Data Exchange Program)
    - Metrology database containing calibration procedures, technical manuals and other related documents.
- MIL-STD-810F
    - DoD test method standard for environmental engineering considerations and laboratory tests.

Antecdotal cases

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- B2 Bomber Crash ï environmental factors/effects not considered
- LECO Carbon Content (CO2 Analysis) ï cross-contamination of samples
- Thermocouple calibration ï wrong reference junction and readout device used.
- Tin Wiskers ï analysis