Optimization of calibration interval based on equipment metrological history

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**FOREWORD**

- Calibration needed to ensure traceability to the international system of units
- Periodic calibration is a tool to ensure that no significant drift has occurred during the elapsed period
- IMS often required to comply with ISO/IEC 17025
  - Periodic calibration is a tool to ensure that no significant drift has occurred during the elapsed period
- Reference dosemeters expired (fading, natural background...)
  - Cannot be used for an infinite number of time periods
- Need to balance cost, process efficiency and quality

**METHOD IMPLEMENTATION AND BASIC PRINCIPLES**

**STEP 1: DEFINITION OF DRIFT TOLERANCE**

- Relative drift tolerance: \( RT_{\text{drift}} \)
- Calibration factor output vs elapsed time
- Measurement system output quantity: \( H_p(d) \)
- Maximum permissible measurement error (VIM 4.26): \( MPME \)

\[
RT_{\text{drift}} = \text{Maximum} \left( \frac{|d| \pm 2\sigma_d}{\sigma_H p(d)} \right)
\]

- Maximum permissible measurement error not standardized for passive individual monitoring.

**STEP 2: DRIFT ASSESSMENT**

- Single measurement system
  - Calibration factor output vs elapsed time
  - Linear fit (dashed blue line): drift = slope

- Multiple equivalent measurement systems
  - Calibration factor output vs elapsed time for each reader
  - Calibration just before and just after the maintenance (ideal case)
  - Individual drift: measured for each period \( k \) and each reader \( j \) in between two maintenances:
    - Two points: linear interpolation
    - More than 2 points: linear fit
  - Drift: average of the \( d_j \) values
    \[
    \text{Drift} \equiv \text{average of the } d_j \text{ values} = \text{max}(|d| \pm 2\sigma_d)
    \]

**STEP 3: CALIBRATION PERIOD ESTIMATE**

- Definition of the (expanded) calibration period
  - Calibration just before and after the maintenance
  - \( d_j \) values from the reader calibration history
  - Linear interpolation/linear fit

**EXAMPLE OF INLIGHT READERS AR500 FOR \( H_p(10) \)**

- Method 2: Control chart
  - Prerequisite:
    - Uncertainty estimate on measured quantity
    - Uncertainty on the calibration
    - System drift measurable
    - Calibration data available

- Relative drift tolerance: \( RT_{\text{drift}} \)
  - Calibration factor output vs elapsed time
  - Measurement system output quantity: \( H_p(d) \)

- Maximum permissible measurement error (VIM 4.26): \( MPME \)

\[
RT_{\text{drift}} = \text{Maximum} \left( \frac{|d| \pm 2\sigma_d}{\sigma_H p(d)} \right)
\]

- Maximum permissible measurement error not standardized for passive individual monitoring.

- Suggestion: use maximum recommended value on equipment metrological history
  - No maintenance or maintenance period large enough to cumulate calibration factor data

- Calibration just before and just after the maintenance (ideal case)
  - Suggested interval is based on intuition

- Individual drift: measured for each period \( k \) and each reader \( j \) in between two maintenances:
  - Two points: linear interpolation
  - More than 2 points: linear fit

- Drift: average of the \( d_j \) values
  \[
  \text{Drift} \equiv \text{average of the } d_j \text{ values} = \text{max}(|d| \pm 2\sigma_d)
  \]

- Method is easy to implement and does not depend on the measurement system
- Results are obtained based on available data
- Justification of calibration period is based on metrology

- Expanded calibration period [m]: 26.9
  - Expanded calibration period [m]: 8.2
  - MPME: 30 %
  - MPME: 16 %

- Tolerated drift \( RT_{\text{drift}} \): 47 % for MPME=30 % (RP 160)
  - Tolerated drift \( RT_{\text{drift}} \): 14 % for MPME=16 %