EQUIPMENT MANAGEMENT AND CALIBRATION: DO WE KNOW ENOUGH?

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- The National Measurement System
- QA and QC of Measurement Data
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Revisit Case for Calibration

a case for calibration

G. W. Boulton, Calibration Systems Ltd

The perfect instrument is a rarity and, in general, designs are a compromise between performance, stability, cost and reliability. It is on this basis that the requirement for regular performance tests or calibration is reasonably established, leaving only the enigmatic question 'how often?' to be answered.

Efficiency equates directly to condition—in its widest definition—and is a direct function of preventive maintenance and calibration. There is no virtue in neglect, and this truism applies to electronic equipment as it does to everything else. If by omitting regular checks it is possible to save money, then there might be some justification.

However, the sad fact is that the minimum cost of work required to reproduce the original performance from neglected equipment is approximately equivalent to the cost of the total number of calibrations it should have had. Furthermore, this simple linear relationship does not apply to efficiency, which will be degenerating at a far greater rate.

A definition of calibration

The previous statement implies that calibration is more than just the application of a test to ensure that the performance is within the stated limits. This very basic minimum is immediately extended when preset adjustments are provided; it is then part of the correct procedure to reset to the best possible performance, because it is probable that the manufacturer's specifications. Ideally, to give confidence in the equipment, it is better to effect full calibration every six months, and then to determine the period by examination of the variations in the calibration results. When the equipment is not being stretched to its full capability, but is being used generously within its limits, the calibration interval may reasonably be extended to the maximum period. Other factors, such as frequency of use and environmental conditions, may reduce this period.

Total measurement capability within a company is very often not considered, and yet it can be valuable. For instance, the frequency accuracy of most r.f. generators is generally of the order of ±1%, but this parameter should never assume importance when a digital frequency meter is available, to which measurements to at least ±0·01% are commonplace; a few quick and simple tests will verify the overall performance of the equipment, and provide the user with the information on which it can be assessed.

Another useful source is calibration records, which can show the stability of the measured parameters.

Standards of calibration

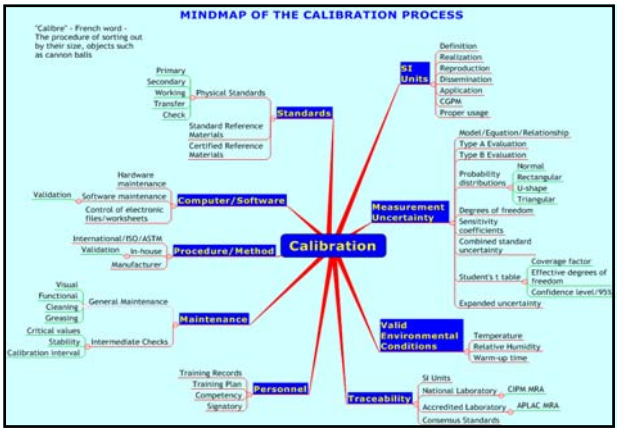
It is difficult to avoid using the hackneyed term 'trace-

Electronic Engineering January 1972

CALIBRATION

New Definition (VIM)

operation that, under specified conditions, in a first step establishes a relation between the **quantity values** with **measurement uncertainties** provided by **measurement standards** and corresponding **indications** with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a **measurement result** from an indication


MINDMAP OF THE CALIBRATION PROCESS
"Calibre" - French word - The procedure of sorting out by their size, objects such as cannon balls
Calibration
Standards
Primary
Secondary
Working
Transfer
Check
Physical Standards
Standard Reference Materials
Certified Reference Materials
SI Units
Definition
Realization
Reproduction
Dissemination
Application
CGPM
Proper usage
Computer/Software
Hardware maintenance
Validation
Software maintenance
Control of electronic files/worksheets
Measurement Uncertainty
Model/Equation/Relationship
Type A Evaluation
Type B Evaluation
Probability distributions
Normal
Rectangular
U-shape
Triangular
Degrees of freedom
Sensitivity coefficients
Combined standard uncertainty
Coverage factor
Effective degrees of freedom
Student's t table
Confidence level(95%)
Expanded uncertainty
Procedure/Method
International/ISO/ASTM
Validation
In-house
Manufacturer
Maintenance
Visual
Functional
Cleaning
Greasing
General Maintenance
Critical values
Stability
Intermediate Checks
Calibration Interval
Valid Environmental Conditions
Temperature
Relative Humidity
Warm-up time
Personnel
Training Records
Training Plan
Competency
Signatory
Traceability
SI Units
National Laboratory
CIPM MRA
Accredited Laboratory
APLAC MRA
Consensus Standards


PRECISION MANUFACTURING
Made everywhere, assembled at one place
RM 1 billion Instrument?
Significant torque measurement
Parts and components
Major structural sections of the A380 are built in France, Germany, Spain, and the United Kingdom
Components of the A380 are provided by suppliers from around the world; the five largest contributors, by value, are Rolls-Royce, SAFRAN, United Technologies, General Electric and Goodrich
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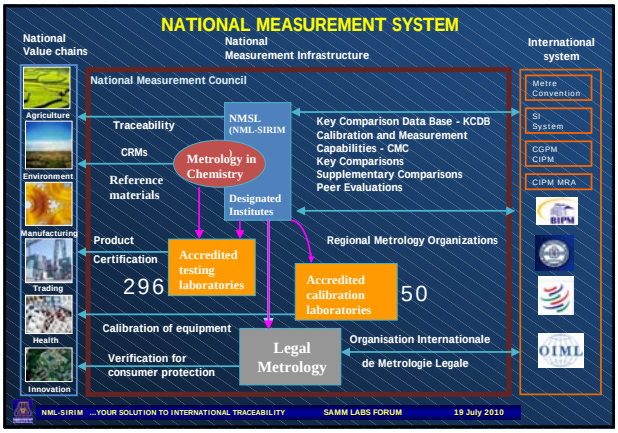
NATIONAL MEASUREMENT SYSTEM
National Value chains
National Measurement Infrastructure
International system
National Measurement Council
Agriculture
Environment
Manufacturing
Trading
Health
Innovation
Traceability
CRMs
Reference materials
Product Certification
296
Calibration of equipment
Verification for consumer protection
NMSL (NML-SIRIM
Metrology in Chemistry
Designated Institutes
Accredited testing laboratories
Accredited calibration laboratories
50
Legal Metrology
Key Comparison Data Base - KCDB
Calibration and Measurement Capabilities - CMC
Key Comparisons
Supplementary Comparisons
Peer Evaluations
Regional Metrology Organizations
Organisation Internationale de Metrologie Legale
Metre Convention
SI System
CGPM CIPM
CIPM MRA
BIPM
OIML
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Measurement in Health
Blood Pressure
Blood Analysis
Laser power
Temperature
Measurement in Trade
Weight
Dimension
Volume
Measurement in Food Safety
Antibiotics in fish and prawn
Pesticide in Tea Leaves
Measurement in Environment
Air Pollution
Noise
Solar Radiation
HC/CO Emission
Measurement for Quality of Life
Needs for CRMs
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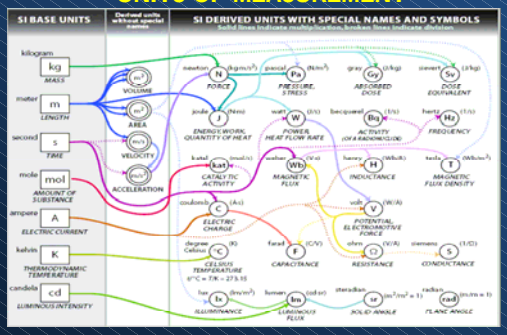
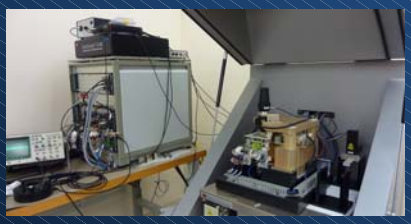
UNITS OF MEASUREMENT



Changes to the definition of some of the base units in the near future

New Capability at NML: Nanoscale Measurement



Equipment characteristic:
Range of measurement: 25 mm x 25 mm x 5 mm
Resolution: 0.1 nm
Uncertainty: < than 10 nm

Measurement Data
Quality Assurance vs. Quality Control

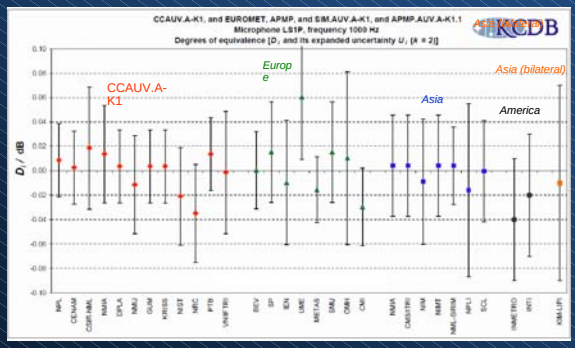
Quality Assurance

An overall management plan to guarantee the integrity of data (The "system")

Quality Control

A series of analytical measurements used to assess the quality of the analytical data (The "tools")

Comparison results in the KCDB are publicly available, ensuring the transparency of the whole CIPM MRA process.

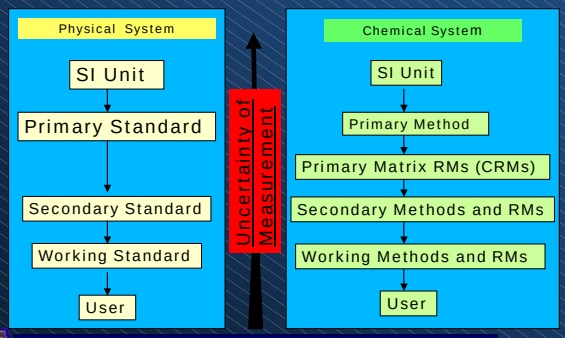


TRACEABILITY

NEW DEFINITION (VIM)

property of a **measurement result** whereby the result can be related to a stated reference through a documented unbroken chain of **calibrations,** each contributing to the **measurement uncertainty**

Traceability System for Physical and Chemical Standards

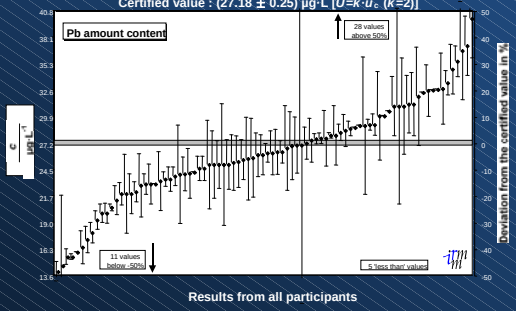


Metrology in Physics vs Chemistry

	Physics	Chemistry
Measurement	Comparing a quantity, e.g., length, time, temperature	Comparing a quantity of analyte, e.g. Melamine in milk
Units	m, s, K	mol/kg, mg/kg
Influenced by...	Often relies on direct measurements	Various factors affect the result
Major impact	Equipment calibration	Chemical treatment (e.g., extraction, digestion); reference material used; . . . equipment calibration.
Dependent on...	To a large extent "sample independent"	Strongly "Sample dependent"
Example	Length of table	Concentration of lead (Pb) in seawater, soil, or blood etc.

IMEP - 16: Pb in wine

Certified value : (27.18 ± 0.25) µg·L^{-1} [$U=k\cdot u_c$ (k=2)]

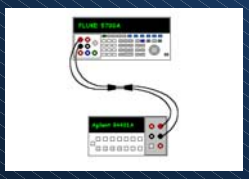


Results from all participants

SINGLE/FIXED VALUE vs MULTIVALUE TRACEABILITY







There should be one-to-one correspondence between a calibration point and its traceability

Otherwise, creation of complicated path which is difficult to prove

MANAGING CALIBRATION INTERVALS

Data obtained from calibration and metrological confirmation histories, and advancing knowledge and technology, may be used for determining calibration intervals.

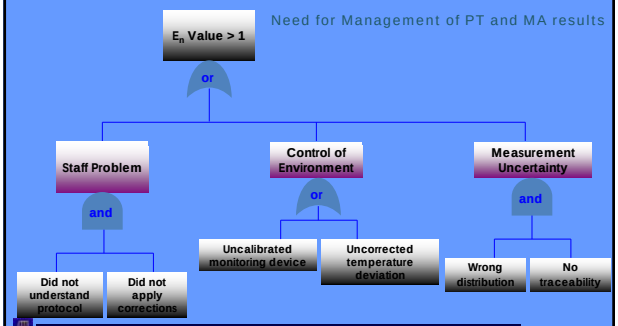
Records obtained using statistical process control techniques for measurements can be useful in determining whether or not to modify calibration intervals

METHODS OF REVIEWING CALIBRATION INTERVALS

1. Automatic adjustment or "staircase" (calendar-time)
2. Control chart (calendar-time)
3. "In-use" time
4. In service checking
5. Other statistical approaches (plus software tools)

CAUSE AND EFFECT TREE FOR UNSATISFACTORY MEASUREMENT RESULTS

Need for Management of PT and MA results



The Way Forward for Calibration Field

- 4-column format for Scope of Accreditation to enhance laboratory information
- CMC should be used. CMC is equivalent to BMC.
- Long-term analysis of measurement uncertainty versus short-term analysis (Calibration time does not represent actual performance of the equipment)
- One-to-one correspondence of calibration points with traceability
- Equipment management should go beyond calibration requirement only
  - Intermediate checks data should be a source of new knowledge, trend analysis
  - Use of pooled data for similar devices
  - Statistical analysis of collected data

THANK YOU

THANK YOU

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GOOD LUCK IN YOUR MEASUREMENT!