ACCREDITATION SCHEME FOR LABORATORIES

Technical Notes MET 001

Specific Requirements for Calibration and Measurement Laboratories

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1.0 Introduction

1.1 Accreditation for calibration work is not restricted to high precision instruments. It can be obtained for comparatively large measurement uncertainties if this is appropriate for the work being done by the laboratory.

1.2 This technical note is to be considered in conjunction with the document. SAC 01, “Terms and Conditions for Accreditation”; SAC-SINGLAS 002, “ Requirements for the Application of ISO/IEC 17025” and “ISO/IEC 17025 - General Requirements for the Competence of Testing and Calibration Laboratories". It highlights critical aspects in the area of calibration but is not intended to be a complete checklist.

2.0 Definition of Terms

The definitions given below are extracted from International Vocabulary of Metrology - Basic and General Concepts and associated terms (VIM), 3rd Edition, JCGM 200:2008 [1].

2.1 *Reference quantity value*
Quantity value used as a basis for comparison with values of quantities of the same kind

NOTE 1 A reference quantity value can be a true quantity value of a measurand, in which case it is unknown, or a conventional quantity value, in which case it is known.

NOTE 2 A reference quantity value with associated measurement uncertainty is usually provided with reference to
a) a material, e.g. a certified reference material,
b) a device, e.g. a stabilized laser,
c) a reference measurement procedure,
d) a comparison of measurement standards.

2.2 *Calibration*
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

NOTE 1 A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

NOTE 2 Calibration should not be confused with adjustment of a measuring system, often mistakenly called “self-calibration”, nor with verification of calibration.

NOTE 3 Often, the first step alone in the above definition is perceived as being calibration.

2.3 *Verification*

Provision of objective evidence that a given item fulfils specified requirements

NOTE 1 When applicable, measurement uncertainty should be taken into consideration.

NOTE 2 The item may be, e.g. a process, measurement procedure, material, compound, or measuring system.

NOTE 3 The specified requirements may be, e.g. that a manufacturer's specifications are met.

NOTE 4 Verification in legal metrology, as defined in VIML[53], and in conformity assessment in general, pertains to the examination and marking and/or issuing of a verification certificate for a measuring system.

NOTE 5 Verification should not be confused with calibration. Not every verification is a validation.

NOTE 6 In chemistry, verification of the identity of the entity involved, or of activity, requires a description of the structure or properties of that entity or activity.

2.4 *Validation*

Verification, where the specified requirements are adequate for an intended use

2.5 *Adjustment of a measuring system*

Set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

NOTE 1 Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

NOTE 2 Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

NOTE 3 After an adjustment of a measuring system, the measuring system must usually be recalibrated.

2.6 *Correction*

Compensation for an estimated systematic effect

NOTE 1 See ISO/IEC Guide 98-3:2008, 3.2.3, for an explanation of ‘systematic effect’.

NOTE 2 The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

2.7 *Measurement Error*
Error of measurement
Measured quantity value minus a reference quantity value

NOTE 1 The concept of 'measurement error' can be used both

a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the measurement error is known, and

b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

NOTE 2 Measurement error should not be confused with production error or mistake.

2.8 *Measurement Precision*
Closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions

NOTE 1 Measurement precision is usually expressed numerically by measures of imprecision, such as standard deviation, variance, or coefficient of variation under the specified conditions of measurement.

NOTE 2 The 'specified conditions' can be, for example, repeatability conditions of measurement, intermediate precision conditions of measurement, or reproducibility conditions of measurement (see ISO 5725-3:1994).

NOTE 3 Measurement precision is used to define measurement repeatability, intermediate measurement precision, and measurement reproducibility.

NOTE 4 Sometimes "measurement precision" is erroneously used to mean measurement accuracy.

2.9 *Measurement Accuracy*
Closeness of agreement between a measured quantity value and a true quantity value of a measurand

NOTE 1 The concept 'measurement accuracy' is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

NOTE 2 The term "measurement accuracy" should not be used for measurement trueness and the term measurement precision should not be used for 'measurement accuracy', which, however, is related to both these concepts.

NOTE 3 'Measurement accuracy' is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.

2.10 *Instrumental Drift*

Continuous or incremental change over time in indication, due to changes in metrological properties of a measuring instrument

NOTE Instrumental drift is related neither to a change in a quantity being measured nor to a change of any recognized influence quantity.

2.11 *Resolution*

Smallest change in a quantity being measured that causes a perceptible change in the corresponding indication

NOTE Resolution can depend on, for example, noise (internal or external) or friction. It may also depend on the value of a quantity being measured.

2.12 *Metrological Traceability*

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

NOTE 1 For this definition, a 'reference' can be a definition of a measurement unit through its practical realization, or a measurement procedure including the measurement unit for a non-ordinal quantity, or a measurement standard.

NOTE 2 Metrological traceability requires an established calibration hierarchy.

NOTE 3 Specification of the reference must include the time at which this reference was used in establishing the calibration hierarchy, along with any other relevant metrological information about the reference, such as when the first calibration in the calibration hierarchy was performed.

NOTE 4 For measurements with more than one input quantity in the measurement model, each of the input quantity values should itself be metrologically traceable and the calibration hierarchy involved may form a branched structure or a network. The effort involved in establishing metrological traceability for each input quantity value should be commensurate with its relative contribution to the measurement result

NOTE 5 Metrological traceability of a measurement result does not ensure that the measurement uncertainty is adequate for a given purpose or that there is an absence of mistakes.

NOTE 6 A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the quantity value and measurement uncertainty attributed to one of the measurement standards.

NOTE 7 The ILAC considers the elements for confirming metrological traceability to be an unbroken metrological traceability chain to an international measurement standard or a national measurement standard, a documented measurement uncertainty, a documented measurement procedure, accredited technical competence, metrological traceability to the SI, and calibration intervals (see ILAC P-10:2002).

NOTE 8 The abbreviated term "traceability" is sometimes used to mean 'metrological traceability' as well as other concepts, such as 'sample traceability' or 'document traceability' or 'instrument traceability' or 'material traceability', where the history ("trace") of an item is meant. Therefore, the full term of "metrological traceability" is preferred if there is any risk of confusion.

2.13 *National Measurement Standard*
Measurement standard recognized by national authority to serve in a state or economy as the basis for assigning quantity values to other measurement standards for the kind of quantity concerned

2.14 *Primary Measurement Standard*
Measurement standard established using a primary reference measurement procedure, or created as an artifact, chosen by convention

2.15 *Secondary Measurement Standard*
measurement standard established through calibration with respect to a primary measurement standard for a quantity of the same kind

NOTE 1 Calibration may be obtained directly between a primary measurement standard and a secondary measurement standard, or involve an intermediate measuring system calibrated by the primary measurement standard and assigning a measurement result to the secondary measurement standard.

NOTE 2 A measurement standard having its quantity value assigned by a ratio primary reference measurement procedure is a secondary measurement standard.

2.16 *Reference Measurement Standard*
Measurement standard designated for the calibration of other measurement standards for quantities of a given kind in a given organization or at a given location

2.17 *Working Measurement Standard*
Measurement standard that is used routinely to calibrate or verify measuring instruments or measuring systems

NOTE 1 A working measurement standard is usually calibrated with respect to a reference measurement standard.

NOTE 2 In relation to verification, the terms “check standard” or “control standard” are also sometimes used.

3.0 Measurement Standards and Equipment

3.1 All measurement standards and equipment shall meet the requirements of the calibration method and/or shall be capable of meeting the measurement uncertainties nominated by the laboratory for the purposes of accreditation.

3.2 The laboratory shall ensure that its equipment is suitable for the purpose for which it is used and that its suitability for that purpose is maintained throughout its working life.

3.3 Calibration is only one element of the laboratory's responsibility for its equipment and by itself is not an adequate assurance of measurement accuracy. This overall responsibility for equipment encompasses its selection, its installation, its maintenance and intermediate checks between successive calibration as well as proper operation of the equipment.

3.4 Accuracy ratio is the ratio of the accuracy of the measurement standards to the accuracy of the equipment under test. Generally, the accuracy ratio is targeted between 4:1 and 10:1 but with a minimum of 2:1, wherever possible.

4.0 Traceability of Measurement [3]

4.1 The elements of traceability are characterised by:

a) an unbroken chain of comparisons – going back to stated references acceptable to the parties, usually a national or international standard;

b) uncertainty of measurement – the uncertainty of measurement for each step in the traceability chain must be calculated or estimated according to agreed methods and must be stated so that an overall uncertainty for the whole chain may be calculated or estimated;

Note: The measurement uncertainty for each step in the traceability chain shall be evaluated according to the ISO “Guide to the Expression of Uncertainty in Measurement “ (GUM).

c) documentation - each step in the chain must be performed according to documented and generally acknowledged procedures; the results must be recorded;

d) competence - the laboratories or bodies performing one or more steps in the chain must supply evidence for their technical competence (e.g. by demonstrating that they are accredited);

e) reference to SI units – the chain of comparisons must, where possible, end at primary standard for the realisation of the SI units.

f) calibration intervals - calibrations must be repeated at appropriate intervals; the length of these intervals will depend on a number of variables, (eg. uncertainty required, frequency of use, way of use, stability of the equipment).

5 Calibration Intervals

5.1 All new quantitative measuring instruments and measurement standards shall be calibrated before being put into service.

5.2 Measuring instruments and measurement standards in a calibration system shall be calibrated at intervals established on the basis of their stability, purpose, environment and degree of usage.

5.3 The maximum calibration interval determined from at least three earlier calibrations shall indicate that the measurement standard is stable.

5.4 The frequency of calibration of each of this equipment shall be such as to establish reasonable confidence that the limits of specification between successive calibrations are not exceeded.

5.5 Calibration intervals should not exceed the maximum period specified by the accreditation body as indicated in Appendix A, Recommended Calibration Intervals. However, laboratories may choose to exceed the recommended maximum intervals provided that substantial past calibration records and evaluation have proven the calibration intervals could be extended without increasing risk of instruments being out of specification.

5.6 In the event, where laboratory require the techniques to extend or reduce their calibration interval, reference may be made to ILAC G24, Guidelines for the determination of calibration intervals of measuring instruments.

6.0 Calibration Labelling

6.1 All measurement standards and measuring equipment shall be labelled, coded or otherwise identified to indicate their calibration status, i.e. the date of last calibration and the next calibration date.

6.2 Any limitation of calibration or restriction of use shall be clearly indicated on the equipment.

6.3 When neither labelling nor coding is practicable, or is not considered essential for control purposes, other procedures shall be established to ensure conformance to these requirements.

7.0 Sealing for Integrity

7.1 Access to adjustable devices on measurement standards and measuring equipment, which are fixed at the time of calibration, shall be sealed or otherwise safeguarded to prevent tampering by unauthorised personnel.

7.2 Seals shall be designed so that tampering will destroy them.

NOTE: This requirement does not apply to adjustable devices that are intended to be set by the user without needing external references.

8.0 Environment

8.1 Measuring equipment and measurement standards shall be calibrated and used in an environment adequately controlled for the intended purpose. Due consideration shall be given to temperature, rate of change of temperature, humidity, vibration, dust control, cleanliness, electromagnetic disturbance, interference, lighting and other factors affecting measurement.

8.2 When pertinent, factors affecting calibration shall be continuously monitored and recorded, and when necessary, compensating corrections shall be applied to the measurement data. Records shall contain both the original and the corrected data.

9.0 Use of Measurement Standards

9.1 Measuring equipment can be used as calibration standards when there are means for thoroughly checking linearity and accuracy on a long and short term basis, or even immediately prior to each use if necessary, with an adequate alternative device or standard.

9.2 A measurement standard or equipment to be calibrated externally should be checked on its performance before being sent away and after it arrived back, with another equipment which stays at the "home" laboratory. This is to be done to establish whether there is any change due to the transport of the equipment which was being calibrated externally.

10.0 Computerised Calibration System

10.1 The equipment shall be satisfactory for its intended purpose. The adequacy of the equipment will be determined by the accuracy and speed of making the reading.

10.2 The system shall be satisfactory calibrated. If the measuring equipment cannot be isolated from the data processing system, the system as a whole shall be calibrated either statically or dynamically. If the measuring equipment can be isolated from the data processing system, the equipment can be calibrated in the conventional manner and a separate verification of the data processing system can be undertaken.

10.3 The data processing system shall maintain the original integrity of the measured data. The limiting factor on the precision of the numbers which the data processing system can handle must be taken into account.

10.4 The data processing system shall allow for the detection of errors in data input and the monitoring of the progress of the calibration.

10.5 The system shall be capable of being checked for error-free operation with respect to data capture, data processing and freedom from sources of external interference. This check shall be determined by manual check or by a set of artefact data, etc.

11.0 Calibration Reports

11.1 Measurement Uncertainty

11.1.1 In developing the measurement uncertainty evaluation, the laboratory shall refer to the international document "Guide to the Expression of Uncertainty in Measurement" (GUM). A simpler version on the concept of measurement uncertainty to suit the local industries needs has been collated in SINGLAS Technical Guide 1[5].

11.1.2 All measurement uncertainty evaluation shall be documented with the mathematical models.

11.2. Compliance Statement

11.2.1 As required in ISO/IEC 17025 clause 5.10.4.2, when statement of compliance is made, the uncertainty of measurement shall be taken into consideration. The approach of stating the compliance statement is to be made reference to ILAC G8:03/2009, Guidelines on the Reporting of Compliance with Specification.

11.2.2 When a specification describes an interval with an upper and lower limit, a statement of compliance or non-compliance should only be made where the ratio of the expanded uncertainty interval to the specified interval is reasonably small and fit for purpose (meaning that the laboratory should be able to meet the needs of the customer).

References:

1 International Vocabulary of Metrology - Basic and General Concepts and associated terms (VIM), 3rd Edition, JCGM 200:2008.

2 ILAC G8:03/2009, Guidelines on the Reporting of Compliance with Specification

3 ILAC-P10:2002, ILAC Policy on Traceability of Measurement Results.

4 ILAC G24 :2007, Guidelines for the determination of calibration intervals of measuring instruments

5. SAC-SINGLAS Technical Guide 1, Guidelines on the Expression and Evaluation of Measurement Uncertainty, second edition, March 2001

APPENDIX A

RECOMMENDED CALIBRATION INTERVALS

A.1 The following table sets out nominal maximum periods between successive calibrations for a number of reference standards and measuring instruments. It must be stressed that these periods are generally considered to be the maximum appropriate in each case providing that the other criteria as specified below are met:

(a) that the equipment is of good quality and proven adequate stability, and

(b) that the laboratory has both the equipment capability and staff expertise to perform adequate intermediate checks, and

(c) that if any suspicion or indication of overloading or mishandling arises the equipment will be checked immediately and thereafter at fairly frequent intervals until it can be shown that stability has not been impaired.

A.2 Where the above criteria cannot be met appropriately, shorter intervals shall be specified.

A.3 The list of standards and measuring instruments is by no means exhaustive, and will be updated periodically.

TYPE OF EQUIPMENT	RECOMMENDED MAX PERIOD BETWEEN SUCCESSIVE CALIBRATIONS
MECHANICAL	
Masses	
i) Reference	Three years
ii) Working	One year
Balances	
i) Electronic	One year with monthly single point check at full scale.
ii) Analytical	One year with monthly single point check at full scale.
Deadweight Pressure Tester (piston cylinder unit and stainless steel mass set)	
i) Oil pressure deadweight tester	Three years
ii) Gas pressure deadweight tester	Two years
Test Gauge for calibrating Pressure Gauge	Six months

TYPE OF EQUIPMENT	RECOMMENDED MAX PERIOD BETWEEN SUCCESSIVE CALIBRATIONS
Strain Gauge Transducer	One year or less
Torque	
i) Masses	One year or less
ii) Length Beam	Two years or less
Flow (Gas / Liquid)	One year
Acoustic	One year
Volumetric	One year or less
Force (Load Cells)	One year or less
DIMENSIONAL	
Angle Gauges	
Reference	Five years
Working	One year
Gauge Blocks	
i) Reference	Five years
ii) Working	One year
Calipers	One year
Comparators	
Optical Comparators	Two years
Optical Microscope	Two years
Dial Gauges	One year
Digital Instruments	One year
Height Gauges	
Height Setting Micrometers and Riser Block	Three years
Digital Height Gauges	One year
Vernier Height Gauges	One year
Length Bars	
Reference	Three years
Working	One year

TYPE OF EQUIPMENT	RECOMMENDED MAX PERIOD BETWEEN SUCCESSIVE CALIBRATIONS
<u>Linear Scales</u>	
Glass Scales	Three years
Stage Micrometer	Three years
Steel Rules	One year
Micrometers	Three years
Optical Flats/parallels	Three years
<u>Squares</u>	
Cylinder Square	Three years
Block Square	Three years
Try Square	Two years
Granite Surface Plates	Three years
ELECTRICAL	
<u>DC / LF</u>	
Bridges	Three years (full calibration) Check against laboratory standards annually.
Capacitors	Three years. Compare annually.
Digital meters	One year
Electronic Standard Cells	One year
Resistors	Three years. Compare annually.
Frequency Oscillator	One year
<u>RF / Microwave</u>	
Attenuators	Three years (frequency response) Resistance check annually where appropriate.
RF Power measuring equipment	One year
Signal Generators	One year

TYPE OF EQUIPMENT	RECOMMENDED MAX PERIOD BETWEEN SUCCESSIVE CALIBRATIONS
TEMPERATURE	
Dry Block	One year
Hygrometer	Six months to one year, depending on the stability.
Radiation Thermometer	One year
Thermocouples :	
i) Rare metal, reference for use below 1000°C	100 hours use or three years, whichever is earlier.
ii) Rare metal, reference for use above 1000°C	10 hours use or three years, whichever is earlier.
iii) Rare metal, working	100 hours use or three years.
iv) Base metal, working	One year if use below 300 °C. For above 300 °C, recalibration of base metal thermocouple is generally not recommended. Replace, rather than a recalibration, the used thermocouple with a calibrated thermocouple.
v) Stored reels	10 years, calibrate 3 samples of wire from end points and middle of reel.
Resistance Thermometer	One year, ice point to be checked before use.
PHOTOMETRY	
Luminous intensity lamps	One year
Luminous flux lamps	One year
Illuminance (lux) meters	One year
Luminance meters	One year

TYPE OF EQUIPMENT	RECOMMENDED MAX PERIOD BETWEEN SUCCESSIVE CALIBRATIONS
RADIOMETRY	
Spectral Irradiance lamps	100 hours burning time or three years, whichever is earlier.
UV irradiance meters	Six months (heavy usage). One year (light usage).
Laser/optical power meters	One year
Fibre optic power meters	One year
Laser wavelength (fibre optic)	One year
SPECTROPHOTOMETRY	
Wavelength standard filters	One year
Transmittance standard filters	One year
Reflectance standards	One year