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Policy on Calibration and Measurement Capability (CMC) and Measurement Uncertainty in Calibration

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1. INTRODUCTION

ISO/IEC 17025: 2017 requires calibration and testing laboratories to have and apply procedures for the evaluation of measurement uncertainty. ISO 15195 and ISO 17034 have similar requirements for reference measurement laboratories and reference material producers. Specific guidance on the evaluation of measurement uncertainty can be found in the ISO/IEC Guide 98-3:2008 - "Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995)". This Guide establishes general rules for evaluating and expressing uncertainty in measurement that can be followed in broad spectrum of physical and chemical measurements. This Guide also describes an unambiguous and harmonized way of evaluating and stating the uncertainty of measurement results obtained in testing and calibration laboratories.

In order to enhance the harmonization in the expression of uncertainty of measurement on calibration certificates and on scope of accreditation of calibration laboratories, ILAC has published a policy document ILAC P14: 09/2020 "ILAC Policy for Measurement Uncertainty in Calibration". ILAC and BIPM have also agreed to harmonize the terminology namely the "Best Measurement Capability (BMC)" used on scopes of accreditations of calibration laboratories in line with the "Calibration and Measurement Capability (CMC)" of the Appendix C of the KCDB (Key Comparison Data Base) of CIPM MRA used to indicate the capabilities of National Metrology Institutes.

2. SCOPE

This document sets forth the NABL policy regarding the requirements for the:

2.1 Evaluation of the calibration and measurement capability (CMC), which forms part of scope of accreditation of calibration laboratories

2.2 Evaluation of uncertainty of measurement in calibration and measurement

2.3 Reporting of measurement uncertainty on the certificates of calibration and measurement.

The document is in line with ILAC-P14:09/2020 'ILAC Policy for Measurement Uncertainty in Calibration'.

3. TERMS AND DEFINITIONS

For the purpose of this document, the relevant terms and definitions given in ISO/IEC Guide 99:2007 - International vocabulary of metrology - Basic and general concepts and associated terms (VIM) and the following apply:

3.1 **Calibration Laboratory**

In this policy, "calibration laboratory" further means a laboratory that provides calibration and measurement services.

3.2 **Calibration and Measurement Capability**

In the context of the CIPM MRA and ILAC Arrangement, and in compliance with the CIPM-ILAC Common Statement, the following definition is agreed upon:

3.2.1 A CMC is a calibration and measurement capability available to customers under normal conditions:

a) As described in the laboratory's scope of accreditation granted by a signatory to the ILAC Arrangement; or

b) As published in the BIPM key comparison database (KCDB) of the CIPM MRA.

3.3 **Best Existing Device**

Best Existing Device is understood as a device to be calibrated that is commercially or otherwise available for customers, even if it has a special performance (stability) or has a long history of calibration.

Note: Under a CMC, the measurement or calibration should be:

- *performed according to a documented procedure and have an established uncertainty budget under the management system of the NMI or the accredited laboratory;*
- *performed on a regular basis (including on demand or scheduled for convenience at specific times in the year); and*
- *available to all customers*

4. POLICY ON EVALUATION OF MEASUREMENT UNCERTAINTY

As per NABL policy, all accredited calibration laboratories shall evaluate and report the measurement uncertainty of all calibrations covered by their scope of accreditation. Guidance on evaluation of measurement uncertainty is given in NABL document NABL 141 'Guidelines for Estimation and Expression of Uncertainty in Measurement'.

5. POLICY ON SCOPES OF ACCREDITATION OF CALIBRATION LABORATORIES

5.1 The scope of accreditation of an accredited calibration laboratory shall include the calibration and measurement capability (CMC) expressed in terms of:

5.1.1 Measurand or Reference Material;

5.1.2 Calibration or Measurement Method or Procedure and type of instrument or material to be calibrated or measured;

5.1.3 Measurement range and additional parameters where applicable, e.g., frequency of applied voltage;

5.1.4 Measurement uncertainty (presented in the same unit as that of the measurand or in a term relative to the measurand e.g. percent).

Note: The SI units of measurements shall be used in the calibration certificates / reports. Whenever it is required to be reported in non SI unit, in such cases values in SI units are also to be reported along with.

5.2 There shall be no ambiguity on the expression of the CMC on the scopes of accreditation and, consequently, on the smallest measurement uncertainty that can be expected to be achieved by a laboratory during a calibration or a measurement.

5.3 Care should be taken when the measurand covers a value or a range of values. This shall generally be achieved through employing one or more of the following methods for expression of the measurement uncertainty:

5.3.1 A single value, which is valid throughout the measurement range.

5.3.2 A measurement range. In this case the calibration laboratory shall ensure that linear interpolation is appropriate in order to find the uncertainty at intermediate values.

Note:

i. The recommended ranges shall be split on the basis of capability of the reference standard(s)/master(s) used and different methods/procedures adopted by the laboratory. It is preferably advisable to split ranges to ensure linear relationship between CMC ranges and measurement ranges of the parameter.

ii. *Wherever linearity is not feasible in a range, it is recommended that the other form of regression equation (i.e. polynomial, exponential) can be used. However, in all the cases, a more conservative fit should be applied by correcting the best fit equation. Or else uncertainties at those points may be specified separately for the relevant part of the range.*

5.3.3 An explicit function of the measurand and/or a parameter.

5.3.4 A matrix where the values of the uncertainty depend on the values of the measurand and additional parameters.

5.3.5 A graphical form, providing there is sufficient resolution on each axis to obtain at least two significant digits for the uncertainty.

Open intervals ((example 1) "0 < U < x", or (example 2) for a resistance interval of 1 to 100 ohms, the uncertainty stated as "less than 2 μΩ/Ω") are incorrect in the expressions of CMCs.

5.4 The uncertainty covered by the CMC shall be expressed as the expanded uncertainty having a coverage probability of approximately 95%. The unit of the uncertainty shall always be the same as that of the measurand or in a term relative to the measurand. e.g., percent, μV/V or part per 10^6. Because of the ambiguity of definitions, the use of terms "PPM" and "PPB" are not acceptable.

5.5 Calibration laboratories shall provide evidence that they can provide calibrations to customers in compliance with 5.1.2 so that measurement uncertainties equal those covered by the CMC. In the formulation of CMC, laboratories shall include the performance of the "best existing device" which is available for a specific category of calibrations. To demonstrate the competence, the laboratory shall choose a "best existing device" as a DUC (Device Under Calibration).

5.6 A reasonable amount of contribution to uncertainty from repeatability shall be included and contributions due to reproducibility should be included in the CMC uncertainty component, when available. There should, on the other hand, be no significant contribution to the CMC uncertainty component attributable to physical effects that can be ascribed to imperfections of even the best existing device under calibration or measurement.

Note -

i. *When it is possible that the best existing device can have a contribution to uncertainty from repeatability equal to zero, this value may be used in the evaluation of the CMC. However other fixed uncertainties associated with the best existing device shall be included.*

ii. *Reasonable amount of contribution to uncertainty from repeatability generally means the repeatability in a short span of time. If any part of the repeatability is not to be taken, it should be supported by*

Technical justification.

iii. *Reasonable amount of contribution to uncertainty from reproducibility is to be taken where necessary and asked by the Standard method.*

iv. *Wherever possible and identifiable, Imperfection of best existing devices like hysteresis, relative accuracy etc. are not to be taken directly. However, Type A (Repeatability) can not considered as imperfection in this context.*

v. *The resolution of Device to be considered when reading the variations in observations on DUC; in cases where variations are read on reference standard; the resolution of reference standard to be considered.*

vi. *It is recognized that for some calibrations a "best existing device" does not exist and/or contributions to the uncertainty attributed to the device significantly affect the uncertainty. If such contributions to uncertainty from the device can be separated from other contributions, then the contributions from the device may be excluded for arriving at CMC figure. For such case, however, the scope of accreditation shall clearly identify that the contributions to the uncertainty from the device are excluded while evaluating CMC figures. (The above case is generally applicable to higher end calibration where Reference standard better than DUC does not normally exist.)*

5.7 Where laboratories offer services such as reference value provision, the uncertainty covered by the CMC shall include factors related to the measurement procedure as it will be carried out on a sample, i.e., typical matrix effects, interferences, etc. shall be considered. The uncertainty covered by the CMC will not generally include contributions arising from the instability or inhomogeneity of the material. The CMC shall be based on an analysis of the inherent performance of the method for typical stable and homogeneous samples.

Note: The uncertainty described by the CMC for the reference value measurement is not identical with the uncertainty associated with a reference material provided by a reference materials producer. The expanded uncertainty of a certified reference material will in general be higher than the uncertainty described by the CMC of the reference measurement on the reference material.

5.8 For the applicant laboratories, during the final assessment, the CMCs will be based on the actual representative demonstration during the assessment.

In subsequent assessments however, the laboratory may apply for better CMCs. Such CMCs may be considered:

a) Either based on records of the past routine calibrations done by the laboratory provided the laboratory has evidence for eg. by using either better reference standard, appropriate environmental control and performing calibration using best existing device.

b) based on the actual demonstration.

However, in the former case, the laboratory shall demonstrate the practice and process followed with any available device.

6. POLICY ON STATEMENT OF MEASUREMENT UNCERTAINTY ON CALIBRATION CERTIFICATES

6.1 ISO/IEC 17025:2017 requires calibration laboratories to report, in the calibration certificate, the measurement uncertainty of the measurement result in the same unit as that of the measurand or in a term relative to the measurand (e.g. percent) and a statement identifying how the measurements are metrologically traceable.

Accredited calibration laboratories shall report the measurement uncertainty, in compliance with GUM and with the requirements in 6.2 to 6.5 of this section.

6.2 The measurement result shall include the measured quantity value y and the associated expanded uncertainty U. In calibration certificates the measurement result should be reported as y ± U associated with the units of y and U. Tabular presentation of the measurement result may be used and the relative expanded uncertainty U / |y| may also be provided if appropriate. The coverage factor and the coverage probability shall be stated on the calibration certificate. To this an explanatory note shall be added, which may have the following content:

"The reported expanded measurement uncertainty is stated as the standard measurement uncertainty multiplied by the coverage factor k such that the coverage probability corresponds to approximately 95 %."

Note: For asymmetrical uncertainties other presentations than y ± U may be needed. This concerns also cases when uncertainty is determined by Monte Carlo simulations (propagation of distributions) or with logarithmic units.

6.3 The numerical value of the expanded uncertainty shall be given to, at most, two significant digits.

6.3.1 Where the measurement result has been rounded, that rounding shall be applied when all calculations have been completed; resultant values may then be rounded for presentation the numerical value of the measurement result shall in the final statement be rounded to the least significant digit in the value of the expanded uncertainty assigned to the measurement result.

6.3.2 For the process of rounding, the usual rules for rounding of numbers shall be used, subject to the guidance on rounding provided i.e. in ISO/IEC Guide 98-3:2008 - Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995).

Note: For further details on rounding, see the GUM and ISO 80000-1:2009

6.4 Contributions to the uncertainty stated on the calibration certificate shall include relevant short-term contributions during calibration and contributions that can reasonably be attributed to the customer's device. Where applicable the uncertainty shall cover the same contributions to uncertainty that were included in evaluation of the CMC uncertainty component, except that uncertainty components evaluated for the best existing device shall be replaced with those of the customer's device. Therefore, reported uncertainties tend to be larger than the uncertainty covered by the CMC. Contributions that cannot be known by the laboratory, such as transport uncertainties, should normally be excluded in the uncertainty statement. If, however, a laboratory anticipates that such contributions will have significant impact on the uncertainties attributed by the laboratory, the customer should be notified according to the general clauses regarding tenders and reviews of contracts in ISO/IEC 17025.

6.5 As the definition of CMC implies, accredited calibration laboratories shall not report a smaller uncertainty of measurement than the uncertainty of the CMC for which the laboratory is accredited. *It is further emphasized that the uncertainty smaller than CMC shall not be reported in any form.*

6.6 As required in ISO/IEC 17025, accredited calibration laboratories shall present the measurement uncertainty in the same unit as that of the measurand or in a term relative to the measurand (e.g. percent).

Note: The SI units of measurements shall be used in the calibration certificates / reports. Whenever it is required to be reported in non SI unit, in such cases values in SI units are also to be reported along with.

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