**PNAC POLICY ON MEASUREMENT UNCERTAINTY IN CALIBRATIONS**

1. **Purpose**

This policy outlines the requirements of PNAC to meet requirement of ISO/IEC 17025 in calibration laboratories.

1. **Scope**

This policy is applicable to all calibration labs seeking accreditation / accredited by PNAC.

1. **Policy**

The Pakistan National Accreditation Council (PNAC) establishes policies on uncertainty in calibration, addressing the requirements for the evaluation of measurement uncertainty in calibration and measurement, the assessment of Calibration and Measurement Capability (CMC), and the reporting of uncertainty on calibration and measurement certificates. These policies are also designed to meet the requirements for the estimation of measurement uncertainty specified in ISO/IEC 17025. This standard mandate that calibration laboratories and testing laboratories must have and apply procedures for estimating measurement uncertainty. This document is applicable to calibration laboratories, and relevant sections of this policy may also be applicable to testing laboratories that conduct their own calibrations (In-house calibration) please also see PNAC policy for in-house calibration.

3.1. Calibration laboratories accredited by PNAC shall estimate uncertainties of measurement for all calibrations and measurements covered by the scope of accreditation in compliance with the "Guide to the Expression of Uncertainty in Measurement" (GUM), including its supplement documents and/or ISO Guide 35.

**3.2 Policy on Scopes of Accreditation of Calibration Laboratories**

* + 1. The scope of accreditation of an accredited calibration laboratory by PNAC shall include the calibration and measurement capability (CMC) expressed in terms of:
1. measurand or reference material.
2. calibration or measurement method or procedure and type of instrument/material to be calibrated/measured.
3. measurement range and additional parameters where applicable, e.g., frequency of applied voltage.
4. measurement uncertainty.
	* 1. 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. Where the measurand covers value, or a range of values, one or more of the following methods for expression of measurement uncertainty shall be applied:
5. A single value, which is valid throughout the measurement range.
6. A measurement ranges. In this case a calibration laboratory shall ensure that linear interpolation is appropriate to find the uncertainty at intermediate values.
7. An explicit function of the measurand and/or a parameter.
8. A matrix where the values of the uncertainty depend on the values of the measurand and additional parameters.
9. A graphical form, providing there is sufficient resolution on each axis to obtain at least two significant figures for the uncertainty.

*Note: Open intervals (e.g., "U < x") are not allowed in the specification of uncertainties.*

* + 1. The uncertainty covered by the CMC shall be expressed as the expanded uncertainty having a specific 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 106. Because of the ambiguity of definitions, the use of terms "PPM" and "PPB" are not acceptable.
		2. The CMC quoted shall include the contribution from a best existing device to be calibrated such that the CMC claimed is demonstrably realizable.

*Note: The term "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: 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.*

*Note: In exceptional instances, it is recognized that a "best existing device" does not exist and/or contributions to the uncertainty attributed to the device may 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 from the CMC statement. For such a case, however, the scope of accreditation shall clearly identify that the contributions to the uncertainty from the device are not included.*

* + 1. 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 CMG 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 covered by the CMG of the reference measurement on the reference material.*

1. **Policy on Statement of Uncertainty of Measurement on Calibration Certificates**
	* 1. PNAC requires calibration laboratories to report, in the calibration certificate, the uncertainty of measurement and/or a statement of compliance with an identified metrological specification or clauses thereof, based on 1S0/IEC 17025.
		2. Accredited calibration laboratories shall report the measured quantity value and the uncertainty of measurement, in compliance with the requirements in 3.2-3.5 of this section.
		3. By exception, and where it has been established during contract review that only a statement of compliance with a specification is required, then the measured quantity value and the measurement uncertainty may be omitted on the calibration certificate. The following shall however apply:
2. The calibration certificate is not intended to be used in support of the further dissemination of metrological traceability (i.e. to calibrate another device);
3. As specified in 1S0/IEC 17025 clause 7.8.6, the laboratory shall determine the uncertainty and take that uncertainty into account when issuing the statement of compliance; and
4. The laboratory shall retain documentary evidence of the measured quantity value and the uncertainty of measurement, as specified in 1S0/IEC 17025 clauses 7.8.6 and 7.5, and shall provide such evidence upon request.
	* 1. 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 uncertainty of measurement is stated as the standard uncertainty of measurement 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.*

* + 1. The numerical value of the expanded uncertainty shall be given to, at most, two significant figures. Further the following applies:
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.
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 Section 7 of the GUM.

*Note: For further details on rounding, see ISO 80000-1:2022.*

* + 1. 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.
		2. As the definition of CMC implies, accredited calibration laboratories shall not report a smaller measurement uncertainty than the uncertainty described by the CMC for which the laboratory is accredited.
		3. 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).
1. **References**
2. EA-4/02. (2022). Expression of the uncertainty of measurement in calibration. Paris: European Accreditation.
3. ILAC-P14. (2020). ILAC policy for measurement uncertainty in calibration.
4. ISO 80000-1. (2022). Quantities and units - Part 1: General. Geneva: ISO Standard.
5. ISO Guide 35. (2017). Reference material -Guidance for characterization and assessment of homogeneity and stability. Geneva: ISO Standard.
6. ISO/IEC 17025. (2017). General requirements for the competence of testing and calibration laboratories. Geneva: ISO Standard.
7. ISO/IEC Guide 98-3. (2008). Uncertainty of measurement-part 3: guide to the expression of uncertainty in measurement for standardization. Geneva: ISO Standard.
8. ISO/IEC Guide 99. (2007). International Vocabulary of Metrology-Basic General Concepts and Associated Terms (VIM). Geneva: ISO Standard.
9. JCGM 100:2008, GUM 1995 with minor corrections, Evaluation of measurement data – Guide to the expression of uncertainty in measurement. Also includes a suite of guides on Evaluation of measurement data (Available from https://www.bipm.org/en/publications/guides/)
10. JCGM 200:2012 International vocabulary of metrology – Basic and general concepts and associated terms (Available from www.BIPM.org)