

## Policy for determination of uncertainty of measurement

### 1. Introduction:

ISO/IEC 17025 requires testing/calibration laboratories to apply procedures for estimating uncertainty of measurement, report the estimated uncertainty of measurement, where applicable and retain records as necessary.

Laboratories shall identify the contributions to measurement uncertainty. When evaluating measurement uncertainty, all contributions which are of significance, including those arising from sampling, shall be taken into account using appropriate methods of analysis.

A laboratory performing calibrations, including of its own equipment, shall evaluate the measurement uncertainty for all calibrations

A laboratory performing testing shall evaluate measurement uncertainty. Where the test method precludes rigorous evaluation of measurement uncertainty, an estimation shall be made based on an understanding of the theoretical principles or practical experience of the performance of the method.

In order to prevent laboratories interpreting the term of uncertainty of measurement and procedures of estimation incorrectly and giving wrong impression to customers, it would be necessary to guide them in the proper direction.

The ILAC P14 policy document addresses the estimation of uncertainty of measurement and its expression on calibration certificates of accredited calibration laboratories and the evaluation of the CMC on the scopes of accreditation in line with the principles agreed up on between ILAC and the BIPM.

### 2. Scope:

This policy provides information required to estimate and calculate uncertainty of measurement in testing and calibration as well as Calibration Measurement Capabilities of laboratories.

### 3. Responsibility:

Conformity Assessment Bodies

Team Leaders /Technical Assessors/ Technical Expert

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#### 4. Reference:

**ISO/ IEC 17025:** General Requirements for the Competence of Testing and Calibration Laboratories

**ILAC- P14 01/2013:** ILAC Policy for uncertainty in calibration

**EURACHEM / CITAC Guide CG 4: 2012:** Quantifying Uncertainty in Analytical Measurement

**ILAC-G8 03/2009:** Guidelines on the Reporting of Compliance with Specification

**ILAC – G17 2002:** Introducing the Concept of Uncertainty of Measurement in testing in association with the application of the Standard ISO/IEC 17025

**JCGM -200:2012:** International vocabulary of metrology – Basic and general concepts and associated terms (VIM), 3<sup>rd</sup> edition

#### 5. Definitions:

**5.1 Uncertainty (of measurement):** Parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand.

#### 5.2 Calibration and Measurement Capability

In the context of the CIPM MRA and ILAC Arrangement, and in relation to the CIPM-ILAC Common Statement, the following shared definition was agreed upon:

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

(a) as published in the BIPM key comparison database (KCDB) of the CIPM MRA; or

(b) as described in the laboratory’s scope of accreditation granted by a signatory to the ILAC Arrangement. ”

Where the term NMI is used it is intended to include Designated Institutes (DIs) within the framework of the CIPM MRA.”

**Source:** <https://www.bipm.org/utis/common/documents/CIPM-MRA/CIPM-MRA-D-04.pdf>

**5.3 Standard uncertainty:** Uncertainty of the result of a measurement expressed as a standard deviation.

**5.4 Combined standard uncertainty:** Standard uncertainty of the results of a measurement when the result is obtained from the values of a number of other quantities equal to the positive square root of a sum of terms, the terms being the variances of these other quantities weighted according to how the measurement result varies with these quantities.

**5.5 Expanded uncertainty:** Quantity defining an interval about the result of a measurement that

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may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand.

## 5.6 Validation:

verification where the specified requirements are adequate for an intended use

EXAMPLE A measurement procedure, ordinarily used for the measurement of mass concentration of nitrogen in water, may be validated also for measurement of mass concentration of nitrogen in human serum

## 5.7 Verification

Provision of objective evidence that a given item fulfils specified requirements

EXAMPLE 1 Confirmation that a given reference material as claimed is homogeneous for the quantity value and measurement procedure concerned, down to a measurement portion having a mass of 10 mg.

EXAMPLE 2 Confirmation that performance properties or legal requirements of a measuring system are achieved.

EXAMPLE 3 Confirmation that a target measurement uncertainty can be met.

Note 1 to entry: When applicable, measurement uncertainty should be taken into consideration.

Note 2 to entry: The item may be, for example, a process, measurement procedure, material, compound, or measuring system.

Note 3 to entry: The specified requirements may be, for example, that a manufacturer's specifications are met.

Note 4 to entry: Verification in legal metrology, as defined in VIML, 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 to entry: Verification should not be confused with calibration. Not every verification is a *validation*.

Note 6 to entry: 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.

## 5.8 Calibration Laboratory

A laboratory that provides calibration and measurement services

## 6. Policies and Procedures

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- 6.1** Each laboratory where appropriate, shall estimate uncertainty of measurement where specified by the method, where required by the client and/or where the interpretation of results could be compromised by lack of knowledge of uncertainty. This calculation is essentially required for all tests including laboratory developed, non-standard methods or methods adopted by the laboratory based on technical references or manuals of manufacturers of equipment. Due to the fact that uncertainty of the results shall be based on scientific understanding of the theoretical principles of the method and practical experience, the method shall be validated appropriately before use.
- 6.2** Well recognized methods specifying limits of major sources of uncertainty require no special action from the laboratory but could follow the uncertainty procedure given in the method. But laboratories shall verify that standard methods can be properly operated before introducing them in the laboratory. In case of changes in the method or using it outside the intended scope, the range and uncertainty of values shall be identified.
- 6.3** The term uncertainty is expressed as a standard deviation (or a given multiple of it) or a width of confidence interval and comprises of many components. These components can be expressed in terms of accuracy, detection limit, selectivity, linearity, repeatability, reproducibility, robustness and cross-sensitivity, as applicable. Some of those components may be evaluated from statistical distribution and others from assumed probability distributions.
- 6.4** Laboratories shall identify all the components able to influence uncertainty of measurement in the given situation and make a reasonable estimation based on existing knowledge and methods of analysis. This estimation shall be based on the knowledge of the performance of the method, measurement scope, previous experience and validation data.
- 6.5** Statistical random and systematic factors/ effects contribute to the overall uncertainty of test results. Random errors typically arises from unpredictable variations of influence quantities and such error cannot be compensated by correction but it can be usually be reduced by increasing the number of observations. A systematic error which remains constant or varies in a predictable way is independent of number of measurements and the result of measurement shall be corrected.
- 6.6** The sources contributing to the uncertainty may include measurand (in many cases in chemical analysis the measurand will be the concentration of an analyte), sampling, transportation, storage and handling of samples, preparation of samples, calibration standards and reference materials used, software and methods and equipment used, environmental conditions, properties and condition of the item being tested or calibrated, persons carrying out tests, uncertainty arising from the correction of the measurement results for system effects etc.
- 6.7** The steps which are to be performed in order to obtain an estimate of the uncertainty associated with a measurement are as follows;
- **Specification** – Clear statement of what is being measured, including the relationship between the measurand and the parameters
  - **Identification of uncertainty sources** – List possible sources of uncertainty
  - **Quantification of uncertainty components** – Estimate the size of uncertainty associated with each potential source of uncertainty identified
  - **Calculation of total uncertainty** – Combine the quantified uncertainty components

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expressed as standard deviations and apply the appropriate coverage factor to give an expanded combined uncertainty

- 6.8** For a given test, it may be beneficial to identify all the steps involved in testing from start to end and determine each source of uncertainty and treat it separately to obtain the contribution from that source. A schematic flow chart (*Cause & Effect Diagram / Fish bone diagram*) may be ideal for identification of steps involved in testing.
- 6.9** Each of separate contributions shall be expressed as a standard deviation (standard uncertainty) while the correlation between any components shall be taken into account by determining covariance. A cause and effect diagram may be helpful for identification of all contributing factors.

*For example, the following contributory factors could be identified for a test for determining ammonia in water (ppm).*

*Purity of buffer (concentration), Stock solution (mass, volume, purity), Meter (tolerance, Repeatability), Electrode (resolution, calibration) Sample (volume), Sub solution (dilution factor, glassware calibration)*

*E.g. Uncertainty of stock solution = uncertainty ( $U_{\text{mass}}$ ,  $U_{\text{volume}}$ ,  $U_{\text{purity}}$ )*

- 6.10** The general relationship between the uncertainty of a value and the uncertainty of the independent parameters  $p$ ,  $q$ ,  $r$  .... is the square root of the additions of each variable's contribution. Each variable's contribution is just the square of the associated uncertainty expressed as a standard deviation multiplied by the square of the relevant partial differential. In certain instances, the above value is multiplied by a constant.
- 6.11** When combined expanded uncertainty is expressed, which provides an interval expected to include a large fraction of the distribution of values reasonably attributable to the measurand, it is achieved by multiplying the combined uncertainty by a chosen coverage factor. A statement of confidence level is also required with the uncertainty value/coverage factor. (Ex. At 95% Confidence interval)
- 6.12** When reporting expanded uncertainty, the uncertainty of measurement shall be reported along with the result, i.e.  $X \pm U$  (units). When uncertainty is expressed as the combined standard uncertainty as a single standard deviation the following form is recommended; result:  $X$ ; standard uncertainty: uncertainty value.
- 6.13** When expressing results, the numerical values of the result and its uncertainty should not be given with an excessive number of digits. Whether expanded uncertainty or standard uncertainty is given it is seldom necessary to give more than two significant digits for the uncertainty. Results should be rounded off to be consistent with the uncertainty given.

- 6.14** Being a member of ILAC Mutual Recognition Arrangement (the ILAC MRA), SLAB requires accredited calibration laboratories to estimate uncertainties of measurement for all calibrations and measurements covered by the scope of accreditation. Applicant and Accredited Calibration laboratories shall estimate uncertainties of measurement in compliance with the "Guide to the Expression of Uncertainty in Measurement" (GUM), including its supplement documents and/or ISO Guide 35.

## **7. Reporting of Compliance with Specification**

- 7.1** This section provided guidelines to assist testing and calibration laboratories reporting compliance with specification of quantitative measurements. In order to satisfy the requirements of ISO/IEC 17025, laboratories should provide customers with statements of measurement results, their uncertainty, and the

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assessment of compliance with specification when requested to do so, in accordance with this guideline.

For testing laboratories, ISO/IEC 17025:2005 (clause 5.10.3.1 b) requires that “the test report shall, where necessary for the interpretation of the test results include..., where relevant, a statement of compliance/non-compliance with requirements and/or specification”.

As per clause 7.1.3 of ISO/IEC 17025:2017, when the customer requests a statement of conformity to a specification or standard for the test or calibration (e.g. pass/fail, in-tolerance/out-of-tolerance) the specification or standard, and the decision rule shall be clearly defined. Unless inherent in the requested specification or standard, the decision rule selected shall be communicated to, and agreed with, the customer and reported as per clause 7.8.6.

The decision rule that describes how measurement uncertainty is accounted for when stating conformity with a specified requirement.

## 7.2 Stating compliance with Specification for a single quantity

7.2.1 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).

7.2.2 When compliance with a specification is made it should be clear to the customer which coverage probability for the expanded uncertainty has been used. In general, the coverage probability will be 95 % and the reporting shall include a remark such as “*The statement of compliance is based on a 95% coverage probability for the expanded uncertainty.*”

This means that the probability that the measurement is below the upper specification limit is higher than 95 %, i.e. approximately 97.5 % for symmetrical distributions. A lower limit is treated similarly. Other values for the coverage probability for the expanded uncertainty should be agreed between the laboratory and the customer. Coverage probabilities for the expanded uncertainty higher than 95 % might be chosen while lower values should be avoided.

7.2.3 The following approach for a certain upper specification limit is recommended. (A lower limit is treated similarly as detailed in the Annex 01 of this document.):

(a) **Compliance:** If the specification limit is not breached by the measurement result plus the expanded uncertainty with a 95% coverage probability, then compliance with the specification can be stated (See Case 1 of Fig.1).

This can be reported as “*Compliance*” or “*Compliance – The measurement result is within (or below) the specification limit when the measurement uncertainty is taken into account*”.

(b) **Non-compliance:** If the specification limit is exceeded by the measurement result minus the expanded uncertainty with a 95% coverage probability, then noncompliance with the specification can be stated. (See Case 4 of Fig.1)

This can be reported as “*Non-compliance*” or “*Non-compliance – The measurement result is outside (or above) the specification limit when the measurement uncertainty is taken into account*”.

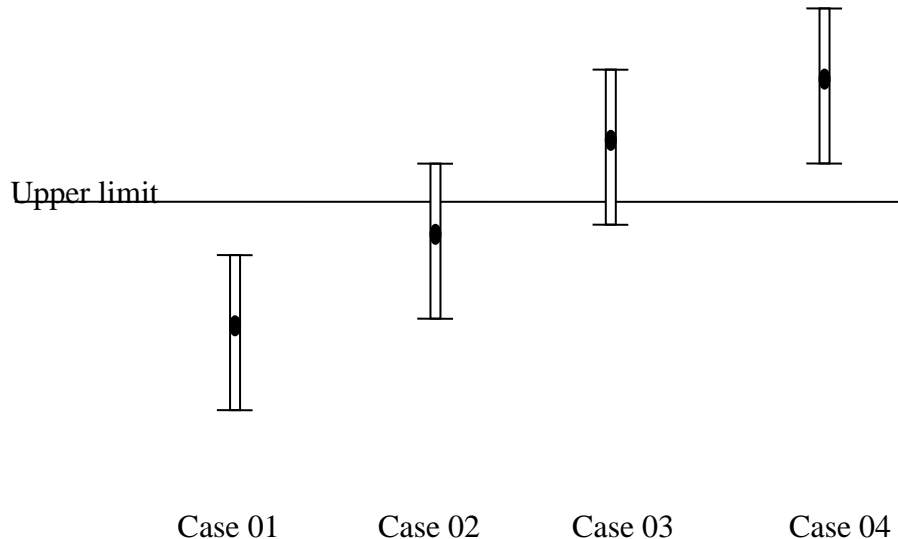
(c) If the measurement result plus/minus the expanded uncertainty with a 95 % coverage probability overlaps the limit (See Case 2 and 3 of Fig.1), it is not possible to state compliance or non - compliance. The measurement result and the expanded uncertainty with a 95 % coverage probability should then be reported together with a statement indicating that neither compliance nor non-

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compliance was demonstrated.

A suitable statement to cover these situations would be “*It is not possible to state compliance*”. In Case 2 of Fig.1 it is possible to indicate, that the measurement is below the limit, which can be done using a similar statement “*It is not possible to state compliance using a 95 % coverage probability for the expanded uncertainty although the measurement result is below the limit*”.

If shorter statements are reported it shall not give the impression that the result complies with specification.



**Fig.1** Compliance with specification for an upper limit. Compliance statements may be expanded to explicitly state whether compliance concerns an upper or a lower limit of specification using a coverage probability of 95 %.

- 7.2.4 A statement of compliance should not be reported in a way where it could be confused with inspection or product certification. For this purpose a remark can be added, such as “*The test results and the statement of compliance with specification in this report relate only to the test sample as analyzed/tested and not to the sample/item from which the test sample was drawn*”.
- 7.2.5 If compliance with specification (for an upper limit) is defined as the measured value being less than the specification limit and the measurement result is equal to the specification limit, then non-compliance shall be stated. A lower limit is treated similarly.
7. 2.6 In testing, a specification or a documented code of practice may require a statement of compliance with specification in the test report, which does not take into account the effect of measurement uncertainty.

In this case, the specification usually holds an implicit assumption that the uncertainty of the agreed measurement method does not vary (i.e. due to prescribed classes of instruments used during test). It should be explicitly stated in the standard or specification that measurement uncertainty has been accounted for when setting the limits. The specification may also be set by national regulation to accommodate a reasonable amount of measurement uncertainty.

Whenever the measurement uncertainty is not taken into account, special care should be taken in the reporting. Laboratories should include notes and explanations in order to ensure unambiguous reporting.

- 7.2.7 If national or other regulations require a decision be made regarding rejection or approval, Case 2 of Fig. 1 can be stated as compliance, and Case 3 of Fig. 2 as noncompliance with the specification limit.

### 7.3 Stating compliance with Specification for a multiple quantity

- 7.3.1 If the evaluation of compliance with specification comprises more quantities (and/or measurands) each

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measurement value should be evaluated independently.

7.3.2 An overall evaluation of compliance with requirements or specification may be formulated in one of the following 3 ways, or by combining them, and may be reported to the customer in a summary according to:

- (a) “All measured values comply with the specification limit(s)” or “The item/sample complies with the requirements”. This covers situations where all measurements comply with specification (Case 1 of Fig.1).
- (b) “For some of the measured values it is not possible to make a statement of compliance with specification”. This covers situations where some of the measurements demonstrate neither compliance nor non-compliance with specification (Case 2 and 3 of Fig.1).
- (c) “Some of the measured values do not comply with specifications” or “The item/sample does not comply with the requirements”. This covers situations where one or more measurements are in non-compliance with specifications (Case 4 of Fig.1).

If an overall evaluation is made it should include a statement regarding the coverage probability for the expanded uncertainty such as “The statement(s) of compliance with specification (or requirement) is based on a 95% coverage probability for the expanded uncertainty of the measurement results on which the decision of compliance is based”.

The statement shall clearly indicate if other values for the coverage probability for the expanded uncertainty have been agreed between the laboratory and the customer or refer to relevant regulations or codes of practice.

7.4 When a specification describes an interval with an upper and lower limit, the ratio of the uncertainty of measurement to the specified interval shall be reasonably small.

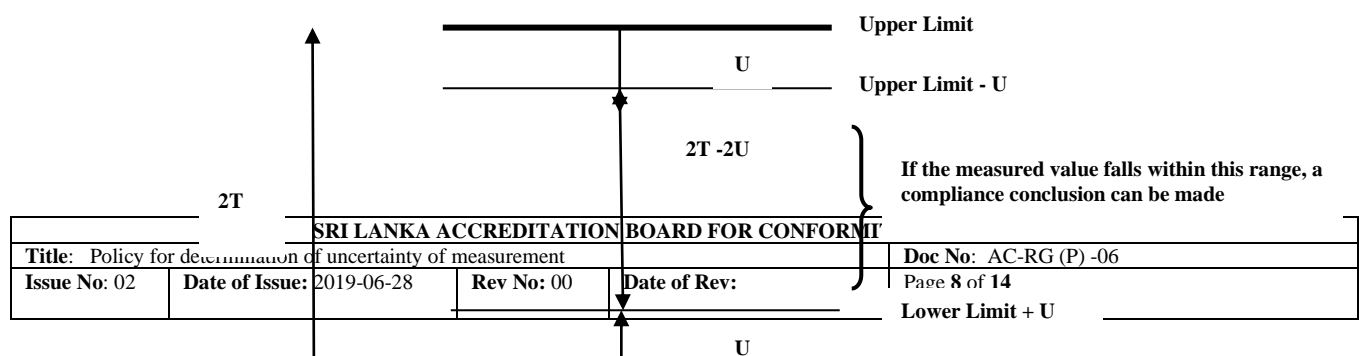
**Notes: 1.**

For an uncertainty of measurement  $U$  and a specified interval  $2T$ ,

Where  $(\text{upper limit} - \text{lower limit}) / 2$ , the ratio  $U:T$  is a measure of the ability of the measurement method in distinguishing compliance from non-compliance.

7.5 As explained in Figure 2, a conclusion of compliance can be made for any measured value falling within the range from  $[\text{lower limit} + U]$  to  $[\text{upper limit} - U]$ . If  $U:T$  is 1:3, the interval between the  $[\text{lower limit} + U]$  and the  $[\text{upper limit} - U]$  will be 66.7% of the interval  $2T$ . In such a case, if the value is measured to be within the specified interval, there will be a 66.7% probability that a conclusion of compliance can be made. A ratio of 1:3 can thus be considered as a reference value.

## 7.6 Ability to Distinguish Compliance from Non-compliance





U = uncertainty of measurement

$T = (\text{Upper limit} - \text{Lower Limit}) / 2$

Assume U: T is 1:3 or  $U = 1/3 T$

Then  $2T - 2U = 2T - 2 \times 1/3 T = 66.7\%$  of  $2T$

7.7 If compliance with a specification is determined in accordance with section 7 of this document, a larger U:T ratio can be tolerated. However, it should be noted that, as this ratio is an indicator of the capability of the measurement method to distinguish compliance from non-compliance, a measurement method having a U:T ratio approaching unity will be unable to confirm compliance nor non-compliance for samples having marginal properties.

7.8 When the property of a batch of product or material is assessed by testing samples taken from it, details of the sampling scheme, the sampling procedure, the number of samples tested and how the reported measured value is related to the measured values obtained from individual samples (e.g. by averaging sample results) shall be included in the report.

#### 7.9 Special cases

7.9.1 In exceptional cases, where a particular factor or factors can influence the results but where the magnitude cannot be either measured or reasonably assessed, the reported statement will need to include reference to that fact.

7.9.2 Any uncertainty that results from the test sample not being fully representative of the single unit of product shall normally be identified separately in the evaluation of uncertainty. However, there may be insufficient information to enable this to be done, in which case this shall be stated in the report.

“A possible remark could be “The test results in this report relate only to the test sample as analyzed and not to the single unit of product from which the test sample was drawn.”

## 8. Scopes of Accreditation of Calibration Laboratories

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

- a) measurand or reference material;
- b) calibration/measurement method/procedure and/or type of instrument/material to be calibrated/measured;

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- c) measurement range and additional parameters where applicable, e.g., frequency of applied voltage;
- d) uncertainty of measurement.

8.2 There shall be no ambiguity on the expression of the CMC on the scopes of accreditation and, consequently, on the smallest uncertainty of measurement that can be expected to be achieved by a laboratory during a calibration or a measurement. Particular care should be taken when the measurand covers a range of values. This is generally achieved through employing one or more of the following methods for expression of the uncertainty:

- a) single value, which is valid throughout the measurement range.
- b) A range. In this case a calibration laboratory should have proper assumption for the interpolation to find the uncertainty at intermediate values.
- c) An explicit function of the measurand or a parameter.
- d) A matrix where the values of the uncertainty depend on the values of the measurand and additional parameters.
- e) A graphical form, providing there is sufficient resolution on each axis to obtain at least two significant figures for the uncertainty.

Open intervals (e.g., “ $U < x$ ”) are not allowed in the specification of uncertainties.

8.3 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. Usually the inclusion of the relevant unit gives the necessary explanation.

8.4 Calibration laboratories shall provide evidence that they can provide calibrations to customers in compliance with 5.1 b) so that measurement uncertainties equal those covered by the CMC. In the formulation of CMC, laboratories shall take notice of the performance of the “best existing device” which is available for a specific category of calibrations.

8.5 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.

8.6 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 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.

8.7 The term “best existing device” is understood as a device to be calibrated that is commercially

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or otherwise available for customers, even if it has a special performance (stability) or has a long history of calibration.

- 8.8 Where laboratories provide services such as reference value provision, the uncertainty covered by the CMC should generally 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 in-homogeneity of the material. The CMC should be based on an analysis of the inherent performance of the method for typical stable and homogeneous samples.
- 8.9 The uncertainty covered 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 covered by the CMC of the reference measurement on the reference material.

## **9 Statement of Uncertainty of Measurement on Calibration Certificates**

- 9.1 ISO/IEC 17025 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.
- 9.2 Accredited/Applicant calibration laboratories shall report the measured quantity value and the uncertainty of measurement, in compliance with the requirements in this document.
- 9.3 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:
- The calibration certificate is not intended to be used in support of the further dissemination of metrological traceability (i.e. to calibrate another device);
  - As specified in ISO/IEC 17025:2005 clause 5.10.4.2, the laboratory shall determine the uncertainty and take that uncertainty into account when issuing the statement of compliance as per section 07 of this document;
  - As specified in ISO/IEC 17025:2017 clause 7.8.6, the laboratory shall determine the uncertainty and take that uncertainty into account when issuing the statement of compliance as per section 07 of this document;
  - The laboratory shall retain documentary evidence of the measured quantity value and the uncertainty of measurement, as specified in ISO/IEC 17025:2005 clauses 5.10.4.2 and 4.13, and shall provide such evidence upon request.
  - As specified in ISO/IEC 17025:2017, clauses 7.8.4, in addition to the requirements listed in clause 7.8.2 of ISO/IEC 17025:2017 calibration certificates shall include the measurement uncertainty of the measurement result presented in the same unit as that of the measurand or in a term relative to the measurand (e.g. percent);

NOTE: According to JCGM 200:2012, a measurement result is generally expressed as a single

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measured quantity value including unit of measurement and a measurement uncertainty

- 9.4 The measurement result shall normally include the measured quantity value  $y$  and the associated expanded uncertainty  $U$ . In calibration certificates the measurement result should be reported as  $y \pm U$  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:
- 9.5 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 %.
- 9.6 For asymmetrical uncertainties other presentations than  $y \pm U$  may be needed. This concerns also cases when uncertainty is determined by Monte Carlo simulations (propagation of distributions) or with logarithmic units.
- 9.7 The numerical value of the expanded uncertainty shall be given to, at most, two significant figures. Further the following applies:
- a) The numerical value of the measurement result shall in the final statement be rounded to the least significant figure in the value of the expanded uncertainty assigned to the measurement result.

Where the measurement uncertainty is relevant to the validity or application of the results, when a client's instructions require so, or when the uncertainty affects compliance with a specification limit, the expanded measurement uncertainty appropriate to approximately a 95% level of confidence should be calculated and result and its expanded uncertainty shall be reported in the following manner:

Measured value 100.1 (units)  
Uncertainty of measurement 0.1 (units)  
Level of confidence 95%

- b) 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 80000-1:2009.

9.8 For non-numerical results, where the method is unambiguously defined in the test or calibration criteria, test or calibration specifications, client specifications or codes of practice, and, in the absence of any client instruction to do otherwise, it can be assumed that the measurement uncertainty has already been taken into consideration in the method and the laboratory does not need to estimate it. In this case, reporting the non-numerical result alone is adequate. Where deviations from the specified method are necessary, the laboratory shall evaluate the extent to which the test validity is affected. In this case, details of the deviations from the specified method and their effects on the validity of the result shall be recorded and reported.

- 9.8 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

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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. Random 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 shall be notified according to the general clauses regarding tenders and reviews of contracts in ISO/IEC 17025.

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.

**Note:** A paper by the joint BIPM/ILAC working group is given as an Informative Annexure in ILAC - P14:01/2013. The whole document could be downloaded from the following web link for more information - <http://ilac.org/publications-and-resources/ilac-documents/procedural-series/>.

#### **Annex A**

<b>Case 01</b>	<b>Case 02</b>	<b>Case 03</b>	<b>Case 04</b>	<b>Case 05</b>
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Specified  
upper  
limits

Specified  
lower  
limits

<p>The measured result is under the upper limit, even when extended upwards by half of the uncertainty interval</p> <p>The product therefore complies with the specification</p>	<p>The measured result is below the upper limit, but by a margin less than half of the uncertainty interval; it is therefore not possible to state compliance</p> <p>However, where a confidence level of less than 95% is acceptable, a compliance statement may be possible.</p>	<p>The measured result is on the limit itself; it is therefore not possible to state compliance nor non-compliance at any significant level of confidence.</p> <p>However, where a decision must be made regardless of the level of confidence and the requirement is: measured result <math>\leq</math> the upper limit, a compliance statement may be possible. When the requirement is: measured value <math>&lt;</math> the upper limit, a noncompliance statement may be possible.</p>	<p>The measured result is above the upper limit, but by a margin less than half of the uncertainty interval; it is therefore not possible to state noncompliance</p> <p>However, where a confidence level of less than 95% is acceptable, a noncompliance statement may be possible</p>	<p>The measured result is beyond the upper limit, even when extended downwards by half of the uncertainty interval.</p> <p>The product therefore does not comply with the specification.</p>
<b>Case 06</b>	<b>Case 07</b>	<b>Case 08</b>	<b>Case 09</b>	<b>Case 10</b>
<p>The measured result is above the lower limit, even when extended downwards by the half of the uncertainty interval. The product therefore complies with the specification.</p>	<p>The measured result is above the lower limit, but by a margin less than half of the uncertainty interval; it is therefore not possible to state compliance. However, where a confidence level of less than 95% is acceptable, a compliance statement may be possible.</p>	<p>The measured result is on the limit itself; it is therefore not possible to state compliance nor non-compliance at any significant level of confidence. However, where a decision must be made regardless of the level of confidence and the requirement is: measured result <math>\geq</math> lower limit, a compliance statement may be possible. When the requirement is: measured result <math>&gt;</math> lower limit, a noncompliance statement may be possible.</p>	<p>The measured result is below the lower limit, but by a margin less than half of the uncertainty interval; it is therefore not possible to state noncompliance. However, where a confidence level of less than 95% is acceptable, a noncompliance statement may be possible.</p>	<p>The measured result is beyond the lower limit, even when extended upwards by half of the uncertainty interval. The product therefore does not comply with the specification.</p>

◆ = measurement result with agreed method

I = uncertainty interval of agreed method