1. Purpose

1.1. This policy defines how laboratories will express their uncertainty of measurement.

2. Scope

2.1. This policy applies to all laboratories, calibration, testing and dimensional inspection. It is the responsibility of the L-A-B assessors, staff and appointed reviewers to evaluate the compliance of the laboratories with this policy. The laboratories shall have evidence of compliance available for the assessor at the time of the desk audit prior to the assessment visit. Should the documented evidence not be available, the laboratory runs the risk of a delay in the assessment or surveillance.

3. Definitions

3.1. Uncertainty of Measurement VIM 2.26

3.1.1. Non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.

3.1.1.1. Notes:

3.1.1.1.1. Uncertainty of measurement includes components arising from systematic effects, such as components associated with corrections and the assigned quantity values of measurement standards, as well as the definitional uncertainty. Sometimes estimated systematic effects are not corrected for but, instead, associated uncertainties of measurement components are incorporated.

3.1.1.1.2. The parameter may be, for example, a standard deviation called standard uncertainty of measurement (or a specified multiple of it), or the half-width of an interval, having a stated coverage probability.

3.1.1.1.3. Uncertainty of measurement comprises, in general, many components. Some of these may be evaluated by Type A evaluation of uncertainty of measurement from the statistical distribution of the quantity values from series of measurements and can be characterized by standard deviations. The other components, which may be evaluated by Type B evaluation of uncertainty of measurement, can also be characterized by standard deviations, evaluated from probability density functions based on experience or other information.

3.1.1.1.4. In general, for a given set of information, it is understood that the uncertainty of measurement is associated with a stated quantity value attributed to the measurand. A modification of this value results in a modification of the associated uncertainty.

3.2. Calibration VIM 2.39

3.2.1. 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.

3.2.1.1. Notes:

3.2.1.1.1. 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 uncertainty of measurement.

3.2.1.1.2. Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", or with verification of calibration.

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

4. Policy for Uncertainty of Measurement

4.1. Accredited laboratories of L-A-B that are performing calibration(s), dimensional inspection(s), and necessary tests whether commercially, captively, legal for trade or internally are required to apply a procedure for the estimation of the uncertainty of measurement.

4.1.1. Uncertainty of measurement comprises, in general, many components. Some of these components may be estimated on the basis of the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations, and are called Type A evaluation. The Type A can be applied when several independent observations have been made for one of the input quantities under the same conditions of measurement. If there is sufficient resolution in the measurement process, there will be an observable scatter or spread in the values obtained. In this case, the standard uncertainty is the experimental Standard Deviation of the mean that follows from an averaging procedure or an appropriate regression analysis.

4.1.2. Estimates of other components can only be based on experience or by scientific judgment based on all available information on the possible variability of the measurement and other information, and are called Type B evaluation. Values belonging in this category may be derived from:

4.1.2.1. Previous measurement data;

4.1.2.2. Experience with or general knowledge of the behavior and properties of relevant materials and instruments;

4.1.2.3. Manufacturer's specifications;

4.1.2.4. Data provided in calibration and other certificates;

4.1.2.5. Uncertainties assigned to reference data taken from handbooks.

4.1.3. The Uncertainty of measurement for a given calibration is the combination of all the Type A and Type B components of the uncertainty budget.

5. Calibration and Measurement Capability (formerly Best Measurement Capability)

5.1. Calibration and Measurement Capability (always referring to a particular quantity, *viz*. the measurand) is defined as the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation, when performing more or less routine calibrations of nearly ideal measurement standards intended to define, realize, conserve or reproduce a unit of that quantity or one or more of its values, or when performing more or less routine calibrations of nearly ideal measuring instruments designed for the measurement of that quantity. The assessment of Calibration and Measurement Capability of accredited calibration laboratories is based on the method described in this document, and shall be supported or confirmed by experimental evidence.

5.2. L-A-B requires that calibration accredited laboratories state on their Scope of Accreditation an expanded uncertainty of measurement U, obtained by multiplying the standard uncertainty $u(y)$ of the output estimate by a coverage factor of k, $U=ku(y)$

5.3. In cases where a normal (Gaussian) distribution can be attributed to the measurand and the standard uncertainty associated with the output estimate has sufficient reliability, the standard coverage factor $k=2$ shall be used. The assigned expanded uncertainty corresponds to a coverage probability of approximately 95%. These conditions are fulfilled in a majority of cases encountered in calibration work.

5.4. When a calibration certificate or test report contains expanded uncertainty of measurement, a statement of the measurement result and the associated uncertainty must be accompanied by an explanation of the meaning of the uncertainty statement. An example of an explanation might be "*The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95%*". When a calibration certificate contains the expanded uncertainty of measurement and the explanation is not given, the calibration certificate is considered incomplete for the purpose of demonstrating measurement traceability.

5.5. Preferred Guidance documents, based on the "Guide to the Expression of Uncertainty in Measurement, issued by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, AND OIML, are downloadable from their websites.

6. Calibration and Dimensional Inspection Laboratories

6.1. Calibration and dimensional inspection laboratories shall report their uncertainty of measurement on all calibration certificates and inspections reports unless it can be proven that the client does not want it reported. Evidence that the client does not want the calibration and dimensional inspection uncertainty reported shall be available for an assessor to review at the time of an assessment. Regardless of whether the client wants the uncertainty of measurement reported, the laboratory shall retain sufficient information to report the uncertainty.

6.2. Laboratories may issue certificates with a statement of compliance (or conformance to a specification). When the laboratory issues a statement of compliance it must ensure that:

6.2.1. The specification is a national / international standard or one that has been provided or agreed to by the customer.

6.2.2. The measurements needed to determine conformance are within the scope of accreditation.

6.2.3. When the measurement result is determined to be within a specified tolerance, the associated uncertainty of the measurement result is properly taken into account with respect to the tolerance by a documented procedure or policy. The policy or procedure must be established and implemented by the laboratory that defines the decision rules used by the laboratory for declaring in or out of tolerance conditions.

6.2.3.1. With agreement from the customer, other decision rules may be used as provided for in this section of the Requirements.

6.3. The certificate relates only to metrological quantities and states which clauses of the specification are certified to have been met.

6.4. The calibration laboratory shall report its Calibration and Measurement Capability, as defined above, on its proposed Scope of Accreditation.

6.5. The uncertainty reported on a certificate / report shall not be numerically lower than what is reported on the current scope of accreditation. The laboratory may report the CMC if appropriate for the particular calibration / dimensional inspection represented on the certificate / report, e.g. the item calibrated is similar to the item used in the estimation of that CMC uncertainty.

6.5.1. Laboratories shall estimate their Calibration and Measurement Capabilities under the best normal conditions:

- normal environmental conditions expected by the laboratory;

- the laboratory's most accurate equipment;
- the smallest instrument resolution the laboratory routinely encounters; and
- repeatability studies based on these "best case" conditions.

6.5.2. Laboratories wishing to reduce their burden of estimating large numbers of uncertainties by reporting only those values from their scope of accreditation must estimate their Calibration and Measurement Capabilities so as not to understate the uncertainty of any calibration or measurement. CMC uncertainty budgets shall be estimated using:

- the environmental extremes expected by the laboratory;
- the laboratory's least accurate equipment;
- the largest instrument resolution the laboratory routinely encounters; and
- repeatability studies based on these "worst case" conditions.

6.5.3. Where situations other than those seen when estimating the CMC uncertainties, the laboratory shall have and report an estimate of the uncertainty of measurement for the particular situation so as not to understate the uncertainty of that particular calibration or measurement.

7. Testing Laboratories

7.1. The complexity involved in estimation of uncertainty of measurement in the case of testing varies considerably from one test field to another and also within one field itself. A less metrologically rigorous process than that which can be followed for calibration can also often be used.

7.2. Guide to the Expression of uncertainty in Measurement (see clause 5.4.6.3, note 3 of ISO/IEC 17025) is often regarded as having the more rigorous approach to the estimation of uncertainty. However, in certain cases, the validity of results from a particular mathematical model may need to be verified, e.g. through inter-laboratory comparisons.

7.3. Uncertainty components/budgets are a combination of many factors that may include, but are not limited to:

7.3.1. Reference standards

7.3.2. Reference materials

7.3.3. T/C methods used

7.3.4. Equipment used

7.3.5. Environmental conditions

7.3.6. Properties and condition of item being tested

7.3.7. Calibration

7.3.8. Operator

7.3.9. Known physical characteristics of components such as, coefficient of thermal expansion. These often can be looked.

7.4. The laboratory shall do a Needs Assessment for all tests within their Scope of Accreditation. The Laboratory shall define the categories and what actions will be necessary with regard to the reporting of uncertainty. The Needs Assessment shall group the tests into four (4) categories as defined below.

7.4.1. Type A Test - Qualitative or semi-quantitative tests are not numerical or are not based on numerical data (e.g., pass/fail, positive/negative, or based on visual or tactile or other qualitative examinations) estimates of uncertainty or other variability are not required.

7.4.2. Type B Test - A test performed to well-recognized test methods that specify limits to the values of the major sources of uncertainty of measurement and specifies the form of presentation of calculated results. These are defined in ISO/IEC 17025 Clause 5.4.6.2 Note 2.

7.4.3. Type C Test - Test methods based on published in international, national, regional or a technically reputable organization for which uncertainty is not defined in the method. For these types of test, uncertainty can be estimated using the standard deviation of laboratory control samples for more than 50 points. (This does not include laboratory-developed methods that require validation and are covered below).

7.4.4. Type D Test - Identify contributors of uncertainty and detailed uncertainty of measurement budgets calculated in accordance with published methods that are consistent with the ISO "Guide to the Expression of Uncertainty of Measurements".

7.5. Uncertainty that arises from sampling; uncertainty of measurement strictly applies only to the result of a specific measurement on an individual specimen.

7.5.1. During contract review, consideration and agreement with the customer as to whether the test result and uncertainty are to be applied to the specific sample tested or to the bulk from which it came.

7.5.2. Where sampling (or sub-sampling) is to be treated as part of the test, the uncertainty arising from such sampling is to be considered by the laboratory. Estimating the representativeness of a sample or set of samples from a larger population requires understanding of the homogeneity of the larger population and additional statistical analysis.

7.5.3. Where a test method includes specific sampling procedures designed to characterize a batch, lot or larger population, the measurement uncertainties for individual measurements are often insignificant relative to the statistical variation of the batch, lot or larger population. In cases where the uncertainty of measurement of individual measurements is significant in relation to the standard deviation of the sampling, the uncertainty of measurement is to be taken into consideration when characterizing the batch, lot or larger population.

8. Requirements for Reporting Uncertainty of Measurement in Testing Laboratories

8.1. For quantitative test results, uncertainty of measurement shall be reported, where required, by clause 5.10.3.1 (c) of ISO/IEC 17025, which includes the following circumstances:

8.1.1. When it is relevant to the validity or application of the result;

8.1.2. When a customer's instructions require it.

8.1.3. When the uncertainty affects compliance with a specification limit. For the requirements of making statements of compliance see refer to 6.2.3.1 above.

8.1.4. When reporting uncertainty of measurement, the reporting format recommended in the GUM is recommended. The results of the uncertainty estimations are to be reported based on a level of confidence approximately 95%. The indiscriminate use of a coverage factor of 2 is not recommended. Not all combined uncertainties are normally distributed and, where practicable, the uncertainty approximately 95% confidence level for the appropriate distribution is to be used. The coverage factor used for calculating the expanded uncertainty is to be reported.

9. Revision History

Revision Level	Revision Date	Revised By	Brief Description of Revision
Original Issue	06/01/09	Ryan Fischer	Split the Policy 001 into two Policies. Uncertainty of Measurement is now its own Policy 001.1. Added a requirement for calibration certificate or test reports to state the confidence level with the coverage factor. Clearly defined that the uncertainty listed on calibration certificates shall not be lower than the scope of accreditation
1	2/15/10	Randy Long	Updated to replace references to BMC with CMC, clarified Section 6.5

APPROVED:____________________ **Date: 02/15/10**