R218 - Applications for Calibration Scopes of Accreditation

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I. Introduction and scope

Scopes of accreditation serve two purposes:

a) To define the specific areas of a laboratory's activities which are covered by the laboratory's accreditation (it is recognized that other activities may be undertaken by a laboratory for which it has not sought public recognition of its competence);

b) To provide the user of an accredited laboratory with a clear description of the specific calibrations covered by the accreditation;

The purpose of this application document for calibration scopes of accreditation is to address sources of variability to the extent possible so that all calibration scopes have the same general appearance and level of detail; to outline the concept of Calibration and Measurement Capability (CMC) and expectations of Conformance Assessment Bodies (CABs); to outline the requirements for statements of uncertainty on

This document will be supplemented from time to time on an as-needed basis by additional annexes to provide details concerning scopes for specific fields of calibration.

II. Flexibility and responsiveness

Assessors and staff need to consider the level of detail included in each scope of accreditation to ensure that there is a practical balance between the amount of information needed by the users of our accredited laboratories and flexibility on the part of accredited laboratories to offer their services within appropriate scopes of their recognized competence.

Too much detail in scopes results in unnecessary demands for constant changes in scopes of accreditation, resulting in processing delays on our end and unwarranted restriction of competent services to laboratory users. Too little detail can result in a laboratory offering accredited calibration service in an area in which it has not been assessed.

In determining the appropriate balance between detail of scopes and flexibility, consideration should be given to the ability of individual labs to update or modify generic methods or to implement new methods (to take account of technological progress or to satisfy changing needs of clients), provided that such changes do not involve significant deviation from the scope and are made only after proper notification to the accreditation body.

Above all, the fundamental considerations relating to the format and information content of scopes have to do with the objectives of having a scope in the first place: the needs of the accredited laboratory and its users which bear on the necessity for consistency following established precedent, avoiding unnecessary complexity and ambiguity, and striving for simplicity, clarity, and uniformity of expression.

III. Calibration scopes of accreditation

3.1 Calibration scopes of accreditation shall contain at least the following elements (note italicized text is from ILAC P14:11/2010 *ILAC Policy for Uncertainty in Calibration*):

3.1.1 Reference to the general discipline(s) of calibration covered in the scope (e.g., Dimensional, Electrical, Mechanical, etc);

3.1.2 Identification of the measuring instrument or type of instrument/material, measuring system, *measurand* (quantity to be measured), items calibrated; or reference materials or standards measured or calibrated; or parameters being calibrated;

3.1.3 Identification of the specific calibrations performed (properties or quantities measured);

3.1.4 Identification of the specification, standard method/*procedure* or measurement technique used;

3.1.5 Identification of the specific ranges of measurement covered by the accreditation.

3.1.6 Identification of the accredited Calibration and Measurement Capability (CMC). For more information on the requirements of the CMC see Section IV.

3.1.7 The Calibration and Measurement Capability (CMC):

3.2 Particular care should be taken when the measurand covers a range of values. This shall be *achieved through employing one or more of the following methods for expression of the uncertainty:*

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

3.2.2 A range. In this case a calibration laboratory should have proper assumption for the interpolation to find the uncertainty at intermediate values; See also section 4.12.

3.2.3 An explicit function of the measurand or a parameter;

3.2.4 A matrix where the values of the uncertainty depend on the values of the measurand and additional parameters;

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

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

3.4 When a laboratory lists a specification, or standard method on the scope of accreditation, if the entirety of the specification or standard method cannot be adhered to when performing the calibration the limitation of the specification or standard method must be included on the scope of accreditation.

3.5 A Recognized National Metrology Institute (NMI) or recognized designated institute (DI) is based on the Institute being a signatory to the CIPM (Comité International des Poids et Mesures) MRA (Mutual Recognition Arrangement) and supporting the measurement comparison activities of the CIPM and a listing of these recognized Institutes can be found at: http://www.bipm.org/en/cipm-mra/participation/signatories.html. Please note that the information listed on this site is the Calibration and Measurement Capability (best capability) of the NMI and may differ from the uncertainty values listed for the "commercial" calibration services that the NMI provides to its customers.

3.6 Organizations are not permitted to claim a Calibration and Measurement Capability (CMC) on their scope of accreditation that is smaller than the CMC claimed by the National Metrology Institute (as stated in the key comparison database listed on the BIPM website) through which traceability is achieved unless allowance is made by A2LA. For those parameters approved, the laboratory shall use the following footnote on the scope of accreditation:

"The CMC claim is smaller than that of the expanded uncertainty claim for (*insert name of NMI*) as listed in the BIPM Key Comparison Database. A2LA has evaluated the laboratory's CMC claim and has verified this information to be correct and appropriate."

A2LA may also accept uncertainties smaller than the NMI's "commercial" uncertainty that is provided to its own customers on a case-by-case basis.

IV. Calibration and Measurement Capability (CMC) requirements

4.1 The concept of Calibration and Measurement Capability (CMC) is defined and explained in ILAC P14:11/2010 *ILAC Policy for Uncertainty in Calibration*. Since a laboratory's CMC is one of the most important pieces of information found on a scope of accreditation, this concept is explained in detail in this document. The following italicized text is taken from the ILAC document with additional criteria noted as plain text. Minor changes to the original text have been made without comment.

4.2 *In the context of the CIPM MRA and ILAC Arrangement, and in compliance with the CIPM-ILAC Common Statement, the following definition* for Calibration and Measurement Capability (CMC) *is agreed upon:*

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.

4.3 *The meanings of the terms Calibration and Measurement Capability, CMC, (as used in the CIPM MRA), and Best Measurement Capability, BMC, (as used historically in connection with the uncertainties stated in the scope of an accredited laboratory) are identical. The terms BMC and CMC should be interpreted similarly and consistently in the current areas of application.*

4.4 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.

4.5 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.

4.6 *Calibration laboratories shall provide evidence that they can provide calibrations to customers in compliance with section IV so that measurement uncertainties equal those covered by the CMC.*

4.7 *In the formulation of the CMC a reasonable amount of contribution to uncertainty from repeatability shall be included and contributions due to reproducibility should be included, when available. There should, on the other hand, be no significant contribution to the CMC attributable to physical effects that can be ascribed to imperfections of even the best existing device under calibration.* See P110 – Policy on Measurement Uncertainty in Calibration.

4.8 *Normally there are four ways in which a complete statement of uncertainty may be expressed (range, equation, fixed value and a matrix). Uncertainties* shall *comply with the Guide to the Expression of Uncertainty in Measurement (GUM)* and P110 - A2LA Policy on Measurement Uncertainty*, and should include the components listed in the relevant key comparison protocols of the CIPM Consultative Committees. These can be found in the reports of comparisons published in the CIPM MRA KCDB as a key or supplementary comparison.*

4.9 *The term "best existing device" is* defined *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.*

4.10 *In the formulation of CMC, laboratories* shall include a contributor due to *the performance of the "best existing device" which is available for a specific category of calibrations, however, 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*** under the following conditions:

4.10.1 Documentation of the contribution to the CMC from the device shall be included as part of the record of CMC calculation.

4.10.2 Documentation of the justification for the exclusion of the contribution of the "best existing device" from the CMC shall be included as part of the record of CMC calculation.

4.10.3 *The scope of accreditation* shall contain a footnote that *clearly identifies that the contributions to the uncertainty from the device are not included.*

Example 1: "The contributions from the "best existing device" are not included in the CMC claim."

Example 2: "The CMC for this Parameter/Equipment applies for performance verification of the "best existing" device under test and not for the assignment of reference values, and therefore certain characteristics of the "best existing" device under test (e.g. resolution) are not included in this CMC estimate."

4.11 *Where laboratories provide services such as reference value provision, the uncertainty covered by the CMC* shall:

4.11.1 *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.*

4.11.2 *the uncertainty covered by the CMC* shall *not include contributions arising from the instability or inhomogeneity of the material.*

4.11.3 *the CMC* shall *be based on an analysis of the inherent performance of the method for typical stable and homogeneous samples.*

NOTE: 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.

4.12 If a laboratory claims a CMC across a range of values, this value shall be applicable across the entire range. Therefore, it will be necessary for the laboratory to either limit the span of the ranges to publish a more accurate representation of its capabilities or to properly represent the CMC at the highest range.

For example:

Inappropriate

Parameter/Equipment	Range	CMC[2] (±)	Comments
Mass	(0 to 10) kg	70 µg	Class S1 weights

Appropriate

Parameter/Equipment	Range	CMC[2] (±)	Comments
Mass	(0 to 1) g (1 to 10) g (10 to 100) g (0.1 to 1) kg (1 to 10) kg	70 µg 150 µg 0.2 mg 70 mg 220 mg	Mechanical comparison to Class S1 weights

Or

Parameter/Equipment	Range	CMC[2] (±)	Comments
Mass	(0 to 10) kg	220 mg	Class S1 weights

V. Recommended descriptors

5.1 A2LA's classification scheme for various measurement types and parameters is found in *F204 – Scope of Accreditation Selection List: Calibration Laboratories* and in the *R205 – Specific Requirements – Calibration Laboratory Accreditation Program* but it seems desirable to reproduce the list here and also to expand and comment on it.
Any calibration or verification for which A2LA offers accreditation can be placed into one of eleven broad disciplines as follows:

5.1.1 Acoustical quantities such as microphones, sound level, artificial mastoids, and noise dosimeters;

5.1.2 Chemical quantities such as pH meters, conductivity meters, and so on;

5.1.3 Dimensional quantities including length measurements such as laser wavelength, length gages, line scales and distances, length measuring instruments, diameter, form error, roughness, thread quantities, coordinate measuring machines, machine tools and work pieces, and angle measurements such as angle gages, index tables and clinometers;

5.1.4 Electrical quantities including DC/Low Frequency (≤ 13 MHz) quantities such as voltage, current, voltage ratio, AC/DC transfer (voltage and current), power and energy, resistance, capacitance, inductance, dissipation factor, high voltage quantities, and high voltage impulse quantities as well as RF/Microwave (> 13 MHz) quantities such as impedance (reflection coefficient), power, attenuation, noise, and electric/magnetic field quantities;

5.1.5 Fluid Quantities such as gas and liquid flow rate, volume of flowing gases and liquids, velocity of gases, mass and volume and density of gases and liquids, and viscosity;

5.1.6 Ionizing radiation and radioactivity quantities including radiometric quantities, dosimetric quantities, radioprotection quantities, and activity of radioactive sources;

5.1.7 Magnetic Quantities such as magnetic flux density and magnetic material properties;

5.1.8 Mechanical quantities such as force, mass, weighing instruments, pressure and vacuum quantities, torque, acceleration and vibration, and hardness;

5.1.9 Optical Quantities such as quantities of optical radiation, photometric quantities, and optical system properties;

5.1.10 Thermodynamic quantities including resistance thermometry, thermocouples, liquid-in-glass thermometers, radiation thermometers, and humidity.

5.1.11 Time and Frequency quantities including time interval, frequency, rise time, and phase angle;

5.2 Any question concerning how a measurement not listed above should be classified can be answered simply by identifying the measurand or unit of measure. For example, calibration of electrical temperature indicators/controllers is sometimes placed under the “thermodynamic” section, but since the measurand is, for example, voltage, the proper classification is under “electrical”.

VI. Use of the word "generate" on scopes of accreditation

6.1 Scopes of accreditation, particularly in the electrical field, currently use the word "generate" to describe a laboratory's ability to generate a quantity with a certain level of uncertainty. For example, "DC Volts – Generate" has been taken to mean that a laboratory can generate one or several multiples and/or submultiples of a volt and that its representation of this quantity is accurate to within the claimed level of uncertainty. Thus, laboratories with this capability can calibrate devices used to measure DC Volts.

6.2 Although this usage is most prevalent in electrical scopes of accreditation, the same idea may not be extended to other disciplines where the inadequacy of this concept for describing a laboratory's calibration capabilities would not be clear. As such, the use of the "generate" term is only currently used for the electrical and microwave/RF disciplines in scopes of accreditation. Other considerations will be made on a case-by case basis upon written request from the laboratory.

VII. The use of the International System of units (SI) and other systems of units

This section provides information on issues relating to punctuation and layout of unit and quantity symbols on scopes of accreditation.

7.1 *International System of units*

7.1.1 NIST Special Publications 330, *The International System of Units (SI)*, and 811, *Guide for the Use of the International System of Units (SI)* as well as *ASTM SI10 American Nationa Standard for Use of the International System of Units(SI): The Modern Metric System*, are the primary guidance documents for the use of the SI system of units on A2LA scopes of accreditation. While it is A2LA policy to follow the principles of these documents as closely as possible, particularly SP 811 and its editorial conventions, it is recognized that the obsolete inch-pound system of units is so deeply embedded in American society that it is impossible to present scopes of accreditation solely in terms of the SI. With this point in mind as similar circumstances may exist for other measurements, A2LA will consider and may choose to allow best practices such as this in the information published on a laboratory's scope of accreditation. It should be noted that a laboratory can request inclusion of both industry-accepted units as well as the SI unit on the scope for any given parameter. Each request will be considered on a case-by-case basis.

7.2 Key Points

The key points of SP 811 are summarized here and accompanied by explanatory text where necessary. None of the superscripts in this section are footnotes.

7.2.1 Only units of the SI and those units recognized for use with the SI are used to express the values of quantities. Equivalent values in other units are given in parentheses following values in acceptable units only when deemed necessary for the intended audience.

NOTE: Clearly, it is desirable that documents with an international readership, such as scopes of accreditation, should be as independent of language as possible. On the other hand, A2LA scopes of accreditation are primarily intended for users of our accredited calibration laboratories and these users are primarily American. Therefore, it is necessary to strike a balance between best practice (exclusive use of the SI) and practical necessities.

7.2.2 Abbreviations such as sec (for either s or second), cc (for either cm^3 or cubic centimeter), or mps (for either m/s or meter per second), are avoided and only standard unit symbols, SI prefix symbols, unit names, and SI prefixes are used.

7.2.3 The combinations of letters "ppm," "ppb," and "ppt," and the terms part per million, part per billion, and part per trillion, and the like, as well as the use of scientific notation with quantity symbols, are not to be used to express the values of quantities. The use of scientific notation with quantity symbols may be used to express the value of frequency quantities only.

7.2.4 It should be noted that a phrase such as "*x* ppm" simply means $x \times 10^{-6}$. For this reason, statements such as "the expanded uncertainty of the voltage measurement is 10 ppm + 10 μV" are not permitted on A2LA scopes of accreditation since one cannot add the dimensionless quantity 10×10^{-6} to 10 μV. Instead, a statement such as "the expanded uncertainty of the voltage measurement is $U/\mu V = 10\ \mu V/V + 10\ \mu V$", where V is the quantity symbol for voltage, are used.

NOTE 1: The position of NIST SP 811 is that documents intended for an international audience, such as scopes of accreditation, should be as independent of language as possible. The terms for large numbers such as 10^9 are not standardized internationally and so, for example, in the USA 10^9 is called one "billion": in most other countries, this number is called one "trillion". Therefore, language-dependent terms such as "million," "billion," and so on are to be avoided. Where it is absolutely necessary to use these terms (or their abbreviations), these will be defined in the laboratory's scope of accreditation. Such instances will be considered on a case-by-case basis.

NOTE 2: Examples of how "ppm" is equivalent to "μX/X" are noted below, where $(10^{-6}) = \mu$ (micro) and $(10^{-12}) = p$ (pico):

a. <u>3 ppm on 1 V range = 3 μV/V:</u>

3 ppm $= 3 \cdot (10^{-6})$ of 1 V per 1 V range

$= 3 \cdot (10^{-6}) \cdot [1\ V/1\ V]$
$= 3 \cdot \mu \cdot [V/V]$
$= 3\ \mu V/V$

b. <u>3 ppm on 10 V range means 3 μV/V:</u>

3 ppm $= 3 \cdot (10^{-6})$ of 10 V per 10 V range

$= 3 \cdot (10^{-6}) \cdot [10\ \text{V}/10\ \text{V}]$
$= 3 \cdot \mu \cdot [\text{V/V}]$
$= 3\ \mu\text{V/V}$

c. <u>3 ppm on 0.001 V range means 3 μV/V:</u>

3 ppm $= 3 \cdot (10^{-6})$ of 0.001 V per 0.001 V range

$= 3 \cdot (10^{-6}) \cdot [0.001\ \text{V}/0.001\ \text{V}]$
$= 3 \cdot \mu \cdot [\text{V/V}]$
$= 3\ \mu\text{V/V}$

d. <u>7 ppm on 10 pF range means 7 μF/F:</u>

7 ppm $= 7 \cdot (10^{-6})$ of 10 pF per 10 pF range

$= 7 \cdot (10^{-6}) \cdot [10 \cdot \text{pF}/10 \cdot \text{pF}]$
$= 7 \cdot \mu \cdot [(10^{-12})\ \text{F}/(10^{-12})\ \text{F}]$
$= 7 \cdot \mu \cdot [\text{F/F}]$
$= 7\ \mu\text{F/F}$

7.2.5 For frequency parameters, a fixed point is listed in the range column and the CMC is listed as either X parts in 10^{xx} of the value of the range or with the quantity symbol for frequency.

Note: An Example of how a CMC of 2 parts in 10^{11} at 10 MHz equals 0.2 mHz:

<u>2 parts in 10^{11} of 10 MHz means 0.2 mHz:</u>

2 parts in 10^{11} $= 2 \cdot (10^{-11}) \cdot [10 \cdot 10^{6}\ \text{Hz}]$
$= 2 \cdot (10^{-11}) \cdot [10^{7}\ \text{Hz}]$
$= 2 \cdot 10^{-4}\ \text{Hz}$
$= 0.2\ \text{mHz}$

7.2.6 Unit symbols (or names) are not modified by the addition of subscripts or other information. The following forms, for example, are used instead.

$V_{max} = 1000$ V	*but not:*	$V = 1000\ \text{V}_{max}$
a mass fraction of 10 %	*but not:*	10 % (*m*/*m*) or 10 % (by weight)

7.2.7 Statements such as "the length l_1 exceeds the length l_2 by 0.2 %" are avoided because it is recognized that the symbol % represents simply the number 0.01. Instead, forms such as "$l_1 = l_2(1 + 0.2\ \%)$" or "$\Delta = 0.2\ \%$" are used, where Δ is defined by the relation $\Delta = (l_1 - l_2)/l_2$.

7.2.8 Information is not mixed with unit symbols (or names). For example, the form "the water content is 20 mL/kg" is used and not "20 mL H_2O/kg" or "20 mL of water/kg."

7.2.9 It is clear to which unit symbol a numerical value belongs and which mathematical operation applies to the value of a quantity because forms such as the following are used.

35 cm × 48 cm	*but not:*	35 × 48 cm
1 MHz to 10 MHz or (1 to 10) MHz	*but not:*	1 MHz – 10 MHz or 1 to 10 MHz or 1 – 10 MHz
20 °C to 30 °C or (20 to 30) °C	*but not:*	20 °C – 30 °C or 20 to 30 °C or 20 – 30 °C
123 g ± 2 g or (123 ± 2) g	*but not:*	123 ± 2 g
70 % ± 5 % or (70 ± 5) %	*but not:*	70 ± 5 %
240 × (1 ± 10 %) V	*but not:*	240 V ± 10 % (since one cannot add 240 V and 10 %)

7.2.10 Unit symbols and unit names are not mixed and mathematical operations are not applied to unit names. For example, only forms such as kg/m^3, kg · m^{-3}, or kilogram per cubic meter are used and *not* forms such as kilogram/m^3, kg/cubic meter, kilogram/cubic meter, kg per m^3, or kilogram per meter^3.

7.2.11 Values of quantities are expressed in acceptable units using Arabic numerals and the symbols for the units.

m = 5 kg	*but not:*	*m* = five kilograms or *m* = five kg
the current was 15 A	*but not:*	the current was 15 amperes

7.2.12 There is a space between numerical value and unit symbol, even when the value is used in an adjectival sense, except in the case of superscript units for plane angle.

a 25 kg sphere	*but not:*	a 25-kg sphere
an angle of 2°3’4”	*but not:*	an angle of 2 °3 ’4” or 2° 3’ 4” or 2 ° 3 ’ 4 ”

7.2.13 The digits of numerical values having more than four digits on either side of the decimal marker are separated into groups of three using a thin, fixed space counting from both the left and right of the decimal marker. For example, 15 739.012 53 is highly preferred to 15739.01253. Commas are not used to separate digits into groups of three.

7.2.14 Equations between quantities are used in preference to equations between numerical values, and symbols representing numerical values are different from symbols representing the corresponding quantities. When a numerical-value equation is used, it is properly written and the corresponding quantity equation is given where possible.

7.2.15 Standardized quantity symbols such as those given in ISO 31 Parts 0 – 13 are used, for example R for resistance and A_r for relative atomic mass, and not words, acronyms, or ad hoc groups of letters. Similarly, standardized mathematical signs and symbols such as are given in ISO 31–11 are used, for example, "tan x" and not "tg x." More specifically, the base of "log" in equations is specified when required by writing $\log_a x$ (meaning log to the base a of x), lb x (meaning $\log_2 x$), ln x (meaning $\log_e x$), or lg x (meaning $\log_{10} x$).

7.2.16 Unit symbols are in roman type, and quantity symbols are in italic type with superscripts and subscripts in roman or italic type as appropriate.

7.2.17 When the word "weight" is used, the intended meaning is clear. (In science and technology, weight is a force, for which the SI unit is the newton; in commerce and everyday use, weight is usually a synonym for mass, for which the SI unit is the kilogram.)

7.2.18 A quotient quantity, for example, mass density, is written "mass divided by volume" rather than "mass per unit volume."

7.2.19 An object and any quantity describing the object are distinguished. (Note the difference between "surface" and "area," "body" and "mass," "resistor" and "resistance," "coil" and "inductance."

7.2.20 The obsolete term normality and the symbol N, and the obsolete term molarity and the symbol M, are not used, but the quantity amount-of-substance concentration of B (more commonly called concentration of B), and its symbol c_B and SI unit mol/m^3 (or a related acceptable unit), are used instead. Similarly, the obsolete term molal and the symbol m are not used, but the quantity molality of solvent B, and its symbols b_B or m_B and SI unit mol/kg (or a related SI unit), are used instead.

7.3. Other systems of units

7.3.1 In the English customary systems there are no official symbols or abbreviations. For many English units a variety of symbols are used. Sometimes these symbols duplicate metric symbols; for example, "A" is sometimes used in English for the acre instead of the ampere. A2LA policy is to apply the SI rules to the use of English symbols[1]. This is done for both consistency and clarity. It avoids a number of problems caused by the traditional abbreviations for the English units, especially the following:

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[1] See http://www.unc.edu/~rowlett/units/ for the original exposition of this policy and an exhaustive list of abbreviations for the English customary units. This web site is the basis for this section of this document.

7.3.1.1 In the English systems, there is no general agreement as to whether symbols for units are capitalized or not. Consequently, English-speaking writers applying this informal practice to metric symbols sometimes create unintended errors, such as "10 ML" used for 10 **milli**liters when it actually means 10 **mega**liters. Even standard dictionaries in English sometimes give the wrong case for metric symbols. For A2LA scopes, the SI convention for capitalization is applied (with a very few exceptions) to the English symbols as well: a letter is capitalized only if it comes from a proper name. Thus we write Btu (not BTU) for the British thermal unit.

7.3.1.2 In English traditional unit abbreviations, the letter "p" is often used as an abbreviation for "per", "sq" or "s" as an abbreviation for "square", and "cu" or "c" as an abbreviation for "cubic". These conventions can lead to confusing symbols and should be avoided. Although it is traditional to write "psi" for pounds per square inch, the symbol lbf/in^2 is much clearer; similarly, traditional abbreviations such as cfm (for cubic feet per minute, a unit of flow) may not be understood by general readers: ft^3/min is less ambiguous. Where necessary, any clarification regarding the use of these abbreviations will be defined in a footnote in the scope document.

7.4. Test method-specific unit symbols

7.4.1 Unit symbols that are defined in, for example, ASTM test methods shall be written exactly as specified in the test method and individual variations are not permitted. Hardness testing is one of the most common examples of lapses in this area. Thus, for example, the unit symbol for Rockwell hardness (ASTM E18) on the C scale is HRC. Generalization to other scales by dropping the scale letter (i.e. using HR to represent any Rockwell hardness scale) is not permitted on scopes of accreditation.

7.4.2 The principles explained above shall apply to the use of any unit symbol defined in a test method.

VIII. References

A2LA *F204 – Scope of Accreditation Selection List - Calibration Laboratories*

A2LA *R104 – General Requirements: Accreditation of Field Testing and Field Calibration Laboratories*

A2LA *R205 – Specific Requirements – Calibration Laboratory Accreditation Program*.

"How many? A dictionary of units of measurement", by Russ Rowlett, Director, Center for Mathematics and Science Education, University of North Carolina at Chapel Hill, http://www.unc.edu/~rowlett/units/

IEEE/ASTM SI0-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*

ILAC P14:11/2010 *ILAC Policy for Uncertainty in Calibration*

ILAC G18:04/2010 *Guideline for the Formulation of Scopes of Accreditation for Laboratories*

Guide 99: International vocabulary of metrology – Basic and general concepts and associated terms (VIM), ISO, 2007.

NIST Special Publication 330, 2008 Edition, *The International System of Units* (SI).

NIST Special Publication 811, 2008 Edition, *Guide for the Use of the International System of Units* (SI).

Quantities and units — Part 0: *General principles*, ISO 31-0:1992.

Quantities and units — Part 1: *Space and time*, ISO 31-1:1992.

Quantities and units — Part 2: *Periodic and related phenomena*, ISO 31-2:1992.

Quantities and units — Part 3: *Mechanics*, ISO 31-3:1992.

Quantities and units — Part 4: *Heat*, ISO 31-4:1992.

Quantities and units — Part 5: *Electricity and magnetism*, ISO 31-5:1992.

Quantities and units — Part 6: *Light and related electromagnetic radiations*, ISO 31-6:1992.

Quantities and units — Part 7: *Acoustics*, ISO 31-7:1992.

Quantities and units — Part 8: *Physical chemistry and molecular physics*, ISO 31-8:1992.

Quantities and units — Part 9: *Atomic and nuclear physics*, ISO 31-9:1992.

Quantities and units — Part 10: *Nuclear reactions and ionizing radiations*, ISO 31-10:1992.

Quantities and units — Part 11: *Mathematical signs and symbols for use in physical sciences and technology*, ISO 31-11:1992.

Quantities and units — Part 12: *Characteristic numbers*, ISO 31-12:1992.

Quantities and units — Part 13: *Solid state physics*, ISO 31-13:1992.

SI units and recommendations for the use of their multiples and of certain other units, ISO 1000:1992.

*(***Note**: ISO 31-0:1992 — ISO 31-13:1992 and ISO 1000:1992 are reprinted in the ISO Standards Handbook *Quantities and units* (International Organization for Standardization, Geneva, Switzerland, 1993).

Document Revision History

Date	Description
November 6, 2008	New document renamed from G101 to a requirements document, minor edits for clarification of A2LA practices
July 13, 2010	• Revision to change "best uncertainty" to "best measurement capability" and "best measurement capability" to Calibration and Measurement Capability (CMC)" • Addition of language indicating that CMCs lower than NMI claims as found on the BIPM website will not be allowed on A2LA scopes. • Revision to ppm to update that the use of scientific notation with quantity symbols, are not to be used to express the values of quantities and to outline how CMCs are expressed for frequency parameters.
May 5, 2011	• Revision for addition of information from ILAC P14, removal of information to EA-04/02, realignment/numbering of sections of the document and addition of R104 reference.