NIST Handbook
NIST Handbook 150-2e2024

NVLAP Calibration Laboratories

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This publication is available free of charge from:
https://doi.org/10.6028/NIST.HB.150-2e2024

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

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NVLAP Calibration Laboratories

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October 2024

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

NIST HB 150-2e2024
October 2024

Publication History
Approved by the NIST Editorial Review Board on 2023-05-25
Supersedes NIST Handbook 150-2-2019 (July 2019) https://doi.org/10.6028/NIST.HB.150-2e2024

How to Cite this NIST Technical Series Publication
Guerrieri, J., Knake, R., Harper, K. (2024) NVLAP Calibration Laboratories. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Handbook (HB) 150-2e2024. https://doi.org/10.6028/NIST.HB.150-2e2024

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NVLAP AND THE NVLAP LOGO

Abstract

NIST Handbook 150-2 presents the technical requirements and provides guidance for the accreditation of laboratories under the NVLAP Calibration Laboratories Accreditation Program (Calibration LAP). It supplements the NVLAP procedures and general requirements found in NIST Handbook 150, by tailoring the general criteria found in that Handbook to the specific calibrations and types of calibrations covered by the Calibration LAP. It is intended for information and use by accredited laboratories, laboratories seeking accreditation, laboratory accreditation systems, users of laboratory services, and others needing information on the requirements for accreditation under this program. The 2024 edition of NIST Handbook 150-2 contains a few changes to the requirements applicable to all calibration laboratories and more significant changes to the annexes that cover specific technical fields of calibration. The document summarizes the changes in its Foreword. The requirements of NIST Handbook 150 and the specific requirements and interpretations in the NIST Handbook 150-2 must be combined to produce the criteria for accreditation in the NVLAP Calibration LAP. For more information visit the NVLAP website.

Keywords

accreditation; calibration; conformity assessment; ISO/IEC 17025; laboratory; management system; NVLAP; standards.

Contents

Foreword

The NIST Handbook 150 publication series sets forth the procedures, requirements, and guidance for the accreditation of testing and calibration laboratories by the National Voluntary Laboratory Accreditation Program (NVLAP). The series comprises the following publications:

- NIST Handbook 150, *NVLAP Procedures and General Requirements* (hereafter referred to as NIST Handbook 150), which contains the general procedures and requirements under which NVLAP operates as an unbiased third-party accreditation body;
- NIST Handbook 150-xx program-specific handbooks, which supplement NIST Handbook 150 by providing additional requirements, guidance, and interpretive information applicable to specific NVLAP laboratory accreditation programs (LAPs).

The program-specific handbooks are not stand-alone documents, but rather are companion documents to NIST Handbook 150. They tailor the general criteria found in NIST Handbook 150 to the specific tests, calibrations, or types of tests or calibrations covered by a LAP.

NIST Handbook 150-2, *NVLAP Calibration Laboratories,* presents the technical requirements and guidance for the accreditation of laboratories under the NVLAP Calibration Laboratories LAP. It was written with the participation of technical experts in eight fields of calibration: dimensional, electromagnetics – dc/low frequency, electromagnetics – rf/microwave frequency, time and frequency, ionizing radiation, mechanical, optical radiation, and thermodynamic. The 2024 edition of NIST Handbook 150-2 supersedes and replaces the 2019 edition.

The revisions in the 2024 edition of this handbook were made with inputs from technical experts from the laboratory, assessor, and State weights and measures areas. The following significant changes have been made to this handbook with respect to the previous edition:

- Sections 7.6.2 and 7.8.1 have been updated to fully reflect the requirements of ILAC P14:2020.
- Section 7.7.2.1 has been updated to include the use of risk-based thinking in the establishment of proficiency testing intervals.
- Annex D sets out technical requirements not covered in NIST Handbook 150 that are applicable to a laboratory performing mechanical calibrations in the areas of force, mass, and now flow. The requirements related to flow are not new; rather they have been in place in the form of a NVLAP Lab bulletin, LB-100-2017, since August 2017 and have now been incorporated into the handbook.
- Requirements applicable only to legal metrology laboratories have been removed from Annex D with the exception of flow. Note that this resulted in the complete removal of the volume section. (See the next bullet item for further details on legal metrology.)

- Annex E sets out logistical requirements not covered in NIST Handbook 150 that are applicable to the NVLAP assessment and accreditation of laboratories that are recognized by the NIST Office of Weights and Measures and that perform legal metrology as State weights and measures laboratories. NVLAP assesses these laboratories to the requirements of the current versions of ISO/IEC 17025, NIST Handbook 150, NIST Handbook 150-2 (this Handbook), and NIST Handbook 143.

Additional annexes covering the remaining fields of calibration will be published upon the completion of their review and updating. For areas where additional annexes have not yet been developed, it is suggested that laboratories continue to follow best practices for those fields of calibration.

Previously issued NVLAP lab bulletins pertaining to the Calibration Laboratories LAP have been incorporated into the appropriate clauses of the handbook. References and definitions have been updated, where necessary. Lastly errata collected on the 2019 version have been addressed in this revision.

This handbook is also available on the NVLAP website.

Questions or comments concerning this handbook should be submitted to NVLAP, National Institute of Standards and Technology, 100 Bureau Drive, Mailstop 2140, Gaithersburg, MD, 20899-2140; phone: 301-975-4016; fax: 301-926-2884; e-mail: nvlap@nist.gov.

Introduction and acknowledgments

The Calibration Laboratories Accreditation Program was developed by the National Voluntary Laboratory Accreditation Program (NVLAP) at the National Institute of Standards and Technology (NIST) at the request of the National Conference of Standards Laboratories (now NCSL International). The goal of the program is to provide a means by which calibration laboratories can be assessed for competency. This voluntary program is not designed to impose specific calibration procedures or minimum uncertainties on applicant laboratories; instead, the program allows for all scientifically valid calibration schemes and requires that laboratories derive and document their calibration and measurement capabilities (CMCs).

In order to streamline program documentation, this handbook consolidates and replaces the previous technical guidance documents in the NIST Handbook 150-2 series. Clauses 3 through 8 and the normative annexes of this handbook include requirements for accreditation that are in addition to those found in ISO/IEC 17025. Annexes for the fields of calibration will be published as they are completed. The authors wish to thank our NIST colleagues who provided technical contributions and reviews for the revision of this handbook.

1 General information

1.1 Scope

1.1.1 This handbook specifies the technical requirements and provides guidance for the accreditation of laboratories under the NVLAP Calibration Laboratories Accreditation Program (Calibration LAP). It supplements the NVLAP procedures and general requirements found in NIST Handbook 150 by tailoring the general criteria found in NIST Handbook 150 to the specific calibrations and types of calibrations covered by the Calibration LAP.

1.1.2 NIST Handbook 150, ISO/IEC 17025, and this handbook constitute the collective body of requirements that must be met by a laboratory seeking NVLAP accreditation for the Calibration LAP.

1.1.3 This handbook is intended for information and use by accredited calibration laboratories, assessors conducting on-site assessments, laboratories seeking accreditation, other laboratory accreditation systems, users of laboratory services, and others needing information on the requirements for accreditation under the Calibration LAP.

1.1.4 Within this handbook, the term calibration report is used. Calibration certificate is an equally acceptable alternate name to use for such documents.

1.2 Organization of handbook

1.2.1 The numbering scheme used in clauses 4 through 8 of this handbook corresponds to that used in ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*. In some cases, upper-level headings have been included for clarity with no additional text and refer the reader to ISO/IEC 17025 or to a specific technical annex.

1.2.2 The following technical annexes form a normative part of this handbook, meaning they contain provisions that laboratories must meet in order to conform to the requirements for accreditation:

- Annex A, Optional addition to scope of compliance with ANSI/NCSL Z540-1-1994, Part I;
- Annex B, Dimensional measurements;
- Annex C, Time and frequency measurements;
- Annex D, Mechanical measurements (force, mass, flow);
- Annex E, Requirements for NVLAP-accredited legal metrology laboratories.

1.2.3 The word ‘shall’ is used throughout this handbook and describes mandatory requirements for accreditation. The word ‘should’ is used where guidance is provided but does not preclude other acceptable practices.

1.2.4 A note (shown as NOTE and in a smaller font) contains additional information intended to assist the understanding or use of the document. Notes may provide clarification of the text, examples, and guidance; they do not contain requirements.

1.3 Program description

1.3.1 In 1994 the Calibration LAP began accepting applications for accreditation. Presently, the LAP encompasses eight fields of calibration covering a wide variety of parameters and includes accreditation in multifunction measuring and test equipment calibrations. Depending on the breadth of its calibration capabilities, a laboratory may seek accreditation for all or only selected parameters and/or calibrations offered in the Calibration LAP.

1.3.2 A laboratory may request to have parameters or calibrations added to the scope of the Calibration LAP. Any additions will be handled in accordance with NVLAP procedures for adding to or modifying an established LAP (see NIST Handbook 150, clause 2).

1.4 References

The following documents are referenced in this handbook and pertain to the overall Calibration LAP. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) shall apply within one year of publication or within another time limit specified by regulations or other requirement documents.

References that are specific to a field of calibration are listed in the appropriate annex of this handbook. Additional references are posted on the Calibration LAP webpage on the NVLAP website.

[1] ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories
[2] ANSI/NCSLI Z540-1-1994 (R2002), Calibration Laboratories and Measuring and Test Equipment – General Requirements
[3] BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, Guide to the Expression of Uncertainty in Measurement (GUM)
[4] ILAC-P14:09, ILAC Policy for Uncertainty in Calibration
[5] ILAC-P09:06, ILAC Policy for Participation in Proficiency Testing Activities
[6] ISO/IEC 17043, Conformity assessment – General requirements for proficiency testing
[7] ISO 80000, Quantities and units – Part 1: General laboratories
[8] NIST Handbook 150, NVLAP Procedures and General Requirements

1.5 Terms and definitions

For the purposes of this handbook, the terms and definitions given in NIST Handbook 150, ISO/IEC 17025, and the following apply:

1.5.1
measuring and test equipment (M & TE)
All of the measuring instruments, measurement standards, reference materials, auxiliary apparatus, and instructions that are necessary to perform a measurement. This term includes measuring equipment used in the course of testing and inspection, as well as that used in calibration.

NOTE In the context of this handbook, the term *measuring and test equipment* is taken to encompass *measurement instruments* and *measurement standards*. Moreover, a *reference material* is considered to be a type of *measurement standard*.

1.5.2
precision
Repeatability of measurement data; the similarity of successive independent measurements of a single magnitude generated by repeated applications of a process under specified conditions.

1.5.3
uncertainty, Type A (evaluation of)
Method of evaluation of uncertainty by the statistical analysis of a series of observations.

1.5.4
uncertainty, Type B (evaluation of)
Method of evaluation of uncertainty by means other than the statistical analysis of a series of observations.

1.5.5
field(s) of calibration
The top-level division of the broad range of measurement areas in which NVLAP accredits laboratories. The eight current fields of calibration in which NVLAP offers accreditation are: dimensional, electromagnetics – dc/low frequency, electromagnetics – rf/microwave frequency, time and frequency, ionizing radiation, mechanical, optical radiation, and thermodynamic.

1.6 Program documentation

1.6.1 General

Assessors use NVLAP checklists to ensure that each laboratory receives an assessment comparable to that received by others. Checklists assist assessors in documenting the

assessment to the NVLAP requirements found in NIST Handbook 150, ISO/IEC 17025, and this handbook. Checklists contain definitive statements or questions about all aspects of the NVLAP requirements for accreditation and form part of the onsite assessment report (see NIST Handbook 150 clause 3.3.3).

1.6.2 NVLAP General Criteria Checklist

All NVLAP programs use the NVLAP General Criteria Checklist which contains the requirements published in NIST Handbook 150 and ISO/IEC 17025. The checklist items are numbered to correspond to ISO/IEC 17025, clauses 4 through 8, and to NIST Handbook 150, annexes A, B, and E. Applicant or accredited laboratories may contact a NVLAP Program Manager to obtain a copy of this checklist.

1.6.3 NIST Handbook 150-2 Checklist

The NIST Handbook 150-2 Checklist addresses the requirements specific to the Calibration LAP (also referred to as the Calibration LAP Program-Specific Checklist). This checklist is available on the NVLAP Interactive Web System (NIWS) portal.

1.6.4 NVLAP Lab Bulletins

NVLAP Lab Bulletins are issued to laboratories and assessors, when needed, to clarify program-specific requirements and to provide information about program additions and changes.

2 LAP establishment, development, and implementation

This clause contains no information additional to that provided in NIST Handbook 150, clause 2.

3 Accreditation process

3.1 General

An overview of the laboratory accreditation process is provided in NIST Handbook 150, clause 3, and includes information pertaining to application for accreditation; onsite assessment; proficiency testing; accreditation decision; granting accreditation; renewal of accreditation; changes to scope of accreditation; monitoring visits; and suspension, denial, revocation, and voluntary termination of accreditation.

3.1.1 Uncertainty budgets

Laboratories shall submit uncertainty budgets for all requested CMCs with their application (new or at each renewal), and at any time when there are changes requiring a revision to the

scope of accreditation. These shall be source documents that allow NVLAP staff and assessors to see calculations and constants. The laboratories shall not convert the spreadsheet to a pdf.

3.1.2 Proficiency testing plan

With each renewal of accreditation, an accredited calibration laboratory shall provide an updated proficiency testing (PT) participation plan, including evidence that previously planned activities have been completed. (See section 7.7.2.4)

NVLAP Program Managers review the plan and work with the laboratory as necessary to ensure that it adequately covers the scope of accreditation. During the onsite assessment, the assessors review the results of proficiency testing.

3.2 Management system review

Prior to applying to NVLAP for accreditation, a laboratory should have a fully implemented management system. If the management system of the laboratory uses different numbering than that of ISO/IEC 17025, the laboratory shall create a cross-reference document allowing the laboratory and a NVLAP assessor to verify that all requirements of clauses 4 through 8 of the international standard, as well as other applicable general NVLAP requirements, are met by the management system. Additionally, the locations within the laboratory's management system of the requirements given in this document, NIST Handbook 150-2, shall be provided in a cross-reference document. Note that the NVLAP General Criteria Checklist contains a column for the location of specific requirements within a laboratory's management system and, when this column is completed, it may serve as a core part of a cross-reference document. The checklist associated with this handbook may be similarly used.

NOTE A subset of requirements may be fulfilled by some laboratories without either program, policy, procedure, or resulting records. When completing the cross-reference document, for clauses where no documentation is required and your laboratory meets the requirement without documentation, it is acceptable to simply note *met without documentation* for the relevant clause. These requirements will be assessed through discussion during the onsite assessment.

3.3 Onsite assessment

3.3.1 Overview

The onsite assessment process is described in NIST Handbook 150, section 3.3. In most cases, the assessment of a calibration laboratory's full scope of accreditation requires several days at the laboratory's site with a team of assessors. The assigned team leader will coordinate activities with the laboratory and the assessment team.

3.3.2 Assessment of field locations

3.3.2.1 Many NVLAP-accredited laboratories provide calibrations in the field by sending a calibration technician from their main laboratory (the facility listed on the scope of accreditation) to a customer's site. When such a service is available for a given calibration, it is indicated on the scope of accreditation.

NOTE The additional requirements in the next subclause do not apply to field service calibrations performed by staff based at the main laboratory.

3.3.2.2 When a laboratory has technical aspects of its accredited work being performed at a field location by staff not based at the laboratory's main facility, the following requirements for NVLAP accreditation in a) through j) shall apply:

a) The laboratory shall demonstrate that all requirements of ISO/IEC 17025 and NIST Handbook 150 (other than the calibration) are being managed, performed, or otherwise controlled at the main facility.
b) The management system documentation shall clearly cover the processes for managing the field operations and identify the personnel specifically authorized to perform calibrations at the field locations.
c) For an initial accreditation of a calibration laboratory having one or more field locations, at least one field location shall be assessed by NVLAP.
d) In addition, all signatories shall be present at the initial assessment of the main facility.
e) The laboratory shall have field representatives (signatories and/or calibration technicians) available at the main facility for renewal assessments. In advance of the assessment, NVLAP will notify the laboratory which, or how many, of the field representatives are to be present.
f) As described in NIST Handbook 150, assessments are normally held biennially. During what would otherwise be a non-assessment year, an assessment of a field representative shall be done at his or her usual location if all field locations were not visited as part of the regular biennial assessment.
g) The laboratory shall demonstrate that field personnel are trained at the main facility, by staff from the main facility, or by field-based training staff specifically trained at the main facility.
h) The manner in which field personnel are trained shall be included in the training system documentation.
i) Calibration reports shall be issued by the main facility, indicate the physical locations where the calibrations were performed, and be signed by approved signatories.
j) The laboratory shall have a defined interlaboratory comparison program between its headquarters and field locations.

3.4 Laboratories seeking accreditation for calibrations with uncertainties near those provided by a national metrology institute (NMI)

There are additional requirements in cases where laboratories are seeking accreditation for calibrations with uncertainties deemed by NVLAP to be near those provided by an NMI. These requirements include assessment by an NMI expert, detailed review of uncertainty budgets by

NMI technical experts, and proficiency testing of rigor comparable to an NMI key or regional supplementary comparison.

3.5 Policy on scopes of accreditation of calibration laboratories[1]

Section 3.5 is informational in nature and is included as explanation to laboratories about the data NVLAP collects for the scopes of accreditation that represent their accredited capabilities.

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

a) measurand;
b) calibration/measurement method/procedure;
c) type of instrument to be calibrated/measured;
d) measurement range and additional parameters where applicable, e.g., frequency of applied voltage;
e) uncertainty of measurement.

3.5.2 There shall be no ambiguity in 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) a single value, which is valid throughout the measurement range;
b) a range, in which case a calibration laboratory should have proper assumptions 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;
f) also, open intervals (e.g., “U < x”) are incorrect in the expression of CMCs.

NOTE In order to harmonize scopes within NVLAP, NVLAP may require a specific form of expressing range and/or uncertainty of measurement for any given parameter.

3.5.3 The uncertainty covered by the CMC shall be expressed, unless explicitly agreed upon, as the expanded uncertainty having a specific coverage probability of approximately 95 %. The unit of the uncertainty shall be the same as that of the measurand or in a term relative to the measurand, e.g., percent, µV/V, or part in 10^6. This is excepted where U.S. industry practice dictates a specific expression of uncertainty.

[1] ILAC-P14:09/2020, *ILAC Policy for Uncertainty in Calibration.*

4 General requirements

4.1 Impartiality

There are no requirements additional to those set forth in ISO/IEC 17025.

4.2 Confidentiality

There are no requirements additional to those set forth in ISO/IEC 17025.

5 Structural requirements

There are no requirements additional to those set forth in ISO/IEC 17025.

6 Resource requirements

6.1 General

There are no requirements additional to those set forth in ISO/IEC 17025.

6.2 Personnel

Any requirements for personnel competence in a specific technical area that go beyond those described in ISO/IEC 17025 are given in the annex associated with that field of calibration.

6.3 Facilities and environmental conditions

Any requirements for accommodation and environmental conditions in a specific technical area that go beyond those described in ISO/IEC 17025 are given in the annex associated with that field of calibration.

6.4 Equipment

Any requirements for equipment in a specific technical area that go beyond those described in ISO/IEC 17025 are given in the annex associated with that field of calibration.

6.5 Metrological traceability

There are no additional requirements to those set forth in ISO/IEC 17025 and NIST Handbook 150, Annex B.

6.6 Externally provided products and services

There are no additional requirements to those set forth in ISO/IEC 17025.

7 Process requirements

7.1 Review of requests, tenders and contracts

There are no additional requirements to those set forth in ISO/IEC 17025.

7.2 Selection, verification and validation of methods

7.2.1 Selection and verification of methods

Any requirements for calibration methods and their selection in a specific technical area that go beyond those described in ISO/IEC 17025 are given in the annex associated with that field of calibration.

7.2.2 Validation of methods

There are no additional requirements to those set forth in ISO/IEC 17025.

7.3 Sampling

There are no additional requirements to those set forth in ISO/IEC 17025.

7.4 Handling of calibration items

Any requirements for handling of calibration items in a specific technical area that go beyond those described in ISO/IEC 17025 are given in the annex associated with that field of calibration.

7.5 Technical records

There are no additional requirements to those set forth in ISO/IEC 17025.

7.6 Evaluation of measurement uncertainty[1]

7.6.1 Calibration laboratories shall provide evidence that they can provide calibrations to customers so that measurement uncertainties equal those covered by the CMC.

7.6.2 The CMC quoted shall include the contribution from a best existing device to be calibrated such that the CMC claimed is demonstrably realizable.

NOTE 1 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 2 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 as per 7.6.2.

NOTE 3 In very 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 NVLAP scope of accreditation shall clearly identify that the contributions to the uncertainty from the device are not included.

7.7 Ensuring the validity of results

7.7.1 Proficiency testing[2]

Proficiency testing is an important tool to demonstrate laboratory competence and to assist with maintaining the quality of a laboratory's performance.

7.7.2 Proficiency testing (PT) requirements

7.7.2.1 Frequency of PT

A calibration laboratory shall meet the following requirements for frequency of PT:

a) For those measurement parameters for which it is available, laboratories shall participate in appropriately rigorous PT (testing at the level of the laboratory's accredited capabilities).
b) An applicant laboratory shall show satisfactory participation in at least one PT prior to initial accreditation.
c) Initially, an accredited laboratory shall participate in proficiency testing in each field of calibration published on their scope at least once every four years. If a trend of successful performance in appropriately challenging proficiency tests in a given field of calibration has been established, a laboratory may, at their discretion, perform a risk analysis to determine if it is in their interest to extend this frequency.
d) If a laboratory makes a decision to extend their interval between proficiency testing for a field of calibration, they shall notify NVLAP, submit an updated proficiency testing plan reflecting the change, and provide a summary of the risk analysis on which they based their decision.

NOTE For some fields of calibration, e.g., ionizing radiation, NVLAP supports industry sector requirements for increased proficiency testing frequency. When this is the case, additional information is given in the technical annex for that field. In cases where an industry sector requires an increased frequency, it overrides the flexibility to extend the interval based on a risk analysis, regardless of the results of the analysis. The industry sector requirement is considered to be fixed.

e) A laboratory shall meet any additional PT requirements stated in the annexes in this handbook related to the parameter(s) for which it is accredited.

[2] ILAC-P09:06/2014, *ILAC Policy for Participation in Proficiency Testing Activities.*

f) As established in section 3.4 of this handbook, laboratories seeking accreditation for calibrations with uncertainties deemed by NVLAP to be near those provided by an NMI, proficiency testing of rigor comparable to an NMI key or regional supplementary comparison will be required, and at a specified frequency that may exceed that in 7.7.2.1c. Such PT may be identified by NVLAP in consultation with NIST experts for parameters where laboratories are operating at or near NIST uncertainties. In this case, the laboratory shall participate in the identified PT.

7.7.2.2 Acceptable PT activities

A calibration laboratory shall use one or more of the following types of proficiency testing:

a) PT through a provider accredited to ISO/IEC 17043 for the parameter being tested at the uncertainty level of that test, where that the accreditation to ISO/IEC 17043 is issued by a body that is signatory to a mutual recognition arrangement (MRA) for proficiency testing accreditation in a regional body recognized by the International Laboratory Accreditation Cooperation (ILAC); or
b) PT that is coordinated through the NIST Office of Weights and Measures (OWM) Regional Measurement Assurance Program (RMAP); or
c) PT or Measurement Assurance Program (MAP) offered through a NIST technical division; or
d) an exception: it is possible that PT providers that are not accredited may be acceptable. In this case, the non-accredited PT provider shall meet the requirements of ISO/IEC 17043, where applicable. The acceptability of proficiency tests from such providers will be determined by NVLAP in consultation with the laboratory.

7.7.2.3 Reporting of PT

A calibration laboratory shall meet the following requirements for reporting proficiency testing:

a) PT results shall be available for review during onsite assessments.
b) The E-normal value (E_n) shall be reported for each measurement result, where applicable.

E_n numbers are calculated using the equation:

$$E_n = \frac{x - X}{\sqrt{{U_{lab}}^2 + {U_{ref}}^2}}$$

where:

x is the participant's result;

X is the reference value;

U_{lab} is the expanded uncertainty of the participant's result; and

U_{ref} is the expanded uncertainty of the reference value.

$|E_n| \leq 1.0$ indicates "satisfactory" performance.

$|E_n| > 1.0$ indicates "unsatisfactory" performance.

NOTE Where the proficiency test has multiple E_n values for a range of measurements, allowance for a number of individual measurement E_n values to be greater than 1 may be applied. This allowance is based on the coverage probability of 95 % as long as sufficient (typically 10 or more) measurement points are taken for determination.

c) Laboratories are required to address unsatisfactory PT results. Records of corrective actions taken to address unsatisfactory results shall be available for review during assessments.

7.7.2.4 Laboratory PT Plan

A calibration laboratory shall have a PT plan meeting the following requirements:

a) An applicant calibration laboratory shall develop a proficiency testing participation plan, describing how the laboratory will meet requirements for minimum participation in PT given above.
b) With each renewal of accreditation, an accredited calibration laboratory shall provide an updated PT participation plan, including evidence that planned activities have been completed. NVLAP Program Managers review the plan and work with the laboratory as necessary to ensure that it adequately covers the scope of accreditation. During the onsite assessment, the assessors review the results of proficiency testing.
c) The PT plan shall reflect the laboratory's past-year PT activities as well as planned activities for the next three years to provide continuing evidence that technical competence is being maintained.
d) The PT plan shall be regularly reviewed by the laboratory in response to changes in scope, staffing, methodology, instrumentation, etc.

NOTE Review of the PT plan by the laboratory may occur as part of the management review process.

7.8 Reporting results

7.8.1 Calibration measurement results[1]

When calibration measurement results are reported on calibration certificates, the following requirements shall be met:

a) 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 $y \pm U$, each 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.

b) 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 (*U*) 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 presentations other than $y \pm U$ may be needed. This may also be the case when uncertainty is determined by Monte Carlo simulations (propagation of distributions) or with logarithmic units.

c) The numerical value of the expanded uncertainty shall be given to, at most, two significant figures.
d) Rounding shall be used to determine the numerical value of the expanded uncertainty to two significant figures or less.
   i) When all calculations have been completed, resultant values shall then be rounded for presentation.
   ii) For the process of rounding, the usual rules for rounding of numbers shall be used, subject to the guidance on rounding provided, e.g., in Section 7 of the GUM.

NOTE For further details on rounding, see the GUM and/or ISO 80000-1:2009.

e) Contributions to the uncertainty stated on the calibration certificate shall include relevant short-term contributions during the calibration and contributions that can reasonably be attributed to the customer's device.
f) 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. 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 should be notified according to the general clauses regarding tenders and reviews of contracts in ISO/IEC 17025.
g) 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.

7.8.2 Additional requirements for specific technical areas

Information regarding additional requirements on reporting of results in a specific technical area, if any, are given in the annex associated with that area.

7.9 Complaints

There are no requirements additional to those set forth in ISO/IEC 17025.

7.10 Nonconforming work

There are no requirements additional to those set forth in ISO/IEC 17025.

7.11 Control of data and information management

There are no requirements additional to those set forth in ISO/IEC 17025.

8 Management system requirements

There are no additional requirements to those set forth in ISO/IEC 17025 in any of the management system requirement subsections 8.1 through 8.9.

9 Additional requirements

The following annexes contain requirements that are specific to each technical program area and its associated calibration methods.

Annex A: ANSI/NCSL Z540-1-1994, Part I (normative)

[Optional addition to scope: compliance with ANSI/NCSL Z540-1-1994, Part I]

A.1 General

This annex addresses the general accreditation requirements prescribed in ANSI/NCSL Z540-1-1994, *Calibration Laboratories and Measuring and Test Equipment – General Requirements, Part I* that are not directly addressed in ISO/IEC 17025. Laboratories wishing to be recognized for compliance with the requirements of ANSI/NCSL Z540-1-1994, Part I shall meet the requirements listed below, in addition to those found in ISO/IEC 17025 and this handbook.

A.2 Management requirements for accreditation

The quality system adopted to satisfy the requirements of ANSI/NCSL Z540-1-1994 shall be reviewed at least once a year by the management to ensure its continuing suitability and effectiveness and to introduce any necessary changes or improvements.

A.3 Calibration methods and method validation

A.3.1 Calibration procedures shall contain the required range and tolerance or uncertainty of each item or unit parameter being calibrated or verified.

A.3.2 In addition, the procedures shall contain the generic description of the measurement standards and equipment needed with the required parameter, range, tolerances or uncertainties, and specifications for performing the measurement of the calibration or verification, and/or representative types (manufacturer, model, option) that are capable of meeting the generic description for the measurement standards.

A.3.3 The procedures shall be consistent with the accuracy required and with any standard specifications relevant to the calibrations/verifications concerned.

A.4 Equipment

A.4.1 Tamper-resistant seals shall be affixed to operator-accessible controls or adjustments on measurement standards or measuring and test equipment which, if removed, will invalidate the calibration.

A.4.2 The laboratory’s calibration system shall provide instructions for the use of such seals and for the disposition of equipment with damaged or broken seals.

A.5 Reporting the results

In addition to the list of required items in section 7.8 of ISO/IEC 17025, each calibration report shall include a statement that the calibration report shall not be reproduced except in full, without the written approval of the laboratory.

Annex B: Dimensional measurements (normative)

B.1 General

This annex contains specific technical requirements not covered in ISO/IEC 17025 that are applicable to a laboratory recognized as competent to carry out dimensional calibrations.

B.2 Accommodation and environmental conditions

B.2.1 Thermal conditions affecting artifacts

B.2.1.1 Measurement results are generally reported as the length at 20 °C. If measurements are made at temperatures other than 20 °C, the uncertainties of the appropriate thermal corrections for the artifacts shall be included in the total uncertainty.

B.2.1.2 For comparison measurements, the uncertainty component shall reflect the uncertainty in the thermal corrections of both the master and unknown artifacts, as well as the temperature difference between them, and the uncertainty of the temperature sensor used.

B.2.2 Ambient temperature considerations

B.2.2.1 The temperature stability of the environment shall be sufficient for the gage and measurement system to be in thermal equilibrium.

B.2.2.2 If measurements are made in slowly changing environments, a suitable measurement model, which includes the effects of the drift, shall be used. Theoretical and experimental verification of the model should be available.

B.2.3 For typical gages made of well-characterized materials (steel, carbide, or ceramic), ± 10 % shall be used as the standard uncertainty of the thermal expansion coefficient unless there is documentation of a lower value.

B.2.4 The laboratory shall have a documented policy regarding responses to environmental conditions outside of specified range.

B.3 Equipment

B.3.1 The laboratory shall have temperature-measuring capabilities suitable for the calibration procedure and the desired measurement uncertainty.

NOTE Calibrations involving direct comparisons of artifacts of similar size and materials will, in general, have modest requirements. Absolute calibrations or comparisons between artifacts of different sizes and/or materials will require more accurate temperature measurement or adjustment of the measurement uncertainty.

B.3.2 A laboratory that makes mechanical comparisons of masters and test pieces of dissimilar materials shall have force-measuring equipment to determine the force on the probe or probes. A correction for differential probe penetration should be applied as long as the probe has maintained its desired geometry.

Annex C: Time and/or frequency measurements (normative)

C.1 General

This annex contains specific technical requirements not covered in ISO/IEC 17025 that are applicable to a laboratory recognized as competent to carry out time and/or frequency calibrations.

C.2 Measurement traceability

C.2.1 Because a waveform is a set of ordered pairs (i.e., time, voltage), traceability of both the time and voltage shall be in place.

NOTE This is normally demonstrated by calibration of a high-speed oscilloscope or calibration of a fast-rise generator by an external source meeting the requirements in NIST Handbook 150, Annex B.

C.2.2 Laboratories that utilize a Global Positioning System Disciplined Oscillator (GPSDO) to establish traceability shall:

a) have procedures in place to ensure the GPS is locked and working properly;
b) consider the internal oscillator's short-term stability and measurement time in the laboratory's reported uncertainty.

Annex D: Mechanical measurements (normative)

D.1 Force calibrations

D.1.1 General

The purpose of this section is to specify the technical criteria that shall be met when performing calibrations of force-measuring instruments.

D.1.2 Procedural standard methods

All measurement procedures, accommodations and environmental conditions, instruments and equipment used, and the reporting of results when conducting a force-related calibration, shall comply with one or both of the following referenced standards documents, except in special circumstances (see below):

- ASTM E74, *Standard Practices of Calibration and Verification of Force-Measuring Instruments*
- ISO 376, *Metallic materials – Calibration of force-proving instruments used for the verification of uniaxial testing machines*

Special circumstances: Laboratories may be accredited to other documentary standards methods or laboratory-developed methods once they have been assessed for them.

D.1.3 Accommodation and environmental conditions

D.1.3.1 All instruments shall be allowed sufficient time to reach room temperature prior to calibration.

D.1.3.2 The recommended calibration temperature is 23 °C (73.4 °F), however, calibrations shall be conducted within the temperature ranges specified by the procedural method used.

D.1.3.3 During calibration, the temperature shall be monitored at a location that reflects the temperature of the instrument.

D.1.3.4 If the temperature variations exceed ± 0.2 °C during the calibrations of non-temperature compensated instruments such as proving rings, the calibration data shall be corrected in accordance with the applicable force calibration standard.

D.1.4 Equipment

D.1.4.1 Primary force standards (ASTM E74)

D.1.4.1.1 A laboratory that performs primary force standards calibrations shall directly apply a deadweight force without intervening mechanisms such as levers, hydraulic multipliers, or the like, whose mass has been determined by comparison with mass reference standards traceable to the International System of Units (SI).

D.1.4.1.2 Primary force standard deadweight machines shall not have any mechanism for amplifying the force such as levers, hydraulic multipliers or the like, or any mechanism that counterbalances the frame (or tare).

D.1.4.1.3 Weights used as primary standards in deadweight machines shall be made of rolled, forged, or cast metal.

D.1.4.1.4 The surface roughness of the weights shall meet the requirements of the applicable force calibration standard.

D.1.4.1.5 If the weights are plated or coated, the finish shall be of a proven design and of a material such as cadmium or nickel-chromium.

D.1.4.1.6 The forces developed by the weights shall be determined using formula 1,

$$F = Mg[1 - (\rho_a/\rho_w)], \quad (1)$$

where:

F = force (N),
M = true mass (kg),
g = local acceleration due to gravity (m/s^2),
ρ_a = density of air, and
ρ_w = density of the weight (same units as ρ_a).

D.1.4.1.7 The laboratory shall have knowledge of the local gravity, its uncertainty, and the local air buoyancy correction.

D.1.4.1.8 The uncertainty of the vertical component of force applied by the weights shall also be stated in the laboratory records and in reports of calibration.

D.1.4.1.9 The masses of the weights shall be determined initially, and the determination repeated if damage or disassembly of the machine occurs or if evaluation of uncertainty indicates masses need to be reevaluated.

D.1.4.1.10 Verification of force realization shall be demonstrated through an intercomparison program as outlined by the laboratory's quality system.

D.1.4.2 Secondary force standards (ASTM E74)

D.1.4.2.1 Secondary force standards shall have been calibrated against primary force standards, with the exception that secondary force standards having capacities exceeding 1 000 000 lbf (4.4 MN) may be calibrated against a combination of several lower-capacity secondary force standards loaded in parallel.

D.1.4.2.2 If several secondary force standards are combined and loaded in parallel to meet special needs for high capacities exceeding 1 000 000 lbf (4.4 MN):

a) those secondary force standards shall have equal compliance, and
b) forces shall be applied equally to each of those secondary force standards.

D.1.4.2.3 Secondary force standards used shall have a suitable force calibration frame or mechanism to ensure an axial force application to the unit under test. The secondary system should exhibit no parasitic, frictional or mechanical losses during use.

D.1.4.2.4 Any perturbations shall have been characterized.

D.1.4.3 Uncertainty of the applied forces

The uncertainty of the applied forces generated shall be determined using appropriate methods, such as recommended in ASTM E74 and ISO 376.

D.1.4.4 Overloaded or repaired instruments

D.1.4.4.1 Any force standard or multiplying system that is repaired or modified in a way that may result in changes in the calibration curve shall be recalibrated prior to use.

D.1.4.4.2 Any instrument that sustains an overload that produces a change in the zero-force output of 1 % or more shall be recalibrated prior to use.

D.1.4.5 Accessory hardware

All calibration hardware that is subject to calibration forces such as coupling nuts, pull-rods, adapters, etc., shall be clearly labelled with the maximum allowable force they can sustain.

D.1.5 Calibration

D.1.5.1 Distribution and number of calibration forces

The calibration forces shall be distributed over the full range of the force-measuring instrument as specified by the procedural method used. Note that the requirements of ASTM E74 and ISO 376 differ.

D.1.5.2 Randomization of force application conditions

Randomization of force application conditions is of primary importance. The instrument undergoing calibration shall be rotated in the calibration machine and subjected to other randomizations in accordance with the procedural method used.

D.1.6 Reporting the results

D.1.6.1 In addition to the report requirements of ISO/IEC 17025, the laboratory shall provide calibration reports that conform to the requirements of ASTM E74, ISO 376, or both.

D.1.6.2 The calibration report shall state which documentary standard(s) was (were) followed.

D.1.6.3 In cases where other procedural standards are followed, the calibration report shall, at a minimum, contain the following information beyond those given in ISO/IEC 17025:

a) type of reference standard used (i.e., primary standard, secondary standard), including the uncertainty in the applied force;
b) if critical to transducer performance, identification of the force application fittings used;
c) temperature range during the calibration;
d) listing of the calibration forces applied and deflections observed;
e) the calibration curve, including the method of analysis used to obtain the curve, and the deviations of the experimental data for the fitted curve;
f) the limits of assigned force ranges if such limits are required.

D.2 Mass calibrations

D.2.1 General

The purpose of this annex is to specify the criteria needed to assess the competence of a calibration laboratory that performs mass calibrations. Note that the echelon classifications referenced below are further defined in NIST Handbook 143, Table 16.

D.2.2 Procedural Standard Methods

All measurement procedures, accommodation and environmental conditions, instruments and equipment used, and the reporting of results when conducting a mass-related calibration, shall comply with at least one of the following referenced standards documents, except in special circumstances (see below):

- ASTM E617, *Standard Specifications for Laboratory Weights and Precision Mass Standards,*
- OIML R111, *Weights of classes E_1, E_2, F_1, F_2, M_1, M_2, M_{2-3}, and M_3,*
- NIST HB 105-1, *Specifications and Tolerances for Field Standard Weights,*
- NIST IR 6969 SOP 4, SOP 7, or SOP 8, *Selected Laboratory and Measurement Practices, and Procedures to Support Basic Mass Calibrations,*
- NIST IR 5672 SOP 5 or SOP 28, *Advanced Mass Calibration and Measurement Assurance Program for State Calibration Laboratories*

Special circumstances: Laboratories may be accredited to other documentary standards methods or laboratory-developed methods once they have been assessed for them.

D.2.3 Accommodation and environmental conditions

D.2.3.1 To be deemed capable of making adequate measurements, calibration laboratories shall provide an environment with environmental controls appropriate for the level of measurements to be made, according to echelon classes.

D.2.3.2 The environmental conditions shall be within the specifications of the weighing instruments where applicable.

D.2.3.3 During calibration, the temperature shall be monitored at a location that reflects the temperature of the weighing instrument used. For Echelon I, temperature may be measured inside the weighing chamber when there is a difference between the air temperature in the balance chamber and the surrounding area.

D.2.3.4 The laboratory shall maintain limited access to the calibration area and minimize contamination (maintain a clean surface) for locations where calibration items are being tested.

D.2.3.5 Vibration shall not diminish the performance of precision analytical balances and mass comparators.

D.2.3.6 Undesirable effects due to static electricity shall be controlled, if needed, with methods such as humidity, anti-static, deionizing radiation devices, the grounding of balances or operators, or with the use of special conductive flooring, and selection of proper clothing for staff.

D.2.3.7 Laboratories shall evaluate the level of significance for buoyancy corrections for mass calibrations.

a) For Echelon I and Echelon II, buoyancy corrections shall be made.
b) For Echelon III, if optional buoyancy corrections are not made, an appropriate uncertainty component shall be included in the expanded uncertainty.

D.2.4 Procedures and method validation

D.2.4.1 The procedures and formula chosen for the mass measurement, the reference standard(s) to be used, and the equipment to be used for a calibration shall provide acceptable levels of uncertainty for that calibration.

D.2.4.2 A documented procedure, compliant with the requirements of OIML or ASTM documentary standards for mass, shall be available in the laboratory to determine the correct algorithm to be used for the specific calibration.

D.2.5 Equipment

D.2.5.1 The precision of the scale, analytical balance, or mass comparator, as determined through appropriate process control charts, shall be suitable to the echelon class for which it is used.

D.2.5.2 For an application where external standards are used for comparison, appropriate control charts shall be maintained to evaluate the process standard deviation.

D.2.5.3 Balances

D.2.5.3.1 Balances used as a direct comparison to the mass unit for Echelon III work shall be calibrated prior to use.

D.2.5.3.2 For an application requiring balance accuracy, the laboratory shall choose appropriate and correct calibration procedures and calculations.

D.2.5.3.3 Balances used as dividers and multipliers of the mass unit shall be capable of providing the appropriate uncertainty and linearity requirements of the echelon class for which they are used.

D.2.5.3.4 Calibration of built-in standards shall be performed periodically and shall be verified prior to use when the balance is used for direct comparison. History from measurement control programs (surveillance testing) may be used to determine calibration intervals.

D.2.5.4 Environmental sensors

D.2.5.4.1 Measurement results data from instruments used to monitor environmental conditions in the laboratory shall be traceable to the International System of Units (SI) through a suitable national laboratory (directly or by way of an accredited laboratory).

D.2.5.4.2 These instruments shall be recalibrated periodically unless intrinsic (defining) standards are employed. Reverification may be used to extend the period for recalibration.

D.2.5.4.3 Calibration and intercomparison periods shall be documented by the laboratory.

D.2.5.4.4 For intrinsic standards, data from intercomparison with standards of known measurement values shall be available.

D.2.5.4.5 Means shall be provided to measure barometric air pressure, air temperature, and relative humidity of the laboratory environment adequate to the method used.

D.2.5.4.6 Documentation of the uncertainty and traceability of these environmental measurement results shall be maintained.

D.2.6 Standards

D.2.6.1 Suitable reference standards shall be available at each echelon and range for which the laboratory is accredited.

D.2.6.2 Sufficient historical data and uncertainty analysis shall be available to support the standards used at each level of a traceability hierarchy.

D.2.6.3 Suitable calibration intervals shall be documented and ensured.

D.2.6.4 For Echelon I, the laboratory shall state the presence of a possible systematic error in the combined uncertainty associated with the use of an assumed or reported density in the primary or reference standards (additional type B component) or the laboratory shall have appropriate means to measure the density of mass standards.

D.2.6.5 The laboratory shall provide evidence, such as periodic surveillance, that the mass standards are, in principle, stable and acceptable for providing calibration services at each echelon for which they are used.

D.2.7 Handling of test and calibration items

D.2.7.1 The laboratory shall allow adequate stabilization time for mass standards to ensure environmental and thermal stability prior to calibration.

D.2.7.2 Documented procedures to ensure adequate tracking of calibration items shall be appropriate to the class of mass standard. Strings, tags, or labels fastened to the standard are inappropriate for all types of mass standards.

D.2.8 Assuring the quality of calibration results

D.2.8.1 Appropriate measurement control programs shall be in place and available for review for each echelon and nominal mass range covered on the scope for which calibration data is provided.

D.2.8.2 Measurement control techniques shall exhibit results consistent with the procedures used to perform calibrations and be integrated into the measurement procedures to accurately reflect the measurement process.

D.2.8.3 For those situations in which statistical information is not inherent to the process, i.e., simple measurements without built-in redundancy checks, additional measurements shall be made to provide experimental characterization of the measurement sufficient for an adequate estimation of the process uncertainty.

D.2.9 Reporting the results

D.2.9.1 Calibration reports shall describe the mass standards mentioned in the report with sufficient detail to avoid any ambiguity.

D.2.9.2 Calibration reports for Echelon I and II calibrations require additional items beyond those required by ISO/IEC 17025. These additional required items shall be included such that the calibration reports comply with the applicable documentary standard.

D.2.9.3 Ranges of values of environmental parameters measured during the calibration shall be provided.

D.2.9.4 Calibration reports may include reference to OIML or ASTM classification schemes and tolerances. It is the responsibility of the requestor of the calibration, not the laboratory, to select classifications acceptable for their needs. If conformity is being assessed:

a) items being calibrated shall meet appropriate specifications for evaluation as well as tolerances, or state which items are and/or are not evaluated;

b) for upper Echelon I classifications of ASTM 0, ASTM 00, or ASTM 000 and OIML E1 and E2, in instances where magnetism, surface finish, density, or other requirements of the specifications are not evaluated, a statement to that effect shall be included on the calibration report.

D.3 Flow

D.3.1 General

The purpose of this section is to specify the technical criteria that shall be met by laboratories performing calibrations of flow-measuring instruments, including:

- those outputting measurements from a meter's internal flow computer, directly in units of flow;
- those outputting meter performance indicators, such as discharge coefficient, meter factor, flow coefficients, or a dimensionless quantity appropriate for the meter type;
- flow instrument calibrations in which fluid properties directly or indirectly impact the uncertainty of the calibration results.

Requirements are detailed for:

- information necessary for NVLAP to clearly represent the flow capabilities of accredited laboratories on their NVLAP scopes;
- determination of uncertainties for calibration reports; and,
- proficiency testing requirements for laboratories performing accredited flow measurements.

NOTE The requirements in this annex have been in force under the previously issued Lab Bulletin 100-2017 and have been brought into the Handbook during this revision. No additional requirements have been added.

D.3.2 References

WGFF Guidelines for CMC Uncertainty and Calibration Report Uncertainty, International Committee for Weights and Measures (CIPM), Consultative Committee for Mass and Related Quantities (CCM), Working Group for Fluid Flow (WGFF), October 21, 2013.

D.3.3 Data for describing flow capabilities on scopes of accreditation

Section D.3.3 is informational in nature and is included as explanation to flow laboratories about the data NVLAP collects for the scopes of accreditation that represent their accredited capabilities. In addition to the information required for all CMCs listed on NVLAP scopes of accreditation (measurand, range of measurand, CMC uncertainty), the following requirements apply for CMCs in flow:

D.3.3.1 Measurands for accredited flow CMCs shall be one of the following: liquid flow, gas flow, air speed, liquid volume, or hydrometer correction;

D.3.3.2 Instrument type restrictions: If a laboratory is a flow instrument manufacturer only accredited to perform calibrations on its own equipment, this shall be noted on the scope;

D.3.3.3 Fluid type, and where appropriate, kinematic viscosity, shall be included in the CMC listing on the scope or in the Notes section of the scope;

D.3.3.4 Minimum and maximum values of pressure in the fluid applied to the device under test during calibration shall be included in the CMC listing on the scope or in the Notes section of the scope;

D.3.3.5 Minimum and maximum values of temperature in the fluid applied to the device under test during calibration shall be included in the CMC listing on the scope or in the Notes section of the scope.

D.3.4 Reporting uncertainties

D.3.4.1 The uncertainty listed in the NVLAP scope of accreditation shall be less than or equal to the uncertainty in a calibration report for a customer's instrument. Uncertainty contributors in the uncertainty budget for calibration of a customer's device vary with the measurand and the type of meter being calibrated and shall be understood, quantified, and reported by a laboratory accredited to calibrate that meter type.

D.3.4.2 The following sources of uncertainty that may arise in a meter calibration shall be considered and their contributions included in reported uncertainties when applicable:

a) Repeatability or short-term reproducibility of the customer's meter under test;
b) Instrumentation used to acquire data from the meter under test, such as frequency, pressure, or temperature sensors;
c) Fluid properties, when they impact the uncertainty of the reported measurand, whether this impact is direct (e.g., impact of uncertainty in viscosity when calculating flow coefficient in a laminar flow meter) or indirect (e.g, when turbine meter calibration is presented as a ratio of Strouhal number versus Roshko number – where Roshko number varies inversely with kinematic viscosity, the impact of the uncertainty of kinematic viscosity yields uncertainty in the Roshko number, and through the ratio, must also be considered in the uncertainty of the Strouhal number. Further, the degree of impact of the viscosity uncertainty increases with the slope of the calibration curve.)

D.3.5 Proficiency testing requirements for flow

D.3.5.1 An acceptable proficiency test shall use a transfer standard.

D.3.5.1.1 Preliminary tests shall be conducted to assess the stability of the transfer standard.

D.3.5.1.2 These preliminary tests shall demonstrate that the transfer standard has reproducibility less that the accredited laboratory's uncertainty. If such a device does not exist, the transfer standard shall have the best commercially available calibration stability.

D.3.5.1.3 At a minimum, the calibration results for the transfer standard from the beginning and the end of the proficiency test done by one of the participants shall be used to quantify transfer standard stability.

D.3.5.2 Proficiency testing shall be performed with other laboratories having uncertainties comparable within a factor of 2 for the subject capability.

D.3.5.3 The proficiency test will be blind, i.e., the pilot laboratory or another third party shall not share measurement results with the accredited laboratory until all measurements are completed.

D.3.5.4 The comparison shall be performed at 2 or more values of the measurand differing by at least a factor of 5, with wider ranges encouraged within the capability of the transfer standard.

D.3.6 Other measurement assurance activities

NOTE An accredited laboratory may use the required measurement assurance activities detailed below to reduce the number of proficiency tests it performs (subject still to the requirements of section 7.7.2.1.)

D.3.6.1 The accredited laboratory shall perform internal comparisons between calibration systems with overlapping measurement ranges and maintain records of these internal comparisons.

D.3.6.2 The accredited laboratory shall maintain control charts showing stability of calibration results from periodic recalibrations of the same reference standard.

Annex E: NIST Handbook 143: OWM Recognition Program Handbook (normative)

[Addition to scope for OWM-recognized State weights and measures laboratories: compliance with NIST Handbook 143]

E.1 General

The purpose of this annex is to specify the criteria State weights and measures laboratories shall meet that are in addition to the requirements of ISO/IEC 17025, NIST HB 150, and NIST HB 150-2. These additional requirements apply to State weights and measures laboratories that are Office of Weights and Measures (OWM)-recognized and are, or are seeking to become, NVLAP accredited.

NOTE NVLAP assigns technical assessors with legal metrology background and training to do the assessments of OWM-recognized laboratories.

E.2 References

NIST Handbook 143, *Office of Weights and Measures (OWM) Recognition Program Handbook*

E.3 OWM Recognition status

Knowing the value of accreditation as a complement to their recognition program, OWM provides financial support for accreditation and assessment fees for those State weights and measures laboratories that they determine are ready to apply for accreditation. This support continues as long as these laboratories maintain their recognition status.

E.3.1 A State weights and measures laboratory that seeks NVLAP accreditation shall have OWM recognition before applying for NVLAP accreditation if it will be relying on OWM for financial support with accreditation costs.

E.3.2 An OWM-recognized and NVLAP-accredited State weights and measures laboratory that has a change to either of these statuses shall promptly notify the other organization of that change.

E.3.3 A State weights and measures laboratory that is both OWM-recognized and NVLAP-accredited shall maintain its OWM recognition in good standing in order to maintain its NVLAP accreditation in good standing.

E.4 Technical requirements

Laboratories maintaining both OWM recognition and NVLAP accreditation shall meet the requirements of the current version of following requirements documents:

- ISO/IEC 17025
- NIST Handbook 150
- NIST Handbook 150-2 (this Handbook)
- NIST Handbook 143, the OWM Recognition Program Handbook

NOTE 1 Specific legal metrology requirements for State weights and measures laboratories in the areas of training, proficiency testing, and regional measurement assurance program participation are among those technical requirements covered in NIST Handbook 143.

NOTE 2 The requirements for specific technical areas given in the other annexes in this Handbook are also covered in NIST Handbook 143, along with additional requirements that are specific to State weights and measures laboratories. Therefore, the other annexes to NIST Handbook 150-2 are not assessed for State weights and measures laboratories. Rather, those requirements are covered in the NVLAP assessment to NIST Handbook 143 via the NVLAP Checklist for that Handbook.