

NIST HANDBOOK 150-1A
2009 Edition

National
Voluntary
Laboratory
Accreditation
Program

ENERGY EFFICIENT
LIGHTING PRODUCTS –
SOLID STATE LIGHTING

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Foreword

The National Institute of Standards and Technology (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 is comprised of the following publications:

- NIST Handbook 150, *NVLAP Procedures and General Requirements*, 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 150-1A, *NVLAP Energy Efficient Lighting Products – Solid State Lighting*, addresses the addition of test methods for testing solid state lighting products and LED sources to the NVLAP Energy Efficient Lighting Products (EEL) LAP. This handbook presents the technical requirements and guidance for the accreditation of laboratories for testing solid state lighting products and LED sources and addresses specific measurement issues in the emerging solid-state lighting technology. This handbook was written under the direction of NVLAP with the participation of technical experts in the field of testing energy efficiency of solid state lighting products and LED sources and incorporates the release of the newest editions of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, and NIST Handbook 150.

This handbook is also available on the NVLAP web site (<http://www.nist.gov/nvlap>).

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

Introduction

As part of broader energy conservation issues, the Energy Policy and Conservation Act (Public Law 94-163) was passed in 1975 in response to the oil crisis of the early 1970s. It has been amended several times, most notably in 1992 by the Energy Policy Act (EPAcT) (Public Law 102-486). The “Energy Policy Act of 1992” requires that the Department of Energy specify energy efficiency standards for certain types of fluorescent and incandescent reflector lamps.¹ New efficiency standards created by the Energy Policy Act of 2005 (EPAcT 2005) (Public Law 109-58) were signed into law on August 8, 2005, and went into effect on January 1, 2006.

Additionally, EPAcT 2005 formally recognizes the federal ENERGY STAR® program (Section 131 of the Energy Policy Act, Public Law 109-58) to identify and promote energy-efficient products and buildings through labeling. As written in Section 131: “There is established within the U.S. Department of Energy and the U.S. Environmental Protection Agency a voluntary program to identify and promote energy-efficient products and buildings in order to reduce energy consumption, improve energy security, and reduce pollution through voluntary labeling of, or other forms of communication about, products and buildings that meet the highest energy conservation standards.” Section 131 calls for enhancing public awareness of ENERGY STAR®, preserving the integrity of the label, regularly updating performance criteria, soliciting comments from interested parties, and providing appropriate lead time when changes are being made to program criteria. Lighting products currently covered by the ENERGY STAR® program included exit signs, residential lighting fixtures, residential ceiling fans, ventilating fans, and medium-screw base compact fluorescent lamps (CFLs).

As part of the ENERGY STAR® program for solid state lighting, the U.S. Department of Energy requested NVLAP, which is the Laboratory Accreditation Group within NIST, to add to the NVLAP Energy Efficient Lighting Products (EEL) LAP specific test methods used in testing certain types of solid state lighting products and LED sources. The purpose of this addition of test methods is to accredit testing laboratories to ensure that standard test methods for product performance (excluding product safety) are followed in testing solid state lighting products and LED sources. NIST Handbook 150-1A presents the technical requirements and guidance for the accreditation of laboratories for testing solid state lighting products and LED sources.

The names and contact information of NVLAP-accredited laboratories are published on the NVLAP web site (<http://www.nist.gov/nvlap>).

¹ Refer to Code of Federal Regulations, Title 10 – Energy, Part 430 – Energy Conservation Program for Consumer Products (10 CFR Part 430) and Title 42 U.S. Code 6291-6295 for the energy efficiency standards and related test procedures.

1 General information

1.1 Scope

1.1.1 NIST Handbook 150-1A specifies the technical requirements and provides guidance for the accreditation of laboratories under the NVLAP Energy Efficient Lighting Products Laboratory Accreditation Program (EEL Program) for testing solid state lighting products and LED sources. It supplements the NVLAP procedures and general requirements found in the latest edition of NIST Handbook 150, *NVLAP Procedures and General Requirements*, by tailoring the general criteria found in NIST Handbook 150 to the specific tests and types of tests for solid state lighting products and LED sources in the EEL Program.

1.1.2 NIST Handbook 150, NIST Handbook 150-1A, and their respective checklists (see 1.6) constitute the collective body of requirements that must be met by a laboratory seeking NVLAP accreditation under the EEL Program for testing solid state lighting products and LED sources.

1.1.3 This handbook is intended for information and use by laboratories accredited to test solid state lighting products and LED sources, 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 EEL Program for testing solid state lighting products and LED sources.

1.2 Organization of handbook

The numbering and titles of the first five clauses of this handbook match those of NIST Handbook 150. The primary subclauses in clauses 4 and 5 (e.g., 4.1, 4.2, etc.) are also numbered and titled to correspond with the subclauses in NIST Handbook 150, even when there are no requirements additional to those in NIST Handbook 150.

1.3 Program description

1.3.1 The NVLAP EEL Program provides for laboratory accreditation for testing solid state lighting products and LED sources to ensure that standard test procedures are followed to measure electrical, photometric, colorimetric, and lumen maintenance characteristics of solid state lighting products and LED sources. The program accredits laboratories that use test methods developed by the Illuminating Engineering Society (IES).

1.3.2 A listing of the test methods included in the NVLAP program for solid state lighting products and LED sources is given in the EEL Test Method Selection List, which is part of the EEL application package and available from NVLAP upon request. A laboratory may seek accreditation to all or a subset of the selected methods offered in the EEL Program. A laboratory may request test methods to be added to the program. Test method additions will be handled in accordance with NVLAP procedures in NIST Handbook 150 for adding to or modifying an established LAP (see NIST Handbook 150, clause 2).

1.4 References

The following referenced documents are indispensable for the application (or understanding) of this handbook. For dated references, only the edition cited applies. If no date is given in the reference, then the latest edition (including any amendments) shall apply within one year of publication or within another time limit specified by regulations or other requirement documents.

- ANSI C82.2:2002, *For Lamp Ballasts - Method of Measurement of Fluorescent Lamp Ballasts*, National Electrical Manufacturers Association
- ANSI C82.77:2002, *Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment*, National Electrical Manufacturers Association
- ANSI/IESNA RP-16:2005, *Nomenclature and Definitions for Illuminating Engineering*, Illuminating Engineering Society of North America
- ASTM E178:2008, *Standard Practice for Dealing with Outlying Observations*
- CIE Publication No. 13.3:1995, *Method of Measuring and Specifying Color Rendering of Light Sources*, Commission Internationale de l’Eclairage
- CIE Publication No. 15:2004, *Colorimetry*, Commission Internationale de l’Eclairage
- ENERGY STAR® *Program Requirements for Solid State Lighting Luminaires, Eligibility Criteria – Version 1.0*
- IES LM-16:1993, *Practical Guide to Colorimetry of Light Sources*, Illuminating Engineering Society of North America
- IES LM-58:1994, *Spectroradiometric Measurements*, Illuminating Engineering Society of North America
- IES LM-79:2008, *Electrical and Photometric Measurements of Solid-State Lighting Products*, Illuminating Engineering Society of North America
- IES LM-80:2008, *Measuring Lumen Maintenance of LED Sources*, Illuminating Engineering Society of North America
- *IESNA Lighting Handbook*, Illuminating Engineering Society of North America, 2000
- 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 and ANSI/IESNA RP-16-05 apply. In particular, the following are provided from ANSI/IESNA RP-16-05. The term “solid state lighting products and LED sources” used in this document encompasses both LED luminaires (1.5.3) and integrated LED lamps (1.5.2) and other solid state devices covered by the scopes of IES LM-79 and IES LM-80.

1.5.1

color rendering index (CRI) (of a light source)

Measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source of comparable color temperature.

1.5.2

LED lamp, integrated

A lamp with LED packages (or LED array, LED module), and other optical, thermal, mechanical and electrical components, with an integrated LED driver, and an ANSI standardized base that is designed to connect to the branch circuit via an ANSI standardized lampholder/socket.

1.5.3

LED luminaire (solid state lighting luminaire)

A complete LED lighting unit consisting of a light source and driver together with parts to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED array, an LED module, or an LED lamp. The LED luminaire is intended to connect directly to a branch circuit.

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 and to assure completeness, uniformity, and objectivity. Checklists assist assessors in documenting the assessment to the NVLAP requirements found in NIST Handbook 150, this handbook, and the checklists themselves. Checklists contain definitive statements or questions about all aspects of the NVLAP requirements for accreditation and form part of the On-Site Assessment Report (see NIST Handbook 150). The current version of each checklist is available from the NVLAP web site at <<http://www.nist.gov/nvlap>>.

1.6.2 NIST Handbook 150 Checklist

All NVLAP programs use the NIST Handbook 150 Checklist (formerly called the General Operations Checklist), which contains the requirements published in NIST Handbook 150. The checklist items are numbered to correspond to clauses 4 and 5 and annexes A and B of NIST Handbook 150.

1.6.3 NIST Handbook 150-1A Checklist

The NIST Handbook 150-1A Checklist addresses the requirements specific to the EEL program for testing solid state lighting products and LED sources given in NIST Handbook 150-1A. The checklist emphasizes observing and performing tests, testing accuracy and uncertainty, traceability chain and associated calibration uncertainty of standard reference lamps and standard photometers, instrumentation, calibration, personnel competency, and test reporting. The checklist contains requirements expressed at a more detailed level than found in this handbook.

1.6.4 Test Method Review Summary

The assessor uses the Test Method Review Summary to review the laboratory's ability to perform test methods for solid state lighting products and LED sources. The review of the test methods by the assessor ranges from observing tests to having laboratory staff describe the test procedures. The assessor notes on the Test Method Review Summary the depth into which each part of the test method was reviewed (Observed Test, Examined Apparatus, Walked/Talked Through Test, Listened to Description of Procedures).

1.6.5 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; on-site 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.

3.2 Management system review

3.2.1 Prior to applying to NVLAP for accreditation, a laboratory shall have a fully implemented management system. A copy of the management system documentation, including a cross-reference document, shall be sent to NVLAP with the application forms. The requirement for a cross-reference document applies to both applicant laboratories and laboratories already accredited by NVLAP (see 4.2.2).

3.2.2 The cross-reference document shall verify that all requirements of this handbook and clauses 4 and 5 and annexes A and B of NIST Handbook 150 are addressed and their locations clearly identified in the management system documentation. As described in 4.2.2, the cross-reference requirement can be satisfied in a number of ways.

3.2.3 Prior to the on-site assessment, the assigned assessor reviews all relevant management system documentation for conformity with NVLAP requirements, including the requirements of this handbook and NIST Handbook 150. During this review, the assessor may request additional management system documents and/or records, which will be returned upon request.

3.3 On-site assessment

3.3.1 The purpose of the on-site assessment is to determine whether the laboratory is following its documented management system and to assess the competence of the laboratory's delivery of its testing services.

3.3.2 The on-site assessment will take place at the laboratory site. Prior to the visit, the NVLAP assessor provides a preliminary agenda, which may change due to findings observed during the on-site assessment. Efforts will be made to minimize disruption to the normal working routines during the assessment. The assessor will need time and workspace to complete assessment documentation during his/her time at the laboratory site.

3.3.3 All laboratory equipment required to perform accredited testing shall be available for assessment and in good working order. Although all test methods need not be set up and operational during the on-site assessment, the laboratory shall be prepared to demonstrate selected test methods as requested by the assessor. For those cases where the test methods are not operational and a demonstration is not requested, the laboratory shall be prepared to describe the test method and procedures it would follow and show the actual equipment, fixtures and arrangements that would be used. The assessment will cover the requirements identified in this handbook, NIST Handbook 150, the NIST Handbook 150-1A Checklist, the laboratory's management system documentation, and the laboratory's written detailed test instructions.

3.3.4 The laboratory shall make available all supporting technical information in a format that is conducive to a detailed review. The assessor may request additional information to clarify issues regarding nonconformities or to delve more deeply into technical issues.

3.3.5 The activities covered during a typical on-site assessment are described below.

- a) *Opening meeting:* The NVLAP assessor will meet with laboratory management, supervisory personnel, and other appropriate staff members to explain the purpose of the on-site assessment and to discuss the schedule for the assessment activities. Information provided by the laboratory on its application form may be discussed during this meeting.
- b) *Staff interviews:* The NVLAP assessor will ask the laboratory manager to assist in arranging times for individual interviews with laboratory staff members. The assessor will interview staff members filling key positions (e.g., Laboratory Manager, Technical Director, Quality Manager, Authorized Representative, Approved Signatories) and staff members who have an effect on the outcome of the testing, including staff who conduct the testing. Depending upon the number of involved staff, the assessor does not need to talk to all staff members; however, the assessor will select staff members representing all aspects of the laboratory. These interviews are conducted to determine if the staff members are properly trained, assigned, and supervised, and are technically competent for the tasks assigned to them.
- c) *Records review:* The NVLAP assessor will review laboratory documentation, including the management system documentation, equipment and maintenance records, record-keeping procedures, testing procedures, laboratory test records and reports, personnel competency records, personnel training plans and records, and safeguards for the protection of sensitive and proprietary information. The assessor will review the laboratory's own detailed instructions (see 5.4.1) to perform the test methods for solid state lighting products and LED sources according to the standard test procedures for which the laboratory is accredited (or is seeking accreditation),

the range of solid state lighting products and LED sources and conditions it can test, and the descriptions of the maintenance and calibration of its specific equipment. The assessor will also review:

- 1) sample identification and tracking procedures and copies of completed test reports;
- 2) records of internal audits, use of quality control procedures, and participation in NVLAP proficiency testing or other similar programs;
- 3) personnel records, including résumés and job descriptions of key personnel and competency evaluations for all staff members who routinely perform the test method for which accreditation is sought;
- 4) calibration records and certificates (see 5.6.5 and 5.6.6);
- 5) records of evaluations, verifications and testing of purchased services, equipment, etc. (see 4.6).

Laboratory staff shall be available to answer questions pertaining to the accreditation review; however, the assessor may wish to review the documents and records alone. The assessor usually does not ask to remove any laboratory documents or records from the laboratory premises.

NVLAP assessors do not need access to employee information that may be considered sensitive or private such as salary, medical information, or performance reviews for work done outside the scope of the laboratory's accreditation. However, this information is often stored together with technical information that an assessor will need to check (e.g., job descriptions, résumés, and technical performance reviews). In these cases, the assessor will work with the laboratory to ensure the review is performed without violating individual privacy. At the discretion of the laboratory, a member of its human resources department may be present during the review of personnel information.

- d) *Internal audit and management review:* The assessor will review and discuss with the laboratory staff the laboratory's internal audit and management review activities, which are separate and distinct activities. The discussion will include all aspects of those activities including the management system procedures, the audit findings, the root cause determination, the actions taken to resolve problems identified, the actions taken to prevent recurrence, and the results of the management review.
- e) *Equipment and software:* The assessor will examine and determine the suitability of all equipment and facilities required to perform the standard test methods for which the laboratory is accredited (or is seeking accreditation). The appropriate environmental conditions required for testing will be assessed. The assessor will observe the demonstration of selected procedures by appropriate personnel assigned to conduct the tests, and will interview those personnel. The assessor will review test data, examine hardware and software for function and appropriateness, and review software validation and verification procedures.
- f) *Demonstrations:* The demonstrations requested may be selective or all-inclusive. The NVLAP assessor will observe the demonstration of testing procedures by technical personnel assigned to conduct the tests, and will discuss the tests with the technical personnel to assure their understanding of the procedures. The demonstrations shall include sample solid state lighting products and LED sources, preparation of devices, establishment of test conditions, and the

setup/use of major equipment. The assessor will use the Test Method Review Summary (see 1.6.4) and the NIST Handbook 150-1A Program-Specific Checklist (see 1.6.3) in reviewing and summarizing the laboratory's ability to conduct the test methods.

The assessor may select and trace the history of one or more samples of solid state lighting products and LED sources from receipt to final issuance of the test reports.

- g) *Proficiency testing:* The assessor will discuss all aspects of proficiency testing results with appropriate staff. Test methodology and records documenting the laboratory's execution of the testing will be reviewed and discussed. Any unusual trends or outlying results will be discussed.

The assessor may provide a solid state lighting product(s) and LED source(s) as a proficiency test specimen and request testing or a demonstration.

- h) *On-site assessment report:* The assessor will complete an On-Site Assessment Report, which summarizes the findings and clearly lists all nonconformities and comments (positive or negative). This report normally consists of the On-Site Assessment Summary, the On-Site Assessment Narrative Summary, the NIST Handbook 150 Checklist, the NIST Handbook 150-1A Program-Specific Checklist, and the Test Method Review Summary. The first page of the report shall be signed by the assessor and the laboratory's Authorized Representative or designee to acknowledge receiving the on-site report, but signing the report does not necessarily indicate agreement by the laboratory. A copy of the report will be given to the laboratory representative for retention and the assessor will send the original to NVLAP. All observations made by the assessor will be held in confidence as stated in the declaration signed by all assessors and NVLAP staff.

- i) *Closing meeting:* The assessor will conduct a closing meeting with the laboratory manager, supervisory personnel, and other appropriate staff members to discuss the findings. During the visit the assessor will have categorized all problems identified as nonconformities and comments. They will be discussed at the closing meeting and resolutions may be mutually agreed upon. The assessor will specifically note items that have been corrected during the on-site assessment along with any recommendations for other action(s). The process for resolving nonconformities identified during the on-site assessment is documented in NIST Handbook 150. Disagreements between the laboratory and the assessor(s) should be referred to NVLAP for resolution.

3.3.6 The laboratory shall resolve or formulate a plan (plan shall include a timetable for completion) to resolve all nonconformities and provide a response to NVLAP within 30 days from the date of the on-site assessment. In the case of an initial accreditation, all nonconformities shall be satisfactorily resolved before accreditation can be granted.

3.3.7 The laboratory shall review all comments for potential improvements in the testing of solid state lighting products and LED sources.

3.4 Proficiency testing

3.4.1 NIST Handbook 150 defines proficiency testing and describes how it is included in the accreditation process. The test methods for solid state lighting products and LED sources that require proficiency testing are identified by an asterisk in the EEL Test Method Selection List. Special proficiency testing rounds may be scheduled separately for specific needs. Proficiency testing fees are

required from all laboratories accredited for one or more test methods for which proficiency testing is being offered.

3.4.2 Laboratories applying for initial accreditation shall participate satisfactorily in a bilateral proficiency testing with NIST before accreditation will be granted. Solid state lighting products and LED sources along with instructions for specimen handling, preparation (including seasoning and pre-burning), conditioning, mounting, and testing, and data forms are provided to the participating laboratory. The completed test data forms are sent by the participating laboratory to NIST. The results are summarized in a report, which is sent by NVLAP to the participant.

3.4.3 As NVLAP prescribes, NVLAP or a proficiency testing contractor conducts rounds at regular intervals. Solid state lighting products and LED sources along with instructions for specimen handling, preparation (including seasoning and pre-burning), conditioning, mounting, and testing, and data forms are provided to the participating laboratories. The completed test data forms are sent by the participating laboratories to NVLAP or, as directed, to the proficiency testing contractor. The results of all participants are summarized in a Tech Brief, which is edited and sent by NVLAP to the participants. The identity and performance of individual laboratories are kept confidential.

3.4.4 Laboratories renewing accreditation shall have satisfactorily participated in all required proficiency testing during their previous accreditation period. Failure to participate in proficiency testing or to return the completed test data forms by the deadline is considered a nonconformity and may result in suspension of laboratory accreditation for those test methods in question.

3.4.5 Generally, it is required that the specific proficiency test procedure be conducted in accordance with the applicable standard test method. At times, however, NVLAP may specify special conditions to assure uniformity in procedures and test conditions among participants. These may include the number of replicate measurements, special conditions of temperature, and other test parameters. Also, proficiency testing may consist of several parts in order that the operation of a laboratory might be evaluated. Portions of the standard test procedure may be emphasized, such as measurement, instrumentation, hardware, and data analysis. **The proficiency testing shall not be contracted out to another laboratory.**

3.4.6 **In no case shall proficiency test samples be considered as calibration standards or standard reference materials or be used as substitutes for calibration standards that are traceable to NIST or other national metrology institutes (NMIs).**

3.4.7 Under the direction of NVLAP or the proficiency testing contractor, proficiency test samples may be temporarily detained (e.g., for retesting) at a laboratory. Also, on occasion, the on-site assessor hand carries proficiency test samples to the laboratory. All proficiency test samples, like all other samples received by the laboratory, shall be listed or entered into the normal sample tracking and identification system for control and data recording. NVLAP or the proficiency testing contractor will direct the laboratory to send the proficiency test samples to a specified destination (e.g., next laboratory, proficiency testing contractor, NVLAP, or the on-site assessor).

3.4.8 Proficiency test data are analyzed by NVLAP using statistical procedures to determine distributions and parameters, such as averages, standard deviations, and outliers (see ASTM E178). Using the test data from proficiency testing, the laboratory shall monitor its own testing performance. Procedures for analyzing and monitoring the laboratory's own test results shall be documented in its management system. These procedures shall include comparing the laboratory's proficiency testing results with those from NIST and/or other NVLAP-accredited laboratories.

3.4.9 Unsatisfactory performance in proficiency testing (e.g., outlying results as determined by NVLAP) is a technical nonconformity that must be resolved by the laboratory to maintain its accreditation for the test method(s) in question. If the laboratory performs unsatisfactorily in any proficiency test, it shall take corrective action to investigate and resolve nonconformities in a timely manner, according to the requirements in 4.9 of NIST Handbook 150 for the control of nonconforming work. Unsatisfactory performance in proficiency testing may result in suspension or revocation of accreditation.

3.4.10 The results of proficiency testing are made available to NVLAP assessors for use during laboratory on-site assessment visits. Any problems indicated by proficiency testing shall be discussed at the on-site assessment with appropriate laboratory personnel responsible for developing and implementing plans for resolving the problems.

4 Management requirements for accreditation

4.1 Organization

There are no requirements additional to those set forth in NIST Handbook 150.

4.2 Management system

4.2.1 The laboratory shall ensure that the requirements of NIST Handbook 150 are met so that staff is knowledgeable of the electronic- or paper-based documentation system and can demonstrate, if authorized, the retrieval of needed documents and/or records.

4.2.2 The laboratory shall create a cross-reference document that facilitates verification by both the laboratory and the NVLAP assessor that all program requirements have been addressed by the management system. This review includes clauses 4 and 5 and annexes A and B of NIST Handbook 150 and the corresponding NIST Handbook 150-1A. The cross-reference document requirement can be satisfied in a number of ways. One way is to number and organize the management system documentation to be the same as the NIST Handbook 150 Checklist; however, other methods may be acceptable.

4.2.3 The laboratory shall have readily available the latest published version of all of the solid state lighting product and LED source test methods for which accreditation has been requested.

4.2.4 If a customer, for whatever reason (e.g., regulatory requirement), requires accreditation to versions of a test method that are not the latest published version, then the laboratory shall document that requirement and shall have readily available the required version of the test method.

4.2.5 When a test method references another test method, guide, practice, or specification, the laboratory shall have readily available the referenced documents, where relevant.

4.2.6 In addition to the information specified in NIST Handbook 150, the management system documentation shall include:

- a) testing facilities and scope of services offered;

- b) policy and procedures for use of subcontractors, if applicable;
- c) procedures and actions concerning damaged or altered solid state lighting product and LED source test specimens;
- d) procedures by which the laboratory describes the solid state lighting product and LED source specimen and the criteria for determining if the specimen is to be accepted or rejected, e.g., rejected due to damage or outside the testing range [see 4.2.6.e)];
- e) the type and range (e.g., size, shape, level of light output) that a laboratory can test for each test method (see note below);
- f) procedures for maintenance and calibration (including in-house calibration) of the equipment used in conducting the tests on solid state lighting products and LED sources that include frequency of maintenance and calibration;
- g) procedures for the laboratory's participation in NVLAP proficiency testing, including analyzing and monitoring the laboratory's results, describing any corrective actions taken because of the results, and comparing the laboratory's proficiency test results with those from NIST or other NVLAP-accredited laboratories;
- h) the personnel training and competency evaluations demonstrating that the test procedures are being conducted correctly.

NOTE In some cases, a laboratory's equipment may be limited so that the laboratory cannot measure the properties of the complete range of specimens. Therefore, the laboratory's testing capability is documented by listing the type and range of specimens it can test.

4.3 Document control

There are no requirements additional to those set forth in NIST Handbook 150.

4.4 Review of requests, tenders and contracts

The laboratory shall ensure that it has the required capability [see 4.2.6 e)] to conduct the testing.

4.5 Subcontracting of tests and calibrations

There are no requirements additional to those set forth in NIST Handbook 150.

4.6 Purchasing services and supplies

The laboratory shall evaluate vendors and verify or test incoming services, equipment, software, materials, and supplies that affect the quality and accuracy of the test results. Examples include general laboratory equipment and supplies, equipment vendors, data acquisition and processing equipment, software vendors, software packages for data processing and calculations, calibration service providers (CSP) and certificates, standard reference lamps, secondary (working) reference lamps, and standard

photometers. Records that these evaluations, verifications, and testing of services, equipment, etc. have been reviewed for technical completeness will be examined by the assessor.

4.7 Service to the customer

There are no requirements additional to those set forth in NIST Handbook 150.

4.8 Complaints

There are no requirements additional to those set forth in NIST Handbook 150.

4.9 Control of nonconforming testing and/or calibration work

There are no requirements additional to those set forth in NIST Handbook 150.

4.10 Improvement

There are no requirements additional to those set forth in NIST Handbook 150.

4.11 Corrective action

There are no requirements additional to those set forth in NIST Handbook 150.

4.12 Preventive action

There are no requirements additional to those set forth in NIST Handbook 150.

4.13 Control of records

4.13.1 In addition to the requirements in 4.13.2.1 of NIST Handbook 150 to identify the personnel responsible for sampling, testing, calibration and checking results, the personnel responsible for specimen preparation, and where appropriate, the associated date(s), shall also be identified in the records (test/calibration/verification, etc.; hard copy and electronic).

4.13.2 Records will be reviewed during the on-site assessment either in total or by selective sampling.

4.13.3 The records to be maintained include, but are not limited to:

- a) acceptance/rejection (e.g., rejected due to damage) of solid state lighting products and LED sources submitted for test [see 4.2.6 d) and 4.2.6 e)];
- b) comprehensive logs for tracking specimens and test activities;
- c) original data collected by laboratory;

- d) calibration and verification data;
- e) data and results of quality control;
- f) equipment and maintenance records;
- g) test reports.

4.13.4 Records for each test, including calibration of test equipment, shall contain sufficient information to permit the same or another laboratory to reproduce the test plan in a manner that would make it possible to obtain comparable test results. These records shall be kept for a period of at least three years following the issuance of a test report, unless a longer period is required by the customer, regulation, or the laboratory's own procedures.

4.14 Internal audits

4.14.1 The internal audit shall cover compliance with NVLAP, laboratory management system, contractual, testing, and test method requirements.

4.14.2 An applicant laboratory shall conduct at least one complete internal audit, including the test methods that are requested to be on the laboratory's scope of accreditation, prior to the first on-site assessment. The internal audit report and pertinent records will be reviewed by the NVLAP assessor before or during the pre-accreditation on-site assessment.

4.14.3 For accredited laboratories, reports and pertinent records for internal audits conducted since the previous on-site assessment shall be made available for review during the on-site assessment.

4.14.4 Internal audits are separate and distinct from management reviews (see 4.15).

4.15 Management reviews

4.15.1 Periodic reviews of the management system shall reflect adherence to NVLAP requirements and the laboratory's quality objectives.

4.15.2 Management reviews shall review all nonconformities and may reflect positive aspects of the management system.

4.15.3 An applicant laboratory shall perform at least one complete management review prior to the first on-site assessment. The management review report(s) and pertinent records will be reviewed by the NVLAP assessor before or during the pre-accreditation on-site assessment.

4.15.4 For accredited laboratories, reports and pertinent records for management reviews conducted since the previous on-site assessment shall be made available for review during the on-site assessment.

5 Technical requirements for accreditation

5.1 General

There are no requirements additional to those set forth in NIST Handbook 150.

5.2 Personnel

5.2.1 Personnel records

5.2.1.1 Key NVLAP accreditation personnel — The laboratory shall maintain a list of personnel designated to fulfill NVLAP requirements including: Laboratory Director, Technical Director, Team Leaders, NVLAP Authorized Representative, NVLAP Approved Signatories, and the staff responsible for conducting the testing.

5.2.1.2 All testing laboratory staff — The laboratory shall document and maintain records on the required qualifications of each staff member, including a résumé of qualifications; laboratory testing procedures to which the person is assigned and authorized to perform; and the results of periodic testing performance (competency) reviews (see also 5.2.3.4), which may include interlaboratory testing and/or repeated testing by the same operator or comparative testing with two or more operators.

5.2.1.3 Notification of changes — The laboratory shall notify NVLAP when key personnel (see 5.2.1.1) are added to or removed from the staff. Notification to NVLAP of personnel changes shall include a current résumé for each new staff member.

5.2.2 Specific experience and competence of Technical Director

The laboratory's Technical Director (or an appropriate supervisor) shall be experienced in testing solid state lighting products and LED sources and shall have the technical competence and the supervisory capability to direct the work of professionals and technicians in testing solid state lighting products and LED sources.

5.2.3 Competency reviews

5.2.3.1 The NIST Handbook 150-1A Checklist lists specific personnel competency requirements as related to testing.

5.2.3.2 The laboratory shall evaluate the competency of each staff member for each test method the staff member is authorized to conduct.

5.2.3.3 For each staff member, the staff member's immediate supervisor, or a designee appointed by the Laboratory Director, shall conduct annually an assessment and an observation of performance competency.

5.2.3.4 These annual performance competency reviews shall be documented, dated, signed by the supervisor and the employee, retained in the personnel files and be available for review by the assessor. For the purpose of on-site assessments, a separate personnel folder of information specific to applicable NVLAP requirements may be provided instead of the complete folder, which may contain confidential information not needed for the assessment.

5.2.4 Training

5.2.4.1 The laboratory shall have a description of its training program for ensuring that staff is able to perform accredited testing properly.

5.2.4.2 The training program shall be updated and current staff members shall be given additional training when accredited test methods are updated or procedures change, or when the individuals are assigned new responsibilities.

5.2.4.3 Each staff member may receive training for assigned duties either through on-the-job training, formal classroom study, attendance at conferences, or another appropriate mechanism.

5.2.4.4 The laboratory shall ensure that each new staff member is properly trained to conduct accredited testing. Minimum training requirements are described in the EEL Handbook 150-1A Checklist.

5.2.4.5 Training materials that are maintained within the laboratory shall be kept up-to-date, including applicable versions of standard test methods, as well as appropriate reference documents, texts, and scientific and industry periodicals. These materials shall be readily available to the laboratory staff.

5.2.5 Subcontractors

Individuals hired to perform testing activities are sometimes referred to as *subcontractors*. NVLAP does not make a distinction between full-time laboratory employees and individuals hired on a contract to work in that laboratory. NVLAP requires that the testing laboratory maintain responsibility for and control of any work performed within its scope of accreditation. The laboratory shall ensure all individuals performing testing activities satisfy all NVLAP requirements, irrespective of the means by which individuals are compensated (e.g., the laboratory must ensure all test personnel receive proper training and supervision and are subject to annual performance reviews, etc.).

5.3 Accommodation and environmental conditions

5.3.1 The laboratory workspace and environmentally controlled spaces shall be checked for compliance to the required conditions (see 5.3.2).

5.3.2 Monitoring and control devices shall be calibrated (if required – see 5.6.1 and 5.6.2.2.1 and their notes in NIST Handbook 150) and functioning properly so as to maintain and record the environmental conditions required (a) by the standards or laboratory methods or (b) where the environmental conditions influence the quality of the test results.

5.3.3 Specific environmental requirements for laboratories testing solid state lighting products and LED sources are provided in the NIST Handbook 150-1A Checklist.

5.4 Test and calibration methods and method validation

5.4.1 Standard test methods

5.4.1.1 The management system documentation shall contain or make reference to detailed written documentation of the procedures, practices, instructions and equipment that the laboratory uses in conducting the test methods for the different types of solid state lighting products and LED sources for which it seeks or holds accreditation. These detailed instructions, including those for equipment operation, calibration checks, and quality control checks, shall address any laboratory-specific information not contained in the standard method. When necessary, the test method shall be supplemented with additional detailed instructions beyond the test method to ensure consistent application.

5.4.1.2 The photometric, colorimetric, electrical, and lumen maintenance test procedures included in the solid state lighting products and LED sources program have been developed to be generally applicable to a variety of solid state lighting products and LED sources that differ by factors such as size, shape, spectral characteristics, and intensity. As a consequence, the management system documentation shall include laboratory-specific (see 5.4.1.1) detailed descriptions of the operation and calibration of the test equipment and instrumentation the laboratory uses for the particular type(s) of solid state lighting products and LED sources it tests.

5.4.1.3 The Illuminating Engineering Society (IES) LM-58, *Spectroradiometric Measurements*, prescribes in general terms the instrument and measurement requirements, calibration procedures, and physical standards for conducting the measurements, but is not specific as to instrument, object, or material. Laboratories seeking or holding accreditation for colorimetric measurements of solid state lighting products and LED sources conducted in accordance with IES LM-58 shall include, in the management system documentation, detailed laboratory-specific (see 5.4.1.1) descriptions of the procedures it uses to conduct the tests.

5.4.2 Estimation of measurement uncertainty

At a minimum, the management system documentation shall list the important components that substantially affect the uncertainty of the test results. This can be done for groups of similar test methods (e.g., grouped by electrical, photometric [intensity, flux], colorimetric, or lumen maintenance properties) rather than for each test method. The uncertainty shall be determined and reported if required by the test method, the regulator, or the customer.

5.5 Equipment

5.5.1 The laboratory shall notify NVLAP when key testing equipment is added, removed, or altered. Documentation of the validation of the equipment performance shall be provided by the laboratory to NVLAP.

5.5.2 The NIST Handbook 150-1A Checklist contains additional requirements related to testing equipment (see 5.6.2).

5.6 Measurement traceability

5.6.1 By definition, measurement traceability is a property of the measurement result. Therefore, it applies to the result of the test as it relates to a stated reference. However, traceability is established to the

stated reference usually through the calibration of the measurement and test equipment (M&TE) used to conduct the test, and this calibration is achieved with the use of a reference standard or certified reference materials, having a known value(s) and uncertainty and with established traceability. Uncertainty is also a property of the measurement result and is therefore necessary for traceability to exist.

5.6.2 To account for the effects on traceability of the calibration of M&TE, the laboratory shall determine equipment calibration (and verification and maintenance) intervals based on the equipment's frequency of use and the environment in which it is used, and also in accordance with standard test methods, manufacturer's recommendations, or as recommended in the NIST Handbook 150-1A Checklist, whichever results in a shorter time between calibrations. Ultimately, the laboratory shall be responsible for the determination and documentation of the calibration (and verification and maintenance) intervals. Extension of the time interval between calibrations is acceptable if the laboratory can provide justification for increasing the interval.

5.6.3 Proper performance of the testing equipment shall be periodically verified as needed through the use of cross-checks and working standards.

5.6.4 The reference standards used and the environmental conditions at the time of calibration shall be documented for all calibrations.

5.6.5 The following requirements apply for calibrations and calibration certificates.

- a) Certificates shall be required for calibrations performed by outside services. A calibration certificate shall indicate uncertainty or accuracy tolerance limits, and traceability of reference standards.
- b) Certificates may not be required when a laboratory performs its own calibration and records are kept. If the testing laboratory performs its own calibration, the identity of the personnel involved, the standard metrological procedures used, the environmental conditions, and the measurement uncertainty shall be documented. Evidence and demonstration of traceability as required in NIST Handbook 150, Annex B, shall be available. Records shall contain sufficient information to permit repetition of the calibration.
- c) For calibrations performed by the testing laboratory, it shall have properly trained personnel who understand the importance of the various factors that affect the uncertainty of the calibration and its effect on the uncertainty of the final test result (see NIST Handbook 150, 5.4.6 and Annex B).
- d) Solid state lighting products and LED sources testing laboratories, for their standard reference lamps and standard photometers, shall document each step of the traceability chain and, for each step, the magnitude of the associated uncertainty as stated on their calibration certificates (or the uncertainty as determined [or estimated] by the laboratory if it is an in-house calibration conducted by the laboratory).

5.6.6 In addition to the information specified in NIST Handbook 150, 5.5.5, calibration or verification records shall include the following:

- a) a list of all equipment parameters requiring calibration, traceability, or verification;
- b) range of calibration/traceability/verification;

- c) resolution (precision or the number of digits read) of the instrument and its allowable error (i.e., tolerance);
- d) periodic verification dates and schedule;
- e) identity of the laboratory individual/group or external service responsible for calibration;
- f) identity and source of reference standard(s) and traceability.

5.7 Sampling

The NIST Handbook 150-1A Checklist contains additional requirements related to sampling plans and procedures.

5.8 Handling of test and calibration items

There are no requirements additional to those set forth in NIST Handbook 150.

5.9 Assuring the quality of test and calibration results

There are no requirements additional to those set forth in NIST Handbook 150.

5.10 Reporting the results

5.10.1 General

5.10.1.1 Where appropriate, test reports shall clearly state that the test results apply to the product or system as tested and, if required, conform to regulatory requirements.

5.10.1.2 Test reports shall clearly reference the test method and edition, including the published year, applied to the product or system tested.

5.10.2 Data analysis and report generation

5.10.2.1 In some cases, raw data collected by computer are collated, reduced, analyzed, or otherwise treated for direct incorporation in the test report. Such treatment involving transmission of the data, writing, and generation of the test report is generally performed at the laboratory or at an area close to the facility and under the control of laboratory personnel. In such cases, the laboratory personnel responsible for the report writing and generation shall be available during the laboratory's on-site assessment to be interviewed by the assessor for evaluation of the laboratory's compliance with the NVLAP criteria for test reports.

5.10.2.2 At times, the final report may be written and generated at an off-site facility that is located some distance from the testing laboratory such that the assessor cannot interview the off-site personnel. In such a case, the laboratory shall have in place for assessor review appropriate written descriptions in the management system documentation of procedures and documentation for assuring the accuracy and validity of the data transmission, the incorporation and accurate analysis of the data in the test report, and the compliance of the test report with NVLAP criteria. Depending on the on-site laboratory evaluations of

these written descriptions, a visit to the off-site facility may be required. When warranted, an assessor shall visit the off-site facility at additional cost to the laboratory before accreditation is granted or renewed.

5.10.2.3 When a test report is written at an off-site facility such that the assessor cannot interview the off-site personnel, the report shall include the names and addresses of both those responsible for conducting the laboratory tests and for writing and generating the test report. Copies of typical reports written at an off-site facility shall be available at the laboratory at the time of the on-site assessment and these typical reports shall be reviewed by the assessor for compliance with NVLAP requirements.

5.10.2.4 If a laboratory uses several organizational departments for the discrete functions of testing, data collection, data processing, and test report preparation and generation, it is necessary that lines of responsibility with distinct supervisory positions be defined and that no conflicts exist. The assessor shall review the procedures and documentation of the lines of responsibility with distinct supervisory positions during the on-site assessment, and also shall verify that all NVLAP requirements regarding the writing and storage of reports are followed.

6 Additional requirements

NIST Handbook 150-1A Checklist, section 6, contains additional requirements related to sample preparation and identification, environmental conditions, calibration of standards, test report and data recording requirements, test equipment and circuitry requirements, absorption corrections, and instrument electrical loss adjustments where appropriate for particular standard specifications.