ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

Management and Technical Requirements for Laboratories Performing Environmental Analysis

TNI Standard

P.O. Box 2439
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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Proficiency Testing Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Standard Revision History

Module	Action	Date
1	Working Draft Standard Published	January 14, 2007
	Voting Draft Standard Published	June 15, 2007
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2	Working Draft Standard Published	January 14, 2007
	Voting Draft Standard Published	June 15, 2007
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Environmental Laboratory Sector

Volume 1

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ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 1: Proficiency Testing

TNI Standard

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PREFACE

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This Standard may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Sections 4.2.1 a), d), and e); 6.1 a); and 7.2 (deleted section) of this document have been processed in accordance with the TNI requirement for a Tentative Interim Amendment. The same or similar amendment will undergo the consensus standards development process within the time-frame specified in SOP 2-100.

Standard Revision History

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VOLUME 1, MODULE 1

Proficiency Testing

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VOLUME 1, MODULE 1

Proficiency Testing

1.0 INTRODUCTION, SCOPE AND APPLICABILITY

1.1 Introduction

Volume 1, Module 1 provides the requirements for laboratory participation in the TNI Proficiency Testing (PT) program.

1.2 Scope

The purpose of the TNI PT program is to provide a means for a primary accreditation body (Primary AB) to evaluate a laboratory's performance, under specified conditions relative to a given set of criteria in a specific area of testing, through analysis of proficiency testing (PT) samples provided by an external source.

1.3 Applicability

1.3.1 Volume 1, Module 1 is applicable to any laboratory attempting to gain or maintain accreditation from a Primary AB that uses this Standard as the basis for accreditation regardless of the number of personnel working in the laboratory or the scope of testing performed by the laboratory.

1.3.2 This Standard does not apply to fields of accreditation that are not designated as fields of proficiency testing (FoPT) by the TNI Proficiency Testing (PT) Board.

1.3.3 Where there is an Appendix to this Volume that describes the proficiency testing requirements for a specific FoPT, the requirements of such an Appendix supersedes this module.

2.0 NORMATIVE REFERENCES

Not Applicable.

3.0 TERMS AND DEFINITIONS

For the purpose of this Standard, the relevant terms and definitions conform to *ISO/IEC 17011:2004* and *ISO/IEC 17025:2005*. Additional relevant terms are defined below.

3.1 **Accreditation Body:** The territorial, state or federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation.

3.2 **Accreditation Field of Proficiency Testing:** Same as "Field of Proficiency Testing".

3.3 **Analysis Date:** The calendar date of analysis associated with the analytical result reported for an accreditation or experimental field of proficiency testing.

3.4 **Experimental Field of Proficiency Testing** (**Experimental FoPT**)**:** Analytes for which a laboratory is required to analyze a PT sample if they seek or maintain accreditation for the field of accreditation but for which successful analysis is not required in order to obtain or maintain accreditation.

3.5 **Field of Accreditation:** Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.

3.6 **Field of Proficiency Testing** (**FoPT**)**:** Analytes for which a laboratory is required to successfully analyze a PT sample in order to obtain or maintain accreditation, collectively defined as: matrix, technology/method, analyte.

3.7 **Primary Accreditation Body (Primary AB):** The accreditation body responsible for assessing a laboratory's total quality system, on-site assessment, and PT performance tracking for fields of accreditation.

3.8 **Proficiency Testing (PT):** A means to evaluate a laboratory's performance under controlled conditions relative to a given set of criteria, through analysis of unknown samples provided by an external source.

3.9 **Proficiency Testing Program (PT Program):** The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of results and the collective demographics and results summary of all participating laboratories.

3.10 **Proficiency Testing Provider (PTP):** A person or organization accredited by the TNI-approved Proficiency Testing Provider Accreditor to operate a TNI-compliant PT program.

3.11 **Proficiency Testing Provider Accreditor (PTPA):** An organization that is approved by TNI to accredit and monitor the performance of proficiency testing providers.

3.12 **Proficiency Testing Sample (PT Sample):** A sample, the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.

3.13 **Proficiency Testing Study (PT Study):** A single complete sequence of circulation of proficiency testing samples to all participants in a proficiency test program.
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3.14 **PT Study Closing Date:** The calendar date for which analytical results for a PT sample shall be received by the PT provider from the laboratory.

3.15 **PT Study Opening Date:** The calendar date that a PT sample is first made available to any laboratory by a PT provider.

3.16 **Revocation:** The total or partial withdrawal of a laboratory's accreditation by an accreditation body.

3.17 **Study:** This term refers to a PT Study or Supplemental PT Study.

3.18 **Supplemental Proficiency Testing Study** (**Supplemental PT Study**)**:** A PT sample that may be from a lot previously released by a PT Provider that meets the requirements for supplemental PT samples given in Volume 3 of this Standard but that does not have a pre-determined opening date and closing date.

3.19 **Suspension:** The temporary removal of a laboratory's accreditation for a defined period of time, which shall not exceed six (6) months or the period of accreditation, whichever is longer, in order to allow the laboratory time to correct deficiencies or area of non-conformance with the Standard.

3.20 **TNI PT Board:** A board consisting of TNI members or affiliates, appointed by the TNI Board of Directors, which is responsible for the successful implementation and operation of the TNI Proficiency Testing Program. The duties of the TNI PT Board are defined in the TNI PT Board Charter.

4.0 REQUIREMENTS FOR ACCREDITATION

4.1 Initial Accreditation

4.1.1 To obtain initial accreditation, the laboratory shall successfully analyze two unique TNI compliant PT samples for each accreditation FoPT that correspond to the fields of accreditation for which it seeks accreditation.

Note 1: The requirements for successful PT performance are described in Volume 2, Module 2, and in Volume 3.

Note 2: Accreditation and experimental FoPT are established by the TNI PT Board. The official Tables of FoPT are posted to the TNI website.

4.1.2 The PT samples used for initial accreditation shall be obtained from any PTPA-accredited PTP as part of a TNI-compliant study. If a PT sample for an accreditation FoPT is not available from any accredited PTP, the laboratory shall obtain the PT sample from any non-PTPA-accredited PTP.

4.1.3 When the PT samples used for initial accreditation were analyzed by the laboratory prior to the date of application, the analysis dates of the PT samples for the same accreditation FoPT shall be no more than eighteen (18) months prior to the application date of accreditation, with the analysis date of the most recent PT sample having been no more than six (6) months prior to the application date for accreditation. Otherwise, there shall be at least fifteen (15) calendar days between the analysis dates of successive PT samples for the same accreditation FoPT.

4.2 Continued Accreditation

4.2.1 To maintain accreditation the laboratory shall:

a) analyze at least two TNI-compliant PT samples per calendar year for each accreditation FoPT for which the laboratory is accredited unless TNI-compliant PT samples are not available from any PTPA approved PT provider at least twice per year, in which case the laboratory shall analyze the PT samples in the minimum time frame in which the PT samples are available . The analysis dates of successive PT samples for the same accreditation FoPT shall be at least five (5) months apart and no longer than seven (7) months apart unless the PT sample is being used for corrective action to reestablish successful history in order to maintain continued accreditation, or is being used to reinstate accreditation after suspension, in which case the analysis dates of successive PT samples for the same accreditation FoPT shall be at least fifteen (15) days apart;

b) maintain a history of at least two (2) successful performances out of the most recent three (3) attempts; for each accreditation FoPT; and

c) obtain the PT samples from any PTPA-accredited PTP. If a PT sample for a FoPT is not available from any accredited PTP, the laboratory shall obtain the PT sample from any non-PTPA-accredited PTP.

d) Whole Effluent Toxicity testing laboratories shall analyze at least one (1) TNI-compliant PT sample per calendar year for each accredited FoPT for which the laboratory holds accreditation with the primary AB. The laboratory shall perform corrective action when a PT study has been failed. Corrective action shall include:

i. A written corrective action report,

ii. A copy of the raw data used for the study,

iii. A copy of the current Standard Reference Toxicant (SRT) control chart relevant to the PT study, and

iv. Other documentation the laboratory deems necessary to support the conclusions of the report.

e) For Whole Effluent Toxicity Testing fields of proficiency testing, the study closing date for non DMR-QA Studies shall be no more than ninety (90) calendar days after the opening date of the study. For DMR-QA Studies, the laboratory must meet the time frames as stated in the Announcement letter.

4.2.2 When a laboratory is accredited for a field of accreditation for which the FoPT is an experimental FoPT, the laboratory shall analyze two (2) PT samples for the experimental FoPT per year within the same time frames specified for accreditation FoPT. However, successful performance of the experimental PT is not a requisite for continued accreditation.

5.0 REQUIREMENTS FOR PT SAMPLE HANDLING, ANALYSIS & REPORTING

5.1 PT Sample Analysis Requirements

5.1.1 The laboratory shall analyze PT samples in the same manner as used for routine environmental samples using the same staff, sample tracking, sample preparation and analysis methods, standard operating procedures, calibration techniques, quality control procedures and acceptance criteria.

Note: The laboratory is permitted to analyze the same PT sample for any accreditation or experimental FoPT by multiple methods so long as those test methods are within the same field of accreditation matrix. If the laboratory is accredited for multiple test methods that use the same technology within a field of accreditation, the laboratory is not required to analyze a PT sample for each test method, except for fields of accreditation for the drinking water accreditation matrix for which a PT sample per test method is required. The laboratory may analyze and report the PT sample by one test method and an acceptable performance score for that test method will be acceptable for all test methods that use that same technology within that field of accreditation. When the laboratory reports an analytical result for an accreditation FoPT within the same field of accreditation and accreditation matrix by more than one test method using the same technology, an unacceptable score for either test method will result in an unacceptable score for all test methods for that accreditation FoPT.

5.1.2 Prior to the closing date of a study, laboratory personnel, including corporate personnel, shall not:

a) subcontract the analysis of any PT sample or a portion of a PT sample to another laboratory for any accreditation or experimental FoPT.

b) knowingly receive and analyze any PT sample or portion of a PT sample from another laboratory for which the results of the PT sample are intended for use for initial or continued accreditation.

c) communicate with any individual at another laboratory concerning the analysis of the PT sample prior to the closing date of the study.

d) attempt to obtain the assigned value of any accreditation or experimental FoPT from the PTP.

5.2 PT Sample Reporting Requirements

5.2.1 The laboratory shall evaluate and report the analytical result for accreditation or experimental FoPT as follows:

a) For instrument technology that employs a multi-point calibration, the laboratory shall evaluate the analytical result to the value of the lowest calibration standard established for the test method used to analyze the PT sample. The working range of the calibration under which the PT sample is analyzed shall be the same range as used for routine environmental samples.

i. A result for any FoPT at a concentration above or equal to the lowest calibration standard shall be reported as the resultant value.

ii. A result for any FoPT at a concentration less than the lowest calibration standard shall be reported as less than the value of the lowest calibration standard.

b) For instrument technology (such as ICP-AES or ICP-MS) that employ standardization with a zero point and a single point calibration standard, the laboratory shall evaluate the analytical result to the limit of quantitation (LOQ) established for the test method used to analyze the PT sample. The LOQ for the FoPT shall be the same as used for routine environmental samples.

i. A result for any FoPT at a concentration above or equal to the LOQ shall be reported as the resultant value.

ii. A result for any FoPT at a concentration less than the LOQ shall be reported as less than the value of the LOQ.

Note: The definitions and requirements for calibration and limit of quantitation are included in Volume 1, Module 2.

5.2.2 The laboratory shall report the analytical results for accreditation and experimental FoPTs to the PTP on or before the closing date of the study using the reporting format specified by the PTP.

5.2.3 On or before the closing date of the study, the laboratory shall authorize the PTP to release the laboratory's final evaluation report directly to the laboratory's Primary AB.

5.3 PT Sample Record Retention Requirements

5.3.1 The laboratory shall retain all records necessary to facilitate historical reconstruction of the analysis and reporting of analytical results for PT samples for a minimum of five years.

5.3.2 The historical records shall include a copy of the reporting forms used by the laboratory to report the analytical results for PT samples to the PTP. If the analytical results for the PT samples were entered or uploaded electronically to a PTP website, the laboratory shall retain a copy of the on-line data entry summary or similar documentation of entry of the PT results from the PTP's website.

5.3.3 The laboratory shall make these records available for review upon request by the Primary AB.

6.0 REQUIREMENTS FOR CORRECTIVE ACTION

6.1 When the laboratory receives a "not acceptable" performance score from a PTP or a Primary AB, the laboratory shall perform corrective action. The requirements for corrective action are described in Volume 1, Module 2.

When the laboratory receives an evaluation of not acceptable for an accreditation FoPT in any study, the laboratory may choose to re-establish successful history for the accreditation FoPT with a PT sample from any study. The following requirements shall apply to the PT sample used to re-establish successful history:

a) The PT sample shall be obtained from any PTPA–accredited PTP unless there are not any PTPA-accredited PTP for the FoPT in which case the PT sample may be purchased from any PTP. The laboratory shall notify the PTP that the PT sample will be used for corrective action purposes so the PTP may ensure that the PT sample supplied meets the requirements for supplemental PT as defined in Volume 3 of this standard.

b) The laboratory shall ensure that there are at least fifteen calendar days between the analysis dates of successive PT samples for the same accreditation FoPT.

c) The PT sample shall be analyzed and reported in accordance with the requirements described this Module.

7.0 REQUIREMENTS FOR COMPLAINT RESOLUTION

7.1 The laboratory shall submit questions about PT samples or performance evaluations made by the PTP to the PTP. If the PTP is not able or is unwilling to resolve the question to the satisfaction of the laboratory, the laboratory shall refer those questions to the PTP's PTPA.

8.0 REQUIREMENTS FOR REINSTATEMENT OF ACCREDITATION AFTER SUSPENSION OR REVOCATION

8.1 To reinstate accreditation for an accreditation FoPT after suspension, the laboratory shall meet the requirements for continued accreditation as described in Section 4.2 of this module.

8.2 To reinstate accreditation for an accreditation FoPT after revocation, the laboratory shall meet the requirements for initial accreditation as described in Section 4.1 of this module.

ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 2: Quality Systems General Requirements

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

It is conformant with the requirements of ISO/IEC 17025:2005(E). This publicly available TNI document does not contain the ISOI/IEC copyright protected language, but does reference applicable ISO clauses. In these situations, it is useful to read the TNI Standard along with the ISOI/IEC Standard. Wherever an ISO clause is referenced *(in italics),* the language from that clause is applicable. Any additional TNl language then follows, in plain text, as a NOTE or as an additional numbered Standard item.

TNI has an agreement with ASTM International and the American National Standards Institute (ANSI) to provide, to TNI members at a discounted rate, a version of this Standard with the ISO/IEC language included; contact Jerry Parr at TNI for more information.

This Standard may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

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VOLUME 1, MODULE 2

Quality Systems General Requirements

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VOLUME 1, MODULE 2

Quality Systems General Requirements

1.0 INTRODUCTION, SCOPE AND APPLICABILITY

1.1 Introduction

Each laboratory shall have a quality system. The laboratory's quality system is the means by which an organization ensures the quality of the products or services it provides and includes a variety of management, technical, and administrative elements such as:

a) policies and objectives,
b) procedures and practices,
c) organizational authority,
d) responsibilities, and
e) performance measures.

The quality system provides the framework for planning, implementing, assessing, and improving work performed by an organization so as to provide the client with data of known and documented quality, sufficient to evaluate the usability of the data to the clients needs. The quality system shall be documented in the laboratory's quality manual and related quality documentation, and shall be referenced in the quality manual.

This Standard contains detailed quality system requirements for consistent and uniform implementation by the laboratories conducting testing and the consistent and uniform evaluation of those laboratories by accreditation bodies. Each laboratory seeking accreditation under this Standard shall ensure that they are implementing their quality system and that all Quality Control procedures specified in this module are being followed. The Quality Assurance policies, which establish quality control procedures, are applicable to environmental laboratories regardless of size and complexity.

This Standard is consistent with ISO/IEC 17025:2005 requirements that are relevant to the scope of environmental testing services.

All items identified in this document shall be available for an on-site assessment.

1.2 Scope

The requirements in this document give the basis for a laboratory's quality system in order to carry out environmental tests. It covers testing performed using reference methods, non-reference methods, and laboratory-developed methods. This document contains the essential elements required to establish a quality system that produces data of known and documented quality, and demonstrates proficiency through the use of proficiency testing and employee training.

The general requirements of this document apply to all organizations performing environmental tests, regardless of the number of personnel or the degree of environmental testing activities. When the use of the data requires compliance with the Standards, these Standards shall be followed.

This document is for use by laboratories, clients, regulatory authorities, and accreditation bodies to ensure the laboratory has appropriate management and technical quality systems to perform environmental testing. This document specifies technical, managerial, and documentation requirements needed for assessment by organizations or accreditation bodies to grant approval. This document provides the requirements needed for laboratory accreditation. If the requirements of this document are met, the laboratory operates a quality system in conformance with the applicable clauses of ISO/IEC 17025:2005(E).

2.0 NORMATIVE REFERENCES *(ISO/IEC 17025:2005(E), Clause 2)*

3.0 TERMS AND DEFINITIONS

The relevant definitions listed in the referenced ISO/IEC documents apply when using those documents. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

3.1 Additional Terms and Definitions

Acceptance Criteria: Specified limits placed on characteristics of an item, process, or service defined in requirement documents.

Accreditation: The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory.

Accuracy: The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.

Analyst: The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

Analytical Uncertainty: A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.

Assessment: The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its systems to defined criteria (to the standards and requirements of laboratory accreditation).

Audit: A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.

Batch: Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one (1) to twenty (20) environmental samples of the same quality systems matrix, meeting the above mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be twenty-four (24) hours. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed twenty (20) samples.

Bias: The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).

Blank: A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. Blanks include:

Method Blank: A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.

Calibration: A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values

represented by a material measure or a reference material, and the corresponding values realized by standards.

1) In calibration of support equipment the values realized by standards are established through the use of reference standards that are traceable to the International System of Units (SI).

2) In calibration according to methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.

Calibration Curve: The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.

Calibration Standard: A substance or reference material used for calibration.

Certified Reference Material (CRM): Reference material accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.

Chain of Custody Form: Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; the collector; time of collection; preservation; and requested analyses.

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: Second column confirmation, Alternate wavelength, Derivatization, Mass spectral interpretation, Alternative detectors, or Additional cleanup procedures.

Data Reduction: The process of transforming the number of data items by arithmetic or statistical calculation, standard curves, and concentration factors, and collating them into a more useful form.

Demonstration of Capability: A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision.

Field of Accreditation: Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.

Finding: An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement.

Holding Times: The maximum time that can elapse between two specified activities.

Internal Standard: A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.

Legal Chain of Custody Protocols: Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Limit(s) of Detection (LOD): A laboratory's estimate of the minimum amount of an analyte in a given matrix that an analytical process can reliably detect in their facility.

Limit(s) of Quantitation (LOQ): The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

Matrix: The substrate of a test sample.

Matrix Duplicate: A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.

Matrix Spike (spiked sample or fortified sample): A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate (spiked sample or fortified sample duplicate): A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Measurement System: A method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s).

Method: A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.

Mobile Laboratory: A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans, and skid-mounted structures configured to house testing equipment and personnel.

National Institute of Standards and Technology (NIST): A federal agency of the US Department of Commerce's Technology Administration that is designed as the United States national metrology institute (NMI).

Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: Any conditions under which a sample must be kept in order to maintain chemical and/or biological integrity prior to analysis.

Procedure: A specified way to carry out an activity or process. Procedures can be documented or not.

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.

Protocol: A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) which must be strictly followed.

Quality Assurance: An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Control: The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.

Quality Control Sample: A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.

Quality Manual: A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

Quality System: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance (QA) and quality control (QC) activities.

Quality System Matrix: These matrix definitions are to be used for purposes of batch and quality control requirements:

Air and Emissions: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbant tube, impinger solution, filter, or other device.

Aqueous: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, ground water effluents, and TCLP or other extracts.

Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.

Chemical Waste: A product or by-product of an industrial process that results in a matrix not previously defined.

Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.

Non-Aqueous Liquid: Any organic liquid with <15% settleable solids.

Saline/Estuarine: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.

Solids: Includes soils, sediments, sludges and other matrices with >15% settleable solids.

Raw Data: The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.

Reference Material: Material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

Reference Standard: Standard used for the calibration of working measurement standards in a given organization or at a given location.

Sampling: Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.

Selectivity: The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent or that may behave similarly to the target analyte or parameter within the measurement system.

Sensitivity: The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.

Standard: The document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.

Standard Operating Procedures (SOPs): A written document that details the method for an operation, analysis, or action, with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.

Technology: A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.

Traceability: The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.

Verification: Confirmation by examination and objective evidence that specified requirements have been met.

NOTE: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.

The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

3.2 Sources

40CFR Part 136 Guidelines Establishing Test Procedures for the Analysis of Pollutants

American Society for Quality Control (ASQC), Definitions of Environmental Quality Assurance Terms, 1996

American National Standards Institute (ANSI), Style Manual for Preparation of Proposed American National Standards, Eighth Edition, March 1991

ANSI N42.23-1995, Measurement and Associated Instrument Quality Assurance for Radiobioassay Laboratories

International Vocabulary of Basic and General Terms in Metrology (VIM): 1984. Issued by Bureau International des Poids et Mesures (BIPM), International Electrotechnical Commission (IEC), International Organization for Standardization (ISO)/IEC and International Organization of Legal Metrology (OIML)

National Institute of Standards and Technology (NIST)

National Environmental Laboratory Accreditation Conference (NELAC), July 2003 Standards

Random House College Dictionary

United States Environmental Protection Agency (US EPA) Quality Assurance Management Section (QAMS), Glossary of Terms of Quality Assurance Terms, 8/31/92 and 12/6/95

Webster's New World Dictionary of the American Language

Uniform Federal Policy for Quality Assurance Project Plans (UFP QAPP) March 2005

VIM – Draft edition October 2005

TNI Technical Modules, as follows:

Volume 1, Module 3 Quality Systems for Asbestos Testing

Volume 1, Module 4 Quality Systems for Chemical Testing

Volume 1, Module 5 Quality Systems for Microbiological Testing

Volume 1, Module 6 Quality Systems for Radiochemical Testing

Volume 1, Module 7 Quality Systems for Toxicity Testing

3.3 Exclusions and Exceptions

Reserved

4.0 MANAGEMENT REQUIREMENTS

4.1 Organization *(ISO/IEC 17025:2005(E), Clause 4.1)*

4.1.7 Additional Requirements for Laboratories

4.1.7.1 The laboratory's quality manager and/or his/her designee(s) shall:

a) serve as the focal point for QA/QC and be responsible for the oversight and/or review of quality control data;

b) have functions independent from laboratory operations for which they have quality assurance oversight;

c) be able to evaluate data objectively and perform assessments without outside (e.g., managerial) influence;

d) have documented training and/or experience in QA/QC procedures and the laboratory's quality system;

e) have a general knowledge of the analytical methods for which data review is performed;

f) arrange for or conduct internal audits as per Section 4.14 annually;

g) notify laboratory management of deficiencies in the quality system; and

h) monitor corrective actions.

NOTE: Where staffing is limited, the quality manager may also be the technical manager.

4.1.7.2 The laboratory's technical manager(s), however named, and/or his/her designee(s) shall:

a) be a member of the staff of an environmental laboratory who exercises actual day-to-day supervision of laboratory operations for the appropriate fields of accreditation and reporting of results;

b) be experienced in the fields of accreditation for which the laboratory is seeking accreditation;

c) have duties that include:

i. monitoring standards of performance in quality control and quality assurance, and

ii. monitoring the validity of the analyses performed and data generated in the laboratory to assure reliable data.

d) not be the technical manager(s) of more than one accredited environmental laboratory without authorization from the primary Accreditation Body. Circumstances to be considered in the decision to grant such authorization shall include:

i. the extent to which operating hours of the laboratories to be directed overlap,

ii adequacy of supervision in each laboratory, and

iii the availability of environmental laboratory services in the area served.

e) if absent for a period of time exceeding fifteen (15) consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical manager(s) to temporarily perform this function. If this absence exceeds thirty-five (35) consecutive calendar days, the primary accreditation body shall be notified in writing; and

f) meet qualification requirements as specified in Section 5.2.6.1.

4.2 Management *(ISO/IEC 17025:2005(E), Clause 4.2)*

4.2.8 Additional Management System Requirements

4.2.8.1 The laboratory shall establish and maintain a documented data integrity system. There are four required elements within a data integrity system. These are 1) data integrity training, 2) signed data integrity documentation for all laboratory employees, 3) in-depth, periodic monitoring of data integrity, and 4) data integrity procedure documentation. The data integrity procedures shall be signed and dated by top management. The requirements for data integrity investigation are listed in Section 4.16. The requirements for data integrity training and documentation are listed in Section 5.2.7. Management shall annually review data integrity procedures and update as needed.

a) Laboratory management shall provide a procedure for confidential reporting of data integrity issues in their laboratory. A primary element of the procedure is to assure confidentiality and a receptive environment in which all employees may privately discuss ethical issues or report items of ethical concern.

b) In instances of ethical concern, the procedure shall include a process whereby laboratory management is to be informed of the need for any further detailed investigation.

4.2.8.2 The quality manager shall be responsible for maintaining the currency of the quality manual.

4.2.8.3 The quality manual shall contain:

a) document title;

b) laboratory's full name and address;

c) name, address (if different from above), and telephone number of individual(s) responsible for the laboratory;

d) identification of all major organizational units which are to be covered by this quality manual and the effective date of the version;

e) identification of the laboratory's approved signatories;

f) the signed and dated concurrence (with appropriate names and titles), of all responsible parties including the quality manager(s), technical manager(s), and the agent who is in charge of all laboratory activities, such as the laboratory director or laboratory manager;

g) the objectives of the quality system and contain or reference the laboratory's policies and procedures;

h) the laboratory's official quality policy statement, which shall include quality system objectives and management's commitment to ethical laboratory practices and to upholding the requirements of this Standard; and

i) a table of contents, and applicable lists of references, glossaries and appendices.

4.2.8.4 The quality manual shall contain or reference:

a) all maintenance, calibration and verification procedures used by the laboratory in conducting tests;

b) major equipment and reference measurement standards used as well as the facilities and services used by the laboratory in conducting tests;

c) verification practices, which may include inter-laboratory comparisons, proficiency testing programs, use of reference materials and internal quality control schemes;

d) procedures for reporting analytical results;

e) the organization and management structure of the laboratory, its place in any parent organization, and relevant organizational charts;

f) procedures to ensure that all records required under this Standard are retained, as well as procedures for control and maintenance of documentation through a document control system that ensures that all standard operating procedures (SOPs), manuals, or documents clearly indicate the time period during which the procedure or document was in force;

g) job descriptions of key staff and reference to the job descriptions of other laboratory staff;

h) procedures for achieving traceability of measurements;

i) a list of all methods under which the laboratory performs its accredited testing;

j) procedures for ensuring that the laboratory reviews all new work to ensure that it has the appropriate facilities and resources before commencing such work;

k) procedures for handling samples;

l) procedures to be followed for feedback and corrective action whenever testing discrepancies are detected, or departures from documented policies and procedures occur;

m) policy for permitting departures from documented policies and procedures or from standard specifications;

n) procedures for dealing with complaints;

o) procedures for protecting confidentiality (including national security concerns), and proprietary rights;

p) procedures for audits and data review;

q) procedures for establishing that personnel are adequately experienced in the duties they are expected to carry out and are receiving any needed training; and

r) policy addressing the use of unique electronic signatures, where applicable.

4.2.8.5 Laboratories shall maintain SOPs that accurately reflect all phases of current laboratory activities, such as assessing data integrity, corrective actions, handling customer complaints, and all methods.

a) These documents, for example, may be equipment manuals provided by the manufacturer, or internally written documents with adequate detail to allow someone similarly qualified, other than the analyst, to reproduce the procedures used to generate the test result.

b) The relevant SOPs shall be readily accessible to all personnel.

c) Each SOP shall clearly indicate the effective date of the document, the revision number, and the signature(s) of the approving authority.

d) Documents that contain sufficient information to perform the tests, do not need to be supplemented or rewritten as internal procedures if the documents are written in a way that they can be used as written. Any changes, including the use of a selected option, shall be documented and included in the laboratory's method records.

e) The laboratory shall have and maintain an SOP for each accredited analyte or method.

f) The SOP may be a copy of a published or referenced method or may be written by the laboratory. In cases where modifications to the published method have been made by the laboratory or where the referenced method is ambiguous or provides insufficient detail, these changes or clarifications shall be clearly described. Each method shall include or reference the following topics where applicable:

i. identification of the method;
ii. applicable matrix or matrices;
iii. limits of detection and quantitation;
iv. scope and application, including parameters to be analyzed;
v. summary of the method;
vi. definitions;
vii. interferences;
viii. safety;
ix. equipment and supplies;
x. reagents and standards;
xi. sample collection, preservation, shipment and storage;
xii. quality control;
xiii. calibration and standardization;
xiv. procedure;
xv. data analysis and calculations;
xvi. method performance;
xvii. pollution prevention;
xviii. data assessment and acceptance criteria for quality control measures;
xix. corrective actions for out-of-control data;
xx. contingencies for handling out-of-control or unacceptable data;

xxi. waste management;
xxii. references; and
xxiii. any tables, diagrams, flowcharts and validation data.

4.3 Document Control *(ISO/IEC 17025:2005(E), Clause 4.3)*

4.4 Review of Requests, Tenders and Contracts *(ISO/IEC 17025:2005(E), Clause 4.4)*

4.5 Subcontracting of Environmental Tests *(ISO/IEC 17025:2005(E), Clause 4.5)*

4.5.5 When a laboratory subcontracts work, this work shall be placed with a laboratory accredited to this Standard for the tests to be performed or with a laboratory that meets applicable statutory and regulatory requirements for performing the tests and submitting the results of tests performed. The laboratory performing the subcontracted work shall be indicated in the final report. The laboratory shall make a copy of the subcontractor's report available to the client when requested.

4.6 Purchasing Services and Supplies *(ISO/IEC 17025:2005(E), Clause 4.6)*

4.7 Service to the Client *(ISO/IEC 17025:2005(E), Clause 4.7)*

4.8 Complaints *(ISO/IEC 17025:2005(E), Clause 4.8)*

4.9 Control of Nonconforming Environmental Testing Work *(ISO/IEC 17025:2005(E), Clause 4.9)*

4.10 Improvement *(ISO/IEC 17025:2005(E), Clause 4.10)*

4.11 Corrective Action *(ISO/IEC 17025:2005(E), Clause 4.11)*

4.11.6 The laboratory shall have documented procedure(s) to address 4.11.1 and 4.11.3 through 4.11.5. These procedure(s) shall also include:

a) which individual(s) or positions are responsible for assessing each QC data type; and

b) which individual(s) or positions are responsible for initiating and/or recommending corrective actions.

4.11.7 Cause analysis described in Section 4.11.2 applies to failures that indicate a systematic error.

4.12 Preventive Action *(ISO/IEC 17025:2005(E), Clause 4.12)*

4.13 Control of Records *(ISO/IEC 17025:2005(E), Clause 4.13)*

4.13.3 Additional Requirements

a) The laboratory shall establish a record keeping system that allows the history of the sample and associated data to be readily understood through the documentation. This system shall produce unequivocal, accurate records that document all laboratory activities such as laboratory facilities, equipment, analytical methods, and related laboratory activities, such as sample receipt, sample preparation, or data verification, and inter-laboratory transfers of samples and/or extracts.

b) The laboratory shall retain all records for a minimum of five (5) years from generation of the last entry in the records.

c) Records shall be available to the accreditation body.

d) Records that are stored only on electronic media shall be supported by the hardware and software necessary for their retrieval.

e) Access to archived information shall be documented with an access log.

f) All information necessary for the historical reconstruction of data shall be maintained by the laboratory.

i. all raw data, whether hard copy or electronic, for calibrations, samples and quality control measures, including analysts' worksheets and data output records (chromatograms, strip charts, and other instrument response readout records);

ii. a written description or reference to the specific method used, which includes a description of the specific computational steps used to translate parametric observations into a reportable analytical value;

iii. laboratory sample ID code;

iv. date of analysis;

v. time of analysis is required if the holding time is seventy-two hours or less, or when time critical steps are included in the analysis (e.g., extractions and incubations);

vi. instrumentation identification and instrument operating conditions/parameters (or reference to such data);

vii. all manual calculations;

viii. analyst's or operator's initials/signature or electronic identification;

ix. sample preparation, including cleanup, separation protocols, incubation periods or subculture, ID codes, volumes, weights, instrument printouts, meter readings, calculations, reagents;

x. test results;

xi. standard and reagent origin, receipt, preparation, and use;

xii. calibration criteria, frequency and acceptance criteria;

xiii. data and statistical calculations, review, confirmation, interpretation, assessment and reporting conventions;

xiv. quality control protocols and assessment;

xv. electronic data security, software documentation and verification, software and hardware audits, backups, and records of any changes to automated data entries;

xvi. method performance criteria including expected quality control requirements;

xvii. proficiency test results;

xviii. records of demonstration of capability for each analyst; and

xix. a record of names, initials, and signatures for all individuals who are responsible for signing or initialing any laboratory record.

g) All generated data, except those that are generated by automated data collection systems, shall be recorded legibly in permanent ink.

i. An individual making corrections to records shall date and initial the correction.

ii. Corrections due to reasons other than transcription errors shall specify the reason for the correction.

h) The laboratory shall have a plan to ensure that the records are maintained or transferred according to the clients' instructions in the event that a laboratory transfers ownership or goes out of business. In addition, appropriate regulatory and state legal requirements concerning laboratory records shall be followed.

4.14 Internal Audits *(ISO/IEC 17025:2005(E), Clause 4.14)*

4.14.5 Additional Items

a) The laboratory shall have a policy that specifies the time frame for notifying a client of events that cast doubt on the validity of the results.

b) The laboratory management shall ensure that these actions are discharged within the agreed time frame.

c) The Internal audit schedule shall be completed annually,

4.15 Management Reviews *(ISO/IEC 17025:2005(E), Clause 4.15)*

4.15.3 Management review shall be completed on an annual basis.

4.16 Data Integrity Investigations

All investigations resulting from data integrity issues should be conducted in a confidential manner until they are completed. These investigations shall be documented, as well as any notifications made to clients receiving any affected data.

5.0 TECHNICAL REQUIREMENTS

5.1 General *(ISO/IEC 17025:2005(E), Clause 5.1)*

5.2 Personnel *(ISO/IEC 17025:2005(E), Clause 5.2)*

NOTE: All references to Calibration Certificates in *ISO/IEC 17025:2005(E)* are not applicable to environmental testing.

5.2.6 Additional Personnel Requirements

5.2.6.1 Technical Manager Qualifications

The applicable requirements for technical managers are given below.

a) Any technical manager of an accredited environmental laboratory engaged in chemical analysis shall be a person with a bachelor's degree in the chemical, environmental, biological sciences, physical sciences or engineering, with at least twenty-four (24) college semester credit hours in chemistry and at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for which the laboratory seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one year of experience.

b) Any technical manager of an accredited environmental laboratory limited to inorganic chemical analysis, other than metals analysis, shall be a person with at least an earned associate's degree in the chemical, physical or environmental sciences, or two (2) years of equivalent and successful college education, with a minimum of sixteen (16) college semester credit hours in chemistry. In addition, such a person shall have at least two (2) years of experience performing such analysis.

c) Any technical manager of an accredited environmental laboratory engaged in microbiological or biological analysis shall be a person with a bachelor's degree in microbiology, biology, chemistry, environmental sciences, physical sciences or engineering with a minimum of sixteen college semester credit hours in general microbiology and biology and at least two (2) years of experience in the environmental analysis of representative analytes for which the laboratory seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

A person with an associate's degree in an appropriate field of the sciences or applied sciences, with a minimum of four (4) college semester credit hours in general microbiology may be the technical manager(s) of a laboratory engaged in microbiological analysis limited to fecal coliform, total coliform, E. coli, and standard plate count. Two (2) years of equivalent and successful college education, including the microbiology requirement, may be substituted for the associate's degree. In addition, each person shall have one (1) year of experience in microbiological analyses.

d) Any technical manager of an accredited environmental laboratory engaged in radiological analysis shall be a person with a bachelor's degree in chemistry, environmental, biological sciences, physical sciences or engineering with twenty-four (24) college semester credit hours of chemistry with two (2) or more years of experience in the radiological analysis of environmental samples. A master's or doctoral degree in one of the above disciplines may be substituted for one (1) year experience.

e) The technical manager(s) of an accredited environmental laboratory engaged in microscopic examination of asbestos and/or airborne fibers shall meet the following requirements:

i. For procedures requiring the use of a transmission electron microscope, a bachelor's degree, successful completion of courses in the use of the instrument, and one (1) year of experience, under supervision, in the use of the instrument. Such experience shall include the identification of minerals.

ii. For procedures requiring the use of a polarized light microscope, an associate's degree or two (2) years of college study, successful completion of formal coursework in polarized light microscopy, and one year of experience, under supervision, in the use of the instrument. Such experience shall include the identification of minerals.

iii. For procedures requiring the use of a phase contrast microscope, as in the determination of airborne fibers, an associate's degree or two (2) years of college study, documentation of successful completion of formal coursework in phase contrast microscopy, and one (1) year of experience, under supervision, in the use of the instrument.

f) Any technical manager of an accredited environmental laboratory engaged in the examination of radon in air shall have at least an associate's degree or two (2) years of college and one (1) year of experience in radiation measurements, including at least one (1) year of experience in the measurement of radon and/or radon progeny.

5.2.6.2 Technical Manager Qualification Exceptions

a) Notwithstanding any other provision of this Section, a full-time employee of a drinking water or sewage treatment facility who holds a valid treatment plant operator's certificate appropriate to the nature and size of such facility shall be deemed to meet the educational requirements as the technical manager. A technical manager shall have two (2) year testing experience devoted exclusively to the testing of environmental samples specified in the scope of the facility's regulatory permit. Such accreditation for a water treatment facility and/or a sewage treatment facility shall be limited to the scope of that facility's regulatory permit.

b) A full-time employee of an industrial waste treatment facility with a minimum of two (2) years of experience under supervision in testing of environmental samples taken within such facility for the scope of that facility's regulatory permit shall be deemed to meet the requirements for serving as the technical manager of an accredited laboratory. Such accreditation for an industrial waste treatment facility shall be limited to the scope of that facility's regulatory permit.

c) Persons who do not meet the education credential requirements but possess the requisite experience of 5.2.6.1 shall qualify as technical manager(s) subject to the following conditions.

i. The person shall be a technical manager of the laboratory on the date the laboratory applies for accreditation and/or becomes subject to accreditation under this Standard, and shall have been a technical manager in that laboratory continuously for the previous twelve (12) months or more.

ii. The person will be approved as a technical manager for only those fields of accreditation for which he/she has been technical manager in that laboratory for the previous twelve (12) months or more.

iii. A person who is admitted as a technical manager under these conditions, and leaves the laboratory, will be eligible for hire as a technical manager for the same fields of accreditation in another accredited laboratory.

5.2.7 Data Integrity Training

Data integrity training shall be provided as a formal part of new employee orientation and shall also be provided on an annual basis for all current employees. Employees are required to understand that any infractions of the laboratory data integrity procedures shall result in a detailed investigation that could lead to very serious consequences including immediate termination, debarment or civil/criminal prosecution. The initial data integrity training and the annual refresher training shall have a signature attendance sheet or other form of documentation that demonstrates all staff have participated and understand their obligations related to data integrity.

Data integrity training requires emphasis on the importance of proper written narration on the part of the analyst with respect to those cases where analytical data may be useful, but are in one sense or another partially deficient. The topics covered in such training shall be documented in writing (such as an agenda) and provided to all trainees. At a minimum, the following topics and activities shall be included:

a) organizational mission and its relationship to the critical need for honesty and full disclosure in all analytical reporting, how and when to report data integrity issues, and record keeping;

b) training, including discussion regarding all data integrity procedures;

c) data integrity training documentation;

d) in-depth data monitoring and data integrity procedure documentation; and

e) specific examples of breaches of ethical behavior such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.

The data integrity procedures may also include written ethics agreements, examples of improper practices, examples of improper chromatographic manipulations, requirements for external ethics program training, and any external resources available to employees.

5.3 Accommodation and Environmental Conditions *(ISO/IEC 17025:2005(E), Clause 5.3)*

5.4 Environmental Methods and Method Validation

NOTE: All references to Calibration Laboratories and Calibration Methods in *ISO/IEC 17025:2005(E)* in these Clauses are not applicable to environmental testing.

5.4.1 General (*ISO/IEC 17025:2005(E), Clause 5.4.1)*

5.4.2 Selection of Methods (*ISO/IEC 17025:2005(E), Clause 5.4.2)*

5.4.3 Laboratory-Developed Methods *(ISO/IEC 17025:2005(E), Clause 5.4.3)*

5.4.4 Non-Standard Methods *(ISO/IEC 17025:2005(E), Clause 5.4.4*) is not applicable in this module and is addressed in specific technical modules based on technology.

5.4.5 Validation of Methods *(ISO/IEC 17025:2005(E), Clause 5.4.5)* is not applicable in this module and is addressed in specific technical modules based on technology.

5.4.6 Estimation of Analytical Uncertainty

Clause 5.4.6 of the *ISO/IEC/IEC 17025:2005(E)* concerning calibration testing does not apply. The following requirement replaces the *ISO/IEC Clause*. Environmental testing laboratories shall have a procedure(s) for estimating analytical uncertainty. Quality control measurement data may be used to determine analytical uncertainty.

5.4.7 *Control of Data (ISO/IEC 17025:2005(E), Clause 5.4.7)*

5.5 Calibration Requirements (ISO/IEC 17025:2005(E), Clause 5.5)

NOTE: *ISO/IEC Clauses 5.5.1 to 5.5.12* apply with respect to equipment in environmental testing laboratories.

5.5.13 Additional Requirements and Clarifications

Calibration requirements for analytical support equipment are included in this Section while requirements for instrument (testing) calibration are included in technical modules (i.e., Asbestos, Chemistry, Microbiology, Radiochemistry and Toxicology).

5.5.13.1 Support Equipment

This Standard applies to all devices that may not be the actual test instrument, but are necessary to support laboratory operations. These include, but are not limited to: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices (including thermometers and thermistors), thermal/pressure sample preparation devices and volumetric dispensing devices (such as Eppendorf® or automatic dilutor/dispensing devices), if quantitative results are dependent on their accuracy, as in standard preparation and dispensing or dilution into a specified volume.

a) All support equipment shall be maintained in proper working order. The records of all repair and maintenance activities, including service calls, shall be kept.

b) All support equipment shall be calibrated or verified at least annually, using a recognized National Metrology Institute, such as NIST, traceable references when available, bracketing the range of use. The results of such calibration or verification shall be within the specifications required of the application for which this equipment is used or:

i. the equipment shall be removed from service until repaired; or

ii. the laboratory shall maintain records of established correction factors to correct all measurements.

c) Raw data records shall be retained to document equipment performance.

d) On each day the equipment is used, balances, ovens, refrigerators, freezers and water baths shall be checked and documented. The acceptability for use or continued use shall be according to the needs of the analysis or application for which the equipment is being used.

e) Volumetric dispensing devices (except Class A glassware and Glass microliter syringes) shall be checked for accuracy on a quarterly basis.

5.6 Measurement Traceability

5.6.1 General *(ISO/IEC 17025:2005(E), Clause 5.6.1)* is not applicable to environmental testing.

5.6.2 Specific Requirements (*ISO/IEC 17025:2005(E), Clause 5.6.2)* is not applicable to environmental testing.

5.6.3 Reference Standards and Reference Materials *(ISO/IEC 17025:2005(E), Clause 5.6.3)*

5.6.4 Additional Requirements and Clarifications

5.6.4.1 Reference Standards and Reference Materials

The laboratory shall provide satisfactory evidence of correlation of results, for example, by participation in a suitable program of inter-laboratory comparisons, proficiency testing, or independent analysis.

a) Reference Standards

Where commercially available, this traceability shall be to a national standard of measurement.

b) Reference Materials

Where possible, traceability shall be to national or international standards of measurement or to national or international standard reference materials. Internal reference materials shall be checked as far as is technically and economically practicable.

5.6.4.2 Documentation and Labeling of Standards, Reagents, and Reference Materials

Documented procedures shall exist for the purchase, receipt and storage of consumable materials used for the technical operations of the laboratory.

a) The laboratory shall retain records for all standards, reagents, reference materials, and media, including the manufacturer/vendor, the manufacturer's Certificate of Analysis or purity (if available), the date of receipt, and recommended storage conditions.

b) For original containers, if an expiration date is provided by the manufacturer or vendor it shall be recorded on the container. If an expiration date is not provided by the manufacturer or vendor it is not required.

c) Records shall be maintained on standard, reference material, and reagent preparation. These records shall indicate traceability to purchased stocks or neat compounds, reference to the method of preparation, date of preparation, expiration date and preparer's initials.

d) All containers of prepared standards, reference materials, and reagents shall bear a unique identifier and expiration date.

e) Procedures shall be in place to ensure prepared reagents meet the requirements of the method.

f) Standards, reference materials, and reagents shall not be used after their expiration dates unless their reliability is verified by the laboratory.

5.7 Collection of Samples *(ISO/IEC 17025:2005(E), Clause 5.7)*

5.7.4 Additional Requirements

a) Documentation shall include the date and time of sampling.

b) Any deviations from sampling procedures shall be documented.

5.8 Handling Samples and Test Items *(ISO/IEC 17025:2005(E), Clause 5.8)*

5.8.5 Additional Requirements - Documentation

The following are essential to ensure the validity of the laboratory's data.

a) The laboratory shall have a documented system for uniquely identifying the samples to be tested, to ensure that there can be no confusion regarding the identity of such samples at any time. This system shall include identification for all samples, sub-samples, preservations, sample containers, tests, and subsequent extracts and/or digestates.

b) This laboratory code shall maintain an unequivocal link with the unique field ID code assigned to each sample.

c) The laboratory ID code shall be placed as a durable mark on the sample container.

d) The laboratory ID code shall be entered into the laboratory records and shall be the link that associates the sample with related laboratory activities such as sample preparation.

e) In cases where the sample collector and analyst are the same individual, or the laboratory pre-assigns numbers to sample containers, the laboratory ID code may be the same as the field ID code.

5.8.6 Additional Requirements - Sample Acceptance Policy

The laboratory shall have a written sample acceptance policy that includes the following:

a) proper, full, and complete documentation, which shall include sample identification, the location, date and time of collection, collector's name, preservation type, sample type and any special remarks concerning the sample;

b) proper sample labeling to include unique identification and a labeling system for the samples with requirements concerning the durability of the labels (water resistant) and the use of indelible ink;

c) use of appropriate sample containers;

d) adherence to specified holding times;

e) sufficient sample volume to perform the necessary tests;

f) procedures to be used when samples show signs of damage, contamination or inadequate preservation; and

g) qualification of any data that do not meet the above requirements.

5.8.7 Additional Requirements - Sample Receipt Protocols

5.8.7.1 The laboratory shall implement procedures for verifying and documenting preservation.

5.8.7.2 If the sample does not meet the sample receipt acceptance criteria listed in this Standard, the laboratory shall either:

a) retain correspondence and/or records of conversations concerning the final disposition of rejected samples; or

b) fully document any decision to proceed with the analysis of samples not meeting acceptance criteria.

i. The condition of these samples shall be noted on the chain of custody or transmittal form and laboratory receipt documents.

ii. The analysis data shall be appropriately qualified on the final report.

5.8.7.3 The laboratory shall utilize a permanent chronological record such as a logbook or electronic database to document receipt of all sample containers.

a) This sample receipt log shall record the following:

i. client/project name,
ii. date and time of laboratory receipt,
iii. unique laboratory ID code (see Section 5.12.1.b)i.), and
iv. signature or initials of the person making the entries.

b) During the login process, the following information shall be unequivocally linked to the log record or included as a part of the log. If such information is recorded/documented elsewhere, the records shall be part of the laboratory's permanent records, easily retrievable upon request and readily available to individuals who will process the sample.

NOTE: The placement of the laboratory ID number on the sample container is not considered a permanent record.

i. The field ID code, which identifies each sample, shall be linked to the laboratory ID code in the sample receipt log.

ii. The date and time of sample collection shall be linked to the sample and to the date and time of receipt in the laboratory.

iii. The requested analyses (including applicable approved method numbers) shall be linked to the laboratory ID code.

iv. Any comments resulting from inspection for sample rejection shall be linked to the laboratory ID code.

5.8.7.4 All documentation, such as memos, chain of custody, or transmittal forms that are transmitted to the laboratory by the sample transmitter, shall be retained.

5.8.7.5 A complete chain of custody record form, if utilized, shall be maintained.

5.8.8 Additional Requirements - Legal Chain of Custody Protocols

Legal chain of custody procedures are used for evidentiary or legal purposes. If a client specifies that a sample is to be used for evidentiary purposes, then a laboratory shall have a written SOP for how that laboratory will carry out legal chain of custody.

5.8.9 Additional Requirements - Sample Storage and Disposal

a) Samples shall be stored according to the conditions specified by preservation protocols.

i. Samples that require thermal preservation shall be stored under refrigeration that is +/- 2°C of the specified preservation temperature unless regulatory or method specific criteria exist. For samples with a specified storage temperature of 4°C, storage at a temperature above the freezing point of water to 6°C shall be acceptable.

ii. Samples shall be stored away from all standards, reagents, and food. Samples shall be stored in such a manner to prevent cross contamination.

b) Sample fractions, extracts, leachates and other sample preparation products shall be stored according to Section 5.8.9 a) above or according to specifications in the method.

c) The laboratory shall have SOPs for the disposal of samples, digestates, leachates and extracts or other sample preparation products.

5.9 Quality Assurance for Environmental Testing *(ISO/IEC 17025:2005(E), Clause 5.9)*

5.9.3 Essential Quality Control Procedures

These general quality control principles shall apply, where applicable, to all testing laboratories. The manner in which they are implemented is dependent on the types of tests performed by the laboratory (i.e., asbestos, chemical, microbiological, radiological, toxicity) and are further described in Technical Modules. The standards for any given test type shall assure that the applicable principles are addressed:

a) All laboratories shall have detailed written protocols in place to monitor the following quality controls:

i. positive and negative controls (see technical modules), chemical or microbiological as applicable to the test type, to monitor tests such as blanks, matrix spikes, reference toxicants;

ii. tests to define the variability and/or repeatability of the laboratory results such as replicates;

iii. measures to assure the accuracy of the method including calibration and/or continuing calibrations, use of certified reference materials, proficiency test samples, or other measures;

iv. measures to evaluate method capability, such as limit of detection and limit of quantitation or range of applicability such as linearity;

v. selection of appropriate formulae to reduce raw data to final results such as regression analysis, comparison to internal/external standard calculations, and statistical analyses;

vi. selection and use of reagents and standards of appropriate quality;

vii. measures to assure the selectivity of the test for its intended purpose; and

viii. measures to assure constant and consistent test conditions (both instrumental and environmental) where required by the method such as temperature, humidity, light or specific instrument conditions.

b) All quality control measures shall be assessed and evaluated on an on-going basis and quality control acceptance criteria shall be used.

c) The laboratory shall have procedures for the development of acceptance/rejection criteria where no method or regulatory criteria exist.

The quality control protocols specified by the laboratory's SOP shall be followed (see Section 4.2.8.5 in this Standard). The laboratory shall ensure that the essential standards outlined in Technical Modules or mandated methods or regulations (whichever are more stringent) are incorporated into their method manuals. When it is not apparent which is more stringent, the QC in the mandated method or regulations is to be followed.

5.10 Reporting the Results *(ISO/IEC 17025:2005(E), Clause 5.10)*

NOTE: All references to Calibration Certificates in *ISO/IEC 17025:2005* are not applicable to environmental testing.

ISO/IEC 17025:2005(E), Clause 5.10.4 does not apply to environmental testing activities.

5.10.10 Exceptions

Some regulatory reporting requirements or formats, such as monthly operating reports, may not require all items listed below; however, the laboratory shall provide all the required information to their client for use in preparing such regulatory reports.

Laboratories operated solely to provide data for compliance purposes (in-house or captive laboratories) shall have all applicable information specified in Section 5.10 readily available for review by the accreditation body. However, formal reports detailing the information are not required if:

a) the in-house laboratory is itself responsible for preparing the regulatory reports; or

b) the laboratory provides information to another individual within the organization for preparation of regulatory reports. The facility management shall ensure that the appropriate report items are in the report to the regulatory authority, if such information is required; or

c) see Section 5.10.1, paragraph 3.

5.10.11 Additional Requirements

a) Time of sample preparation and/or analysis if the required holding time for either activity is less than or equal to seventy-two hours.

b) Results that are reported on a basis other than as received (e. g., dry weight).

c) Any non-accredited tests shall be clearly identified as such to the client when claims of accreditation to this Standard are made in the analytical report or in the supporting electronic or hardcopy deliverables.

d) Clear identification of numerical results with values outside the calibration range.

ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 3 : Quality Systems for Asbestos Testing

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard supplements Module 2, Quality Systems General Requirements, and may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Standard Revision History

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Quality Systems for Asbestos Testing

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VOLUME 1, MODULE 3

Quality Systems for Asbestos Testing

1.0 ASBESTOS TESTING

1.1 Introduction

This Standard applies to laboratories undertaking the examination of asbestos samples. This Standard is organized by analytical technique including transmission electron microscopy (TEM) for the analysis of water, wastewater, air, and bulk samples; phase contrast microscopy (PCM) for analysis of workplace air; and polarized light microscopy (PLM) for analysis of bulk samples. These procedures for asbestos analysis involve sample preparation followed by detection of asbestos.

1.2 Scope

The essential quality control procedures applicable to asbestos measurements are included in this document. Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.

1.3 Terms and Definitions

The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 are the preferred references. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

1.3.1 Additional Terms and Definitions

Reserved

1.3.2 Exclusions and Exceptions

Reserved

1.4 Method Selection

A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method). When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method. If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology.

The inclusion of the parameter in the method shall meet all required calibration requirements of the method and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method. A method that meets the above requirement shall be identified in such a way so that there is no confusion that the method has been modified.

When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test. The method developed shall have been validated appropriately before use.

1.5 Method Validation

Validation is the confirmation, by examination and objective evidence, that the particular requirements for a specific intended use are fulfilled. The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs of the given application or field of application. The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use.

Laboratories shall participate in proficiency testing programs. The results of these analyses shall be used to evaluate the ability of the laboratory to produce acceptable data.

1.6 Demonstration of Capability (DOC)

1.6.1 General

Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required (see Section 1.6.2).

Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.

In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the on-going DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.

For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed.

An initial DOC shall be completed each time there is a change in instrument type, personnel, or method.

All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.

1.6.2 Initial DOC

An initial DOC shall be conducted prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.

1.6.2.1 The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:

a) analyst(s) involved in preparation and/or analysis;

b) matrix;

c) analyte(s), class of analyte(s), or measured parameter(s);

d) identification of method(s) performed;

e) identification of laboratory-specific SOP used for analysis, including revision number;

f) date(s) of analysis; and

g) summary of analyses, including information outlined in Section 1.6.2.2.c.

1.6.2.2 For asbestos, if the method or regulation does not specify a DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to DOC are adequate.

a) The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four aliquots.

b) At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.

c) Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.

d) Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.

e) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.

i. Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with c) above.

ii. Beginning with c) above, repeat the test for all parameters that failed to meet criteria.

f) Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).

1.6.3 On-Going DOC

1.6.3.1 The laboratory shall have a documented procedure describing ongoing demonstration of capability. The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.

1.6.3.2 For asbestos, this ongoing DOC may be one of the following:

a) acceptable performance of a blind sample (single blind to the analyst);

NOTE: Successful analysis of a blind performance sample on a similar method using the same technology (e.g., GC/MS volatiles by purge and trap for Methods 524.2, 624 or 5030/8260) would only require documentation for one of the test.

b) another initial DOC;

c) at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy. The laboratory shall determine the acceptable limits for precision and accuracy prior to analysis. The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing laboratory control samples (LCS) for each method for each analyst each year;

d) a documented process of analyst review using quality control (QC) samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary; or

e) if a) through d) are not technically feasible, then analysis of real-world samples with results within predefined acceptance criteria (as defined by the laboratory or method) shall be performed.

1.7 Technical Requirements

1.7.1 Calibration

Refer to methods referenced in the following Sections for specific equipment requirements. If NIST standard reference materials (SRM) specified below are unavailable, the laboratory may substitute an equivalent reference material with a certificate of analysis.

1.7.1.1 Transmission Electron Microscopy

Refer to methods referenced in the following Sections for specific equipment requirements.

1.7.1.1.1 Water and Wastewater

All calibrations listed below (unless otherwise noted) shall be performed under the same analytical conditions used for routine asbestos analysis and shall be recorded in a notebook and include date and analyst's signature. Frequencies stated below may be reduced to "before next use" if no samples are analyzed after the last calibration period has expired. Likewise, frequencies may have to be increased following non-routine maintenance or unacceptable calibration performance.

a) Magnification Calibration. Magnification calibration shall be done at the fluorescent screen, with the calibration specimen at the eucentric position, at the magnification used for fiber counting, generally 10,000 and 20,000x. A logbook shall be maintained with the dates of the calibration recorded. Calibrations shall be performed monthly to establish the stability of magnification. Calibration data shall be displayed on control charts that show trends over time.

b) Camera Constant. The camera length of the TEM in the Selected Area Electron Diffraction (SAED) mode shall be calibrated before SAED patterns of unknown samples are observed. The diffraction specimen shall be at the eucentric position for this calibration. This calibration shall allow accurate (<10% variation) measurement of layer-line spacings on the medium used for routine measurement, i.e., the phosphor screen or camera film. This shall also allow accurate (<5% variation) measurement of zone axis SAED patterns on permanent media (e.g., film). Calibrations shall be performed monthly to establish the stability of the camera constant. Where non-asbestiform minerals

may be expected (e.g., winchite, richterite, industrial talc, vermiculite, etc.), an internal camera constant standard such as gold, shall be deposited and measured on each sample to facilitate accurate indexing of zone axis SAED patterns. In such cases, layer line analysis alone shall not be used. Calibration data shall be displayed on control charts that show trends over time.

c) Spot Size. The diameter of the smallest beam spot at crossover shall be less than 250 nm as calibrated quarterly. Calibration data shall be displayed on control charts that show trends over time.

d) Beam Dose. The beam dose shall be calibrated so that beam damage to chrysotile is minimized, specifically so that an electron diffraction pattern from a single fibril >1 µm in length from a NIST SRM chrysotile sample is stable in the electron beam dose for at least 15 seconds.

e) Energy Dispersive X-Ray Analysis (EDXA) System

i. The x-ray energy vs. channel number for the EDXA system shall be calibrated to within 20 eV for at least two peaks between 0.7 keV and 10 keV. One peak shall be from the low end (0.7 keV to 2 keV) and the other peak from the high end (7 keV to 10 keV) of this range. The calibration of the x-ray energy shall be checked prior to each analysis of samples and recalibrated if out of the specified range.

ii. The ability of the system to resolve the Na Kα line from the Cu L line shall be confirmed quarterly by obtaining a spectrum from the NIST SRM 1866 crocidolite sample on a copper grid.

iii. The k-factors for elements found in asbestos (Na, Mg, Al, Si, Ca, and Fe) relative to Si shall be calibrated semiannually, or anytime the detector geometry may be altered. NIST SRM 2063a shall be used for Mg, Si, Ca, Fe, while k-factors for Na and Al may be obtained from suitable materials such as albite, kaersutite, or NIST SRM 99a. The k-factors shall be determined to a precision (2s) within 10% relative to the mean value obtained for Mg, Al, Si, Ca, and Fe, and within 20% relative to the mean value obtained for Na. The k-factor relative to Si for Na shall be between 1.0 and 4.0, for Mg and Fe shall be between 1.0 and 2.0, and for Al and Ca shall be between 1.0 and 1.75. The k-factor for Mg relative to Fe shall be 1.5 or less. Calibration data shall be displayed on control charts that show trends over time.

iv. The detector resolution shall be checked quarterly to ensure a full-width half maximum resolution of <175 eV at Mn Kα (5.90 keV). Calibration data shall be displayed on control charts that show trends over time.

v. The portions of a grid in a specimen holder for which abnormal x-ray spectra are generated under routine asbestos analysis conditions shall be determined and these areas shall be avoided in asbestos analysis.

vi. The sensitivity of the detector for collecting x-rays from small volumes shall be documented quarterly by collecting resolvable Mg and Si peaks from a unit fibril of NIST SRM 1866 chrysotile.

f) Low Temperature Asher. The low temperature asher shall be calibrated quarterly by determining a calibration curve for the weight vs. ashing time of collapsed mixed-celluloseester (MCE) filters. Calibration data shall be displayed on control charts that show trends over time.

g) Grid Openings. The magnification of the grid opening measurement system shall be calibrated using an appropriate standard at a frequency of 20 openings/20 grids/lot of 1000 or 1 opening/sample. The variation in the calibration measurements (2s) is <5% of the mean calibration value.

1.7.1.1.2 Air

All calibrations shall be performed in accordance with Section 1.7.1.1.1, with the exception of magnification. Magnification calibration shall be done at the fluorescent screen, with the calibration specimen at the eucentric position, at the magnification used for fiber counting, generally 15,000 to 20,000x. A logbook shall be maintained with the dates of the calibration recorded. Calibrations shall be performed monthly to establish the stability of magnification.

1.7.1.1.3 Bulk Samples

All calibrations shall be performed in accordance with Section 1.7.1.1.1.

1.7.1.2 Phase Contrast Microscopy

1.7.1.2.1 At least once daily, the analyst shall use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric.

1.7.1.2.2 The phase-shift detection limit of the microscope shall be checked monthly or after modification or relocation using an HSE/NPL phase-contrast test slide for each analyst/microscope combination. This procedure assures that the minimum detectable fiber diameter (<ca. 0.25µm) for this microscope is achieved.

1.7.1.2.3 Prior to ordering the Walton-Beckett graticule, calibration, in accordance with NIOSH 7400, Issue 2, 15 August 1994, Appendix A, shall be performed to obtain a counting area 100 µm in diameter at the image plane. The diameter, dc (mm), of the circular counting area and the disc diameter shall be specified when ordering the graticule. The field diameter (D) shall be verified (or checked), to a tolerance of 100 µm ± 2 µm, with a stage micrometer upon receipt of the graticule from the manufacturer. When changes (zoom adjustment, disassembly, replacement, etc.) occur in the eyepiece-objective-reticle combination, field diameter shall be re-measured (or recalibrated) to determine field area (mm2). Recalibration of field diameter shall also be required when there is a change in interpupillary distance (i.e., change in analyst). Acceptable range for field area shall be 0.00754 mm2 to 0.00817 mm2. The actual field area shall be documented and used.

1.7.1.3 Polarized Light Microscopy

1.7.1.3.1 Microscope Alignment. To accurately measure the required optical properties, a properly aligned polarized light microscope (PLM) shall be utilized. The PLM shall be aligned before each use.

1.7.1.3.2 Refractive Index Liquids. Series of n_D = 1.49 through 1.72 in intervals less than or equal to 0.005. Refractive index liquids for dispersion staining, high-dispersion series 1.550, 1.605, 1.680. The accurate measurement of the refractive index (RI) of a substance requires the use of calibrated refractive index liquids. These liquids shall be calibrated at first use and semiannually, or next use, whichever is less frequent, to an accuracy of 0.004, with a temperature accuracy of 2°C using a refractometer or RI glass beads.

1.7.2 Quality Control

1.7.2.1 Negative Controls

1.7.2.1.1 Transmission Electron Microscopy

a) Water and Wastewater

i. Blank determinations shall be made prior to sample collection. When using polyethylene bottles, one (1) bottle from each batch, or a minimum of one (1) from each twenty-four (24) shall be tested for background level. When using glass bottles, four (4) bottles from each twenty-four (24) shall be tested. An acceptable bottle blank level is defined as < 0.01 Million Fibers per Liter (MFL) > 10 µm.

ii. A process blank sample consisting of fiber-free water shall be run before the first field sample. The quantity of water shall be > 10 mL for a 25-mm diameter filter and > 50 mL for a 47-mm diameter filter.

b) Air

i. A blank filter shall be prepared with each set of samples. A blank filter shall be left uncovered during preparation of the sample set and a wedge from that blank filter shall be prepared alongside wedges from the sample filters. At minimum, the blank filter shall be analyzed for each twenty (20) samples analyzed.

ii. Maximum contamination on a single blank filter shall be no more than 53 structures/mm2. Maximum average contamination for all blank filters shall be no more than 18 structures/mm2.

c) Bulk Samples

i. Contamination checks using asbestos-free material, such as the glass fiber blank in SRM 1866, shall be performed at a frequency of one for every twenty samples analyzed. The detection of asbestos at a concentration exceeding 0.1% will require an investigation to detect and remove the source of the asbestos contamination.

ii. The laboratory shall maintain a list of non-asbestos fibers that can be confused with asbestos. The list shall include crystallographic and/or chemical properties that disqualify each fiber being identified as asbestos.

iii. The laboratory shall have a set of reference asbestos materials, from which a set of reference diffraction and x-ray spectra may be developed.

1.7.2.1.2 Phase Contrast Microscopy

At least two field blanks (or 10% of the total samples, whichever is greater) shall be submitted for analysis with each set of samples. Field blanks shall be handled in a manner representative of actual handling of associated samples in the set with a single exception that air shall not be drawn through the blank sample. A blank cassette shall be opened for approximately thirty (30) seconds at the same time other cassettes are opened just prior to analysis. Results from field blank samples shall be used in the calculation to determine final airborne fiber concentration. The identity of blank filters shall be unknown to the counter until all counts have been completed. If a field blank

yields greater than seven (7) fibers per one hundred (100) graticule fields, report possible contamination of the samples.

1.7.2.1.3 Polarized Light Microscopy

a) Friable Materials. At least one (1) blank slide shall be prepared daily or with every fifty (50) samples analyzed, whichever is less. This is prepared by mounting a sub-sample of an isotropic verified non-asbestos-containing material (non-ACM) (e.g., fiberglass in SRM 1866) in a drop of immersion oils normally used on a clean slide, rubbing preparation tools (forceps, dissecting needles, etc.) in the mount and placing a clean coverslip on the drop. The entire area under the coverslip shall be scanned to detect any asbestos contamination. A similar check shall be made after every twenty (20) uses of each piece of homogenization equipment. An isotropic verified non-ACM shall be homogenized in the clean equipment, a slide prepared with the material and the slide scanned for asbestos contamination. (This can be substituted for the blank slide mentioned in this Section.)

b) Non-Friable Materials. At least one (1) non-ACM non-friable material shall be prepared and analyzed with every twenty (20) samples analyzed. This non-ACM shall go through the full preparation and analysis regimen for the type of analysis being performed.

1.7.3 Test Variability/Reproducibility

1.7.3.1 Transmission Electron Microscopy

Quality assurance analyses shall be performed regularly covering all time periods, instruments, tasks, and personnel. The selection of samples shall be random and samples of special interest may be included in the selection of samples for quality assurance analyses. When possible, the checks on personnel performance shall be executed without their prior knowledge. A disproportionate number of analyses shall not be performed prior to internal or external audits. It is recommended that a laboratory initially be at 100% quality control (all samples re-analyzed). The proportion of quality control samples can later be lowered gradually, as control indicates, to a minimum of 10%.

1.7.3.1.1 Water and Wastewater

All analyses shall be performed on relocator grids so that other laboratories can easily repeat analyses on the same grid openings. Quality assurance analyses shall not be postponed during periods of heavy workloads. The total number of QA samples and blanks shall be greater than or equal to 10% of the total sample workload. Precision of analyses is related to concentration, as gleaned from inter-laboratory proficiency testing. Relative standard deviations (RSD) for amphibole asbestos decreased from 50% at 0.8 MFL to 25% at 7 MFL in inter-laboratory proficiency testing, while RSD for chrysotile was higher, 50% at 6 MFL.

a) Replicate. A second, independent analysis shall be performed on the same grids but on different grid openings than used in the original analysis of a sample. Results shall be within 1.5x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.

b) Duplicate. A second aliquot of sample shall be filtered through a second filter, prepared and analyzed in the same manner as the original preparation of that sample. Results shall be within 2.0x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.

c) Verified Analyses. A second, independent analysis shall be performed on the same grids and grid openings used in the original analysis of a sample. The two sets of results shall be compared according to Turner and Steel (NISTIR 5351). This shall be performed at a frequency of one (1) per twenty (20) samples. Qualified analysts shall maintain an average of ≥ 80% true positives, ≤ 20% false negatives, and ≤ 10% false positives.

1.7.3.1.2 Air

a) All analyses shall be performed on relocator grids so that other laboratories can easily repeat analyses on the same grid openings.

b) The laboratory and TEM analysts shall obtain mean analytical results on NIST SRM 1876b so that trimmed mean values fall within 80% of the lower limit and 110% of the upper limit of the 95% confidence limits as published on the certificate. These limits are derived from the allowable false positives and false negatives given in Section 1.7.3.1.1.c, Verified Analysis, below. SRM 1876b shall be analyzed a minimum of once per year by each TEM analyst.

c) The laboratory shall have documentation demonstrating that TEM analysts correctly classify at least 90% of both bundles and single fibrils of asbestos structures greater than or equal to 1 µm in length in known standard materials traceable to NIST, such as NIST bulk asbestos SRM 1866.

d) Inter-laboratory analyses shall be performed to detect laboratory bias. The frequency of inter-laboratory verified analysis shall correspond to a minimum of one (1) per two hundred (200) grid square analyses for clients.

e) If more than one TEM is used for asbestos analysis, intermicroscope analyses shall be performed to detect instrument bias.

i. Replicate. A second, independent analysis shall be performed in accordance with Section 1.7.3.1.1.a.

ii. Duplicate. A second wedge from a sample filter shall be prepared and analyzed in the same manner as the original preparation of that sample. Results shall be within 2.0x of Poisson standard deviation. This shall be performed at a frequency of one (1) per one hundred (100) samples.

iii. Verified Analyses. A second, independent analysis shall be performed on the same grids and grid openings in accordance with Section 1.7.3.1.1.c.

1.7.3.1.3 Bulk Samples

Bulk samples with low (< 10%) asbestos content are the most problematic. At least 30% of a laboratory's QC analyses shall be performed on samples containing from 1% to 10% asbestos.

a) Intra-Analyst Precision. At least one (1) out of fifty (50) samples shall be re-analyzed by the same analyst. For single analyst laboratories, at least one (1) out of every ten (10) samples shall be re-analyzed by the same analyst.

b) Inter-Analyst Precision. At least one (1) out of fifteen (15) samples shall be re-analyzed by another analyst. Inter-analyst results will require additional re-analysis, possibly including another analyst, to resolve discrepancies when classification (ACM vs. non-ACM) errors occur, when asbestos identification errors occur, or when inter-analyst precision is found to be unacceptable.

c) Inter-Laboratory Precision. The laboratory shall participate in round robin testing with at least one (1) other laboratory. Samples shall be sent to this other laboratory at least four (4) times per year. These samples shall be samples previously analyzed as QC samples. Results of these analyses shall be assessed in accordance with QC requirements. The QC requirements shall address misclassifications (false positives, false negatives) and misidentification of asbestos types.

1.7.3.2 Phase Contrast Microscopy

a) Inter-Laboratory Precision. Each laboratory analyzing air samples for compliance determination shall implement an inter-laboratory quality assurance program that includes participation of at least two (2) other independent laboratories. Each laboratory shall participate in round robin testing at least once every six months with at least all the other laboratories in its inter-laboratory quality assurance group. Each laboratory shall submit slides typical of its own workload for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology. Results of this QA program shall be posted in each laboratory to keep the microscopists informed.

b) Intra- and Inter-Analyst Precision. Each analyst shall select and count a prepared slide from a "reference slide library" on each day on which air counts are performed. Reference slides shall be prepared using well-behaved samples taken from the laboratory workload. Fiber densities shall cover the entire range routinely analyzed by the laboratory. These slides shall be counted by all analysts to establish an original standard deviation and corresponding limits of acceptability. Results from the daily reference sample analysis shall be compared to the statistically derived acceptance limits using a control chart or a database. It is recommended that the labels on the reference slides be periodically changed so that the analysts do not become familiar with the samples. Intra- and inter-analyst precision may be estimated from blind recounts on reference samples. Inter-analyst precision shall be posted in each laboratory to keep the microscopists informed.

1.7.3.3 Polarized Light Microscopy

Refer to Section 1.7.3.1.3

1.7.4 Other Quality Control Measures

1.7.4.1 Transmission Electron Microscopy

a) Water and Wastewater

i. Filter preparations shall be made from all six (6) asbestos types from NIST SRMs 1866 and 1867. These preparations shall have concentrations between one (1) and twenty (20) structures (>10µm) per 0.01 mm^2. One of these preparations shall be analyzed independently at a frequency of one (1) per one hundred (100) samples analyzed. Results shall be evaluated as verified asbestos analysis in accordance with S. Turner and E.B. Steel, NISTIR 5351, Airborne Asbestos Method: Standard Test Method for Verified Analysis of Asbestos by Transmission Electron Microscopy – Version 2.0, 1994.

ii. NIST SRM 1876b shall be analyzed annually by each analyst. Results shall be evaluated in accordance with limits published for that SRM.

b) Air

i. Filter preparations shall be made from all six (6) asbestos types in accordance with Section 1.7.4.1.a)i.

ii. NIST SRM 1876b shall be analyzed annually.

c) Bulk Samples

All analysts shall be able to correctly identify the six (6) regulated asbestos types (chrysotile, amosite, crocidolite, anthophyllite, actinolite, and tremolite). Standards for the six (6) asbestos types listed are available from NIST (SRMs 1866 and 1867).

1.7.4.2 Phase Contrast Microscopy

a) Test for Non-Random Fiber Distribution. Blind recounts by the same analyst shall be performed on 10% of the filters counted. A person other than the counter shall re-label slides before the second count. A test for type II error shall be performed to determine whether a pair of counts by the same analyst on the same slide shall be rejected due to non-random fiber distribution. If a pair of counts is rejected by this test, the remaining samples in the set shall be recounted and the new counts shall be tested against first counts. All rejected paired counts shall be discarded.

b) It shall not be necessary to use this statistic on blank recounts.

c) All laboratories shall participate in a national sample testing scheme such as the Proficiency Analytical Testing (PAT) program or the Asbestos Analysts Registry (AAR) program, both sponsored by the American Industrial Hygiene Association (AIHA).

1.7.4.3 Polarized Light Microscopy

a) Friable Materials. Because accuracy cannot be determined by re-analysis of routine field samples, at least one (1) out of one hundred (100) samples shall be a standard or reference sample that has been routinely resubmitted to determine analyst's precision and accuracy. A set of these samples may be accumulated from proficiency testing samples with predetermined weight compositions or from standards generated with weighed quantities of asbestos and other bulk materials. At least half of the reference samples submitted for this QC shall contain between 1 and 10% asbestos.

b) Non-Friable Materials. At least one (1) out of one hundred (100) samples shall be a verified quantitative standard that has routinely been resubmitted to determine analyst precision and accuracy.

1.7.5 Analytical Sensitivity

1.7.5.1 Transmission Electron Microscopy

1.7.5.1.1 Water and Wastewater

An analytical sensitivity of 200,000 fibers per liter (0.2 MFL) is required for each sample analyzed. Analytical sensitivity is defined as the waterborne concentration represented by the finding of one asbestos structure in the total area of filter examined. This value will depend on the fraction of the filter sampled and the dilution factor (if applicable).

1.7.5.1.2 Air

An analytical sensitivity of 0.005 structures/cm^2 is required for each sample analyzed. Analytical sensitivity is defined as the airborne concentration represented by the finding of one asbestos structure in the total area of filter examined. This value will depend on the effective surface area of the filter, the filter area analyzed, and the volume of air sampled.

1.7.5.1.3 Bulk Samples

The range is dependent on the type of bulk material being analyzed. The sensitivity may be as low as 0.0001%.

1.7.5.2 Phase Contrast Microscopy

The normal quantitative working range of the method is 0.04 to 0.5 fiber/ cm^2 for a 1000 L air sample. An ideal counting range on the filter shall be 100 to 1300 fibers/mm^2. The limit of detection (LOD) is estimated to be 5.5 fibers per 100 fields or 7 fibers/mm^2. The LOD in fiber/cc will depend on sample volume and quantity of interfering dust but shall be <0.01 fiber/cm^2 for atmospheres free of interferences.

1.7.5.3 Polarized Light Microscopy

The laboratory shall utilize a method that provides a limit of detection that is appropriate and relevant for the intended use of the data. Limit of detection shall be determined by the protocol in the method or applicable regulation.

1.7.6 Quality of Standards and Reagents

1.7.6.1 Transmission Electron Microscopy

a) The quality control program shall establish and maintain provisions for asbestos standards.

b) Reference standards that are used in an asbestos laboratory shall be obtained from NIST, EPA, or suppliers who participate in supplying NIST standards or NIST traceable asbestos. Any reference standards purchased outside the United States shall be traceable back to each country's national standards laboratory. Commercial suppliers of reference standards shall conform to ANSI N42.22 to assure the quality of their products.

c) Reference standards shall be accompanied with a certificate of calibration whose content is as described in ANSI N42.22-1995, Section 8, Certificates.

d) All reagents used shall be analytical reagent grade or better.

e) The laboratory shall have mineral fibers or data from mineral fibers that will allow differentiating asbestos from at least the following "look-alikes": fibrous talc, sepiolite, wollastonite, attapulgite (palygorskite), halloysite, vermiculite scrolls, antigorite, lizardite, pyroxenes, hornblende, richterite, winchite, or any other asbestiform minerals that are suspected as being present in the sample.

1.7.6.2 Phase Contrast Microscopy

Standards of known concentration have not been developed for this testing method. Routine workload samples that have been statistically validated and national proficiency testing samples such as Proficiency Analytical Testing (PAT) and Asbestos Analysts Registry (AAR) samples available from the American Industrial Hygiene Association (AIHA) may be utilized as reference samples (refer to Section D.6.2.2 b) to standardize the optical system and analyst. All other testing

reagents and devices (HSE/NPL test slide and Walton-Beckett Graticule) shall conform to the specifications of the method (refer to National Institute for Occupational Safety and Health (NIOSH) 7400, Issue 2, 15 August 1994).

1.7.6.3 Polarized Light Microscopy

Refer to Section 1.7.6.1.

1.7.7 Data Acceptance/Rejection Criteria

1.7.7.1 Transmission Electron Microscopy

1.7.7.1.1 Water and Wastewater

a) The concentration of asbestos in a given sample shall be calculated in accordance with EPA/600/R-94/134, Method 100.2, Section 12.1.

b) Measurement Uncertainties. The laboratory shall calculate and report the upper and lower 95% confidence limits on the mean concentration of asbestos fibers found in the sample.

1.7.7.1.2 Air

a) The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized.

b) Measurement Uncertainties. The laboratory shall calculate and report the upper and lower 95% confidence limits on the mean concentration of asbestos fibers found in the sample.

1.7.7.1.3 Bulk Samples

a) The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized (e.g., EPA/600/R-93/116, July 1993).

b) Measurement Uncertainties. Proficiency testing for floor tiles analyzed by TEM following careful gravimetric reduction has revealed an inter-laboratory standard deviation of approximately 20% for residues containing 70% or more asbestos. Standard deviations range from 20% to 60% for residues with lower asbestos content.

1.7.7.2 Phase Contrast Microscopy

1.7.7.2.1 Airborne fiber concentration in a given sample shall be calculated in accordance with NIOSH 7400, Issue 2, 15 August 1994, Sections 20 and 21.

1.7.7.2.2 Measurement Uncertainties. The laboratory shall calculate and report the intra-laboratory and inter-laboratory relative standard deviation with each set of results (NIOSH 7400, Issue 2, 15 August 1994).

1.7.7.2.3 Fiber counts above 1300 fibers/mm^2 and fiber counts from samples with >50% of the filter area covered with particulate shall be reported as “uncountable” or “probably biased”. Other fiber counts outside the 100-1300 fibers/mm^2 range shall be reported as having “greater than optimal variability” and as being “probably biased”.

1.7.7.3 Polarized Light Microscopy

1.7.7.3.1 The concentration of asbestos in a given sample shall be calculated in accordance with the method utilized (e.g., EPA/600/R-93/116, July 1993).

1.7.7.3.2 Method Uncertainties. Precision and accuracy shall be determined by the individual laboratory for the percent range involved. If point counting and/or visual estimates are used, a table of reasonable expanded errors shall be generated for different concentrations of asbestos.

1.7.8 Constant and Consistent Test Conditions Sample and Sampling Requirements

1.7.8.1 Samples shall be transported to the laboratory as soon as possible after collection. Date and time of sampling shall be noted on submittal forms. The names of the collectors with their signatures and the site shall be included on the chain-of-custody forms. No preservatives are required during sampling.

1.7.8.2 The laboratory shall establish and adhere to written procedures to minimize the possibility of cross contamination between samples.

1.7.8.3 Refer to the specific method of analysis for additional requirements.

ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 4: Quality Systems for Chemical Testing

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard supplements Module 2, Quality Systems General Requirements, and may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Standard Revision History

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VOLUME 1, MODULE 4

Quality Systems for Chemical Testing

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VOLUME 1, MODULE 4

Quality Systems for Chemical Testing

1.0 CHEMICAL TESTING

1.1 Introduction

This document contains detailed quality control requirements for environmental testing activities involving chemical measurements. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.

1.2 Scope

The essential quality control procedures applicable to chemistry measurements are included in this module. Additional quality control requirements that are either specified by method, regulation or project shall be met by laboratories.

1.3 Terms and Definitions

The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 are the preferred references. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

1.3.1 Additional Terms and Definitions

Reserved

1.3.2 Exclusions and Exceptions

Reserved

1.4 Method Selection

A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method). When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method.

If there is not a regulatory requirement for the parameter/method combination, the parameter/ method combination need not be validated under 1.5.1b) as a non-reference method if it can be analyzed by another similar reference method of the same matrix and technology. The inclusion of the parameter in the method shall meet all required calibration requirements and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method. For example, when adding acetone to Method 624, the calibration and QC requirements shall follow Method 624. A method that meets the above requirement shall be identified in such a way so that there is no confusion that the method has been modified.

When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test. The method developed shall have been validated appropriately before use.

1.5 Method Validation

1.5.1 Validation of Methods

a) The laboratory shall validate reference methods via the procedures specified in Sections 1.5.2 and 1.5.3.

b) The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs of the given application or field of application. The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. In the absence of other specifications, the minimum requirements for method validation are given in Sections 1.5.2, 1.5.3 and 1.5.4.

1.5.2 Limit of Detection and Limit of Quantitation (However Named)

Procedures used for determining limits of detection and quantitation shall be documented. Documentation shall include the quality system matrix type. All supporting data shall be retained.

1.5.2.1 Limit of Detection (LOD)

If the laboratory is not reporting a value below the Limit of Quantitation, a Limit of Detection study is not required.

The laboratory shall utilize a method that provides an LOD that is appropriate and relevant for the intended use of the data. If a mandated method or regulation includes protocols for determining detection limits, these shall be followed. The laboratory shall document how LODs were derived from the determinations. If the protocol for determining the LOD is not specified, the selection of the procedure shall reflect instrument limitations and the intended application of the method.

All sample-processing and analysis steps of the analytical method shall be included in the determination or validation of the LOD.

a) When required, the laboratory shall determine or verify the LOD for the method for each target analyte of concern in the quality system matrices.

b) The validity of the LOD shall be verified by detection (a value above zero) of the analyte(s) in a QC sample in each quality system matrix. This QC sample shall contain the analyte at no more than 3X the LOD for single analyte tests and 4X the LOD for multiple analyte tests. This verification shall be performed on every instrument that is to be used for analysis of samples and reporting of data. The validity of the LOD shall be verified as part of the LOD determination process. This verification shall be done prior to the use of the LOD for the sample analysis.

c) An LOD study is not required for any component for which spiking solutions or quality control samples are not available such as temperature.

d) The LOD shall be initially determined for the compounds of interest in each method in a quality system matrix in which there are neither target analytes nor interferences at a concentration that would impact the results or the LOD shall be performed in the quality system matrix of interest.

e) An LOD shall be performed each time there is a change in the method that affects how the test is performed, or when a change in instrumentation occurs that affects the sensitivity of the analysis.

f) The LOD, if required, shall be verified annually for each quality system matrix, technology, and analyte.

1.5.2.2 Limit of Quantitation (LOQ)

a) All sample-processing and analysis steps of the analytical method shall be included in the determination of the LOQ.

b) The LOQ study is not required for any component or property for which spiking solutions or quality control samples are not available or otherwise inappropriate (e.g., pH).

c) The validity of the LOQ shall be verified by successful analysis of a QC sample containing the analytes of concern in each quality system matrix at 1 to 2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the laboratory established method acceptance criteria or client data quality objectives for accuracy.

d) When an LOD is determined or verified by the laboratory, the LOQ shall be above the LOD.

e) The LOQ shall be verified annually for each quality system matrix, technology, and analyte. However, the annual LOQ verification is not required if the LOD was determined or verified annually on that instrument.

1.5.3 Evaluation of Precision and Bias

a) Reference Methods. The laboratory shall evaluate the precision and bias of a reference method for each analyte of concern for each quality system matrix according to Section 1.6 or alternate documented procedure when the analyte cannot be spiked into the sample matrix and QC samples are not commercially available.

b) Non-Reference Methods. For laboratory-developed methods or non-reference methods that were not in use by the laboratory before July 2003, the laboratory shall have a documented procedure to evaluate precision and bias. The laboratory shall also compare results of the precision and bias measurements with criteria established by the client, by criteria given in the reference method or criteria established by the laboratory.

Precision and bias measurements shall evaluate the method across the analytical calibration range of the method. The laboratory shall also evaluate precision and bias in the relevant quality system matrices and shall process the samples through the entire measurement system for each analyte of interest.

Examples of a systematic approach to evaluate precision and bias could be the following:

i. Analyze QC samples in triplicate containing the analytes of concern at or near the limit of quantitation, at the upper-range of the calibration (upper 20%) and at a mid-range

concentration. Process these samples on different days as three (3) sets of samples through the entire measurement system for each analyte of interest. Each day, one (1) QC sample at each concentration is analyzed. A separate method blank shall be subjected to the analytical method along with the QC samples on each of the three (3) days. (Note that the three (3) samples at the LOQ concentration can demonstrate sensitivity as well.) For each analyte, calculate the mean recovery for each day, for each level over each day, and for all nine (9) samples. Calculate the relative standard deviation for each of the separate means obtained. Compare the standard deviations for the different days and the standard deviations for the different concentrations. If the different standard deviations are all statistically insignificant (e.g., F-test), then compare the overall mean and standard deviation with the established criteria from above.

ii. A validation protocol, such as the Tier I, Tier II, and Tier III requirements in US EPA Office of Water's Alternate Test Procedure (ATP) approval process.

1.5.4 Evaluation of Selectivity

The laboratory shall evaluate selectivity by following the checks established within the method, which may include mass spectral tuning, second column confirmation, ICP inter-element interference checks, chromatography retention time windows, sample blanks, spectrochemical absorption or fluorescence profiles, co-precipitation evaluations, and electrode response factors.

1.6 Demonstration of Capability (DOC)

1.6.1 General

Prior to acceptance and institution of any method for which data will be reported, a satisfactory initial DOC is required (see Section 1.6.2).

Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.

In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.

For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed.

An initial DOC shall be completed each time there is a change in instrument type, personnel, or method.

All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.

1.6.2 Initial DOC

An initial DOC shall be conducted prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.

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1.6.2.1 The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:

a) analyst(s) involved in preparation and/or analysis;

b) matrix;

c) analyte(s), class of analyte(s), or measured parameter(s);

d) identification of method(s) performed;

e) identification of laboratory-specific SOP used for analysis, including revision number;

f) date(s) of analysis; and

g) summary of analyses, including information outlined in Section 1.6.2.2.c.

1.6.2.2 If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.

a) The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four (4) aliquots at the concentration specified, or if unspecified, to a concentration of one (1) to four (4) times the limit of quantitation.

b) At least four (4) aliquots shall be prepared and analyzed according to the method(s) either concurrently or over a period of days.

c) Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.

d) Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.

e) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.

i. Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with b) above.

ii. Beginning with b) above, repeat the test for all parameters that failed to meet criteria.

f) Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).

g) When an analyte not currently found on the laboratory's list of accredited analytes is added to an existing accredited method, an initial demonstration shall be performed for that analyte.

1.6.3 Ongoing DOC

1.6.3.1 The laboratory shall have a documented procedure describing ongoing DOC. The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.

1.6.3.2 This on-going demonstration may be one of the following:

a) acceptable performance of a blind sample (single blind to the analyst);

Note: Successful analysis of a blind performance sample on a similar method using the same technology (e.g., GC/MS volatiles by purge and trap for Methods 524.2, 624 or 5030/8260) would only require documentation for one of the tests.

b) another initial DOC;

c) at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy. The laboratory shall determine the acceptable limits for precision and accuracy prior to analysis. The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing LCSs for each method for each analyst each year;

d) a documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary;

e) if a) through d) are not technically feasible, then analysis of real-world samples with results within a predefined acceptance criteria (as defined by the laboratory or method) shall be performed.

1.7 Technical Requirements

1.7.1 Initial Calibration

1.7.1.1 Instrument Calibration

This module specifies the essential elements that shall define the procedures and documentation for initial instrument calibration and continuing instrument calibration verification to ensure that the data shall be of known quality for the intended use. This Standard does not specify detailed procedural steps (“how to”) for calibration, but establishes the essential elements for selection of the appropriate technique(s). This approach allows flexibility and permits the employment of a wide variety of analytical procedures and statistical approaches currently applicable for calibration. If more stringent standards or requirements are included in a mandated method or by regulation, the laboratory shall demonstrate that such requirements are met. If it is not apparent which Standard is more stringent, then the requirements of the regulation or mandated method are to be followed.

The following items are essential elements of initial instrument calibration:

a) the details of the initial instrument calibration procedures including calculations, integrations, acceptance criteria and associated statistics shall be included or referenced in the method SOP. When initial instrument calibration procedures are referenced in the method, then the referenced material shall be retained by the laboratory and be available for review;

b) sufficient raw data records shall be retained to permit reconstruction of the initial instrument calibration (e.g., calibration date, method, instrument, analysis date, each analyte name, analyst's initials or signature; concentration and response, calibration curve or response factor; or unique equation or coefficient used to reduce instrument responses to concentration);

c) sample results shall be quantitated from the initial instrument calibration and may not be quantitated from any continuing instrument calibration verification unless otherwise required by regulation, method, or program;

d) all initial instrument calibrations shall be verified with a standard obtained from a second manufacturer or from a different lot. Traceability shall be to a national standard, when commercially available;

e) criteria for the acceptance of an initial instrument calibration shall be established (e.g., correlation coefficient or relative percent difference). The criteria used shall be appropriate to the calibration technique employed;

f) the lowest calibration standard shall be at or below the LOQ. Any data reported below the LOQ shall be considered to have an increased quantitative uncertainty and shall be reported using defined qualifiers or explained in the narrative;

g) the highest calibration standard shall be at or above the highest concentration for which quantitative data are to be reported. Any data reported above the calibration range shall be considered to have an increased quantitative uncertainty and shall be reported using defined qualifiers or explained in the narrative;

h) the following shall occur for instrument technology (such as ICP or ICP/MS) with validated techniques from manufacturers or methods employing standardization with a zero point and a single point calibration standard:

   i. Prior to the analysis of samples, the zero point and single point calibration standard shall be analyzed and the linear range of the instrument shall be established by analyzing a series of standards, one of which shall be at or below the LOQ. Sample results within the established linear range will not require data qualifiers.

   ii. A zero point and single point calibration standard shall be analyzed with each analytical batch.

   iii. A standard corresponding to the limit of quantitation shall be analyzed with each analytical batch and shall meet established acceptance criteria.

   iv. The linearity is verified at a frequency established by the method and/or the manufacturer.

i) if the initial instrument calibration results are outside established acceptance criteria, corrective actions shall be performed and all associated samples re-analyzed. If re-analysis of the samples is not possible, data associated with an unacceptable initial instrument calibration shall be reported with appropriate data qualifiers; and

j) if a reference or mandated method does not specify the number of calibration standards, the minimum number of points for establishing the initial instrument calibration shall be three.

1.7.2 Continuing Calibration

When an initial instrument calibration is not performed on the day of analysis, the validity of the initial calibration shall be verified prior to sample analyses by a continuing instrument calibration verification with each analytical batch. The following items are essential elements of continuing instrument calibration verification.

a) The details of the continuing instrument calibration procedure, calculations and associated statistics shall be included or referenced in the method SOP.

b) Calibration shall be verified for each compound, element, or other discrete chemical species, except for multi-component analytes such as aroclors, chlordane, total petroleum hydrocarbons, or toxaphene, where a representative chemical, related substance or mixture can be used.

c) Instrument calibration verification shall be performed:

   i. at the beginning and end of each analytical batch. If an internal standard is used, only one verification needs to be performed at the beginning of the analytical batch;

   ii. if the time period for calibration or the most recent calibration verification has expired; or

   iii. for analytical systems that contain a calibration verification requirement.

d) Sufficient raw data records shall be retained to permit reconstruction of the continuing instrument calibration verification (e.g., method, instrument, analysis date, each analyte name, concentration and response, calibration curve or response factor, or unique equations or coefficients used to convert instrument responses into concentrations). Continuing calibration verification records shall explicitly connect the continuing verification data to the initial instrument calibration.

e) Criteria for the acceptance of a continuing instrument calibration verification shall be established. If the continuing instrument calibration verification results obtained are outside the established acceptance criteria and analysis of a second consecutive (immediate) calibration verification fails to produce results within acceptance criteria, corrective actions shall be performed. The laboratory shall demonstrate acceptable performance after corrective action with two consecutive calibration verifications, or a new initial instrument calibration shall be performed. If the laboratory has not verified calibration, sample analyses may not occur until the analytical system is calibrated or calibration verified. If samples are analyzed using a system on which the calibration has not yet been verified the results shall be flagged. Data associated with an unacceptable calibration verification may be fully useable under the following special conditions:

   i. when the acceptance criteria for the continuing calibration verification are exceeded high (i.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise the samples affected by the unacceptable calibration verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted; or

   ii. when the acceptance criteria for the continuing calibration verification are exceeded low (i.e., low bias), those sample results may be reported if they exceed a maximum regulatory limit/decision level. Otherwise the samples affected by the unacceptable verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted.

1.7.3 Quality Control

The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken as specified in this Section.

1.7.3.1 Negative Control – Method Performance: Method Blank

a) The method blank is used to assess the samples in the preparation batch for possible contamination during the preparation and processing steps. The method blank shall be processed along with and under the same conditions as the associated samples to include all steps of the analytical procedure. Procedures shall be in place to determine if a method blank is contaminated. Any affected samples associated with a contaminated method blank shall be reprocessed for analysis or the results reported with appropriate data qualifying codes.

b) The method blank shall be analyzed at a minimum of one (1) per preparation batch. In those instances for which no separate preparation method is used (for example, volatiles in water), the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of twenty (20) environmental samples, not including method blanks, LCS, matrix spikes and matrix duplicates.

c) The method blank shall consist of a quality system matrix that is similar to the associated samples and is known to be free of the analytes of interest.

d) Method blanks are not applicable for certain analyses, such as pH, Conductivity, Flash Point and Temperature.

1.7.3.2 Positive Control – Method Performance: Laboratory Control Sample (LCS)

1.7.3.2.1 The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Results of the LCS are compared to established criteria and, if found to be outside of these criteria, indicates that the analytical system is “out of control.” Any affected samples associated with an out of control LCS shall be reprocessed for re-analysis or the results reported with appropriate data qualifying codes.

1.7.3.2.2 The LCS shall be analyzed at a minimum of one (1) per preparation batch. Exceptions would be for those analytes for which no spiking solutions are available, such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. In those instances for which no separate preparation method is used (example: volatiles in water) the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of twenty (20) environmental samples, not including method blanks, LCS, matrix spikes and matrix duplicates.

1.7.3.2.3 The LCS is a quality system matrix, known to be free of analytes of interest, spiked with known concentrations of analytes.

Note: The matrix spike may be used in place of this control as long as the acceptance criteria are as stringent as for the LCS.

Alternatively, the LCS may consist of a media containing known and verified concentrations of analytes or as Certified Reference Material (CRM). All analyte concentrations shall be within the calibration range of the methods. The following shall be used in choosing components for the spike mixtures:

The components to be spiked shall be as specified by the mandated method or regulation or as requested by the client. In the absence of specified spiking components, the laboratory shall spike per the following:

a) for those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported; and

b) for those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported.

The following criteria shall be used for determining the minimum number of analytes to be spiked. However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period:

i. For methods that include one (1) to ten (10) targets, spike all components.

ii. For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.

iii. For methods with more than twenty (20) targets, spike at least sixteen (16) components.

1.7.3.3 Sample Specific Controls

The laboratory shall document procedures for determining the effect of the sample matrix on method performance. These procedures relate to the analyses of quality system matrix specific Quality Control (QC) samples and are designed as data quality indicators for a specific sample using the designated method. These controls alone are not used to judge laboratory performance.

Examples of matrix-specific QC include: Matrix Spike (MS), Matrix Spike Duplicate (MSD), sample duplicates, and surrogate spikes. The laboratory shall have procedures in place for tracking, managing, and handling matrix-specific QC criteria, including spiking appropriate components at appropriate concentrations, calculating recoveries and relative percent difference, and evaluating and reporting results based on performance of the QC samples.

1.7.3.3.1 Matrix Spike; Matrix Spike Duplicates

a) Matrix-specific QC samples indicate the effect of the sample matrix on the precision and accuracy of the results generated using the selected method. The information from these controls is sample/matrix specific and would not normally be used to determine the validity of the entire batch.

b) The frequency of the analysis of matrix spikes are as specified by the method or may be determined as part of the contract review process.

c) The components to be spiked shall be as specified by the mandated method. Any permit specified analytes, as specified by regulation or client requested analytes, shall also be included. If there are no specified components, the laboratory shall spike per the following:

For those components that interfere with an accurate assessment such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.

For those methods that have extremely long lists of analytes, a representative number may be chosen using the following criteria for choosing the number of analytes to be spiked. However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period.

i. For methods that include one (1) to ten (10) targets, spike all components.

ii. For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.

iii. For methods with more than twenty (20) targets, spike at least sixteen (16) components.

1.7.3.3.2 Matrix Duplicates

a) Matrix duplicates are defined as replicate aliquots of the same sample taken through the entire analytical procedure. The results from this analysis indicate the precision of the results for the specific sample using the selected method. The matrix duplicate may provide a usable measure of sample homogeneity. It may also provide a measure of precision when target analytes are present.

b) The frequency of the analysis of matrix duplicates are as specified by the method or may be determined as part of the contract review process.

c) Matrix duplicates are performed on replicate aliquots of actual samples. The composition is usually not known.

1.7.3.3.3 Surrogate Spikes

a) Surrogates, when required, are chosen to reflect the chemistries of the targeted components of the method and are added prior to sample preparation/extraction.

b) Except where the matrix precludes its use or when not commercially available, surrogate compounds shall be added to all samples, standards, and blanks for all appropriate methods.

c) Surrogate compounds are chosen to represent the various chemistries of the target analytes in the method. They are often specified by the mandated method and are deliberately chosen for their being unlikely to occur as an environmental contaminant. Often this is accomplished by using deuterated analogs of select compounds.

1.7.3.4 Data Reduction

The procedures for data reduction, such as use of linear regression, shall be documented.

1.7.3.5 Reagent Quality, Water Quality and Checks

a) In methods where the purity of reagents is not specified, analytical reagent grade shall be used. Reagents of lesser purity than those specified by the method shall not be used. Documentation of purity shall be available.

b) The quality of water sources shall be monitored and documented and shall meet method specified requirements.

c) The laboratory shall verify the concentration of titrants in accordance with written laboratory procedures.

1.7.3.6 Selectivity

The laboratory shall document selectivity by following the checks established within the method.

1.7.4 Data Acceptance/Rejection Criteria

1.7.4.1 Negative Control – Method Performance: Method Blank

While the goal is to have no detectable contaminants, each method blank shall be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch. The source of contamination shall be investigated and measures taken to minimize or eliminate the problem and affected samples reprocessed or data shall be appropriately qualified if:

a) the concentration of a targeted analyte in the blank is at or above the reporting limit as established by the method or by regulation, AND is greater than 1/10 of the amount measured in the sample;

b) the blank contamination otherwise affects the sample results as per the method requirements or the individual project data quality objectives; and

c) a blank is determined to be contaminated. The cause shall be investigated and measures taken to minimize or eliminate the problem. Samples associated with a contaminated blank shall be evaluated as to the best corrective action for the samples (e.g., reprocessing or data qualifying codes). In all cases the corrective action shall be documented.

1.7.4.2 Positive Control – Method Performance: Laboratory Control Sample (LCS)

a) The results of the individual batch LCS are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation.

The individual LCS is compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits or utilize client specified assessment criteria.

An LCS that is determined to be within the criteria effectively establishes that the analytical system is in control and validates system performance for the samples in the associated batch. Samples analyzed along with an LCS determined to be “out of control” shall be considered suspect and the samples reprocessed and re-analyzed or the data reported with appropriate data qualifying codes. This includes any allowable marginal exceedance as described in b) below.

i. when the acceptance criteria for the positive control are exceeded high (i.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported with data qualifying codes; or

ii. when the acceptance criteria for the positive control are exceeded low (i.e., low bias), those sample results may be reported if they exceed a maximum regulatory limit/decision level with data qualifying codes.

b) Allowable Marginal Exceedances. If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. This may not indicate that the system is out of control, therefore corrective action may not be necessary. Upper and lower marginal exceedance (ME) limits can be established to determine when corrective action is necessary. A ME is defined as being beyond the LCS control limit (three standard deviations), but within the ME limits. ME limits are between three (3) and four (4) standard deviations around the mean. The number of allowable marginal exceedances is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than is allowed, or if any one analyte exceeds the ME limits, the LCS fails and corrective action is necessary. This marginal exceedance approach is relevant for methods with long lists of analytes. It will not apply to target analyte lists with fewer than eleven analytes.

The number of allowable marginal exceedances is as follows:

Number of Analytes in LCS	Number Allowed as Marginal Exceedances
> 90	5
71 – 90	4
51 – 70	3
31 – 50	2
11 – 30	1
< 11	0

If the same analyte exceeds the LCS control limit consecutively, it is an indication of a systemic problem. The source of the error shall be located and corrective action taken. Laboratories shall have a written procedure to monitor the application of marginal exceedance allowance to the LCS.

1.7.4.3 Sample Specific Controls

a) Matrix Spike; Matrix Spike Duplicates

The results from matrix spike/matrix spike duplicate are primarily designed to assess the precision and accuracy of analytical results in a given matrix and are expressed as percent recovery (%R), relative percent difference (RPD), or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation for %R, RPD or other statistical treatment used.

The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For matrix spike results outside established criteria, corrective action shall be documented or the data for that sample reported with appropriate data qualifying codes.

b) Matrix Duplicates

The results from matrix duplicates are primarily designed to assess the homogeneity of the particular sample chosen. If that sample is homogenous it may also describe the precision of analytical results in a given matrix. These may be expressed as relative percent difference (RPD) or another statistical treatment (e.g., absolute differences).

The laboratory shall document the calculation for relative percent difference or other statistical treatments.

Results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For matrix duplicates results outside established criteria, corrective action shall be documented or the data for that sample reported with appropriate data qualifying codes.

c) Surrogate Spikes

The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. Surrogates outside the acceptance criteria shall be evaluated for the effect indicated for the individual sample results. The appropriate corrective action may be guided by the data quality objectives or other site-specific requirements. Results reported from analyses with surrogate recoveries outside the acceptance criteria shall include appropriate data qualifiers.

1.7.5 Sample Handling

a) All samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container is either within 2°C of the required temperature or the method specified range. For samples with a specified temperature of 4°C, samples with a temperature ranging from just above the freezing temperature of water to 6°C shall be acceptable.

i. Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.5.a. In these cases, the samples shall be considered acceptable if the samples were received on ice.

ii. If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required.

iii. Thermal preservation is not required in the field if the laboratory receives and refrigerates the sample within fifteen (15) minutes of collection.

b) The laboratory shall implement procedures for checking sample preservation using readily available techniques, such as pH or chlorine, prior to or during sample preparation or analysis. An exception is allowed for volatile organic compound analyses; chemical preservation may be checked after analysis.

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ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 5: Quality Systems for Microbiological Testing

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard supplements Module 2, Quality Systems General Requirements, and may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Standard Revision History

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VOLUME 1, MODULE 5

Quality Systems for Microbiological Testing

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VOLUME 1, MODULE 5

Quality Systems for Microbiological Testing

1.0 MICROBIOLOGICAL TESTING

1.1 Introduction

This Standard applies to laboratories undertaking microbiological analysis of environmental samples. Microbiological testing refers to and includes the detection, isolation, enumeration, or identification of microorganisms and/or their metabolites, or determination of the presence or absence of growth in materials and media. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.

1.2 Scope

The essential quality control procedures applicable to microbiological analysis are included in this module. Additional quality control requirements that are either specified by method, regulation or project shall be met by laboratories.

1.3 Terms and Definitions

The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

1.3.1 Additional Terms and Definitions

Reserved

1.3.2 Exclusions and Exceptions

Reserved

1.4 Method Selection

A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method). When a laboratory is required to analyze a parameter by a specified method due to a regulatory requirement, the parameter/method combination is recognized as a reference method. If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology.

When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test. The method developed shall have been validated appropriately before use.

1.5 Method Validation

Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.

The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs of the given application or field of application. The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. The minimum requirements for method validation are given in Sections 1.5.1, 1.5.2 and 1.5.3.

The laboratory shall maintain documentation of the validation procedure for as long as the method is in use and for at least five (5) years past the date of last use.

Laboratories shall participate in a proficiency test program when available. The results of these analyses shall be used to evaluate the ability of the laboratory to produce acceptable data.

The following assessment shall be performed. If no reference method exists, or if the data quality objectives are different from the reference method, then the laboratory shall demonstrate that the method meets the quality objectives for the intended use.

1.5.1 Accuracy – Use at least one (1) known pure reference culture at the anticipated environmental conditions, and compare the method results to that of a reference method.

1.5.2 Precision – Perform at least ten (10) replicate analyses with both the proposed and reference method, using the target microorganisms of choice. The results shall show that the methods are not statistically different.

1.5.3 Selectivity (sensitivity) – Verify all responses in at least ten (10) samples using mixed cultures that include the target organism(s), and at varying concentrations (microbial identification testing or equivalent processes may be used). Calculate the number of false positive and false negative results.

1.6 Demonstration of Capability (DOC)

1.6.1 General

Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required (see Section 1.6.2).

Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3, is required.

In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.

For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed.

An initial DOC shall be completed each time there is a change in instrument type, personnel, or method.

All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.

1.6.2 Initial DOC

An initial DOC shall be made prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.

1.6.2.1 The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:

a) analyst(s) involved in preparation and/or analysis;
b) matrix;
c) organism(s);
d) identification of method(s) performed;
e) identification of laboratory-specific SOP used for analysis, including revision number;
f) date(s) of analysis;
g) summary of analyses, including information outlined in Section 1.6.2.2.c.

1.6.2.2 If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.

a) The target organism(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target organisms or interferences are present at concentrations that will impact the results of a specific method). This matrix shall be sterile phosphate or sterile peptone solution unless specified by the manufacturer. Prepare at least four (4) aliquots at the concentration specified, or if unspecified, to the countable range for plate methods or working range for most probable number (MPN) type methods.

b) At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.

c) Using all of the results, convert these results to logarithmic values, then calculate the mean recovery and standard deviation of the log converted results in the appropriate reporting units for each organism of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence, the laboratory shall assess performance against established and documented criteria.

d) For qualitative tests, acceptable performance in a blind study, either internally or externally generated, may be used to meet this Standard, provided that the study consists of a minimum of a blank, a negative culture, and a positive culture for each target organism or metabolite (e.g. b-glucuronidase in E. coli.).

e) Compare the information from c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.

f) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.

i. Locate and correct the source of the problem and repeat the initial DOC for all parameters of interest beginning with b) above.

ii. Repeat the initial DOC for all parameters that failed to meet criteria.

g) Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).

1.6.3 Ongoing DOC

1.6.3.1 The laboratory shall have a documented procedure describing ongoing DOC. The analyst(s) shall demonstrate ongoing capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.

1.6.3.2 This ongoing demonstration may include one of the following or by performing another initial DOC.

a) Analysis of one sample or clean matrix that is fortified with a known quantity of the target organism, with results meeting the laboratory acceptance criteria for accuracy and, where applicable to the testing technique, also meeting the observational details expected for the presumptive, confirmed and completed phases defined in the method.

b) Analysis of one sample in duplicate for each target organism and test, with results meeting the laboratory acceptance criterion for precision.

c) Acceptable results for one-single-blind proficiency test sample for target organisms in each field of accreditation.

d) Performance of an alternate adequate procedure for the field of accreditation, the procedure and acceptance criteria being documented in the laboratory's quality system.

e) A documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary; or

f) if a) through e) are not technically feasible, then analysis of real-world samples with results within a predefined acceptance criteria (as defined by the laboratory or method) shall be performed.

1.7 Technical Requirements

1.7.1 Calibration

a) The laboratory shall have documented procedures for calibration, verification, and quality control of support equipment including conductivity meters, oxygen meters, pH meters, hygrometers, and other similar measurement instruments. These procedures shall refer to applicable reference methods.

b) For instruments that are continuous monitors, such as in-line specific conductance meters:

i. The laboratory shall document acceptable calibration verification at least once a month.

ii. An initial calibration shall be performed if a continuing calibration is unacceptable, or when the instrument is being returned to service after having been taken off line.

1.7.2 Continuing Calibration

Reserved for specific procedures.

1.7.3 Quality Control

1.7.3.1 Sterility Checks and Method Blanks

a) Method Blanks

The laboratory shall demonstrate that the filtration equipment and filters, sample containers, media and reagents have not been contaminated through improper handling or preparation, inadequate sterilization, or environmental exposure.

i. For filtration technique, the laboratory shall conduct method blanks per the analytical method. At a minimum, the filtration series shall include a beginning and ending blank. The filtration series may include single or multiple filtration units, which have been sterilized prior to beginning the series.

ii. The filtration series is considered ended when more than thirty (30) minutes elapses between successive filtrations. During a filtration series, filter funnels shall be rinsed with three (3) 20-30 ml portions of sterile rinse water after each sample filtration. In addition, laboratories shall insert a method blank after every ten (10) samples or sanitize filtration units by UV light after each sample filtration.

iii. For pour plate technique, method blanks of the medium shall be made by pouring, at a minimum, one uninoculated plate for each lot of pre-prepared, ready-to-use media and for each batch of medium prepared in the laboratory.

b) Sterility Checks

i. A sterility check shall be analyzed for each lot of pre-prepared, ready-to-use medium (including chromofluorogenic reagent) and for each batch of medium prepared in the laboratory. This shall be done prior to first use of the medium.

ii. For pre-sterilized single use funnels, a sterility check shall be performed on one funnel per lot. For laboratory-sterilized funnels, a sterility check shall be performed on one funnel per sterilization batch.

iii. Sterility checks on sample containers shall be performed on at least one (1) container for each lot of purchased, pre-sterilized containers. For containers prepared and sterilized in the laboratory, a sterility check shall be performed on one (1) container per sterilized batch with nonselective growth media. These sterility checks may be performed by a contracted laboratory if the laboratory does not have the requisite equipment to perform them. All correspondence and results from a contracted laboratory shall be retained for a period of five (5) years after the completion of the test(s).

iv. A sterility check shall be performed on each batch of dilution water prepared in the laboratory and on each lot of pre-prepared, ready-to-use dilution water with non-selective growth media.

v. At least one (1) filter from each new lot of membrane filters shall be checked for sterility with nonselective growth media.

1.7.3.2 Test Variability/Reproducibility

For methods that specify colony counts such as membrane filter or plated media, duplicate counts shall be performed monthly on one positive sample, for each month that the test is performed. If the laboratory has two or more analysts, each analyst shall count typical colonies on the same plate. Counts shall be within 10% difference to be acceptable. In a laboratory with only one microbiology

analyst, the same plate shall be counted twice by the analyst, with no more than 5% difference between the counts.

1.7.3.3 Sample Specific Controls (where applicable)

a) Matrix spikes shall be performed per method requirements.
b) Sample matrix duplicates shall be performed per method requirements.

1.7.3.4 Data Reduction

The calculations, data reduction and statistical interpretations specified by each method shall be identified and followed.

1.7.3.5 Quality of Standards, Reagents and Media

The laboratory shall ensure that the quality of the reagents and media used is appropriate for the test concerned.

a) Media – Culture media may be prepared from commercial dehydrated powders or may be purchased ready-to-use.

i. Laboratory-prepared media

1. Media prepared by the laboratory from basic ingredients shall be tested for performance (e.g., for selectivity, sensitivity, sterility, growth promotion, and growth inhibition) prior to first use.

2. Media shall be used within the holding time limits specified in the accredited method.

3. Detailed testing criteria information shall be defined in the laboratory's methods, SOPs, or similar documentation.

ii. Ready-to-use media

1. Ready-to-use media shall be used within the manufacturer's expiration date. If the manufacturer's expiration date is greater than those noted in Section 1.7.3.5 a) i) 2. above, the laboratory shall request, and have available documentation from the manufacturer demonstrating media quality for the extended time period.

2. Any ready-to-use media used past the expiration date shall be verified for usability by running quality control checks comparing the media with freshly prepared media or by testing recovery with known densities of culture controls.

b) Reagents and commercial dehydrated powders shall be used within the shelf life of the product, and shall be documented as per TNI Volume 1, Module 2 Quality Systems General Requirements.

c) Reagent Water

i. The quality of the reagent water used in the laboratory, such as distilled water, de-ionized water or reverse-osmosis produced water shall be monitored for bactericidal and inhibitory substances and shall be used in the preparation of media, solutions and buffers.

ii. The quality of the water shall be monitored for chlorine residual, specific conductance, total organic carbon, ammonia/organic nitrogen and heterotrophic bacteria plate count

monthly (when in use), when maintenance is performed on the water treatment system, or at startup after a period of disuse longer than one month.

iii. Analysis for metals and the Bacteriological Water Quality Test (to determine presence of toxic agents or growth promoting substances) shall be performed annually. (An exception to performing the Bacteriological Water Quality Test shall be given to laboratories that can supply documentation to show that their water source meets the criteria, as specified by the method, for Type I or Type II reagent water.)

iv. Results of the above analyses shall meet the specifications of the required method and records of analyses shall be maintained for five (5) years.

v. Reagent water purchased from an outside source and used for the preparations of media, solutions and buffers shall meet the criteria specified in items ii) and iii) above. The laboratory shall have documented records of this information. Purchased reagent water that has been in use for longer than the testing intervals specified in items i) through iv) or in the accredited method shall either be re-tested or discarded.

d) Documentation for media prepared in the laboratory shall include date of preparation, preparer's initials, type, manufacturer, lot number, final pH, expiration date, and the amount of reagents used. Documentation for media purchased pre-prepared, ready-to-use (including reagent water purchased from outside sources) shall include manufacturer, lot number, type of media received, date of receipt, expiration date of the media, and pH of the media.

1.7.3.6 Selectivity

a) All growth and recovery media shall be checked to assure that the target organism(s) respond in an acceptable and predictable manner.

b) To ensure that analysis results are accurate, target organism identity shall be verified as specified in the method (e.g., by use of the completed test, or by use of secondary verification tests such as a catalase test or by the use of a completed test such as brilliant green (BG) or E. coli (EC) broth.

c) In order to ensure identity and traceability, reference cultures used for positive and negative controls shall be obtained from a recognized national collection, organization, or manufacturer recognized by the accreditation body. Microorganisms may be single use preparations or cultures maintained for their intended use by documented procedures that demonstrate the continued purity and viability of the organism.

i. Reference cultures may be revived (if freeze-dried) or transferred from slants and sub-cultured once to provide reference stocks. The reference stocks shall be preserved by a technique that maintains the characteristics of the strains. Reference stocks shall be used to prepare working stocks for routine work. If reference stocks have been thawed, they shall not be refrozen and re-used.

ii. Working stocks shall not be sequentially cultured more than five (5) times and shall not be sub-cultured to replace reference stocks.

d) Culture Controls

i. Negative Culture Controls

1. Negative culture controls demonstrate that the medium does not support the growth of non-target organisms or does not exhibit the typical positive reaction of the target organism(s).

2. Each pre-prepared, ready-to-use lot of selective medium (including chromofluorogenic reagent) and each batch of selective medium prepared in the laboratory shall be analyzed with one or more known negative culture controls (i.e. non-target organisms), as appropriate to the method. This shall be done prior to first use of the medium.

ii. Positive Culture Controls

1. Positive culture controls demonstrate that the medium can support the growth of the target organism(s), and that the medium produces the specified or expected reaction to the target organism(s).

2. Each pre-prepared, ready-to-use lot of medium (including chromofluorogenic reagent) and each batch of medium prepared in the laboratory shall be tested with at least one pure culture of a known positive reaction. This shall be done prior to first use of the medium.

1.7.3.7 Constant and Consistent Test Conditions

a) Laboratory Facilities

Floors and work surfaces shall be non-absorbent and easy to clean and disinfect. Work surfaces shall be adequately sealed. Laboratories shall provide sufficient storage space, and shall be clean and free from dust accumulation. Plants, food, and drink shall be prohibited from the laboratory work area.

b) Laboratory Equipment

i. Temperature Measuring Devices

Temperature measuring devices such as liquid-in-glass thermometers, thermocouples, and platinum resistance thermometers used in incubators, autoclaves and other equipment shall be the appropriate quality to meet specification(s) in the method. The graduation of the temperature measuring devices shall be appropriate for the required accuracy of measurement and they shall be verified to national or international standards for temperature. Verification shall be done at least annually (see TNI Volume 1, Module 2, Section 5.5.13.1).

ii. Autoclaves

The performance of each autoclave shall be initially evaluated by establishing its functional properties and performance, for example heat distribution characteristics with respect to typical uses. Autoclaves shall meet specified temperature tolerances. Pressure cookers shall not be used for sterilization of growth media.

Demonstration of sterilization temperature shall be provided by use of a continuous temperature recording device or by use of a maximum registering thermometer with every cycle. At least once during each month that the autoclave is used, appropriate biological indicators shall be used to determine effective sterilization. The selected biological indicator shall be effective at the sterilization temperature and time needed to sterilize lactose-based media. Temperature sensitive tape shall be used with the contents of each autoclave run to indicate that the autoclave contents have been processed.

Records of autoclave operations shall be maintained for every cycle. Records shall include: date, contents, maximum temperature reached, pressure, time in sterilization mode, total run time (may be recorded as time in and time out) and analyst's initials.

Autoclave maintenance, either internally or by service contract, shall be performed annually, and shall include a pressure check and verification of temperature device. Records of the maintenance shall be maintained in equipment logs.

NOTE: When it has been determined that the autoclave has no leaks, pressure checks can be documented using the formula PV = nRT.

The autoclave mechanical timing device shall be checked quarterly against a stopwatch and the actual time elapsed documented.

iii. Volumetric Equipment

Volumetric equipment shall be verified as follows:

1. equipment with movable parts such as automatic dispensers, dispensers/diluters, and mechanical hand pipettes shall be verified for accuracy quarterly.

2. equipment such as filter funnels, bottles, non-Class A glassware, and other containers with volumetric markings (including sample analysis vessels) shall be verified once per lot prior to first use. This verification may be volumetric or gravimetric.

3. the volume of the disposable volumetric equipment such as sample bottles, and disposable pipettes shall be checked once per lot.

iv. UV Instruments

UV instruments, used for sanitization, shall be tested quarterly for effectiveness with an appropriate UV light meter, by plate count agar spread plates or other methods providing equivalent results such as uvcide strips. Replace bulbs if output is less than 70% of original for light tests or if count reduction is less than 99% for a plate containing 200 to 300 organisms.

v. Incubators, Water Baths, Ovens

1. The uniformity of temperature distribution in incubators and water baths shall be established. Temperature of incubators and water baths shall be documented twice daily, at least four hours apart, on each day of use.

2. Ovens used for sterilization shall be checked for sterilization effectiveness monthly with appropriate biological indicators. Records shall be maintained for each cycle that include date, cycle time, temperature, contents and analyst's initials.

vi. Labware (Glassware and Plasticware)

1. The laboratory shall have a documented procedure for washing labware, if applicable. Detergents designed for laboratory use shall be used.

2. Glassware shall be made of borosilicate or other non-corrosive material, free of chips and cracks, and shall have readable measurement marks.

3. Labware that is washed and reused shall be tested for possible presence of residues that may inhibit or promote growth of microorganisms by performing the Inhibitory Residue Test annually, and each time the lab changes the lot of detergent or washing procedures.

4. Washed labware shall be tested at least once daily, each day of washing, for possible acid or alkaline residue by testing at least one piece of labware with a suitable pH indicator such as bromothymol blue. Records of tests shall be maintained.

1.7.4 Data Acceptance/Rejection Criteria

Methods criteria and evaluation methods shall be used.

1.7.5 Sample Handling

a) Samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container meets the method or mandated temperature requirement.

i. Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.5.a). In these cases, the samples shall be considered acceptable if the samples were received on ice.

ii. If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required.

iii. Thermal preservation is not required in the field if the laboratory receives the sample and either begins the analysis or refrigerates the sample within fifteen (15) minutes of collection.

b) Microbiological samples from known chlorinated sources (such as wastewater effluent), unknown sources where chlorine usage is suspected (such a new client or a new source) and all potable water sources (including source water) shall be checked for absence of chlorine residual. Laboratories that receive samples from potable water sources (including source water) that have a demonstrated history of acceptable preservation may check a sample from each source at a frequency of once per month if:

i. the laboratory can show that the received sample containers are from their laboratory;

ii. sufficient sodium thiosulfate was in each container before sample collection to neutralize at minimum 5 mg/l of chlorine for drinking water and 15 mg/l of chlorine for wastewater samples;

iii. one container from each batch of laboratory prepared containers or lot of purchased ready-to-use containers is checked to ensure efficacy of the sodium thiosulfate to 5 mg/l chlorine or 15 mg/l chlorine as appropriate and the check is documented;

iv. chlorine residual is checked in the field and actual concentration is documented with sample submission.

ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 6: Quality Systems for Radiochemical Testing

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard supplements Module 2, Quality Systems General Requirements, and may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Section 1.7.1 c) of this document has been processed in accordance with the TNI requirement for a Tentative Interim Amendment. The same or similar amendment will undergo the consensus standards development process within the time-frame specified in SOP 2-100.

Standard Revision History

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VOLUME 1, MODULE 6

Quality Systems for Radiochemical Testing

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VOLUME 1, MODULE 6

Quality Systems for Radiochemical Testing

1.0 RADIOCHEMICAL TESTING

1.1 Introduction

This Standard contains detailed quality control requirements for environmental testing activities involving radiochemical measurements. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.

1.2 Scope

These requirements apply to laboratories undertaking the examination of environmental samples by radiochemical analysis. Procedures for radiochemical analysis may involve some form of chemical separation followed by detection of the radioactive emissions of the analyte (or indicative daughters) and tracer isotopes where used. Procedures for the determination of radioactive isotopes by mass spectrometry (e.g., ICP-MS or TIMS) or optical (e.g., KPA) techniques are outside the scope of this document.

The essential quality control procedures applicable to radiochemistry measurements are included in this Standard. Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.

1.3 Terms and Definitions

The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

1.3.1 Additional Terms and Definitions

Reserved

1.3.2 Exclusions and Exceptions

Reserved

1.4 Method Selection

A reference method is a method issued by an organization generally recognized as competent to do so. (When ISO refers to a standard method, that term is equivalent to reference method)**.** When a laboratory is required to analyze a parameter by a specific method due to a regulatory requirement, the parameter/method combination is recognized as a reference method. If there is not a regulatory requirement for the parameter/method combination, the parameter/method combination is recognized as a reference method if it can be analyzed by another similar reference method of the same matrix and technology, and the inclusion of the parameter in the method meets all required calibration requirements of the method and the quality control requirements of the method to which the parameter is being added. If no QC exists in the method, the laboratory shall adhere to the requirements outlined in the similar method.

When it is necessary to use methods not covered by reference methods, these shall be subject to agreement with the client and shall include a clear specification of the client's requirements and the purpose of the environmental test. The method developed shall have been validated appropriately before use.

1.5 Method Validation

1.5.1 Validation of Methods

a) Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.

b) For reference methods, the minimum detectable activity (Section 1.5.2.1) applies. Evaluating precision and bias is covered in Section 1.5.3.

c) The laboratory shall validate non-reference methods, laboratory-designed/developed methods, reference methods used outside their published scope, and amplifications and modifications of reference methods to confirm that the methods are fit for the intended use. The validation shall be as extensive as is necessary to meet the needs of the given application or field of application. The laboratory shall record the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use. The minimum requirements for method validation are given in Sections 1.5.2 – 1.5.5.

1.5.2 Detectable Activity

All procedures used shall be documented. Documentation shall include the quality system matrix type. All supporting data shall be retained.

1.5.2.1 Minimum Detectable Activity (MDA)

The laboratory shall utilize a method that provides an MDA that is appropriate and relevant for the intended use of the data. MDAs shall be determined by the protocol in the mandated method. If the protocol for determining the MDA is not specified, the selection of the procedure shall reflect instrument limitations and the intended application of the method.

a) The laboratory shall determine the MDA for the method for each target analyte of concern in the quality system sample matrices. All sample-processing steps of the analytical method shall be included in the determination of the MDA.

b) The MDA shall be initially determined for the analytes of interest in each method in a quality system matrix in which there are no target analytes and no interferences at levels that would impact the results.

c) The MDA shall be determined each time there is a change in the method that affects how the test is performed, or when a change in instrumentation occurs that affects the analytical detection capability.

d) The MDA is an estimate of the smallest true activity (or activity concentration) of analyte in a sample that ensures a 95% probability of detection, given a detection criterion that ensures only a 5% probability of detection in analyte-free samples.

1.5.2.2 Required Detection Limit for Drinking Water Compliance

Laboratories that analyze drinking-water samples for Safe Drinking Water Act (SDWA) compliance monitoring shall use methods whose detection limits meet the requirements of 40 CFR 141. The

SDWA detection limit is defined in 40 CFR 141.25(c) as equal to the analyte concentration which can be counted with a precision of plus or minus 100% at the 95% confidence level (1.96σ where σ is the standard deviation of the net counting rate of the sample). The SDWA detection limit is equivalent to the concentration at which the relative standard deviation of the measurement due to counting statistics is 1/1.96.

1.5.3 Evaluation of Precision and Bias

a) Reference Methods. The laboratory shall evaluate the precision and bias of a reference method for each analyte of concern for each quality system matrix according to Section 1.6 or alternate documented procedure when the analyte cannot be spiked into the sample matrix and QC samples are not commercially available.

b) Non-Reference Methods. For laboratory-developed methods or non-reference methods that were not in use by the laboratory before July 2003, the laboratory shall have a documented procedure to evaluate precision and bias. The laboratory shall also compare results of the precision and bias measurements with criteria established by the client, given in the reference method, or established by the laboratory.

c) The laboratory shall also evaluate precision and bias in the relevant quality system matrices and shall process the samples through the entire measurement system for each analyte of interest.

d) An example of a systematic approach to evaluate precision and bias could be the following:

Analyze QC samples in triplicate containing the analytes of concern at or near the MDA, at a level near ten (10) times the MDA, and at a mid-range concentration. Process these samples on different days as three (3) sets of samples through the entire measurement system for each analyte of interest. Each day one QC sample at each concentration is analyzed. A separate method blank shall be subjected to the analytical method along with the QC samples on each of the three (3) days. For each analyte, calculate the mean recovery for each day, for each level over days, and for all nine (9) samples. Calculate the relative standard deviation for each of the separate means obtained.

1.5.4 Measurement Uncertainty

All radiochemical measurements shall provide the uncertainty of each quantitative measurement result. The results of the precision evaluation in Section 1.5.3 shall be compared to the uncertainty estimates as a check on the validity of the uncertainty evaluation procedures. The experimentally observed precision at each testing level shall not be statistically greater than the maximum combined standard uncertainty of the measurement results at that level, although it may be somewhat less.

The combined standard uncertainty, when used, is the uncertainty of a measured value expressed as an estimated standard deviation. It is calculated by combining the standard uncertainties of the input estimates.

1.5.5 Evaluation of Selectivity

The laboratory shall evaluate selectivity, if applicable, by following the checks established within the method.

1.6 Demonstration of Capability (DOC)

1.6.1 General

Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required (see Section 1.6.2).

Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.3 (such as laboratory control samples) is required.

In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in instrument type, personnel or method, the ongoing DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.

For the initial DOC, appropriate records as discussed in Section 1.6.2 shall be completed.

An initial DOC shall be completed each time there is a change in instrument type, personnel, or method.

All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.

1.6.2 Initial DOC

An initial DOC shall be made prior to using any method, and at any time there is a change in instrument type, personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.

1.6.2.1 The laboratory shall document each initial DOC in a manner such that the following information is readily available for each affected employee:

a) analyst(s) involved in preparation and/or analysis;

b) matrix;

c) analyte(s), class of analyte(s), or measured parameter(s);

d) identification of method(s) performed;

e) identification of laboratory-specific SOP used for analysis, including revision number;

f). date(s) of analysis;

g) summary of analyses, including information outlined in Section 1.6.2.2.c).

1.6.2.2 If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.

a) The analyte(s) shall be diluted in a volume of clean quality system matrix (a sample in which no target analytes or interferences are present at concentrations that will impact the results of a specific method) sufficient to prepare four (4) aliquots at a laboratory specified concentration. Where gamma-ray spectrometry is used to identify and quantify more than one

analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., 241Am), medium (e.g., 137Cs) and high (e.g., 60Co) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.

b) At least four (4) aliquots shall be prepared and analyzed according to the method either concurrently or over a period of days.

c) Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the laboratory shall assess performance against established and documented criteria.

d) Compare the information from (c) above to the corresponding acceptance criteria for precision and accuracy in the method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters does not meet the acceptance criteria, the performance is unacceptable for that parameter.

e) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst shall proceed according to i) or ii) below.

i. Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with b) above.

ii. Beginning with b) above, repeat the test for all parameters that failed to meet criteria.

f) Repeated failure, however, confirms a general problem with the measurement system. If this occurs, locate and correct the source of the problem and repeat the test for all compounds of interest beginning with b).

g) When an analyte not currently found on the laboratory's list of accredited analytes is added to an existing accredited method, an initial DOC shall be performed for that analyte. When analytes are added to gamma-ray spectrometry and quantified this is not required.

1.6.3 Ongoing DOC

1.6.3.1 The laboratory shall have a documented procedure describing ongoing DOC. The analyst(s) shall demonstrate ongoing capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to ongoing DOC are adequate.

1.6.3.2 This on-going demonstration may include one of the following:

a) acceptable performance of a blind sample (single blind to the analyst);

Note: Successful analysis of a blind performance sample on a similar method using the same technology.

b) another initial DOC;

c) at least four (4) consecutive laboratory control samples with acceptable levels of precision and accuracy. The laboratory shall determine the acceptable limits for precision and accuracy

prior to analysis. The laboratory shall tabulate or be able to readily retrieve four (4) consecutive passing LCS for each method for each analyst each year;

d) a documented process of analyst review using QC samples. QC samples can be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary;

e) if a) through d) are not technically feasible, then analysis of real-world samples with results within predefined acceptance criteria (as defined by the laboratory or method) shall be performed.

1.7 Technical Requirements

1.7.1 Instrument Calibration

a) Initial Calibration

This Section addresses those practices that are necessary for proper calibration of radiation counting instruments for environmental testing involving radioanalytical measurements.

This Section specifies the essential elements that shall define the procedures and documentation for initial instrument calibration and continuing instrument calibration verification to ensure that the data shall be of known quality and be appropriate for a given regulation or decision. This Standard does not specify detailed procedural steps ("how to") for calibration, but establishes the essential elements for selection of the appropriate technique(s). This approach allows flexibility and permits the employment of a wide variety of analytical procedures and statistical approaches currently applicable for calibration. If more stringent standards or requirements are included in a mandated method or regulation, the laboratory shall demonstrate that such requirements are met. If it is not apparent which standard is more stringent, then the requirements of the mandated method or regulation are to be followed.

Given that radiation detection efficiency is essentially independent of sample activity at all but high activity levels (where dead time becomes significant), the requirements for calibration ranges of standards, of data reporting in calibration range, and the number of calibration standards are not applicable to radiochemical method calibrations except for mass attenuation in gas-proportional counting and sample quench in liquid scintillation counting. Nuclear counting instruments are subject to calibration prior to initial use, when the instrument is placed back into service after major repairs and the instrument's response has changed as determined by a performance check, when the instrument's response exceeds predetermined acceptance criteria for the instrument quality control. Instruments may also be recalibrated on a regular frequency even in the absence of these conditions.

The frequency of calibration shall be described in the laboratory method SOP if not specified in the method. A specific frequency (e.g., annually) or calibrations based on observations from the associated control or tolerance chart, shall be specified in the laboratory method SOP.

Instrument calibration shall be performed with reference standards as defined in Section 1.7.2.5.c). The standards shall have the same general characteristics (i.e., geometry, homogeneity, density, etc.) as the associated samples.

The following items are essential elements of initial instrument calibration:

i. The details of the initial instrument calibration procedures including calculations, acceptance criteria and associated statistics shall be included or referenced in the

method SOP. When initial instrument calibration procedures are referenced in the method, then the referenced material shall be retained by the laboratory and be available for review.

ii. Sufficient raw data records shall be retained to permit reconstruction of the initial instrument calibration (e.g., calibration date, method, instrument, analysis date, each analyte name, analyst's initials or signature; activity and response, calibration curve or response factor; or unique equation or coefficient used to reduce instrument responses to activity or concentration).

iii. Sample results shall be quantitated from the initial instrument calibration and may not be quantitated from any continuing instrument calibration verification unless otherwise required by regulation, method, or program.

iv. All initial instrument calibrations shall be verified with a standard obtained from a second manufacturer or lot if the lot can be demonstrated from the manufacturer as prepared independently from other lots. Traceability shall be to a national standard, when commercially available.

v. Criteria for the acceptance of an initial instrument calibration shall be established (e.g., correlation coefficient or relative percent difference). The criteria used shall be appropriate to the calibration technique employed.

vi. If the initial instrument calibration results are outside established acceptance criteria, corrective actions shall be performed and all associated samples re-analyzed. If re-analysis of the samples is not possible, data associated with an unacceptable initial instrument calibration shall be reported with appropriate data qualifiers.

vii. If a reference or mandated method does not specify the number of calibration standards, the laboratory shall have a written procedure for determining the number of points for establishing the initial instrument calibration.

b) Instrument Calibration Verification (Performance Checks)

Performance checks shall be performed using appropriate check sources and monitored with control charts or tolerance charts to ensure that the instrument is operating properly, the detector response has not significantly changed, and therefore the instrument calibration has not changed. The same check source used in the preparation of the tolerance chart or control chart at the time of calibration shall be used in the calibration verification of the instrument (performance checks). The check sources shall provide adequate counting statistics for a relatively short count time and the source should be sealed or encapsulated to prevent loss of activity and contamination of the instrument and laboratory personnel.

i. For gamma-ray spectroscopy systems, performance checks for detection efficiency, energy calibration, and peak resolution shall be performed on a day-of-use basis.

ii. For alpha-particle spectroscopy systems, the performance check for energy calibration shall be performed on a weekly basis and the performance check for detection efficiency shall be performed on at least a monthly basis.

iii. For gas-proportional and liquid scintillation counters, the performance check for detection efficiency shall be performed on a day-of-use basis. For batches of samples that uninterruptedly count for more than a day, a performance check may be performed instead at the beginning and end of the batch as long as this time interval is no greater than one week.

iv. For scintillation counters the calibration verification for detection efficiency shall be performed on a day-of-use basis.

c) Background Measurement

Background measurements shall be made on a regular basis and monitored using control charts or tolerance charts to ensure that a laboratory maintains its capability to meet required measurement quality objectives. (This background measurement is not the short term check for contamination that is addressed in 1.7.1 d). These values must be subtracted from the total measured activity in the determination of the sample activity.

i. For gamma-ray spectroscopy systems, background measurements shall be performed on at least a monthly basis.

ii. For alpha-particle spectroscopy systems, background measurements shall be performed on at least a monthly basis.

iii. For gas-proportional counters background measurements shall be performed on at least a weekly basis.

iv. For scintillation counters, background measurements shall be performed each day of use.

d) Instrument Contamination Monitoring

The laboratory shall have a written procedure for monitoring radiation measurement instrumentation for radioactive contamination. The procedure shall indicate the frequency of the monitoring and shall indicate criteria, which initiates corrective action.

1.7.2 Quality Control for Radiochemistry

The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken as specified in this Section. This monitoring shall be planned and reviewed.

The failure of any QC sample analysis and the corrective actions taken shall be noted in the laboratory report for the associated samples.

1.7.2.1 Negative Control – Method Performance: Method Blank

a) The method blank is used to assess the preparation batch for possible contamination during the preparation and processing steps or for other low-level bias. The method blank shall be processed along with and under the same conditions as the associated samples to include all steps of the analytical procedure. Procedures shall be in place to determine if a method blank result is significantly different from zero. Any affected samples associated with a failed method blank shall be reprocessed for analysis or the results reported with appropriate data-qualifying codes.

b) The method blank shall be analyzed at a minimum of one (1) per preparation batch, which shall be a maximum of twenty (20) field samples, for all radiochemical methods except gross alpha/beta in solid matrices and gamma-ray spectrometry.

c) The method blank shall consist of a quality system matrix that is similar to the associated samples and is known to be as free of the analytes of interest as possible.

There shall be no subtraction of the method blank result from the sample results in the associated preparation or analytical batch unless permitted by method or program. This requirement does not preclude corrections for background radiation (e.g., instrument background, analyte in the tracer or carrier, reagent impurities, peak overlap, etc.) to all analyzed samples, both program/project submitted and internal quality control samples. However, these corrections shall not depend on the result of the method blank analysis, whose purpose is to check for uncorrected contamination or other low-level bias.

The method blank sample shall be prepared with aliquot size similar to that of the routine samples for analysis.

1.7.2.2 Positive Control – Method Performance: Laboratory Control Sample (LCS)

a) The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Results of the LCS are compared to established criteria and, if found to be outside of these criteria may indicate that the analytical system is "out of control." Any affected samples associated with an out-of-control LCS shall be reprocessed for reanalysis or the results reported with appropriate data qualifying codes.

b) The LCS shall be analyzed at a minimum of one per preparation batch. Exceptions would be for those analytes for which no spiking solutions are available.

c) The LCS is a quality system matrix, known to be free of analytes of interest, spiked with known and verified concentrations of analytes.

NOTE: The matrix spike may be used in place of this control as long as the acceptance criteria are as stringent as for the LCS.

d) Alternatively the LCS may consist of a medium containing known and verified concentrations of analytes or as Certified Reference Material (CRM). The components to be spiked shall be as specified by the mandated method or regulation or as requested by the client.

e) The activity of the laboratory control sample shall be: (1) at least ten (10) times the MDA, and (2) at a level comparable to that of routine samples when such information is available if the sample activities are expected to exceed ten times the MDA.

f) The laboratory standards used to prepare the laboratory control sample shall be from a source independent of the laboratory standards used for instrument calibration and shall meet the requirements for reference standards provided in Section 1.7.5.2.c).

g) Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes need be included in the laboratory control sample at the indicated activity level. However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.

h) Where gamma-ray spectrometry is used to identify and quantify more than one analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., 241Am), medium (e.g., 137Cs) and high (e.g., 60Co) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.

i) The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.

1.7.2.3 Sample-Specific Controls

The laboratory shall document procedures for determining the effect of the sample matrix on method performance. These procedures relate to the analyses of quality system matrix specific quality control (QC) samples and are designed as data quality indicators for a specific sample using the designated method.

Examples of matrix-specific QC include: Matrix Spike (MS); Matrix Spike Duplicate (MSD); and replicates. The laboratory shall have procedures in place for tracking, managing, and handling matrix-specific QC criteria including spiking appropriate components at appropriate concentrations, calculating recoveries and relative percent difference, evaluating and reporting results based on performance of the QC samples.

a) Matrix Spike

i. Matrix spikes indicate the effect of the sample matrix on the accuracy of the results generated using the selected method. The results of this analysis shall be one of the quality control measures used to assess the batch.

ii. The frequency of the analysis of matrix spikes are as specified by the method or may be determined as part of the contract review process**.**

iii. The components to be spiked shall be as specified by the mandated method. Any permit specified analytes, as specified by regulation or client requested analytes shall also be included.

iv. The lack of sufficient sample aliquot size to perform a matrix spike shall be noted in the laboratory report.

v. The activity of the matrix spike analytes(s) shall be greater than five times the MDA.

vi. The laboratory standards used to prepare the matrix spike shall be from a source independent of the laboratory standards used for instrument calibration and shall meet the requirements for reference standards of Section 1.7.2.5.c).

vii. The matrix spike shall be prepared by adding a known activity of target analyte after sub-sampling if required but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.). Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes need be included in the matrix spike sample at the indicated activity level. However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.

b) Replicates / Matrix Spike Duplicates / Laboratory Control Sample Duplicates

i. Replicates are defined as replicate aliquots of the same sample taken through the entire analytical procedure. The results from this analysis indicate the precision of the results for the specific sample using the selected method. Replicates provide the most useful measure of precision when target analytes are found in the sample chosen for replication.

ii. The frequency of the analysis of matrix replicates and duplicates are as specified by the method or may be determined as part of the contract review process.

iii. Replicates are performed on replicate aliquots of actual samples.

iv. For low-level samples (less than approximately three times the MDA) the laboratory may analyze a laboratory control samples duplicate or a replicate matrix spike (matrix spike and a matrix spike duplicate) to determine reproducibility within a preparation batch in place of a sample replicate. In addition based on project or program requirements, the laboratory may analyze a laboratory control sample duplicate or a matrix spike duplicate in place of a sample replicate.

c) Tracer

For those methods that employ a tracer for yield determination, each sample result shall have an associated tracer yield calculated and reported. The tracer shall be added to the sample after subsampling, if required, but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.) unless otherwise specified by the method. The tracer yield for each sample result shall be one of the quality control measures to be used to assess the associated sample result acceptance. The tracer yield shall be assessed against the specific acceptance criteria specified in the laboratory method SOP. When the specified tracer yield acceptance criteria are not met, the specified corrective action and contingencies shall be followed. The occurrence of a failed tracer yield and the actions taken shall be noted in the laboratory report to the client.

d) Carrier

For those methods that utilize a carrier for yield determination, each sample shall have an associated carrier yield calculated and reported. The carrier shall be added to the sample after subsampling, if required, but before any chemical treatment (e.g., chemical digestion, dissolution, separation, etc.) unless otherwise specified by the method. The carrier yield for each sample shall be one of the quality control measures to be used to assess the associated sample result acceptance. The carrier yield shall be assessed against the specific acceptance criteria specified in the laboratory method SOP. When the specified carrier yield acceptance criteria are not met, the specified corrective action and contingencies shall be followed. The occurrence of a failed carrier yield and the actions taken shall be noted in the laboratory report to the client.

1.7.2.4 Data Reduction

a) The procedures for data reduction, such as use of linear regression, shall be documented.

b) Measurement Uncertainties. Each result shall be reported with its measurement uncertainty. The report should clearly explain the uncertainty. At a minimum the report shall:

i. indicate whether the uncertainty is the combined standard uncertainty (“one sigma”) or an expanded uncertainty; and

ii. for expanded uncertainties, indicate the coverage factor (k) and optionally the approximate level of confidence.

c) The procedures for determining the measurement uncertainty shall be documented and shall be consistent with the ISO Guide 98: 1995, Guide to the Expression of Uncertainty in Measurement (GUM) and with the recommendations of Chapter 19 of the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) Volume I (EPA 402-B-04-001A), Volume II (EPA 402-B-04-001B), Volume III (EPA 402-B-04-001C), July 2004.

1.7.2.5 Reagent Quality, Water Quality, and Checks

a) In methods where the purity of reagents is not specified, reagents shall be analytical reagent grade or better. Reagents of lesser purity than those specified by the method shall not be used. The labels on the container should be checked to verify that the purity of the reagents meets the requirements of the particular method. Such information shall be available.

b) The quality of water sources shall be monitored and documented and shall meet method specified requirements.

c) The quality control program shall establish and maintain provisions for radionuclide standards.

i. Reference standards that are used in a radiochemical laboratory shall be obtained from NIST or suppliers who participate in supplying NIST standards or NIST traceable radionuclides. Any reference standards purchased outside the United States shall be traceable back to each country's national standards laboratory. Commercial suppliers of reference standards shall conform to ANSI N42.22 to assure the quality of their products.

ii. Reference standards shall be accompanied with a certificate of calibration whose content is as described in ANSI N42.22 - 1995, Section 8, Certificates.

iii. Laboratories should consult with the supplier if the lab's verification of the activity of the reference traceable standard indicates a noticeable deviation from the certified value. The laboratory shall use only the decay-corrected certified value. The laboratory shall have a written procedure for handling, storing, and establishing expiration dates for reference standards.

1.7.2.6 Selectivity

The laboratory shall evaluate selectivity by following the checks established within the method.

1.7.2.7 Constant and Consistent Test Conditions

a) The laboratory shall assure that the test instruments consistently operate within the specifications required of the application for which the equipment is used.

b) Glassware Cleaning. Glassware shall be cleaned to meet the sensitivity requirements of the method. Any cleaning and storage procedures that are not specified by the method shall be documented in laboratory records and SOPs. Note that some applications may require single-use glassware.

c) Radiological Control Program. The laboratory shall maintain a radiological control program that addresses analytical radiological control. The program shall address the procedures for segregating samples with potentially widely varying levels of radioactivity. The radiological control program shall explicitly define how low-level and high-level samples will be identified, segregated and processed in order to prevent sample cross-contamination. The radiological control program shall include the measures taken to monitor and evaluate background activity or contamination on an ongoing basis.

1.7.3 Data Acceptance/Rejection Criteria

1.7.3.1 Negative Control – Method Performance: Method Blank

a) While the goal is to have no statistically significant difference from zero, each method blank shall be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch. The source of contamination or other bias shall be investigated and measures taken to minimize or eliminate the problem and affected samples reprocessed or data shall be appropriately qualified if:

i. the absolute value of the activity of a targeted analyte in the blank exceeds three times its combined standard uncertainty, AND is greater than 1/10 of the activity measured in any sample; or

ii. the method blank result otherwise affects the sample results as per the method requirements or the project-specific measurement quality objectives.

b) The acceptance criteria for samples associated with a failed method blank shall be calculated in a manner that compensates for sample results based on differing aliquot sizes.

c) When a blank result is determined to be significantly different from zero, the cause shall be investigated and measures taken to minimize or eliminate the problem. Samples associated with a failed blank shall be evaluated as to the best corrective action for the samples (e.g., reprocessing or data qualifying codes).

d) The occurrence of a failed method blank and any associated corrective action shall be noted in the laboratory report to the client.

1.7.3.2 Positive Control – Method Performance: Laboratory Control Sample (LCS)

a) The results of the individual batch LCS are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation.

b) The individual LCS is compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits or utilize client specified assessment criteria.

c) An LCS that is determined to be within the criteria effectively establishes that the analytical system is in control and validates system performance for the samples in the associated batch. Samples analyzed along with an LCS determined to be “out of control” shall be considered suspect and the samples reprocessed and re-analyzed or the data reported with appropriate data qualifying codes.

d) The occurrence of a failed LCS and any associated actions shall be noted in the laboratory report to the client.

1.7.3.3 Sample-Specific Controls

a) Matrix Spike; Matrix Spike Duplicates

i. The results from matrix spike/matrix spike duplicate are primarily designed to assess the precision and accuracy of analytical results in a given matrix and are expressed as percent recovery (%R), relative percent difference (RPD), or other appropriate

statistical technique that allows comparison to established acceptance criteria. The laboratory shall document the calculation for %R, RPD or other statistical treatment used.

ii. The results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For matrix spike results outside established criteria, corrective action shall be documented or the data reported with appropriate data qualifying codes.

iii. The occurrence of a failed matrix spike and any associated actions shall be noted in the laboratory report to the client.

b) Replicates

i. The results from replicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD) or another statistical treatment (e.g., normalized differences).

ii. The laboratory shall document the calculation for relative percent difference or other statistical treatments.

iii. Results are compared to the acceptance criteria as published in the mandated method. Where there are no established criteria, the laboratory shall determine internal criteria and document the method used to establish the limits. For replicate results outside established criteria, corrective action shall be documented or the data reported with appropriate data qualifying codes.

iv. The occurrence of a failed replicate and any associated actions shall be noted in the laboratory report to the client.

1.7.4 Sample Handling

a) All samples that require thermal preservation shall be considered acceptable if the arrival temperature of a representative sample container is either within 2°C of the required temperature or the method specified range. For samples with a specified temperature of 4°C, samples with a temperature ranging from just above the freezing temperature of water to 6°C shall be acceptable.

i. Samples that are delivered to the laboratory on the same day they are collected may not meet the requirements of Section 1.7.4.a. In these cases, the samples shall be considered acceptable if the samples were received on ice.

ii. If sample analysis is begun within fifteen (15) minutes of collection, thermal preservation is not required. Thermal preservation is not required in the field if the laboratory receives and refrigerates the sample within fifteen (15) minutes of collection.

b) The laboratory shall implement procedures for checking chemical preservation using readily available techniques, such as pH or chlorine, prior to or during sample preparation or analysis.

ENVIRONMENTAL LABORATORY SECTOR

VOLUME 1

MANAGEMENT AND TECHNICAL REQUIREMENTS FOR LABORATORIES PERFORMING ENVIRONMENTAL ANALYSIS

Module 7: Quality Systems for Toxicity Testing

TNI Standard

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PREFACE

This Standard is the result of many hours of effort by those volunteers on The NELAC Institute (TNI) Quality Systems Committee. The TNI Board of Directors wishes to thank these committee members for their efforts in preparing this Standard as well as those TNI members who offered comments during the voting process.

This Standard supplements Module 2, Quality Systems General Requirements, and may be used by any organization that wishes to implement a program for the accreditation of environmental laboratories.

Standard Revision History

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VOLUME 1, MODULE 7

Quality Systems for Toxicity Testing

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VOLUME 1, MODULE 7

Quality Systems for Toxicity Testing

1.0 TOXICITY TESTING

1.1 Introduction

This Standard applies to laboratories measuring the toxicity and/or bioaccumulation of contaminants in effluents (whole effluent toxicity or WET), receiving waters, sediments, elutriates, leachates and soils. In addition to the essential quality control standards described below, some methods may have additional or other requirements based on factors such as the type of organism evaluated and contain detailed quality control requirements for toxicity testing activities. The evaluation of laboratories for this discipline is in conjunction with a quality system as specified in the general requirements module. Adherence to quality systems requirements will ensure that all quality control procedures specified in this module are being followed.

1.2 Scope

The essential quality control procedures applicable to toxicity measurements are included in this Standard. Additional quality control requirements that are specified by method, regulation or project shall be met by laboratories.

1.3 Terms and Definitions

The relevant definitions from TNI, Volume 1, Module 2, Section 3.0 apply. Definitions related to this document, which are used differently or do not exist in the above references are defined below.

1.3.1 Additional Terms and Definitions

When referred to in this module, “sensitivity” relates to the meaning referenced in the accredited method.

1.3.2 Exclusions and Exceptions

Reserved

1.4 Method Selection

When it is necessary to use testing methods not covered by an approved method, these shall be subject to agreement with the data user and shall include a clear specification of the data user’s requirements and the purpose of the environmental test. The method developed shall have been validated appropriately before use.

The characteristics of validated methods (e.g., the uncertainty of the results, limit of repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of the sample/test object), as assessed for the intended use, shall be relevant to the users’ needs.

1.5 Method Validation

Validation is the confirmation by examination and the objective evidence that the particular requirements for a specific intended use are fulfilled.

1.6 Demonstration of Capability (DOC)

1.6.1 General

Prior to acceptance and institution of any method for data reporting, satisfactory initial DOC is required (see Section 1.6.2).

Thereafter, ongoing DOC (Section 1.6.3), as per the quality control requirements in Section 1.7.1.2 is required.

In cases where a laboratory analyzes samples using a method that has been in use by the laboratory for at least one year prior to applying for accreditation, and there have been no significant changes in personnel or method, the ongoing DOC shall be acceptable as an initial DOC. The laboratory shall have records on file to demonstrate that an initial DOC is not required.

For the initial DOC, appropriate records as discussed in Section 1.6.2.1 shall be completed.

An initial DOC shall be completed each time there is a change in personnel, or method.

In general, this demonstration does not test the performance of the method in real world samples. However, before any results are reported, the initial DOC shall be performed. An intial DOC may be completed by a group of analysts and is for situations in which several individuals perform part of a set of activities that would produce a testing result.

All demonstrations shall be documented. All data applicable to the demonstration shall be retained and readily available at the laboratory.

1.6.2 Initial DOC

An initial DOC shall be made prior to using any method, and at any time there is a significant change in personnel or method or any time that a method has not been performed by the laboratory or analyst in a twelve (12) month period.

1.6.2.1 The laboratory shall document each initial DOC in a manner such that the following information is available for each affected employee:

a) analyst(s) involved in preparation and/or analysis;

b) matrix;

c) species and endpoint(s);

d) identification of method(s) performed;

e) identification of laboratory-specific SOP used for analysis, including revision number;

f) date(s) of analysis;

g) summary of analyses, including information outlined in Section 1.6.2.2.

1.6.2.2 If the method or regulation does not specify an initial DOC, the following procedure is acceptable. It is the responsibility of the laboratory to document that other approaches to initial DOC are adequate.

Each analyst shall meet the quality control requirements as specified in Section 1.7.1.2.

1.6.3 Ongoing DOC

The laboratory shall have a documented procedure describing ongoing DOC. The analyst(s) shall demonstrate on-going capability by meeting the quality control requirements of the method, laboratory SOP, client specifications, and/or this Standard. It is the responsibility of the laboratory to document that other approaches to on-going demonstration of capability are adequate. This on-going demonstration may include performing another initial demonstration of capability as per 1.6.2 or a documented process of analyst review using QC samples can serve as the annual on-going demonstration of capability. QC samples shall be reviewed to identify patterns for individuals or groups of analysts and determine if corrective action or retraining is necessary.

1.7 Technical Requirements

1.7.1 Quality Control

The laboratory shall have quality control procedures for monitoring the validity of environmental tests undertaken. The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to the reviewing of the results. This monitoring shall be planned and reviewed and may include, but not be limited to, the following:

a) regular use of certified reference materials and/or internal quality control using secondary reference materials;

b) participation in inter-laboratory comparison or proficiency-testing program;

c) replicate tests using the same or different methods;

d) retesting of retained samples; and

e) correlation of results for different characteristics of a sample (for example, total phosphate should be greater than or equal to orthophosphate).

1.7.1.1 Essential Quality Control Procedures

These general quality control principles shall apply, where applicable, to all testing laboratories. The manner in which they are implemented is dependent on the types of tests performed by the laboratory and are further described in this module. The standards for any given test type shall assure that the applicable principles are addressed:

a) All laboratories shall have detailed written protocols in place to monitor the following quality controls:

   i. positive and negative controls to monitor tests such as blanks, spikes, reference toxicants;

   ii. tests to define the variability and/or repeatability of the laboratory results such as replicates;

   iii. measures to evaluate method capability, such as percent minimum significant difference (PMSD);

   iv. selection of appropriate formulae to reduce raw data to final results such as regression and statistical analyses;

   v. selection and use of reagents and standards of appropriate quality;

vi. measures to assure the selectivity of the test for its intended purpose; and

vii. measures to assure constant and consistent test conditions (both instrumental and environmental) where required by the method such as temperature, humidity, light or specific equipment conditions.

b) All quality control measures shall be assessed and evaluated on an ongoing basis, and quality control acceptance criteria shall be used to determine the usability of the data.

c) The laboratory shall have procedures for the development of acceptance/rejection criteria where no method or regulatory criteria exist.

d) The quality control protocols specified by the laboratory's method manual shall be followed. The laboratory shall ensure that the essential standards outlined in this document or regulations (whichever are more stringent) are incorporated into their method manuals. When it is not apparent which is more stringent, the QC in the regulations is to be followed.

1.7.1.2 Positive and Negative Controls

a) Positive Control. Reference toxicant tests demonstrate a laboratory's ability to obtain consistent results with the method and evaluate the overall health and sensitivity of test organisms over time.

i. The laboratory shall demonstrate its ability to obtain consistent results with standard reference toxicants (SRT).

ii. Ongoing laboratory performance shall be demonstrated by performing routine SRT testing for each method, species and endpoint in accordance with the minimum frequency requirements specified in Section 1.7.1.2.a)iii).

iii. The frequency of ongoing laboratory reference toxicant testing shall be as follows unless the method specifically requires less frequent SRT tests (e.g., sediment tests).

For methods conducted at a frequency of monthly or greater, SRT tests shall be conducted monthly.

For methods and species commonly used in the laboratory, but which are tested at a frequency of less than monthly, SRT tests shall be conducted concurrently with the environmental test.

If the test organisms are obtained from an outside source, the sensitivity of each batch of organisms received from a supplier shall be determined via a concurrent SRT test unless the supplier can provide control chart data for the last five SRT tests using the same SRT and test conditions. Supplied SRT data may not be older than six (6) months.

iv. These standards do not currently specify a particular reference toxicant and dilution series. However, if the regulation identifies a reference toxicant or dilution series for a particular test, the laboratory shall follow the specified requirements. All reference toxicant tests conducted for a given method and species shall use the same reference toxicant, test concentrations, dilution water and data analysis methods. A dilution factor of 0.5x or greater shall be used for both acute and chronic tests.

v. The reference toxicant tests shall be conducted following the procedures required in the method.

b) Negative Controls – Control, Brine Control, Control Sediment, Control Soil or Dilution Water

i. The standards for the use, type and frequency of testing of negative controls are specified by the methods and by permit or regulation and shall be followed. A negative control is included with each test to evaluate test performance and the health and sensitivity of the specific batch of organisms.

ii. Appropriate additional negative controls shall be included when sample adjustments (for example addition of thiosulfate for dechlorination) or solvent carriers are used in the test.

1.7.1.3 Variability and/or Reproducibility

Intra-laboratory precision shall be determined on an ongoing basis through the use of further reference toxicant tests and related control charts as described above.

1.7.1.4 Test Sensitivity

a) The PMSD shall be calculated according to the formula specified by the method and reported with the test results.

b) Point estimates: (LCp, ICp, or ECp) – Confidence intervals shall be reported as a measure of the precision around the point estimate value, when the calculation is possible.

1.7.1.5 Selection and Use of Reagents and Standards

a) The grade of all reagents used in toxicity tests is specified in the method except the reference standard. All reference standards shall be prepared from chemicals that are analytical reagent grade or better. The preparation of all standards and reference toxicants shall be documented.

b) All standards and reagents associated with chemical measurements, such as dissolved oxygen, pH or specific conductance, shall comply with the Chemistry Module.

c) Only reagent-grade water collected from distillation or de-ionization units is used to prepare reagents.

1.7.1.6 Constant and Consistent Test Conditions

a) If closed refrigerator-sized incubators are used, culturing and testing of organisms shall be separated to avoid cross-contamination.

b) Laboratory space shall be adequate for the types and numbers of tests performed. The building shall provide adequate cooling, heating and illumination for conducting testing and culturing; hot and cold running water shall be available for cleaning equipment.

c) Air used for aeration of test solutions, dilution waters and cultures shall be free of oil and fumes.

d) The laboratory or a contracted outside expert shall positively identify test organisms to species on an annual basis. The taxonomic reference (citation and page(s)) and the names(s) of the taxonomic expert(s) shall be kept on file at the laboratory. When organisms are obtained from an outside source the supplier shall provide this same information.

e) Equipment used for routine support measurements of chemical and physical parameters such as pH, DO, conductivity, salinity, alkalinity, hardness, chlorine, ammonia and weight shall be calibrated, and/or standardized per manufacturer's instructions. All measurements and calibrations shall be documented.

f) Test temperature shall be maintained as specified for the method. Temperature control equipment shall be adequate to maintain the required test temperature(s). The average daily temperature of the test solutions shall be maintained within method specified range. The minimum frequency of measurement shall be once per twenty-four (24) hour period. The test temperature for continuous-flow toxicity tests shall be recorded and monitored continuously. Where electronic data loggers are used, temperature shall be monitored at a frequency sufficient to capture temporal variations of the environmental control system.

g) Reagent grade water, prepared by any combination of distillation, reverse osmosis, ion exchange, activated carbon and particle filtration, shall meet the method specified requirements.

h) The quality of the standard dilution water used for testing or culturing shall be sufficient to allow satisfactory survival, growth and reproduction of the test species as demonstrated by routine reference toxicant tests and negative control performance. Water used for culturing and testing shall be analyzed for toxic metals and organics whenever the minimum acceptability criteria for control survival, growth or reproduction are not met and no other cause, such as contaminated glassware or poor stock, can be identified.

i) The quality of the food used for testing or culturing shall be sufficient to allow satisfactory survival, growth and reproduction of the test species as demonstrated by routine reference toxicant tests and negative control performance. The laboratory shall have written procedures for the evaluation of food acceptance.

j) A subset of organisms used in bioaccumulation tests shall be analyzed at the start of the test (baseline) for the target compounds to be measured in the bioaccumulation tests.

k) Test chamber size and test solution volume shall be as specified in the method. All test chambers used in a test shall be identical.

l) Test organisms shall be fed the quantity and type food or nutrients specified in the method. They shall also be fed at the intervals specified in the methods.

m) All organisms in a test shall be from the same source and lot. Where available, certified seeds are used for soil tests.

n) All organisms used in tests, or used as broodstock to produce neonate test organisms (for example cladocerans and larval fish), shall appear healthy, show no signs of stress or disease and exhibit acceptable survival (90% or greater) during the twenty-four (24) hour period immediately preceding use in tests.

o) All materials used for test chambers, culture tanks, tubing, etc. and coming in contact with test samples, solutions, control water, sediment or soil or food shall be non-toxic and cleaned as described in the methods. Materials shall not reduce or add to sample toxicity. Appropriate materials for use in toxicity testing and culturing are described in the methods.

p) Light intensity shall be maintained as specified in the methods. Measurements shall be made and recorded on a yearly basis. Photoperiod shall be maintained as specified in the methods and shall be documented at least quarterly. For algal and plant tests, the light intensity shall be measured and recorded at the start of each test.

q) The health and culturing conditions of all organisms used for testing shall be documented by the testing laboratory. Such documentation shall include culture conditions (e.g. salinity, hardness, temperature, pH) and observations of any stress, disease or mortality. When organisms are obtained from an outside source, the laboratory shall obtain written documentation of these water quality parameters and biological observations for each lot of organism received. These observations shall adequately address the twenty-four (24) hour time period referenced in item 1.7.1.6 n) above. The laboratory shall also record each of these observations and water quality parameters upon the arrival of the organisms at the testing laboratory.

r) Age and the age range of the test organisms shall be as specified in the method. Supporting information, such as hatch dates and times, times of brood releases and metrics (for example, chironomid head capsule width) shall be documented.

s) The maximum holding time of effluents (elapsed time from sample collection to first use in a test) shall not exceed thirty-six (36) hours; samples may be used for renewal up to seventy-two (72) hours after first use except as prescribed by the method and approved by the regulatory agency having authority for program oversight.

t) All tests shall have at least the minimum number of replicates per treatment as prescribed by the method.

u) The control population of Ceriodaphnia in chronic effluent or receiving water tests shall contain no more than 20% males.

v) The culturing of C. dubia shall be adequate such that blocking by parentage can be established.

w) Dissolved oxygen and pH in aquatic tests shall be within acceptable range at test initiation. Minimal aeration is provided to tests if acceptable dissolved oxygen concentrations cannot be otherwise maintained.

x) Test soils or sediments shall be within the geochemical tolerance range of the test organism.

y) An individual test may be conditionally acceptable if temperature, dissolved oxygen, pH and other specified conditions fall outside specifications, depending on the degree of the departure and the objectives of the tests (see test conditions and test acceptability criteria specified for each method). The acceptability of the test shall depend on the experience and professional judgment of the technical director and the permitting authority.

1.7.2 Data Acceptance/Rejection Criteria

1.7.2.1 Positive Controls

A laboratory shall record the control performance and statistical endpoints (such as NOEC or ECp) for each method and species on control charts. The laboratory shall also evaluate precision (i.e. coefficient of variation, CV) for these tests against method specific or laboratory-derived criteria to determine validity of the testing result.

For endpoints that are point estimates (ICp, ECp), control charts are constructed by plotting the cumulative mean and the control limits, which consist of the upper and lower 95% confidence limits (+/- 2 standard deviations). For endpoints from hypothesis tests (NOEC, NOAEC) the values are plotted directly, and the control limits consist of one concentration interval above and below the concentration representing the central tendency (i.e. the mode).

For endpoints that are point estimates the cumulative mean CV is calculated. For endpoints from hypothesis tests, the PMSD is calculated. These values are maintained on control charts.

Control chart limits are expected to be exceeded occasionally regardless of how well a laboratory performs. Acceptance limits for point estimates (ICp, ECp) that are based on 95% confidence limits should theoretically be exceeded for one in twenty tests. Depending on the dilution factor and test sensitivity, control charts based on hypothesis test values (NOEC, NOAEC) may be expected to be exceeded on a similar frequency. Test results that fall outside of control chart limits at a frequency of 5% or less, or which fall just outside control chart limits (especially in the case of highly proficient laboratories which may develop relatively narrow acceptance limits over time), are not rejected de facto. Such data are evaluated in comparison with control chart characteristics including the width of the acceptance limits and the degree of departure of the value from acceptance limits.

Laboratories shall develop acceptance/rejection policies, consistent with the methods, for SRT data which considers source of test organisms, the direction of the deviation, test dilution factor, test sensitivity (for hypothesis test values), testing frequency, out-of-control test frequency, relative width of acceptance limits, inter-test CV, and degree of difference between test results and acceptance limits.

In the case of reference toxicant data which fails to meet control chart acceptance criteria, the test data are examined for defects, corrective action taken and the test repeated if necessary, using a different batch of organisms or the data is qualified.

Intra-laboratory precision is determined on an ongoing basis through the use of control charts. The control charts shall be plotted as point estimate values, such as EC25 for chronic tests and LC50 for acute tests, or as appropriate hypothesis test values, such as the NOEC or NOAEC, over time within a laboratory.

1.7.2.2 Negative Controls

The test acceptability criteria specified in the method shall be achieved for both the reference toxicant and the effluent or environmental sample toxicity test. The criteria shall be calculated and shall meet the method specified requirements for performing toxicity tests.

1.7.2.3 Selection of Appropriate Statistical Analysis Methods

a) Methods of data analysis and reporting as specified by language in the regulation, permit, or the method shall be followed as required.

b) Toxicity data shall be plotted on semi-logarithmic graph paper, relating time, mortality, and effluent concentration to verify computational results.

1.7.3 Sample Handling

All samples shall be chilled to 0-6°C during or immediately after collection except as prescribed by the method and approved by the regulatory agency having authority for program oversight.