Designation: D7282 – 21ε1

Standard Practice for Setup, Calibration, and Quality Control of Instruments Used for Radioactivity Measurements[1]

This standard is issued under the fixed designation D7282; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorially corrected Fig. X1.1, Fig. X3.1, and Fig. X4.1 in December 2022.

1. Scope

1.1 This practice covers consensus criteria for the setup, calibration, and quality control of nuclear instruments. Setup establishes the operating parameters of the instrument—for example, voltage or discriminator settings. Calibrations determine the instrument's response characteristics—for example, its counting efficiency or gain. Quality control ensures that the performance of the instrument remains acceptable for its intended use and consistent with the performance at the time of calibration.

1.2 This practice addresses four of the most commonly used types of nuclear counting instruments: alpha-particle spectrometer, gamma-ray spectrometer, gas proportional counter, and liquid scintillation counter.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1129 Terminology Relating to Water

D3648 Practices for the Measurement of Radioactivity

D7283 Test Method for Alpha and Beta Activity in Water By Liquid Scintillation Counting

D7902 Terminology for Radiochemical Analyses

E2586 Practice for Calculating and Using Basic Statistics

2.2 *Other Standards:*

ANSI N42.22 Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control[3]

ANSI N42.23 Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories[3]

ANSI/HPS N13.30 Performance Criteria for Radiobioassay[3]

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories[4]

JCGM 100:2008 Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminologies D1129 and D7902 and Practice E2586.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This practice is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.04 on Methods of Radiochemical Analysis.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[5] Available from Bureau International des Poids et Mesures (BIPM), Pavillon de Breteuil F-92312 Sèvres Cedex France, http://www.bipm.org/en/publications/guides/gum.html.

3.2.1 *acceptable verification ratio (AVR), n*—ratio of the absolute difference between the measured value of the verification sample and the known value added to the verification sample to the square root of the sum of the squares of their associated combined standard uncertainties.

3.2.1.1 *Discussion*—See Eq 15 in 16.2.15.

3.2.2 *background subtraction count (BSC), n*—a source count used to determine the background to be subtracted from the sample test source count.

3.2.3 *calibration, n*—determination of an instrument's response to a known amount of radioactive material.

3.2.3.1 *Discussion*—Instrument calibrations may include calibrations for counting efficiency, gain, and resolution.

3.2.4 *calibration source, n*—a known quantity of radioactive material, prepared and configured for calibrating nuclear instruments.

3.2.4.1 *Discussion*—A calibration source used for efficiency calibration must have quantity values and uncertainties with documented traceability to the SI.

3.2.5 *certified calibration source (CCS), n*—a calibration source (see 3.2.4) accompanied by a certificate that provides the values, uncertainties, and reference date of the source's primary radioactive constituents, with documentation of metrological traceability to the SI.

3.2.5.1 *Discussion*—ANSI N42.22 describes the required content of the certificate and presents criteria for ensuring traceability of radionuclide sources to NIST.

3.2.6 *continuing instrument quality control, n*—activities conducted to ensure that an instrument continues to respond in the same manner after its calibration.

3.2.7 *instrument check, n*—a test of the response of a nuclear counting instrument, typically using an instrument check source (see 3.2.8) and including some combination of tests of efficiency, energy calibration, and peak resolution as appropriate for the instrument type.

3.2.8 *instrument check source (ICS), n*—a radioactive source, not necessarily traceable to any standard, that is used to test the response of a nuclear instrument.

3.2.9 *instrument contamination check (ICC), n*—a measurement to determine if a nuclear instrument is contaminated with radioactive material.

3.2.10 *instrument control chart, n*—a chart used to monitor and evaluate the performance of an instrument using predetermined statistically based limits.

3.2.11 *instrument tolerance chart, n*—a chart used to monitor and evaluate the performance of an instrument using tolerance limits appropriate to the method, scope of work, and data quality requirements.

3.2.12 *known value (KV), n*—accepted true value of the analyte activity added to a verification sample.

3.2.12.1 *Discussion*—See Eq 13 in 16.2.13.

3.2.13 *measured value (MV), n*—result of a measurement performed on a verification sample.

3.2.13.1 *Discussion*—See Eq 11 in 16.2.11.

3.2.14 *measurement quality objective (MQO), n*—quantitative or qualitative statement of a performance objective or requirement for a particular method performance characteristic **(1)**.[6]

3.2.15 *normalized residual, ζ_i, n*—quotient of a *residual*, e_i, and its combined standard uncertainty, $u_c(e_i)$

3.2.15.1 *Discussion*—See Appendix X5 for the calculation and use of ζ_i.

3.2.16 *operating parameter, n*—any of the configurable settings of a nuclear counting instrument, such as a detector operating voltage, amplifier gain, or energy discriminator setting.

3.2.17 *quality manual (QM), n*—a document stating the management policies, objectives, principles, organizational structure and authorities, accountability, and implementation of a laboratory's quality system, to assure the quality of its data.

3.2.17.1 *Discussion*—The quality manual shall document the process by which appropriate analytical methods are selected, their capability is evaluated, and their performance is documented. The analytical methods manual and standard operating procedure manuals shall be part of but not necessarily included in the quality manual. The quality manual or standard operating procedures, or both, shall also include instructions that prescribe corrective action, for example, in the event of a failure of an instrument check source (ICS), instrument contamination check (ICC), or background subtraction count (BSC).

3.2.18 *relative residual, $\%\Delta_i$, n*—quotient of a *residual*, e_i, and the corresponding predicted value, $\hat{\varepsilon}_i$, typically expressed as a percentage.

3.2.19 *relative standard deviation (RSD), n*—ratio of the standard deviation to the mean (also known as *coefficient of variation*).

3.2.19.1 *Discussion*—See Practice E2586.

3.2.20 *residual, n*—difference between the observed value of the dependent variable, ε_i, and the corresponding predicted value, $\hat{\varepsilon}_i$.

3.2.21 *sample test source (STS), n*—a sample or sample aliquot prepared or configured for measurement of its emitted radiation.

3.2.22 *tolerance limit, n*—a limit established to evaluate the acceptability of a monitored process parameter.

3.2.23 *working calibration source (WCS), n*—a calibration source (see 3.2.4) diluted or prepared by the laboratory from radioactive reference materials.

3.3 *Acronyms:*

3.3.1 *ADC*—analog-to-digital converter

3.3.2 *AVR*—acceptable verification ratio

3.3.3 *BIPM*—Bureau International des Poids et Mesures (English: International Bureau of Weights and Measures)

3.3.4 *BSC*—background subtraction count

3.3.5 *CCS*—certified calibration source

[6] The boldface numbers in parentheses refer to the list of references at the end of this standard.