Designation: D3648 – 23

Standard Practices for the Measurement of Radioactivity[1]

This standard is issued under the fixed designation D3648; 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.

1. Scope

1.1 These practices cover a review of the accepted counting practices currently used in radiochemical analyses. The practices are divided into four sections:

	Section
General Information	6 – 11
Alpha Counting	12 – 22
Beta Counting	23 – 33
Gamma Counting	34 – 41

1.2 The general information sections contain information applicable to all types of radioactive measurements, while each of the other sections is specific for a particular type of radiation.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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]

D1066 Practice for Sampling Steam
D1129 Terminology Relating to Water
D1943 Test Method for Alpha Particle Radioactivity of Water
D2459 Test Method for Gamma Spectrometry of Industrial Water and Industrial Waste Water (Withdrawn 1986)[3]
D3084 Practice for Alpha-Particle Spectrometry of Water
D3085 Practice for Measurement of Low-Level Activity in Water (Withdrawn 1987)[3]
D3370 Practices for Sampling Water from Flowing Process Streams
D3649 Practice for High-Resolution Gamma-Ray Spectrometry of Water
D7902 Terminology for Radiochemical Analyses
D8293 Guide for Evaluating and Expressing the Uncertainty of Radiochemical Measurements
IEEE/ASTM SI 10 American National Standard for Metric Practice

2.2 *ANSI Standards:*[4]

ANSI N42.14 Calibration and Use of Germanium Spectrometers for the Measurement of Gamma-Ray Emission Rates of Radionuclides

2.3 *Other Documents:*

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 these practices, refer to Terminology D1129 and Terminology D7902. For an explanation of the metric system, including units, symbols, and conversion factors, see IEEE/ASTM SI 10.

4. Summary of Practices

4.1 The practices are a compilation of the various counting techniques employed in the measurement of radioactivity. The important variables that affect the accuracy or precision of counting data are presented. Because a wide variety of instruments and techniques are available for radiochemical laboratories, the types of instruments and techniques to be selected will be determined by the information desired. In a

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[1] These practices are under the jurisdiction of ASTM Committee D19 on Water and are the direct responsibility of 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] The last approved version of this historical standard is referenced on www.astm.org.

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

[5] Available from www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf.

simple tracer application using a single radioactive isotope having favorable properties of high purity, energy, and ample activity, a simple detector will probably be sufficient, and techniques may offer no problems other than those related to reproducibility. The other extreme would be a laboratory requiring quantitative identification of a variety of radionuclides, preparation of standards, or studies of the characteristic radiation from radionuclides. For the latter, a variety of specialized instruments are required. Most radiochemical laboratories require a level of information between these two extremes.

4.2 A basic requirement for accurate measurements is the use of accurate standards for instrument calibration. With the present availability of good standards, only the highly diverse radiochemistry laboratories require instrumentation suitable for producing their own radioactive standards. However, it is advisable to compare each new standard received against the previous standard.

4.3 Thus, the typical laboratory may be equipped with proportional or Geiger-Mueller counters for beta counting, sodium iodide or germanium detectors, or both, in conjunction with multichannel analyzers for gamma spectrometry, and scintillation counters suitable for alpha- or beta-emitting radionuclides.

5. Significance and Use

5.1 This practice was developed for the purpose of summarizing the various generic radiometric techniques, equipment, and practices that are used for the measurement of radioactivity.

GENERAL INFORMATION

6. Experimental Design

6.1 In order to properly design valid experimental procedures, careful consideration must be given to the following;

6.1.1 Radionuclide to be determined,

6.1.2 Relative activity levels of interferences,

6.1.3 Type and energy of the radiation,

6.1.4 Original sample matrix, and

6.1.5 Required accuracy.

6.2 Having considered 6.1.1 – 6.1.5, it is now possible to make the following decisions:

6.2.1 Chemical or physical form that the sample must be in for radioassay,

6.2.2 Chemical purification steps,

6.2.3 Type of detector required,

6.2.4 Energy spectrometry, if required,

6.2.5 Length of time the sample must be counted in order to obtain statistically valid data,

6.2.6 Isotopic composition, if it must be determined, and

6.2.7 Size of sample required.

6.3 For example, gamma-ray measurements can usually be performed with little or no sample preparation, whereas both alpha and beta counting will almost always require chemical processing. If low levels of radiation are to be determined, very large samples and complex counting equipment may be necessary.

6.3.1 More detailed discussions of the problems and interferences are included in the sections for each particular type of radiation to be measured.

7. Apparatus

7.1 *Location Requirements:*

7.1.1 The apparatus required for the measurement of radioactivity consists, in general, of the detector and associated electronic equipment. The latter usually includes a stable power supply, preamplifiers, a device to store or display the electrical pulses generated by the detector, or both, and one or more devices to record information.

7.1.2 Some detectors and high-gain amplifiers are temperature sensitive; therefore, changes in pulse amplitude can occur as room temperature varies. For this reason, it is necessary to provide temperature-controlled air conditioning in the counting room.

7.1.3 Instrumentation should never be located in a chemical laboratory where corrosive vapors will cause rapid deterioration and failure.

7.2 *Instrument Electrical Power Supply*—Detector and electronic responses are a function of the applied voltage; therefore, it is essential that only a very stable, low-noise electrical supply be used or that suitable stabilization be included in the system.

7.3 *Shielding:*

7.3.1 The purpose of shielding is to reduce the background count rate of a measurement system. Shielding reduces background by absorbing some of the components of cosmic radiation and some of the radiations emitted from material in the surroundings. Ideally, the material used for shielding should itself be free of any radioactive material that might contribute to the background. In practice, this is difficult to achieve as most construction materials contain at least some naturally radioactive isotopes (such as ^{40}K, members of the uranium and thorium series, and so forth). The thickness of the shielding material should be such that it will absorb most of the soft components of cosmic radiation. This will reduce cosmic-ray background by approximately 25 %. Shielding of beta- or gamma-ray detectors with anticoincidence systems can further reduce the cosmic-ray or Compton scattering background for very low-level counting.

7.3.2 Detectors have a certain background counting rate from naturally occurring radionuclides and cosmic radiation from the surroundings; and from the radioactivity in the detector itself. The background counting rate will depend on the amounts of these types of radiation and on the sensitivity of the detector to the radiations.

7.3.3 In alpha counting, low backgrounds are readily achieved since the short range of alpha particles in most materials makes effective shielding easy. Furthermore, alpha detectors are quite insensitive to the electromagnetic components of cosmic and other environmental radiation.

7.4 *Care of Instruments:*