

American National Standard

calibration and usage of sodium iodide detector systems

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1. Introduction

The purpose of this document is to provide a standardized basis for the calibration and usage of sodium iodide detector systems for the measurement of gamma-ray emission rates of radionuclides. Typical applications include radionuclide identification and assay in various industrial, environmental, and medical applications.

A sodium iodide detector system consists of: “. . .three major components: a scintillating medium that produces a flash of light when ionizing radiation interacts with it; one or more photomultipliers, optically coupled to the scintillator, which converts the light flash to an amplified electrical impulse; and associated electronic instrumentation which powers the photomultiplier and processes the output signal”. [See ANSI/IEEE Std 398-1972 (Reaff 1977), Test Procedures for Photomultipliers for Scintillation Counting and Glossary for Scintillation Counting Field.]

The theory of operation of sodium iodide detectors is presented in numerous publications, including refs [1]–[3].¹

2. Scope

This standard establishes methods for performance testing, calibration, and usage of sodium iodide detector systems for the measurement of gamma-ray emission rates of radionuclides; the assay for radioactivity; and the determination of gamma-ray energies. It covers both energy calibration and efficiency calibration. The following three techniques are considered:

¹Bracketed numbers refer to the references listed in 4.2.

(1) *Total spectrum counting* (see 5.1) employs a system that counts all events above a low-energy threshold (see 7.1, 7.2, and 7.3).

(2) *Single-channel analyzer counting* (see 5.2) employs a system with a counting window which establishes upper and lower energy boundaries (see 7.1, 7.2, and 7.3).

(3) *Multichannel analyzer counting* (see 5.3) employs a system in which multiple counting windows are utilized. This technique applies to measurements that do not involve overlapping peaks and those for which the continuum under the full-energy peak can be subtracted without introducing unacceptable error [4].

3. Definitions

assay. The determination of the activity of a radionuclide in a sample.

activity response. The net number of counts registered by the detector system per unit of time divided by the activity of the radionuclide that is being measured during the same unit of time.

ambient background. Those counts that can be observed, and thereby allowed for, by measuring a source that is identical to the unknown source in all respects except for the absence of radioactivity. These counts are attributable to environmental radioactivity in the detector itself, the detector shielding material, and the sample container; cosmic rays; electronic noise pulses; etc [5].

check source. A radioactive source, not necessarily calibrated, which is used to confirm the continuing satisfactory operation of an instrument.

correlated photon summing. The simultaneous

detection of two or more photons originating from a single disintegration.

dead time t_d . The time after a triggering pulse during which the system is unable to retrigger.

efficiency. The net number of counts registered by the detector system per unit of time divided by the number of photons of interest originating in the radioactive source that is being measured during the same unit of time.

energy calibration. The relationship between the height of the amplifier output pulse and the energy of the photons originating in the radioactive source.

FWHM (full width at half maximum). The full width of a gamma-ray peak distribution measured at half the maximum ordinate above the continuum.

radioactivity standard. A radioactivity standard, as used in this text, shall be either a radioactivity standard that has been certified by a laboratory recognized as a country's National Standardizing Laboratory for radioactivity measurements or a radioactivity standard that has been obtained from a supplier who participates in measurement assurance activities with the National Standardizing Laboratory when such standards are available. In such measurement assurance activities, the supplier's calibration value should agree with the National Standardizing Laboratory value within the overall uncertainty stated by the supplier in its certification of the same batch of sources or in its certification of similar sources.

random photon summing. The simultaneous detection of two or more photons originating from the disintegrations of more than one atom.

resolution, gamma-ray. The measured FWHM, after background subtraction, of a gamma-ray peak distribution, expressed as a percentage of the energy corresponding to the centroid of the distribution.

shall. Shall, in this text, indicates an action required by this standard.

should. Should, in this text, indicates an action that is to be included when practicable.

simulated source. A radioactive source consisting of one or more long-lived radionuclides

that are chosen to simulate the radiations from a short-lived radionuclide of interest.

4. References

4.1 Standards References

ANSI/IEEE Std 398-1972 (Reaff 1977), Test Procedures for Photomultipliers for Scintillation Counting and Glossary for Scintillation Counting Field.

4.2 References to Other Publications

[1] HEATH, R. L. Scintillation Spectrometry Gamma-Ray Spectrum Catalogue, IDO-16880, 1964, 2nd ed.

[2] ADAMS, F. and DAMS, R. Applied Gamma-Ray Spectrometry, New York, Pergamon Press, 1970, 2nd ed.

[3] MANN, W. B., Ed. A Manual of Radioactivity Measurement Procedures, NCRP Report 58, Washington, DC, NCRP Publications, 1978.

[4] KOKTA, L. Determination of Peak Area, *Nuclear Instruments and Methods*, vol 112, 1973, p 242.

[5] International Commission of Radiation Units and Measurements. Measurement of Low-Level Radioactivity, ICRU Report 22, June 1, 1972.

[6] KOCHER, D.C., Ed. Nuclear Decay Data for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, ORNL/NUREG/TM-102, August 1977. Available from National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

[7] BRINKMAN, G. A., *et al.* Absolute Standardization with NaI(Tl) Crystal-1, *International Journal of Applied Radiation and Isotopes*, vol 14, 1963, p 153.

[8] HARLEY, J. H., Ed. HASL Procedures Manual, HASL-300. 1972 (revised annually). Available from National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

5. Procedure

5.1 Total Spectrum Counting Systems

5.1.1 General. All instruments shall be installed and operated in accordance with the manufacturer's instructions (see 7.4).

5.1.2 Energy Calibration. Following the