Designation: C1133/C1133M – 10 (Reapproved 2018)

Standard Test Method for Nondestructive Assay of Special Nuclear Material in Low-Density Scrap and Waste by Segmented Passive Gamma-Ray Scanning[1]

This standard is issued under the fixed designation C1133/C1133M; 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 This test method covers the transmission-corrected nondestructive assay (NDA) of gamma-ray emitting special nuclear materials (SNMs), most commonly ^{235}U, ^{239}Pu, and ^{241}Am, in low-density scrap or waste, packaged in cylindrical containers. The method can also be applied to NDA of other gamma-emitting nuclides including fission products. High-resolution gamma-ray spectroscopy is used to detect and measure the nuclides of interest and to measure and correct for gamma-ray attenuation in a series of horizontal segments (collimated gamma detector views) of the container. Corrections are also made for counting losses occasioned by signal processing limitations (**1-3**).[2]

1.2 There are currently several systems in use or under development for determining the attenuation corrections for NDA of radioisotopic materials (**4-8**). A related technique, tomographic gamma-ray scanning (TGS), is not included in this test method (**9**, **10**, **11**).

1.2.1 This test method will cover two implementations of the Segmented Gamma Scanning (SGS) procedure: (*1*) Isotope Specific (Mass) Calibration, the original SGS procedure, uses standards of known radionuclide masses to determine detector response in a mass versus corrected count rate calibration that applies only to those specific radionuclides for which it is calibrated, and (*2*) Efficiency Curve Calibration, an alternative method, typically uses non-SNM radionuclide sources to determine system detection efficiency vs. gamma energy and thereby calibrate for all gamma-emitting radionuclides of interest (**12**).

1.2.1.1 Efficiency Curve Calibration, over the energy range for which the efficiency is defined, has the advantage of providing calibration for many gamma-emitting nuclides for which half-life and gamma emission intensity data are available.

1.3 The assay technique may be applicable to loadings up to several hundred grams of nuclide in a 208-L [55-gal] drum, with more restricted ranges to be applicable depending on specific packaging and counting equipment considerations.

1.4 Measured transmission values must be available for use in calculation of segment-specific attenuation corrections at the energies of analysis.

1.5 A related method, SGS with calculated correction factors based on item content and density, is not included in this standard.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 *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.* Specific precautionary statements are given in Section 10.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

[1] This test method is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.10 on Non Destructive Assay.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this test method.

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:*[3]

C1030 Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectrometry

C1128 Guide for Preparation of Working Reference Materials for Use in Analysis of Nuclear Fuel Cycle Materials

C1156 Guide for Establishing Calibration for a Measurement Method Used to Analyze Nuclear Fuel Cycle Materials

C1207 Test Method for Nondestructive Assay of Plutonium in Scrap and Waste by Passive Neutron Coincidence Counting

C1210 Guide for Establishing a Measurement System Quality Control Program for Analytical Chemistry Laboratories Within the Nuclear Industry

C1215 Guide for Preparing and Interpreting Precision and Bias Statements in Test Method Standards Used in the Nuclear Industry

C1316 Test Method for Nondestructive Assay of Nuclear Material in Scrap and Waste by Passive-Active Neutron Counting Using ^{252}Cf Shuffler

C1458 Test Method for Nondestructive Assay of Plutonium, Tritium and ^{241}Am by Calorimetric Assay

C1490 Guide for the Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel

C1592/C1592M Guide for Making Quality Nondestructive Assay Measurements (Withdrawn 2018)[4]

C1673 Terminology of C26.10 Nondestructive Assay Methods

E181 Test Methods for Detector Calibration and Analysis of Radionuclides

2.2 *ANSI Standards:*[5]

ANSI/IEEE 325 Test Procedures for Germanium Gamma-Ray Detectors

ANSI N15.36 Measurement Control Program—Nondestructive Assay Measurement Control and Assurance

3. Terminology

3.1 Refer to Terminology C1673 for terminology definitions.

4. Summary of Test Method

4.1 The assay of the nuclides of interest is accomplished by measuring the intensity of one or more characteristic gamma rays from each nuclide. Corrections are made for count rate-related losses and attenuation by the item. The appropriate mass or efficiency calibration then provides the relationship between observed gamma-ray intensity and nuclide content.

4.2 Either of two distinct calibration methods can be used:

4.2.1 *Isotope Specific Calibration* provides assay results for only those radionuclides for which the SGS is specifically calibrated. Calibration is performed using standards containing the radionuclides to be assayed.

4.2.2 *Efficiency Curve Calibration* entails determination of the system detection efficiency as a function of gamma ray energy. Analysis of assay data consists of using the energy of a peak to infer the emitting radionuclide, and then calculating the radionuclide mass from the specific activity and the gamma emission intensity of the radionuclide, and the corrected count rate and detector efficiency at the peak energy.

4.3 The assay item is rotated about its vertical axis and scanned segment by segment along that axis, thereby reducing the effects of nonuniformity in both matrix density and nuclide distribution (see Fig. 1).

4.4 Count rate-dependent losses from pulse pile-up and analyzer dead time are corrected for by electronic modules, a radioactive source, a pulser, or a combination of these.

4.5 The average linear attenuation coefficient of each horizontal segment is calculated by measurement of the transmitted intensity of an appropriate external gamma-ray source. The source is mounted directly opposite the gamma-ray detector, on the far side of the assay item (see Fig. 1).

4.6 Two conditions must be met to optimize SGS assay results as follows:

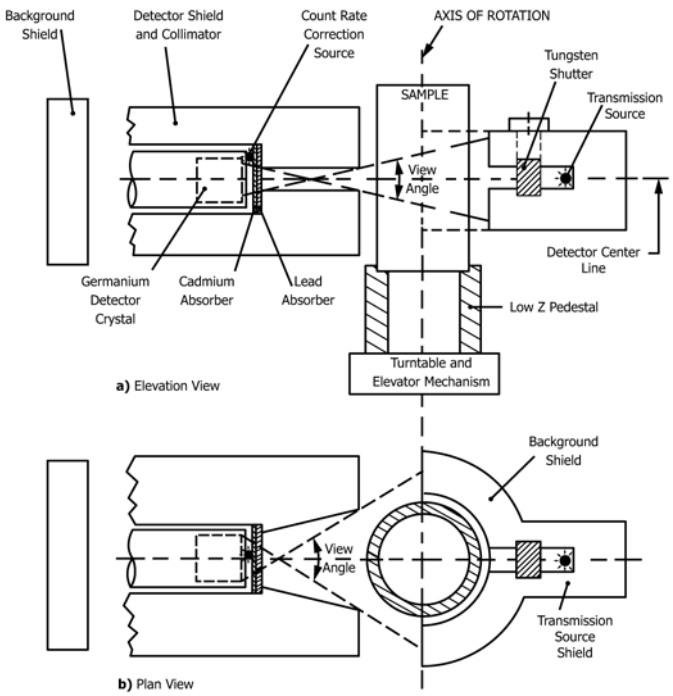

FIG. 1 Typical Arrangement for Segmented Gamma-Ray Scanning

[3] 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.

[4] The last approved version of this historical standard is referenced on www.astm.org.

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