INTERNATIONAL

Designation: C1207 − 10 (Reapproved 2018)

Standard Test Method for Nondestructive Assay of Plutonium in Scrap and Waste by Passive Neutron Coincidence Counting[1]

This standard is issued under the fixed designation C1207; 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 describes the nondestructive assay of scrap or waste for plutonium content using passive thermal-neutron coincidence counting. This test method provides rapid results and can be applied to a variety of carefully sorted materials in containers as large as several thousand liters in volume. The test method applies to measurements of ^{238}Pu, ^{240}Pu, and ^{242}Pu and has been used to assay items whose total plutonium content ranges from 10 mg to 6 kg (**1**).[2]

1.2 This test method requires knowledge of the relative abundances of the Pu isotopes to determine the total Pu mass (Test Method C1030).

1.3 This test method may not be applicable to the assay of scrap or waste containing other spontaneously fissioning nuclides.

1.3.1 This test method may give biased results for measurements of containers that include large amounts of hydrogenous materials.

1.3.2 The techniques described in this test method have been applied to materials other than scrap and waste (**2, 3**).

1.4 This test method assumes the use of shift-register-based coincidence technology (**4**).

1.5 Several other techniques that are often encountered in association with passive neutron coincidence counting exist. These include neutron multiplicity counting (**5, 6**, Test Method C1500), add-a-source analysis for matrix correction (**7**), flux probes also for matrix compensation, cosmic-ray rejection (**8**) to improve precision close to the detection limit, and alternative data collection electronics such as list mode data acquisition. Passive neutron coincidence counting may also be combined with certain active interrogation schemes as in Test Methods C1316 and C1493. Discussions of these established techniques are not included in this method.

1.6 *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.*

1.7 *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:*[3]

C986 Guide for Developing Training Programs in the Nuclear Fuel Cycle (Withdrawn 2001)[4]
C1009 Guide for Establishing and Maintaining a Quality Assurance Program for Analytical Laboratories Within the Nuclear Industry
C1030 Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectrometry
C1068 Guide for Qualification of Measurement Methods by a Laboratory Within the Nuclear Industry
C1128 Guide for Preparation of Working Reference Materials for Use in Analysis of Nuclear Fuel Cycle Materials
C1133/C1133M Test Method for Nondestructive Assay of Special Nuclear Material in Low-Density Scrap and Waste by Segmented Passive Gamma-Ray Scanning
C1210 Guide for Establishing a Measurement System Quality Control Program for Analytical Chemistry Laboratories Within 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

[1] This practice 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.

Current edition approved April 1, 2018. Published April 2018. Originally approved in 1991. Last previous edition approved in 2010 as C1207 – 10. DOI: 10.1520/C1207-10R18.

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

[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.

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

C1493 Test Method for Non-Destructive Assay of Nuclear Material in Waste by Passive and Active Neutron Counting Using a Differential Die-Away System (Withdrawn 2018)[4]

C1500 Test Method for Nondestructive Assay of Plutonium by Passive Neutron Multiplicity Counting

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

C1673 Terminology of C26.10 Nondestructive Assay Methods

2.2 *ANSI Standards:*[5]

ANSI 15.20 Guide to Calibrating Nondestructive Assay Systems

ANSI 15.36 Nondestructive Assay Measurement Control and Assurance

3. Terminology

3.1 Refer to Terminology C1673 for definitions used in this test method.

4. Summary of Test Method

4.1 The even mass isotopes of Pu fission spontaneously. On the average, two or more prompt neutrons are emitted per fission event. The number of time correlated or coincident neutrons detected by the instrument is related to the effective mass of ^{240}Pu, m_{eff}, present in the time. The effective ^{240}Pu mass is a weighted sum of the even mass isotopes of Pu in the assay item. The total Pu mass is determined from the known plutonium isotopic ratios and the measured quantity m_{eff}.

4.2 The shift register technology is intended to correct for the effects of *Accidental* neutron coincidences which result from the registration of neutrons in the coincidence gate which are not correlated in time to the neutron which triggered the inspection of the gate.

4.3 Other factors which may affect the assay are neutron self multiplication, matrix components with large (α, n) reaction rates, neutron absorbers, or moderators. Corrections for these effects are often not possible from the measurement data alone, consequently assay items are commonly sorted into material categories or additional information is sometimes used.

4.4 Corrections are typically made for electronic deadtime and neutron background.

4.5 Calibrations are typically based on measurements of well documented and appropriate reference materials. Modeling based on knowledge of the instrument design and the physical principles of neutron interactions may also be applied.

4.6 This method includes measurement control tests to verify reliable and stable performance of the instrument.

5. Significance and Use

5.1 This test method is useful for determining the plutonium content of scrap and waste in containers ranging from small cans with volumes of the order of a mL to crates and boxes of several thousand liters in volume. A common application would be to 208-L (55-gal) drums. Total Pu content ranges from 10 mg to 6 kg (**1**). The upper limit may be restricted depending on specific matrix, calibration material, criticality safety, or counting equipment considerations.

5.2 This test method is applicable for U.S. Department of Energy shipper/receiver confirmatory measurements (**9**), nuclear material diversion detection, and International Atomic Energy Agency attributes measurements (**10**).

5.3 This test method should be used in conjunction with a scrap and waste management plan that segregates scrap and waste assay items into material categories according to some or all of the following criteria: bulk density, the chemical forms of the plutonium and the matrix, americium to plutonium isotopic ratio, and hydrogen content. Packaging for each category should be uniform with respect to size, shape, and composition of the container. Each material category might require calibration standards and may have different Pu mass limits.

5.4 Bias in passive neutron coincidence measurements is related to item size and density, the homogeneity and composition of the matrix, and the quantity and distribution of the nuclear material. The precision of the measurement results is related to the quantity of nuclear material, the (α,n) reaction rate, and the count time of the measurement.

5.4.1 For both benign matrix and matrix specific measurements, the method assumes the calibration reference materials match the items to be measured with respect to the homogeneity and composition of the matrix, the neutron moderator and absorber content, and the quantity of nuclear material, to the extent they affect the measurement.

5.4.2 Measurements of smaller containers containing scrap and waste are generally more accurate than measurements of larger items.

5.4.3 It is recommended that where feasible measurements be made on items with homogeneous contents. Heterogeneity in the distribution of nuclear material, neutron moderators, and neutron absorbers have the potential to cause biased results.

5.5 The coincident neutron production rates measured by this test method are related to the mass of the even number isotopes of plutonium. If the relative abundances of these isotopes are not accurately known, biases in the total Pu assay value will result.

5.6 Typical count times are in the range of 300 to 3600 s.

5.7 Reliable results from the application of this method require training of the personnel who package the scrap and waste prior to measurement and of personnel who perform the measurements. Training guidance is available from ANSI 15.20, Guides C986, C1009, C1068, and C1490.

6. Interferences

6.1 Conditions affecting measurement uncertainty include neutron background, moderators, multiplication, (α, n) rate, absorbers, matrix and nuclear material heterogeneity, and other sources of coincident neutrons. It is usually not possible to detect these problems or to calculate corrections for these

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