



Standard Test Method for Nondestructive Assay of Plutonium by Passive Neutron Multiplicity Counting¹

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1. Scope

1.1 This test method describes the nondestructive assay of plutonium in forms such as metal, oxide, scrap, residue, or waste using passive neutron multiplicity counting. This test method provides rapid results that are usually more accurate than conventional neutron coincidence counting. The method can be applied to a large variety of plutonium items in various geometries in cans, 208-L drums, or 1900-L Standard Waste Boxes. It has been used to assay items whose plutonium content ranges from 1 g to 1000's of g.

1.2 There are several electronics or mathematical approaches available for multiplicity analysis, including the shift register, the Euratom Time Correlation Analyzer, and the List Mode Module, as described briefly in Ref. (1).²

1.3 This test method is primarily intended to address the assay of ²⁴⁰Pu-effective by moments-based multiplicity analysis using shift register electronics (1, 2) and high efficiency neutron counters specifically designed for multiplicity analysis. This test method requires knowledge of the relative abundances of the plutonium isotopes to determine the total plutonium mass.

1.4 This test method may also be applied to modified neutron coincidence counters which were not specifically designed as multiplicity counters, with a corresponding degradation of results.

2. Referenced Documents

2.1 ASTM Standards:

C 859 Terminology Relating to Nuclear Materials³

C 1030 Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectroscopy³

C 1207 Test Method for Nondestructive Assay of Plutonium in Scrap and Waste by Passive Neutron Coincidence Counting³

C 1458 Test Method for Nondestructive Assay of Plutonium, Tritium, and ²⁴¹Am by Calorimetric Assay³

3. Terminology

3.1 Terms shall be defined in accordance with Terminology C 859 except for the following:

3.2 *alpha* (α), *n*—the ratio of the uncorrelated neutron emission rate from (α ,n) reactions to the spontaneous neutron emission rate from a non-multiplying sample (see Ref. (1) for equation).

3.3 *coincidence gate length* (*G*), *n*—the time interval following the detection of a neutron during which additional neutron counts are considered to be in coincidence with the original neutron. In Fig. 1, this is the length of time the (*R* + *A*) and (*A*) gates are set to accept neutron counts.

3.3.1 *gate fractions*, *n*—the fraction of the total coincidence events that occur within the coincidence gate.

3.3.2 *doubles gate fraction* (f_d), *n*—the fraction of the theoretical double coincidences that can be detected within the coincidence gate (see Eq 1).

3.3.3 *triples gate fraction* (f_t), *n*—the fraction of the theoretical triple coincidences that can be detected within the coincidence gate (see Eq 2).

3.4 *die-away time* (τ), *n*—the average mean life-time of the neutron population as measured from the time of emission to the time of detection, escape, or absorption. Die-away time is a function of the counter assembly design and the assay item. Fig. 1 illustrates the decreasing probability of detection as a function of time.

3.5 *doubles* (*D*), *n*—the doubles are equivalent to the real rate and represents the number of double neutron coincidences/s. The doubles may be determined from the coincidence shift register directly or by reduction of the multiplicity (*R* + *A*) and (*A*) histograms (1).

3.6 *efficiency* (ϵ), *n*—this is usually taken to be the absolute neutron detection efficiency, which is calculated from the ratio of the measured neutron count rate to the declared neutron emission rate of a non-multiplying reference source.

3.7 *factorial moment*, *n*—this is a derived quantity representing a summation of the neutron multiplicity distribution weighted by certain factors (see Ref. (1) for equation).

3.8 *item*, *n*—the entire container being measured and its contents.

3.9 *multiplicity distribution*, *n*—this is the distribution of the number of neutrons emitted in a fission event. This number can vary from 0 to 5 or more.

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 standard.

³ *Annual Book of ASTM Standards*, Vol 12.01.