



Standard Test Method for Non-Destructive Assay of Nuclear Material in Waste by Passive and Active Neutron Counting Using a Differential Die-Away System¹

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1. Scope

1.1 This test method covers a system that performs nondestructive assay (NDA) of uranium or plutonium, or both, using the active, differential die-away technique (DDT), and passive neutron coincidence counting. Results from the active and passive measurements are combined to determine the total amount of fissile and spontaneously-fissioning material in drums of scrap or waste as large as 208 L. Corrections are made to the measurements for the effects of neutron moderation and absorption, assuming that the effects are averaged over the volume of the drum and that no significant lumps of nuclear material are present. These systems are most widely used to assay low-level and transuranic waste, but may also be used for the measurement of scrap materials. While this test method is specific to the second-generation Los Alamos National Laboratory (LANL) passive-active neutron assay system, the principle applies to other DDT systems.

1.1.1 In the active mode, the system measures fissile isotopes such as ²³⁵U and ²³⁹Pu. The neutrons from a pulsed, 14-MeV neutron generator are thermalized to induce fission in the assay item. Between generator pulses, the system detects prompt-fission neutrons emitted from the fissile material. The number of detected neutrons between pulses is proportional to the mass of fissile material. This method is called the differential die-away technique.

1.1.2 In the passive mode, the system detects time-coincident neutrons emitted from spontaneously fissioning isotopes. The primary isotopes measured are ²³⁸Pu, ²⁴⁰Pu, and ²⁴²Pu; however, the system may be adapted for use on other spontaneously-fissioning isotopes as well. The number of coincident neutrons detected is proportional to the mass of spontaneously-fissioning material.

1.2 The active mode is used to assay fissile material in the following ranges.

1.2.1 For uranium-bearing items, the DDT can measure the ²³⁵U content in the range from 0.02 to over 100 g. Normally, the assay of items bearing only uranium is performed using matrix-specific calibrations to account for the

effect of the matrix on the active signal.

1.2.2 For plutonium-bearing items, the DDT method measures the ²³⁹Pu content in the range between 0.01 and 20 g.

1.3 The passive mode is capable of assaying spontaneously-fissioning nuclei, over a nominal range from 0.05 to 15 g of ²⁴⁰Pu, or equivalent. The passive mode can also be used to measure large (for example, kg) quantities of ²³⁸U.

1.4 This test method requires knowledge of the relative abundances of the plutonium or uranium isotopes to determine the total plutonium or uranium mass.

1.5 This test method will give biased results when the waste form does not meet the calibration specifications and the measurement assumptions presented in this test method regarding the requirements for a homogeneous matrix, uniform source distribution, and the absence of nuclear material lumps, to the extent that they effect the measurement.

1.6 The complete active and passive assay of a 208 L drum is nominally 10 min or less.

1.7 Improvements to this test method have been reported (**1, 2, 3, 4**).² Discussions of these improvements are not included in this test method.

1.8 *This standard may involve hazardous materials, operations, and equipment. 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 and health practices and determine the applicability of regulatory limitations prior to use. Specific precautionary statements are given in Section 8.*

2. Referenced Documents

2.1 ASTM Standards:

C 859 Terminology Relating to Nuclear Materials³

C 986 Guide for Developing Training Programs in the Nuclear Fuel Cycle³

C 1009 Guide for Establishing a Quality Assurance Program for Analytical Chemistry Laboratories within the Nuclear Industry³

C 1030 Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectrometry³

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 given in parentheses refer to a list of references at the end of the text.

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