



Standard Test Method for Atom Percent Fission in Uranium and Plutonium Fuel (Neodymium-148 Method)¹

This standard is issued under the fixed designation E321; 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 determination of stable fission product ^{148}Nd in irradiated uranium (U) fuel (with initial plutonium (Pu) content from 0 to 50 %) as a measure of fuel burnup (1-3).²

1.2 It is possible to obtain additional information about the uranium and plutonium concentrations and isotopic abundances on the same sample taken for burnup analysis. If this additional information is desired, it can be obtained by precisely measuring the spike and sample volumes and following the instructions in Test Method E267.

1.3 *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.*

2. Referenced Documents

2.1 ASTM Standards:³

D1193 Specification for Reagent Water

E180 Practice for Determining the Precision of ASTM Methods for Analysis and Testing of Industrial and Specialty Chemicals (Withdrawn 2009)⁴

E244 Test Method for Atom Percent Fission in Uranium and Plutonium Fuel (Mass Spectrometric Method) (Withdrawn 2001)⁴

E267 Test Method for Uranium and Plutonium Concentrations and Isotopic Abundances

¹ This test method is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.05 on Methods of Test.

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² The boldface numbers in parentheses refer to the list of references appended to 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.

3. Summary of Test Method

3.1 Fission product neodymium (Nd) is chemically separated from irradiated fuel and determined by isotopic dilution mass spectrometry. Enriched ^{150}Nd is selected as the Nd isotope diluent, and the mass-142 position is used to monitor for natural Nd contamination. The two rare earths immediately adjacent to Nd do not interfere. Interference from other rare earths, such as natural or fission product ^{142}Ce or natural ^{148}Sm and ^{150}Sm is avoided by removing them in the chemical purification (4 and 5).

3.2 After addition of a blended ^{150}Nd , ^{233}U , and ^{242}Pu spike to the sample, the Nd, U, and Pu fractions are separated from each other by ion exchange. Each fraction is further purified for mass analysis. Two alternative separation procedures are provided.

3.3 The gross alpha, beta, and gamma decontamination factors are in excess of 10^3 and are normally limited to that value by traces of ^{242}Cm , ^{147}Pm , and ^{241}Am , respectively (and sometimes ^{106}Ru), none of which interferes in the analysis. The 70 ng ^{148}Nd minimum sample size recommended in the procedure is large enough to exceed by 100-fold a typical natural Nd blank of 0.7 ± 0.7 ng ^{148}Nd (for which a correction is made) without exceeding radiation dose rates of 20 $\mu\text{Sv/h}$ (20 mR/h) at 1 m. Since a constant amount of fission products is taken for each analysis, the radiation dose from each sample is similar for all burnup values and depends principally upon cooling time. Gamma dose rates vary from 200 $\mu\text{Sv/h}$ (20 mR/h) at 1 m for 60-day cooled fuel to 20 $\mu\text{Sv/h}$ (2 mR/h) at 1 m for 1-year cooled fuel. Beta dose rates are an order of magnitude greater, but can be shielded out with a 1/2-in. (12.7-mm) thick plastic sheet. By use of such simple local shielding, dilute solutions of irradiated nuclear fuel dissolver solutions can be analyzed for burnup without an elaborate shielded analytical facility. The decontaminated Nd fraction is mounted on a rhenium (Re) filament for mass analysis. Samples from 20 ng to 20 μg run well in the mass spectrometer with both NdO^+ and Nd^+ ion beams present. The metal ion is enhanced by deposition of carbonaceous material on the filament as oxygen getter. (Double and triple filament designs do not require an oxygen getter.)