Designation: E 692 – 00

# Standard Test Method for Determining the Content of Cesium-137 in Irradiated Nuclear Fuels by High-Resolution Gamma-Ray Spectral Analysis[1]

This standard is issued under the fixed designation E 692; 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 the number of atoms of $^{137}Cs$ in aqueous solutions of irradiated uranium and plutonium nuclear fuel. When combined with a method for determining the initial number of fissile atoms in the fuel, the results of this analysis allows atom percent fission (burnup) to be calculated **(1)**.[2] The determination of atom percent fission, uranium and plutonium concentrations, and isotopic abundances are covered in Test Methods E 267 and E 321.

1.2 $^{137}Cs$ is not suitable as a fission monitor for samples that may have lost cesium during reactor operation. For example, a large temperature gradient enhances $^{137}Cs$ migration from the fuel region to cooler regions such as the radial fuel-clad gap, or, to a lesser extent, towards the axial fuel end.

1.3 A nonuniform $^{137}Cs$ distribution should alert the analyst to the potential loss of the fission product nuclide. The $^{137}Cs$ distribution may be ascertained by an axial gamma-ray scan of the fuel element to be assayed. In a mixed-oxide fuel, comparison of the $^{137}Cs$ distribution with the distribution of nonmigrating fission-product nuclides such as $^{95}Zr$ or $^{144}Ce$ would indicate the relative degree of $^{137}Cs$ migration.

1.4 *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:*

E 170 Terminology Relating to Radiation Measurements and Dosimetry[3]

E 181 General Methods for Detector Calibration and Analysis of Radionuclides[3]

E 219 Test Method for Atom Percent Fission in Uranium Fuel (Radiochemical Method)[3]

E 267 Test Method for Uranium and Plutonium Concentrations and Isotopic Abundances[3]

E 321 Test Method for Atom Percent Fission in Uranium And Plutonium Fuel (Neodymium-148 Method)[3]

## 3. Summary of Test Method

3.1 $^{137}Cs$ is assayed by measuring the 662[4] keV gamma-ray emission rate from the isomeric transition of its metastable 2.6[5] min $^{137m}Ba$ daughter, using a high-resolution germanium detector and multichannel pulse-height analyzer. Refer to Test Methods E 181.

3.2 The number of atoms of $^{137}Cs$ in a sample is computed from the measured net gamma-ray count rate relative to the measured net gamma-ray count rate from a standard $^{137}Cs$ solution.

## 4. Significance and Use

4.1 This test method uses a high-resolution gamma-ray spectrometer as a basis for measuring the gamma-ray emission rate of $^{137}Cs$-$^{137m}Ba$ in a dilute nitric acid solution containing 10 mg/L of cesium carrier. No chemical separation of the cesium from the dissolved-fuel solution is required. The principal steps consist of diluting a weighed aliquot of the dissolved-fuel solution with a known mass of 1 *M* nitric acid ($HNO_3$) and measuring the 662 keV gamma-ray count rate from the sample, then measuring the 662 keV gamma-ray count rate from a standard source that has the same physical form and counting geometry as the sample.

4.2 The amount of fuel sample required for the analysis is small. For a sample containing 1 mg of fuel irradiated to one atom percent fission, a net count rate of approximately $10^3$ counts per second will be observed for a counting geometry that yields a full-energy peak efficiency fraction of $1 \times 10^{-3}$. The advantage of this small amount of sample is that the concentration of fuel material can be kept at levels well below 1 g/L, which results in negligible self-absorption in the sample aliquot and a small radiation hazard to the analyst.

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[1] This test method is under the jurisdiction of ASTM Committee E-10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.05 on Nuclear Radiation Metrology.

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

[3] *Annual Book of ASTM Standards*, Vol 12.02.

[4] The energy of the gamma ray is more precisely given in Reference **(2)** as 661.657 keV. For simplicity, all citations of this energy in this standard will be given as 662 keV.

[5] The half-life of this state is more precisely given in Reference **(3)** as 2.552 min. For simplicity, all citations of this half-life listed in this standard will be given as 2.6 min.