Designation: E 219 – 80 (Reapproved 1995)

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Atom Percent Fission in Uranium Fuel (Radiochemical Method)[1]

This standard is issued under the fixed designation E 219; 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.

INTRODUCTION

Uranium atom percent fission in a nuclear fuel is frequently determined by measurement of a fission product to uranium (U) ratio in the irradiated U fuel **(1-7)**.[2]

Among radioactive fission products, cesium-137 (^{137}Cs) was among the first used for estimation of fuel burnup. It has a reasonably well-known decay scheme, a low capture cross section, a long half-life, a very low yield from ^{136}Cs by neutron capture, and a high-fission yield which is fairly accurately known and not greatly affected by the type of fissionable material or the neutron spectrum. Disadvantages are found in the volatility of Cs and its precursors at fuel operating temperature (which gives rise to migration within the fuel), interference in counting from ^{134}Cs and ^{136}Cs, some uncertainty in physical constants, and required knowledge of irradiation history.

Although this test method is of historical interest, test methods based on mass spectrometry are preferred as a basis for fuel-warranty settlements because they are more accurate.

1. Scope

1.1 This test method covers the determination of U atom percent fission that has occurred in U fuel from analysis of the ^{137}Cs to U ratio after irradiation.

1.2 The test method is applicable to high-density, clad U fuel (metal, alloy, ceramic compound) in which no separation of Cs and U has occurred.

1.3 The test method is best applied to fuels that have aged several months since irradiation. In such material, the 13-day ^{136}Cs activity is reduced to a small amount through decay **(3).**

1.4 The test method should be restricted to low-exposure samples in which the activity of ^{134}Cs is less than that of ^{137}Cs. Cesium-134 is produced by neutron capture on fission product ^{133}Cs and grows at a rate proportional to the square of the exposure. This capture process limits the test method to samples exposed to less than 0.6×10^{1} nvt. This exposure corresponds to burnups of 12 gigawatt days per metric ton of uranium (GWD/MTU) in Yankee Core I, and 5 GWD/MTU in Dresden Core I. Samples with higher exposures may require the use of a lithium-drifted germanium detector to obtain adequate resolution between ^{134}Cs and ^{137}Cs. The use of such a detector will extend the range of this test method by a factor of about 2. Mass spectrometric isotope dilution analysis of ^{137}Cs with ^{133}Cs as the isotopic diluent would also overcome ^{134}Cs interference.

1.5 The test method is best applied to fuels where overheating has not caused center melting or grain growth, since high temperatures cause ^{137}Cs to distill from the fuel and deposit on cooler regions, such as the cladding. Therefore, cladding should be leached in the dissolver solution or dissolved with the uranium to maintain the true ratio of fission product ^{137}Cs to U. Alternatively, burnup in a maximum flux region of a fuel element can be obtained from analyzing a low-flux region of the element. The burnup measured in this position can be related to the burnup in the peak-flux position by a gamma scan of the element. A gamma scan usually represents the distribution of zirconium-95 and is a reflection of the fission distribution integrated over only the most recent months. This is not always a serious disadvantage, since such studies may be made after short irradiations.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[3]

E 180 Practice for Determining the Precision of ASTM

[1] This test method is under the jurisdiction of ASTM Committee C-26 on Nuclear Fuel Cycle.

Current edition approved Sept. 26, 1980. Published November 1980. Originally published as E 219 – 63 T. Last previous edition E 219 – 69 (1974).

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

[3] *Annual Book of ASTM Standards*, Vol 14.02.