



Standard Test Method for Measuring Reaction Rates by Analysis of Barium-140 From Fission Dosimeters¹

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1. Scope

1.1 This test method describes two procedures for the measurement of reaction rates by determining the amount of the fission product ^{140}Ba produced by the non-threshold reactions ^{235}U (n, f), ^{241}Am (n, f), and ^{239}Pu (n, f), and by the threshold reactions ^{238}U (n, f), ^{237}Np (n, f), and ^{232}Th (n, f).

1.2 These reactions produce many fission products, among which is ^{140}Ba , having a half-life of 12.752 days. ^{140}Ba emits gamma rays of several energies; however, these are not easily detected in the presence of other fission products. Competing activity from other fission products requires that a chemical separation be employed or that the ^{140}Ba activity be determined indirectly by counting its daughter product ^{140}La . This test method describes both procedure (a), the nondestructive determination of ^{140}Ba by the direct counting of ^{140}La several days after irradiation, and procedure (b), the chemical separation of ^{140}Ba and the subsequent counting of ^{140}Ba or its daughter ^{140}La .

1.3 With suitable techniques, fission neutron fluence rates can be measured in the range from $10^7 \text{ n (neutrons)} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$ to approximately $10^{15} \text{ n} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$.

1.4 The measurement of time-integrated reaction rates with fission dosimeters by ^{140}Ba analysis is limited by the half-life of ^{140}Ba to irradiation times up to about six weeks.

1.5 The values stated in SI units are to be regarded as standard.

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:

C 697 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Plutonium

Dioxide Powders and Pellets²

D 1193 Specification for Reagent Water³

E 170 Terminology Relating to Radiation Measurements and Dosimetry⁴

E 181 Test Methods for Detector Calibration and Analysis of Radionuclides⁴

E 261 Practice for Determining Neutron Fluence Rate, Fluence, and Spectra by Radioactivation Techniques⁴

E 704 Test Method for Measuring Reaction Rates by Radioactivation of Uranium-238⁴

E 705 Test Method for Measuring Reaction Rates By Radioactivation of Neptunium-237⁴

E 844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E706 (IIC)⁴

E 944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, (IIA)⁴

E 1005 Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance, E706 (IIA)⁴

E 1018 Guide for Application of ASTM Evaluated Cross Section Data File, Matrix E 706 (IIB)⁴

3. Terminology

3.1 Definitions:

3.1.1 Refer to Terminology E 170.

4. Summary of Test Method

4.1 For nondestructive analysis, the fission dosimeter is allowed to cool for five days or more. The 1.596-MeV gamma energy peak of ^{140}La , which is the daughter product of the ^{140}Ba , is then counted. This information, combined with the decay constants for the La and the Ba, and the fission yield of the ^{140}Ba gives the reaction fission rate. When the proper cross section is used with the reaction rate, the equivalent fission fluence rate can be determined.

4.2 For destructive analysis, the fission product ^{140}Ba is separated from the irradiated fission dosimeter. The activity of the ^{140}Ba is determined by counting the 0.537 MeV gamma energy peak. This information is then used as in 4.1 to give the reaction rate or the equivalent fission fluence rate.

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

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² Annual Book of ASTM Standards, Vol 12.01.

³ Annual Book of ASTM Standards, Vol 11.01.

⁴ Annual Book of ASTM Standards, Vol 12.02.