



Designation: E523 – 16

Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Copper¹

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1. Scope

1.1 This test method covers procedures for measuring reaction rates by the activation reaction $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$. The cross section for ^{60}Co produced in this reaction increases rapidly with neutrons having energies greater than about 4.5 MeV. ^{60}Co decays with a half-life of 1925.27 days (± 0.29 days)(1)² and emits two gamma rays having energies of 1.1732278 and 1.332492 MeV(1). The isotopic content of natural copper is 69.17 % ^{63}Cu and 30.83 % ^{65}Cu (2). The neutron reaction, $^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$, produces a radioactive product that emits gamma rays (1.34577 MeV (E1005)) which might interfere with the counting of the ^{60}Co gamma rays.

1.2 With suitable techniques, fission-neutron fluence rates above $10^9 \text{ cm}^{-2}\cdot\text{s}^{-1}$ can be determined. The $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$ reaction can be used to determine fast-neutron fluences for irradiation times up to about 15 years, provided that the analysis methods described in Practice E261 are followed. If dosimeters are analyzed after irradiation periods longer than 15 years, the information inferred about the fluence during irradiation periods more than 15 years before the end of the irradiation should not be relied upon without supporting data from dosimeters withdrawn earlier.

1.3 Detailed procedures for other fast-neutron detectors are referenced in Practice E261.

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.*

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 The boldface numbers in parentheses refer to a list of references at the end of this standard.

2. Referenced Documents

2.1 ASTM Standards:³

- E170 Terminology Relating to Radiation Measurements and Dosimetry
- E181 Test Methods for Detector Calibration and Analysis of Radionuclides
- E261 Practice for Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques
- E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706 (IIC)
- E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 (IIA)
- E1005 Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance
- E1018 Guide for Application of ASTM Evaluated Cross Section Data File, Matrix E706 (IIB)

3. Terminology

3.1 Definitions:

- 3.1.1 Refer to Terminology E170.

4. Summary of Test Method

4.1 High-purity copper (<1 ppm cobalt) is irradiated in a neutron field, thereby producing radioactive ^{60}Co from the $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$ reaction.

4.2 The gamma rays emitted by the radioactive decay of ^{60}Co are counted in accordance with Test Methods E181 and the reaction rate, as defined by Practice E261, is calculated from the decay rate and irradiation conditions.

4.3 The neutron fluence rate above about 4.5 MeV can then be calculated from the spectral-weighted neutron activation cross section as defined by Practice E261.

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.