



Designation: E 523 – 92 (Reapproved 1996)

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

This standard is issued under the fixed designation E 523; 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 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 5 MeV. ^{60}Co decays with a half-life of 5.271 years² and emits two gamma rays having energies of 1.1732 and 1.3325 MeV². The isotopic content of natural copper is 69.17 % ^{63}Cu and 30.83 % ^{65}Cu .³ The neutron reaction, $^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$, produces a radioactive product that emits gamma rays 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 (for longer irradiations, see Practice E 261).

1.3 Detailed procedures for other fast-neutron detectors are referenced in Practice E 261.

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 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 262 Test Method for Determining Thermal Neutron Reaction and Fluence Rates by Radioactivation Techniques⁴
- 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 (IIIA)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 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 E 181 and the reaction rate, as defined by Practice E 261, is calculated from the decay rate and irradiation conditions.

4.3 The neutron fluence rate above about 5 MeV can then be calculated from the spectral-weighted neutron activation cross section as defined by Practice E 261.

5. Significance and Use

5.1 Refer to Guide E 844 for the selection, irradiation, and quality control of neutron dosimeters.

5.2 Refer to Practice E 261 for a general discussion of the measurement of fast neutron fluence rate with threshold detectors. The general shape of the $^{63}\text{Cu}(n,\alpha)^{60}\text{Co}$ cross section is also shown in Fig. 1.⁵ This figure is for illustrative purposes only to indicate the range of response of the $^{63}\text{Cu}(n,\alpha)$ reaction. Refer to Guide E 1018 for descriptions of recommended tabulated dosimetry cross sections.

5.3 The chief advantages of copper for measuring fast-neutron fluence rate are that it has good strength, is easily fabricated, has excellent corrosion resistance, has a melting temperature of 1083°C, and can be obtained pure. The half-life of ^{60}Co is long and its decay scheme is simple and well known.

5.4 The disadvantages of copper for measuring fast neutron

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.

Current edition approved Oct. 15, 1992. Published May 1993. Originally published as E 523 – 76. Last previous edition E 523 – 87.

² *Nuclear Data Sheets for A = 60*, National Nuclear Data Center, Vol 48, June 1986, p. 251.

³ "Isotopic Compositions of the Elements 1983," International Union of Pure and Applied Chemistry, Vol 56, Pergamon Press, 1984.

⁴ *Annual Book of ASTM Standards*, Vol 12.02.

⁵ "ENDF-201, ENDF/B-VI Summary Documentation," edited by P.F. Rose, Brookhaven National Laboratory Report BNL-NCS-1741, 4th ed., October 1991.