



Designation: E720 – 16

Standard Guide for Selection and Use of Neutron Sensors for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics¹

This standard is issued under the fixed designation E720; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This guide covers the selection and use of neutron-activation detector materials to be employed in neutron spectra adjustment techniques used for radiation-hardness testing of electronic semiconductor devices. Sensors are described that have been used at many radiation hardness-testing facilities, and comments are offered in table footnotes concerning the appropriateness of each reaction as judged by its cross-section accuracy, ease of use as a sensor, and by past successful application. This guide also discusses the fluence-uniformity, neutron self-shielding, and fluence-depression corrections that need to be considered in choosing the sensor thickness, the sensor covers, and the sensor locations. These considerations are relevant for the determination of neutron spectra from assemblies such as TRIGA- and Godiva-type reactors and from Californium irradiators. This guide may also be applicable to other broad energy distribution sources up to 20 MeV.

NOTE 1—For definitions on terminology used in this guide, see Terminology E170.

1.2 This guide also covers the measurement of the gamma-ray or beta-ray emission rates from the activation foils and other sensors as well as the calculation of the absolute specific activities of these foils. The principal measurement technique is high-resolution gamma-ray spectrometry. The activities are used in the determination of the energy-fluence spectrum of the neutron source. See Guide E721.

1.3 Details of measurement and analysis are covered as follows:

1.3.1 Corrections involved in measuring the sensor activities include those for finite sensor size and thickness in the calibration of the gamma-ray detector, for pulse-height analyzer deadtime and pulse-pileup losses, and for background radioactivity.

¹ This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.07 on Radiation Dosimetry for Radiation Effects on Materials and Devices.

Current edition approved Dec. 1, 2016. Published February 2017. Originally approved in 1980. Last previous edition approved in 2011 as E720 – 11. DOI: 10.1520/E0720-16.

1.3.2 The primary method for detector calibration that uses secondary standard gamma-ray emitting sources is considered in this guide and in Test Methods E181. In addition, an alternative method in which the sensors are activated in the known spectrum of a benchmark neutron field is discussed in Guide E1018.

1.3.3 A data analysis method is presented which accounts for the following: detector efficiency; background subtraction; irradiation, waiting, and counting times; fission yields and gamma-ray branching ratios; and self-absorption of gamma rays and neutrons in the sensors.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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 General considerations of neutron-activation detectors discussed in Practice E261, Test Method E262, and Guides E721 and E844 are applicable to this guide. Background information for applying this guide are given in these and other relevant standards as follows:

2.2 ASTM Standards:²

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

² 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.