



Standard Guide for Determining Neutron Energy Spectra from Neutron Sensors for Radiation-Hardness Testing of Electronics¹

This standard is issued under the fixed designation E 721; 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 Department of Defense.

1. Scope

1.1 This guide covers procedures for determining the energy-differential fluence spectra of neutrons used in radiation-hardness testing of electronic semiconductor devices. The types of neutron sources specifically covered by this guide are fission or degraded energy fission sources used in either a steady-state or pulse mode.

1.2 This guide provides guidance and criteria that can be applied during the process of choosing the spectrum adjustment methodology that is best suited to the available data and relevant for the environment being investigated.

1.3 This guide is to be used in conjunction with Guide E 720 to characterize neutron spectra.

NOTE 1—Although Guide E 720 only discusses activation foil sensors, any energy-dependent neutron-responding sensor for which a response function is known may be used (1).²

NOTE 2—For terminology used in this guide, see Terminology E 170.

1.4 The values stated in SI units are to be regarded as the 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 ASTM Standards:

E 170 Terminology Relating to Radiation Measurements and Dosimetry³

E 261 Practice for Determining Neutron Fluence Rate, Fluence, and Spectra by Radioactivation Techniques³

E 262 Test Method for Determining Thermal Neutron Reaction and Fluence Rates by Radioactivation Techniques³

E 263 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron³

E 264 Test Method for Determining Fast-Neutron Reaction Rates by Radioactivation of Nickel³

E 265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32³

E 266 Test Method for Determining Fast-Neutron Reaction Rates by Radioactivation of Aluminum³

E 393 Test Method for Measuring Reaction Rates by Analysis of Barium-140 from Fission Dosimeters³

E 704 Test Method for Measuring Reaction Rates by Radioactivation of Uranium-238³

E 705 Test Method for Measuring Reaction Rates by Radioactivation of Neptunium-237³

E 720 Guide for Selection and Use of Neutron-Activation Foils for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics³

E 722 Practice for Characterizing Neutron Energy Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation-Hardness Testing of Electronics³

E 844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E706 (IIC)³

E 944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, (IIA)³

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

E 1297 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Niobium³

E 1855 Test Method for Use of 2N2222A Silicon Bipolar Transistors as Neutron Spectrum Sensors and Displacements Damage Monitors³

3. Terminology

3.1 **Definitions:** The following list defines some of the special terms used in this guide:

3.1.1 **effect**—the characteristic which changes in the sensor when it is subjected to the neutron irradiation. The effect may be the reactions in an activation foil.

3.1.2 **response**—the magnitude of the effect. It can be the measured value or that calculated by integrating the response function over the neutron fluence spectrum. The response is an integral parameter. Mathematically, the response, $R = \sum_i R_i$, where R_i is the response in each differential energy region at E_i of width ΔE_i .

3.1.3 **response function**—the set of values of R_i in each

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² The boldface numbers in parentheses refer to the list of references at the end of this guide.

³ *Annual Book of ASTM Standards*, Vol. 12.02.