



Standard Practice for Characterizing Neutron Energy Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation-Hardness Testing of Electronics¹

This standard is issued under the fixed designation E 722; 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 practice covers procedures for characterizing a neutron fluence from a source in terms of an equivalent monoenergetic neutron fluence. It is applicable to neutron effects testing, to the development of test specifications, and to the characterization of neutron test environments. The sources may have a broad neutron-energy spectrum, or may be monoenergetic neutron sources with energies up to 20 MeV. The relevant equivalence is in terms of a specified effect on certain physical properties of materials upon which the source spectrum is incident. In order to achieve this, knowledge of the effects of neutrons as a function of energy on the specific property of the material of interest is required. Sharp variations in the effects with neutron energy may limit the usefulness of this practice in the case of mono-energetic sources.

1.2 This practice is presented in a manner to be of general application to a variety of materials and sources. Correlation between displacements **(1-3)²** caused by different particles (electrons, neutrons, protons, and heavy ions) is beyond the scope of this practice. In radiation-hardness testing of electronic semiconductor devices, specific materials of interest include silicon and gallium arsenide, and the neutron sources generally are test and research reactors and californium-252 irradiators.

1.3 The technique involved relies on the following factors: (1) a detailed determination of the energy spectrum of the neutron source, and (2) a knowledge of the degradation (damage) effects of neutrons as a function of energy on specific material properties.

1.4 The detailed determination of the neutron energy spectrum referred to in 1.3 need not be performed afresh for each test exposure, provided the exposure conditions are repeatable. When the spectrum determination is not repeated, a neutron fluence monitor shall be used for each test exposure.

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

E 693 Practice for Characterizing Neutron Exposures in Ferritic Steels in Terms of Displacement per Atom (DPA)³

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

E 721 Test Method for Determining Neutron Energy Spectra with Neutron Activation Foils for Radiation-Hardness Testing of Electronics³

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

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

2.2 International Commission on Radiation Units and Measurements (ICRU) Reports:

ICRU Report 13—Neutron Fluence, Neutron Spectra, and Kerma⁴

ICRU Report 26—Neutron Dosimetry for Biology and Medicine⁴

ICRU Report 33—Radiation Quantities and Units⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *displacement damage function*—($F_{D,mat}$) an energy-dependent parameter proportional to the quotient of the observable displacement damage per target atom and the neutron fluence.

3.1.1.1 *Discussion*—Observable changes in a material's

¹ This practice 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.

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

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

⁴ Available from International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Bethesda, MD 20814.