



Standard Practice for Ensuring Test Consistency in Neutron-Induced Displacement Damage of Electronic Parts¹

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1. Scope

1.1 Nuclear reactors are used to provide neutron and gamma-ray radiation environments for the testing of electronic piece parts, components, and systems. In these applications, reactor environments are most commonly used to determine the degradation in performance of the electronics caused by neutron-induced displacement damage. This practice sets forth requirements to ensure consistency in neutron-induced displacement damage testing of silicon and gallium arsenide electronic piece parts. This requires controls on facility, dosimetry, tester, and communications processes that affect the accuracy and reproducibility of these tests. It provides background information on the technical basis for the requirements and additional recommendations on neutron testing. In addition to neutrons, reactors are used to provide gamma-ray pulses of intensities and durations that are not achievable elsewhere. This practice also provides background information and recommendations on gamma-ray testing of electronics using nuclear reactors.

1.2 Methods are presented for ensuring and validating consistency in neutron displacement damage testing of electronic parts such as integrated circuits, transistors, and diodes. The issues identified and the controls set forth in this practice address the characterization and suitability of the radiation environments. They generally apply to reactor and 14-MeV neutron sources when used for displacement damage testing, and apply to ²⁵²Cf testing when this source is used for this application. Facility and environment characteristics that introduce complications or problems are identified, and recommendations are offered as to how problems can be recognized and minimized or solved. This practice may be used by facility users, test personnel, facility operators, and independent process validators to determine the suitability of a specific environment within a facility and of the testing process as a whole, with the exception of the electrical measurements, which are addressed in other standards. Additional information on conducting irradiations can be found in Practices E 798 and F 1190. This practice also may be of use to test sponsors (that is, organizations that establish test specifications or otherwise

have a vested interest in the performance of electronics in neutron environments).

1.3 Methods for evaluation and control of undesired contributors to damage are discussed in this practice, and references to relevant ASTM standards and technical reports are provided. Processes and methods used to arrive at the appropriate test environments and specification levels for electronics systems are beyond the scope of this practice; however, the process for determining the 1-MeV equivalent displacement specifications from operational environment neutron spectra should employ the methods and parameters described herein. Some important considerations are addressed in Appendix X1.

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 The ASTM standards listed below present methods for ensuring proper determination of neutron spectra and fluences, gamma-ray doses, and damage in silicon and gallium arsenide devices. The proper use of these standards is the responsibility of the radiation metrology or dosimetry organization that is often closely affiliated with facility operations. The references listed in each standard are also relevant to all participants as background material for testing consistency.

2.2 ASTM Standards:

- E 170 Terminology Relating to Radiation Measurements and Dosimetry²
- E 181 Test Methods for Detector Calibration and Analysis of Radionuclides²
- E 261 Practice for Determining Neutron Fluence Rate, Fluence, and Spectra by Radioactivation Techniques²
- E 262 Test Method for Determining Thermal Neutron Reaction and Fluence Rates by Radioactivation Techniques²
- E 263 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron²
- E 264 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Nickel²
- E 265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32²

¹ This practice is under the jurisdiction of ASTM Committee E-10 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 Annual Book of ASTM Standards, Vol 12.02.