



Standard Test Method for Application of Ionization Chambers to Assess the Low Energy Gamma Component of Cobalt-60 Irradiators Used in Radiation-Hardness Testing of Silicon Electronic Devices¹

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1. Scope

1.1 Low energy components in the photon energy spectrum of Co-60 irradiators lead to absorbed dose enhancement effects in the radiation-hardness testing of silicon electronic devices. These low energy components may lead to errors in determining the absorbed dose in a specific device under test. This method covers procedures for the use of a specialized ionization chamber to determine a figure of merit for the relative importance of such effects. It also gives the design and instructions for assembling this chamber.

1.2 This method is applicable to measurements in Co-60 radiation fields where the range of exposure rates is 7×10^{-6} to 3×10^{-2} C kg⁻¹ s⁻¹ (approximately 100 R/h to 100 R/s). For guidance in applying this method to radiation fields where the exposure rate is >100 R/s, see Appendix X1.

NOTE 1—See Terminology E 170 for definition of exposure and its units.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 Dosimetry²

E 668 Practice for Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices²

E 1249 Practice for Minimizing Dosimetry Errors in Radiation Hardness Testing of Silicon Electronic Devices Using Co-60 Sources²

3. Terminology

3.1 *absorbed dose, D*—quotient of $d\bar{\epsilon}$ by dm , where $d\bar{\epsilon}$ is the mean energy imparted by ionizing radiation to the matter in a volume element and dm is the mass of matter in that volume element.

$$D = d\bar{\epsilon}/dm \quad (1)$$

3.2 *absorbed dose enhancement factor*—ratio of the absorbed dose at a point in a material of interest to the equilibrium absorbed dose in that same material.

3.3 *average absorbed dose*—mass-weighted mean of the absorbed dose over a region of interest.

3.4 *average absorbed dose enhancement factor*—ratio of the average absorbed dose in a region of interest to the equilibrium absorbed dose.

3.5 *dosimeter*—any device used to determine the equilibrium absorbed dose in the material and at the irradiation position of interest. Examples of such devices include thermoluminescence dosimeters (TLDs), liquid chemical dosimeters, and radiochromic dye films. (See Practice E 668, for a discussion of TLDs.)

3.6 *equilibrium absorbed dose*—absorbed dose at some incremental volume within the material in which the condition of electron equilibrium (the energies, number, and direction of charged particles induced by the radiation are constant throughout the volume) exists. (See Terminology E 170.)

4. Significance and Use

4.1 Although Co-60 nuclei only emit monoenergetic gamma rays at 1.17 and 1.33 MeV, the finite thickness of sources, and encapsulation materials and other surrounding structures that are inevitably present in irradiators can contribute a substantial amount of low-energy gamma radiation, principally by Compton scattering (**1, 2**).³ In radiation-hardness testing of electronic devices this low-energy photon component of the gamma spectrum can introduce significant dosimetry errors for a device under test since the equilibrium absorbed dose as measured by a dosimeter can be quite different from the absorbed dose deposited in the device under test because of absorbed dose enhancement effects (**3, 4**). Absorbed dose

¹ This method 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 Annual Book of ASTM Standards, Vol 12.02.

³ The boldface numbers in parentheses refer to the list of references appended to this test method.