



Standard Guide for Selection and Use of Mathematical Methods for Calculating Absorbed Dose in Radiation Processing Applications¹

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1. Scope

1.1 This guide describes different mathematical methods that may be used to calculate absorbed dose and criteria for their selection. Absorbed dose calculations determine the effectiveness of the radiation process, estimate the absorbed-dose distribution in product, or supplement and/or complement dosimetry measurements.

1.2 Radiation processing is an evolving field and annotated examples are provided in Annex A4 to illustrate the applications where mathematical methods have been successfully applied. While not limited by the applications cited in these examples, applications specific to neutron transport, radiation therapy and shielding design are not addressed in this document.

1.3 This guide covers the calculation of radiation transport of electrons and photons in the energy range of 0.1 to 25 MeV.

1.4 The mathematical methods described include Monte Carlo, point kernel, discrete ordinate, semi-empirical and empirical methods.

1.5 General purpose software packages are available for the calculation of the transport of charged and/or neutral particles and photons from various types of sources of ionizing radiation. This standard is limited to the use of these software packages or other mathematical methods for the determination of spatial dose distributions for photons emitted following the decay of ¹³⁷Cs or ⁶⁰Co, energetic electrons from particle accelerators, or bremsstrahlung generated by electron accelerators.

1.6 This guide assists the user in determining if mathematical methods are a useful tool. This guide may assist the user in selecting an appropriate method for calculating absorbed dose.

NOTE 1—The user is urged to apply these predictive techniques while being aware of the need for experience and also the inherent limitations of both the method and the available software. Information pertaining to availability and updates to codes for modeling radiation transport, courses, workshops and meetings can be found in Annex A1. For a basic understanding of radiation physics and a brief overview of method selection, refer to Annex A3.

1.7 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 requirements prior to use.

2. Referenced Documents

2.1 ASTM Standards:

- E 170 Terminology Relating to Radiation Measurements and Dosimetry²
- E 482 Guide for Application of Neutron Transport Methods for Reactor Vessel Surveillance²
- E 666 Practice for Calculating Absorbed Dose from Gamma or X Radiation²

2.2 ISO/ASTM Standards:

- 51204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing²
- 51275 Practice for Use of a Radiochromic Film Dosimetry System²
- 51400 Practice for Characterization and Performance of a High-Dose Radiation Dosimetry Calibration Laboratory²
- 51431 Practice for Dosimetry in Electron and Bremsstrahlung Irradiation Facilities for Food Processing²
- 51608 Practice for Dosimetry in an X-ray (Bremsstrahlung) Facility for Radiation Processing²
- 51649 Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies between 300 keV and 25 MeV²
- 51702 Practice for Dosimetry in a Gamma Irradiation Facility for Radiation Processing²
- 51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing²
- 51818 Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies between 80 and 300 keV²
- 51939 Practice for Blood Irradiation Dosimetry²

2.3 International Commission on Radiation Units and Measurements Reports:³

- ICRU Report 14, Radiation Dosimetry: X-Rays and Gamma

¹ This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.01 on Dosimetry for Radiation Processing.

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² Annual Book of ASTM Standards, Vol 12.02.

³ Available from International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Suite 800, Bethesda, MD 20814 USA.