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Practice for dosimetry in an electron beam facility for radiation processing at energies between 80 KeV and 300 KeV

Pratique de la dosimétrie dans une installiation de traitement par irradiation utilisant un faisceau d'électrons d'énergies comprises entre 80 keV et 300 keV

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

ASTM International is one of the world's largest voluntary standards development organizations with global participation from affected stakeholders. ASTM technical committees follow rigorous due process balloting procedures.

A pilot project between ISO and ASTM International has been formed to develop and maintain a group of ISO/ASTM radiation processing dosimetry standards. Under this pilot project, ASTM Subcommittee E10.01, Dosimetry for Radiation Processing, is responsible for the development and maintenance of these dosimetry standards with unrestricted participation and input from appropriate ISO member bodies.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. Neither ISO nor ASTM International shall be held responsible for identifying any or all such patent rights.

International Standard ISO/ASTM 51818 was developed by ASTM Committee E10, Nuclear Technology and Applications, through Subcommittee E10.01, and by Technical Committee ISO/TC 85, Nuclear Energy.

Annex A1 of this International Standard is for information only.

Standard Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies Between 80 and 300 keV[1]

This standard is issued under the fixed designation ISO/ASTM 51818; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision.

1. Scope

1.1 This practice covers dosimetric procedures to be followed to determine the performance of low energy (300 keV or less) single-gap electron beam radiation processing facilities. Other practices and procedures related to facility characterization, product qualification, and routine processing are also discussed.

1.2 The electron energy range covered in this practice is from 80 keV to 300 keV. Such electron beams can be generated by single-gap self-contained thermal filament or plasma source accelerators.

1.3 *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 Dosimetry[2]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[3]

E 456 Terminology Relating to Quality and Statistics[3]

2.2 *ISO/ASTM Standards:*

51261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing[2]

51275 Practice for Use of a Radiochromic Film Dosimetry System[2]

51276 Practice for Use of a Polymethylmethacrylate Dosimetry System[2]

51607 Practice for Use of the Alanine-EPR Dosimetry System[2]

51650 Practice for Use of a Cellulose Acetate Dosimetry System[2]

51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing[2]

2.3 *International Commission on Radiation Units and Measurements (ICRU) Reports:*[4]

ICRU Report 37 Stopping Powers for Electrons and Positrons

ICRU Report 60 Radiation Quantities and Units

2.4 *Methods for Calculating Absorbed Dose and Dose Distribution:*[5]

ZTRAN Monte Carlo Code

Integrated Tiger Series (ITS) Monte Carlo Codes

Energy Deposition in Multiple Layers (EDMULT) Electron Gamma Shower (EGS43) Monte Carlo Codes

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of terms used in this practice may be found in ASTM Terminology E 170 and ICRU Report 60.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *absorbed dose (D)*—quantity of ionizing radiation energy imparted per unit mass of a specified material. The SI unit of absorbed dose is the gray (Gy), where 1 gray is equivalent to the absorption of 1 joule per kilogram of the specified material (1 Gy = 1 J/kg). The mathematical relationship is the quotient of $d\bar{\epsilon}$ by dm, where $d\bar{\epsilon}$ is the mean incremental energy imparted by ionizing radiation to matter of incremental mass dm (see ICRU Report 33).

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

3.2.1.1 *Discussion*—The discontinued unit for absorbed dose is the rad (1 rad = 100 erg/g = 0.01 Gy). Absorbed dose is sometimes referred to simply as dose.

3.2.2 *air gap*—the distance between the product plane and the electron beam window.

3.2.3 *backscatter*—the term used to describe additional absorbed dose caused by scatter of the primary electron beam from nearby material.

3.2.4 *beam current*—time-averaged electron beam current delivered from the accelerator.

3.2.5 *beam length*— *non-scanned electron beam*, the active length of the cathode assembly in vacuum parallel to the product flow and perpendicular to the beam width.

3.2.6 *beam power*—the product of the average electron beam energy and the average beam current (unit kW).

[1] This practice 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, and is also under the jurisdiction of ISO/TC 85/WG 3.

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[2] *Annual Book of ASTM Standards*, Vol 12.02.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from the International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Suite 800, Bethesda, MD 20814, U.S.A.

[5] Available from the Radiation Shielding Information Center (RSIC), Oak Ridge National Laboratory (ORNL), P.O. Box 2008, Oak Ridge, TN 37831, U.S.A.

3.2.7 *beam width—non-scanned electron beam*, the active width of the cathode assembly in vacuum perpendicular to the product flow and beam length.

3.2.8 *bulk processing rate*—mass throughput rate based on the output power in watts of the electron beam, the mass of the irradiated material and the dose. Expressed in kilogray kilograms per kilowatt hour or Megarad pounds per kilowatt hour.

3.2.9 *depth-dose distribution*—variation of absorbed dose with depth from the incident surface of a material exposed to a given radiation (see Fig. 1 for calculated values).

3.2.10 *dose uniformity ratio*—ratio of the maximum to the minimum absorbed dose within the process load. The concept is also referred to as the max/min dose ratio.

3.2.11 *dosimeter*—a device that, when irradiated, exhibits a quantifiable change in some property of the device which can be related to absorbed dose in a given material using appropriate analytical instrumentation and techniques.

3.2.12 *dosimetry system*—a system used for determining absorbed dose, consisting of dosimeters, measurement instruments, and their associated reference standards and procedures for the system's use.

3.2.13 *electron energy*—kinetic energy of the accelerated electron beam (units—eV (electron volts)). Often, acceleration voltage in kV is used to characterize beam energy in keV. The maximum energy of the beam inside the accelerator is equal to the acceleration voltage but expressed in keV units. The beam energy at the product surface is less than the maximum energy inside the accelerator due to losses in the beam path, such as the window and the air gap.

3.2.14 *traceability*—the documentation demonstrating by means of an unbroken chain of comparisons that a measurement is in agreement within acceptable limits of uncertainty with comparable nationally or internationally recognized standards.

3.2.15 *practical electron range*—distance from the incident surface of a homogeneous material where the electron beam enters to the point where the tangent at the steepest point (the inflection point) on the almost straight descending portion of the depth dose distribution curve meets the depth axis.

3.2.16 *process load*—a volume of material with a specified loading configuration irradiated as a single entity.

3.2.17 *production run— continuous-flow irradiation*, a series of process loads, consisting of materials or products having similar radiation-absorption characteristics, that are irradiated sequentially to a specified range of absorbed dose.

3.2.18 *product plane*—the plane corresponding to the top surface of the product being irradiated.

3.2.19 *self-shielded accelerator*—an electron beam source that is integrally designed with radiation shielding, product transport system, and irradiation chamber.

3.2.20 *single-gap accelerator*—an electron beam source consisting of a vacuum tube and a high voltage power supply that can accelerate a dispersed beam of electrons from a high voltage potential to ground potential in one stage.

3.2.21 *surface area rate coefficient (K)*— a quantity relating area irradiated per unit time to beam current and absorbed dose. Typically this value is expressed in kGy meters^2 per milliampere minute, or Megarad feet^2 per milliampere minute. Calculated values using Monte Carlo simulation are shown in Table 1. In the literature, this processing rate concept is sometimes called the processing coefficient.

3.2.22 *uncertainty*—a parameter associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand or derived quantity (see ISO/ASTM Guide 51707).

4. Significance and Use

4.1 A variety of processes use low energy electron beam accelerators to modify product characteristics. Dosimetry requirements, the number and frequency of measurements, and record keeping requirements will vary depending on the type and end use of the products being processed. In many cases dosimetry may be used in conjunction with physical, chemical, or biological testing of the product. In many cases reference

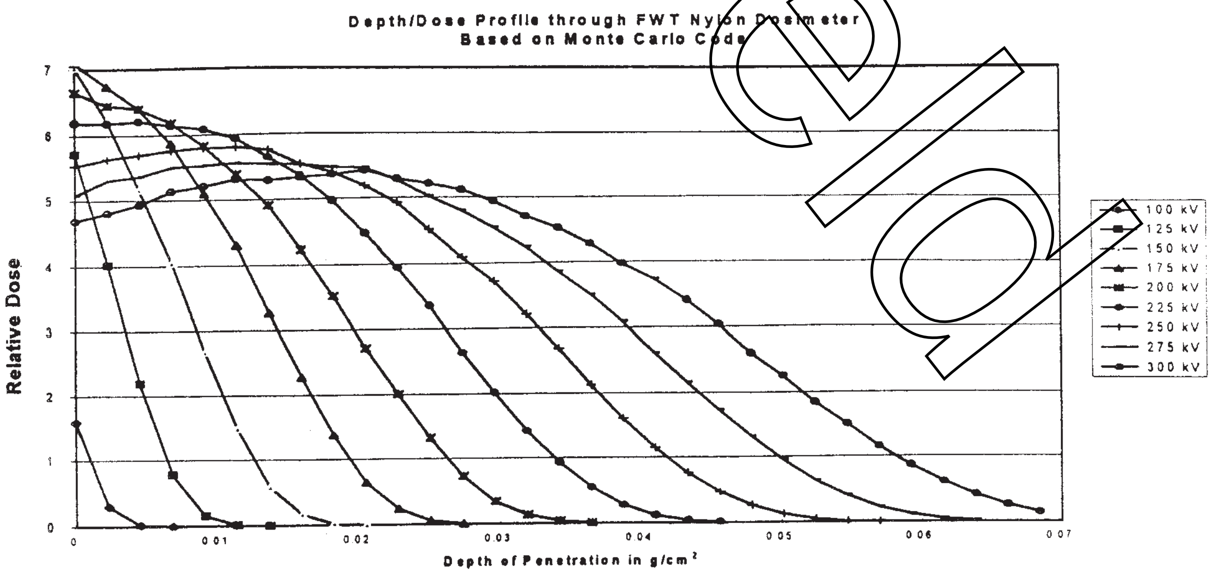

FIG. 1 Depth Dose Curves (0.5 mil Ti Window, 0.5 in. Air Gap)