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Practice for dosimetry for a self- contained dry-storage gamma-ray irradiator

Pratique de la dosimétrie appliquée à un irradiateur gamma
renfermant une source auto-protégée entreposée à sec



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 document 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 52116 was developed by ASTM Committee E10, Nuclear Technology and Applications, through Subcommittee E10.01, and by Technical Committee ISO/TC 85, Nuclear Energy.

Annexes A1 and A2 of this International Standard are for information only.



Standard Practice for Dosimetry for a Self-Contained Dry-Storage Gamma-Ray Irradiator¹

This standard is issued under the fixed designation ISO/ASTM 52116; 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 outlines dosimetric procedures to be followed with self-contained dry-storage gamma-ray irradiators. If followed, these procedures will help to ensure that calibration and testing will be carried out with acceptable precision and accuracy and that the samples processed with ionizing radiation from gamma rays in a self-contained dry-storage irradiator receive absorbed doses within a predetermined range.

1.2 This practice covers dosimetry in the use of dry-storage gamma-ray irradiators, namely self-contained dry-storage ¹³⁷Cs or ⁶⁰Co irradiators (shielded freestanding irradiators). It does not cover underwater pool sources, panoramic gamma-ray sources such as those raised mechanically or pneumatically to irradiate isotropically into a room or through a collimator, nor does it cover self-contained bremsstrahlung x-ray units.

1.3 The absorbed dose range for the use of the dry-storage self-contained gamma-ray irradiators covered by this practice is typically 1 to 10⁵ Gy, depending on the application. The absorbed-dose rate range typically is from 10⁻² to 10³ Gy/min.

1.4 This practice describes general procedures applicable to all self-contained dry-storage gamma-ray irradiators. For procedures specific to dosimetry in blood irradiation, see ISO/ASTM Practice 51939. For procedures specific to dosimetry in radiation research on food and agricultural products, see ISO/ASTM Practice 51900. For procedures specific to radiation hardness testing, see ASTM Practice E 1249. For procedures specific to the dosimetry in the irradiation of insects for sterile release programs, see ISO/ASTM Guide 51940. In those cases covered by ISO/ASTM Practices 51939, 51900, 51940, or ASTM E 1249, those standards take precedence. In addition, this practice does not cover absorbed-dose rate calibrations of radiation protection instrumentation.

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.*

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. Referenced documents

2.1 ASTM Standards:

E 170 Terminology Relating to Radiation Measurements and Dosimetry²

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods³

E 456 Terminology Relating to Quality Statistics³

E 1026 Practice for Using the Fricke Reference Standard Dosimetry System²

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

2.2 ISO/ASTM Standards:

51204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing²

51205 Practice for Use of a Ceric-Cerous Sulfate Dosimetry System²

51261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing²

51275 Practice for Use of a Radiochromic Film Dosimetry System²

51276 Practice for Use of a Polymethylmethacrylate Dosimetry System²

51310 Practice for Use of a Radiochromic Optical Waveguide Dosimetry System²

51400 Practice for Characterization and Performance of a High-Dose Gamma Radiation Dosimetry Calibration Laboratory²

51401 Practice for Use of a Dichromate Dosimetry System²

51431 Practice for Dosimetry in Electron and Bremsstrahlung Irradiation Facilities for Food Processing²

51538 Practice for Use of the Ethanol Chlorobenzene Dosimetry System²

51540 Practice for Use of a Radiochromic Liquid Dosimetry System²

51607 Practice for the Use of the Alanine-EPR Dosimetry System²

51608 Practice for Dosimetry in an X-Ray (Bremsstrahlung) Facility for Radiation Processing²

51650 Practice for Use of the Cellulose Acetate Dosimetry System²

51702 Practice for Dosimetry in a Gamma Irradiation Facility for Radiation Processing²

² Annual Book of ASTM Standards, Vol 12.02.

³ Annual Book of ASTM Standards, Vol 14.02.



51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing²

51900 Guide for Dosimetry in Radiation Research on Food and Agricultural Products²

51939 Practice for Blood Irradiation Dosimetry²

51940 Guide for Irradiation of Insects for Sterile Release Programs²

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

ICRU 14 Radiation Dosimetry: X-Rays and Gamma Rays with Maximum Photon Energies Between 0.6 and 50 MeV
ICRU 44 Tissue Substitutes in Radiation Dosimetry and Measurement

ICRU 51 Quantities and Units in Radiation Protection Dosimetry

ICRU 60 Fundamental Quantities and Units for Ionizing Radiation Metrology

2.4 ANSI Standards:⁵

ANSI N323, Radiation Protection Instrumentation Test and Calibration

ANSI Report N433.1, Safe Design and Use of Self-Contained, Dry-Source Storage Gamma Irradiators (Category I)

2.5 NCRP Publications:⁶

NCRP Report No. 58, Handbook of Radioactivity Measurements

NCRP Report No. 69, Dosimetry of X-Ray and Gamma Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV

2.6 ISO Publications:⁷

ISO/IEC 17025, General Requirements for the Competence of Calibration and Testing Laboratories

ISO 11137 Sterilization of Health Care Products—Requirements for Validation and Routine Control-Radiation Sterilization

2.7 IAEA Publication:⁸

IAEA TECDOC-619 X-Ray and Gamma-Ray Standards for Detector Calibration

3. Terminology

3.1 Definitions:

3.1.1 *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 J/kg 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 51).

⁴ International Commission on Radiation Units and Measurements (ICRU), 7910 Woodmont Ave., Suite 800, Bethesda, MD 20810, U.S.A.

⁵ American National Standards Institute, 25 West 43rd St., New York, NY 10036, U.S.A.

⁶ National Council on Radiation Protection (NCRP), 7910 Woodmont Ave., Suite 800, Bethesda MD 20814, U.S.A.

⁷ International Organization for Standardization (ISO), 1 rue de Varembe, Case Postale 56, CH-1211 Geneva 20, Switzerland.

⁸ International Atomic Energy Agency (IAEA), Wagrammerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria.

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

3.1.1.1 *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. For a photon source under conditions of charged particle equilibrium, the absorbed dose, D , may be expressed as:

$$D = \Phi \cdot E \cdot \frac{\mu_{en}}{\rho} \quad (2)$$

where:

Φ = particle fluence (particles/m²),

E = energy of the ionizing radiation (J/particle), and

μ_{en}/ρ = mass energy absorption coefficient (m²/kg). If bremsstrahlung production within the specified material is negligible, the mass energy absorption coefficient (μ_{en}/ρ) is equal to the mass energy transfer coefficient (μ_{tr}/ρ), and absorbed dose is equal to kerma if, in addition, charged particle equilibrium exists.

3.1.2 *absorbed-dose mapping*—measurement of absorbed dose within a process load using dosimeters placed at specified locations to produce a one-, two-, or three-dimensional distribution of absorbed dose, thus rendering a map of absorbed-dose values.

3.1.3 *absorbed-dose rate ($\dot{D}$)*—the absorbed dose in a material per incremental time interval, that is, the quotient of dD by dt .

$$\dot{D} = \frac{dD}{dt} \quad (3)$$

SI unit: Gy · s⁻¹.

3.1.3.1 *Discussion*—The absorbed-dose rate often is specified in terms of total value of D as a function of longer time intervals, for example, in units of Gy · min⁻¹ or Gy · h⁻¹.

3.1.4 *activity (A)*—of an amount of radioactive nuclide in a particular energy state at a given time, the quotient of dN by dt , where dN is the expectation value of the number of spontaneous nuclear transformations from that energy state in the time interval dt (ICRU 60).

$$A = \frac{dN}{dt} \quad \text{Unit: s}^{-1} \quad (4)$$

The unit of activity, A , is the becquerel (Bq).

3.1.4.1 *Discussion*—The former special unit of activity was the curie (Ci).

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ s}^{-1} = 3.7 \times 10^{10} \text{ Bq (exactly)} \quad (5)$$

The particular energy state is the ground state of the nuclide unless otherwise specified. The activity of an amount of radioactive nuclide in a particular energy state is equal to the product of the decay constant, λ , for that state and the number of nuclei in the state (that is, $A = N\lambda$) (see decay constant).

3.1.5 *calibration*—the process whereby the response of a measuring system or measuring instrument is characterized through comparison with an appropriate standard that is traceable to a nationally or internationally recognized standard.

3.1.6 *calibration curve*—graphical representation of the