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Guidance for dosimetry for radiation research

Lignes directrices de la dosimétrie pour la recherche dans le domaine de l'irradiation

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by ASTM Committee E61, *Radiation processing* (as ASTM E1900-97), and drafted in accordance with its editorial rules. It was assigned to Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies and radiation protection*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

ISO/ASTM 51900:2023(E)

Standard Guidance for Dosimetry for Radiation Research[1]

This standard is issued under the fixed designation ISO/ASTM 51900; 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 document covers essential recommendations for dosimetry needed to conduct research on the effects of ionizing radiation on materials, products and biological samples. Such research includes establishment of the quantitative relationship between absorbed dose and the relevant effects. This document also describes the overall need for dosimetry in such research, and for reporting of the results. Dosimetry should be considered an integral part of the experiment, and the researcher is responsible for ensuring the accuracy and applicability of the dosimetry system used.

NOTE 1—For research involving food products, note that the Codex Alimentarius Commission has developed an international General Standard and a Code of Practice that address the application of ionizing radiation to the treatment of foods and which strongly emphasizes the role of dosimetry for ensuring that irradiation will be properly performed (**1**).[2]

NOTE 2—This document includes tutorial information in the form of Notes. Researchers should also refer to the references provided at the end of the standard, and other applicable scientific literature, to assist in the experimental methodology as applied to dosimetry (**2-5**).

1.2 This document covers research conducted using the following types of ionizing radiation: gamma radiation (typically from Cobalt-60 or Cesium-137 sources), X-radiation (bremsstrahlung, typically with energies between 50 keV and 7.5 MeV), and electrons (typically with energies ranging from 80 keV to more than 10 MeV). See ISO/ASTM 51608, 51649, 51818 and 51702.

1.3 This document describes dosimetry recommendations for establishing the experimental method. It does not include dosimetry recommendations for installation qualification or operational qualification of the irradiation facility. These subjects are treated in ISO/ASTM 51608, 51649, 51818 and 51702.

1.4 This document is not intended to limit the flexibility of the researcher in the determination of the experimental methodology. The purpose of the document is to ensure that the radiation source and experimental methodology are chosen such that the results of the experiment will be useful and understandable to other scientists and regulatory agencies. The total uncertainty in the absorbed-dose measurement results and the absorbed-dose variation within the irradiated sample should be taken into account in the interpretation of the research results (see ISO/ASTM Guide 51707).

1.5 This document is one of a set of standards that provides recommendations for properly implementing dosimetry in radiation processing, and describes a means of achieving compliance with the requirements of ISO/ASTM 52628. This document is thus intended to be read in conjunction with ISO/ASTM 52628.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced documents

2.1 *ASTM Standards:*[3]

E2232 Guide for Selection and Use of Mathematical Methods for Calculating Absorbed Dose in Radiation Processing Applications

E3083 Terminology Relating to Radiation Processing: Dosimetry and Applications

2.2 *ISO/ASTM Standards:*[3]

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

51026 Practice for Using the Fricke Dosimetry System

51261 Practice for Calibration of Routine Dosimetry Systems for Radiation Processing

51275 Practice for Use of a Radiochromic Film Dosimetry System

[1] This document is under the jurisdiction of ASTM Committee E61 on Radiation Processing and is the direct responsibility of Subcommittee E61.04 on Specialty Application, and is also under the jurisdiction of ISO/TC 85/WG 3.

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[2] The boldface numbers in parentheses refer to the bibliography at the end of this document.

[3] For referenced ASTM and ISO/ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

51276 Practice for Use of a Polymethylmethacrylate Dosimetry System
51310 Practice for Use of a Radiochromic Optical Waveguide Dosimetry System
51538 Practice for Use of the Ethanol-Chlorobenzene Dosimetry System
51607 Practice for Use of the Alanine-EPR Dosimetry System
51608 Practice for Dosimetry in an X-ray (Bremsstrahlung) Facility for Radiation Processing
51649 Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies between 300 keV and 25 MeV
51650 Practice for Use of Cellulose Triacetate Dosimetry System
51702 Practice for Dosimetry in a Gamma Facility for Radiation Processing
51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing
51818 Guide for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies Between 80 and 300 keV
51956 Practice for Use of Thermoluminescence Dosimetry (TLD) Systems for Radiation Processing
52116 Practice for Dosimetry for a Self-Contained Dry-Storage Gamma Irradiator
52303 Practice for Absorbed-Dose Mapping in Radiation Processing Facilities
52628 Practice for Dosimetry in Radiation Processing
52701 Guide for Performance Charcterization of Dosimeters and Dosimetry Systems for Use in Radiation Processing

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

ICRU 80 Dosimetry Systems for Use in Radiation Processing
ICRU 85a Fundamental Quantities and Units for Ionizing Radiation

2.4 *ISO Standard:*[5]

12749-4 Nuclear energy, nuclear technologies, and radiological protection – Vocabulary – Part 4: Dosimetry for radiation processing

2.5 *Joint Committee for Guides in Metrology (JCGM) Reports:*

JCGM 100: 2008, GUM 1995, with minor corrections, Evaluation of measurement data – Guide to the expression of uncertainty in measurement[6]
JCGM 200: 2012, VIM International vocabulary of metrology – Basic and general concepts and associated terms[7]

2.6 *NPL Report:*[8]

CIRM 29 : Guidelines for the Calibration of Routine Dosimeters for use in Radiation Processing, Sharpe, P., and Miller, A., September, 2009.

3. Terminology

3.1 *Definitions:*

3.1.1 *absorbed dose (D)*—quotient of $d\bar{\varepsilon}$ by *dm*, where $d\bar{\varepsilon}$ is the mean energy imparted by ionizing radiation to matter of incremental mass *dm* (ICRU 85a), thus

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

3.1.1.1 *Discussion*—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).

3.1.1.2 *Discussion*—For the purposes of this standard, the term dose is used to mean "absorbed dose".

3.1.2 *absorbed-dose mapping*—measurement of absorbed dose within an irradiated product 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* $\dot{D}$—quotient of d*D* by d*t*, where d*D* is the increment of absorbed dose in the time interval d*t* (ICRU 85a), thus

$$\dot{D} = dD/dt \quad (2)$$

3.1.3.1 *Discussion*—

(1) The SI unit is $Gy \cdot s^{-1}$. However, the absorbed-dose rate is often specified in terms of its average value over longer time intervals, for example, in units of $Gy \cdot min^{-1}$ or $Gy \cdot h^{-1}$.

(2) In gamma industrial irradiators, dose rate may be significantly different at different locations where product is irradiated.

(3) In electron-beam irradiators with pulsed or scanned beam, there are two types of dose rate: average value over several pulses (scans) and instantaneous value within a pulse (scan). These values can be significantly different.

3.1.4 *bremsstrahlung*—broad-spectrum electromagnetic radiation emitted when an energetic charged particle is influenced by a strong electric or magnetic field, such as that in the vicinity of an atomic nucleus.

3.1.5 *dose uniformity ratio*—ratio of the maximum to the minimum absorbed dose within the irradiated product.

3.1.5.1 *Discussion*—The concept is also referred to as the max/min dose ratio.

3.1.6 *dosimeter*—device that, when irradiated, exhibits a quantifiable change that can be related to absorbed dose in a given material using appropriate measurement instruments and procedures.

3.1.7 *dosimeter response*—reproducible, quantifiable change produced in the dosimeter by ionizing radiation.

3.1.7.1 *Discussion*—

(1) The dosimeter response value, obtained from one or more measurements, is used in the estimation of the absorbed dose.

[4] Available from the International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Suite 800, Bethesda, MD 20814 USA.
[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.
[6] Document produced by Working Group 1 of the Joint Committee for Guides in Metrology (JCGM WWG1). Available free of charge at the BIPM website (http://www.bipm.org).
[7] Document produced by Working Group 2 of the Joint Committee for Guides in Metrology (JCGM WG2), Available free of charge at the BIPM website (http://www.bipm.org).
[8] Available from National Physical Laboratory, Online, Available: http://www.chemdos.npl.co.uk/docs/NPLReportCIRM29.pdf. 8 May 2019.