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**Practice for use of a
polymethylmethacrylate dosimetry
system**

*Pratique de l'utilisation d'un système dosimétrique au
polyméthylméthacrylate*

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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).

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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 ISO/TC 85, *Nuclear energy, nuclear technologies and radiological protection*, in cooperation with ASTM E61, *Radiation processing*, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on additive manufacturing.

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.

This corrected version of ISO/ASTM 51276:2019 incorporates the following correction:

— Subclause 9.3 has been added back.

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.



Standard Practice for Use of a Polymethylmethacrylate Dosimetry System¹

This standard is issued under the fixed designation ISO/ASTM 51276; 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 is a practice for using polymethylmethacrylate (PMMA) dosimetry systems to measure absorbed dose in materials irradiated by photons or electrons in terms of absorbed dose to water. The PMMA dosimetry system is generally used as a routine dosimetry system.

1.2 The PMMA dosimeter is classified as a Type II dosimeter on the basis of the complex effect of influence quantities (see ISO/ASTM Practice 52628).

1.3 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 “Practice for Dosimetry in Radiation Processing” for a PMMA dosimetry system. It is intended to be read in conjunction with ISO/ASTM Practice 52628.

1.4 This practice covers the use of PMMA dosimetry systems under the following conditions:

- 1.4.1 the absorbed dose range is 0.1 kGy to 150 kGy.
- 1.4.2 the absorbed dose rate is 1×10^{-2} to 1×10^7 Gy·s⁻¹.
- 1.4.3 the photon energy range is 0.1 to 25 MeV.
- 1.4.4 the electron energy range is 3 to 25 MeV.

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

1.6 *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.*

¹ This practice is under the jurisdiction of ASTM Committee E61 on Radiation Processing and is the direct responsibility of Subcommittee E61.02 on Dosimetry Systems, and is also under the jurisdiction of ISO/TC 85/WG 3.

Current edition approved July 16, 2019. Published August 2019. Originally published as E 1276 – 88. ASTM E 1276 - 96¹ was adopted by ISO in 1998 with the intermediate designation ISO 15558:1998(E). The present Fourth Edition of International Standard ISO/ASTM 51276:2019(E) is a major revision of the Third Edition of ISO/ASTM 51276:2012(E).

2. Referenced documents

2.1 ASTM Standards:²

E275 Practice for Describing and Measuring Performance of Ultraviolet and Visible Spectrophotometers

E3083 Terminology Relating to Radiation Processing: Dosimetry and Applications

2.2 ISO/ASTM Standards:²

51261 Practice for Calibration of Routine Dosimetry Systems for Radiation Processing

51707 Guide for Estimation of Measurement Uncertainty in Dosimetry for Radiation Processing

52628 Practice for Dosimetry in Radiation Processing

52701 Guide for Performance Characterization of Dosimeters and Dosimetry Systems for Use in Radiation Processing

2.3 International Commission on Radiation Units and Measurements (ICRU) Reports:³

ICRU Report 80 Dosimetry Systems for Use in Radiation Processing

ICRU Report 85a Fundamental Quantities and Units for Ionizing Radiation

2.4 ISO Standard:⁴

12749-4 Nuclear energy — 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 Measurement⁵

JCGM 200:2012, VIM International Vocabulary of Metrology - Basic and General Concepts and Associated Terms⁶

² 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.

³ Available from International Commission on Radiation Units & Measurements, 7910 Woodmont Ave., Suite 400, Bethesda, MD 20814-3095, <http://www.icru.org>.

⁴ 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>.

⁵ Document produced by Working Group 1 of the Joint Committee for Guides in Metrology (JCGM WG1), Available free of charge at the BIPM website (<http://www.bipm.org>).

⁶ 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>).



3. Terminology

3.1 Definitions:

3.1.1 *dosimeter batch*—quantity of dosimeters made from a specific mass of material with uniform composition, fabricated in a single production run under controlled, consistent conditions, and having a unique identification code.

3.1.2 *dosimeter response (indication)*—reproducible, quantifiable change produced in the dosimeter by ionizing radiation.

3.1.2.1 *Discussion*—The dosimeter response value (indication), obtained from one or more measurements, is used in the estimation of absorbed dose.

3.1.2.2 *Discussion*—For PMMA dosimeters, the dosimeter response value (indication) is obtained from measurement of the optical absorbance.

3.1.3 *dosimeter stock*—part of a dosimeter batch held by the user.

3.1.4 *polymethylmethacrylate (PMMA) dosimeter*—piece of specially selected or developed PMMA material, individually sealed by the manufacturer in an impermeable sachet that, when irradiated, exhibits a characterizable change in specific absorbance that can be related to absorbed dose.

3.1.4.1 *Discussion*—The piece of PMMA, when removed from the sachet after irradiation, is also commonly referred to as the dosimeter.

3.1.5 *specific absorbance (k)*—optical absorbance, A_λ , at a selected wavelength λ , divided by the optical path length, d :

$$k = A_\lambda/d \quad (1)$$

3.2 Definitions of other terms used in this standard that pertain to radiation measurement and dosimetry may be found in ISO/ASTM Practice 52628. Other terms that pertain to radiation measurement and dosimetry may be found in ASTM Terminology E3083 and ISO Terminology ISO 12749-4. Where appropriate, definitions used in these standards have been derived from, and are consistent with definitions in ICRU Report 85a, and general metrological definitions given in the VIM.

4. Significance and use

4.1 The PMMA dosimetry system provides a means for measuring absorbed dose based on a change in optical absorbance.

4.2 PMMA dosimetry systems are commonly used in industrial radiation processing, for example in the sterilization of medical devices and the irradiation of foods.

5. Overview

5.1 PMMA dosimeters may be manufactured by various methods. For example, the raw material has historically been cast, extruded, or injection molded. Fundamentally, ingredients required for the promotion and control of polymerization and stability, and, in the case of dyed dosimeters, specified quantities of dyes appropriate for the required range of response, are dissolved in methylmethacrylate, which is then polymerized. The material is then conditioned to adjust the water content,

and the response to radiation is verified using appropriate sampling and testing before release for packaging, and ultimately for use.

5.2 Ionizing radiation induces chemical reactions in the material, which create or enhance absorption bands in the visible or ultraviolet regions of the spectrum, or both. Optical absorbance determined at appropriate wavelengths within these radiation-induced absorption bands is quantitatively related to the absorbed dose. ICRU Report 80 provides information on the scientific basis and historical development of the PMMA dosimetry systems in current use.

5.3 The difference between the specific absorbance of un-irradiated and irradiated PMMA is dependent upon the wavelength of the light which is used to make the measurement. Typically, the manufacturer specifies the recommended wavelength that optimizes sensitivity and post-irradiation stability. The wavelengths recommended for examples of commonly used systems are given in Table A1.1.

6. Influence quantities

6.1 Factors other than absorbed dose which influence the dosimeter response are referred to as influence quantities and are discussed in the following sections. (See also ISO/ASTM Guide 52701.) Examples of such influence quantities are temperature and dose rate.

6.2 Pre-Irradiation Conditions:

6.2.1 *Dosimeter Conditioning and Packaging*—Pieces of PMMA are pre-conditioned by the manufacturer to optimize water concentration, and sealed in impermeable aluminum foil laminate sachets to maintain that condition.

6.2.2 *Time Since Manufacture*—With appropriate manufacturing, packaging and storage conditions, the shelf-life of some types of PMMA dosimeters has been shown to exceed ten years (1).⁷

6.2.3 *Temperature*—Exposure to temperatures outside the manufacturer's recommended range should be minimized to reduce the potential for adverse effects on dosimeter response.

6.2.4 *Relative Humidity*—The effect of humidity is eliminated by the isolation provided by the sachet.

6.2.5 *Exposure to Light*—The effect of light exposure is eliminated by the isolation provided by the sachet.

6.3 Conditions during Irradiation:

6.3.1 *Irradiation Temperature*—the dosimeter response is affected by temperature and shall be characterized.

6.3.2 *Absorbed-Dose Rate*—the dosimeter response is affected by the absorbed-dose rate and shall be characterized.

6.3.3 *Dose Fractionation*—the dosimeter response may be affected by incremental exposures and should be characterized.

6.3.4 *Relative Humidity*—the effect of humidity is eliminated by the isolation provided by the sachet.

6.3.5 *Exposure to Light*—the effect of light exposure, if any, is eliminated by the isolation provided by the sachet.

⁷ The boldface numbers in parentheses refer to the bibliography at the end of this practice.