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Standard Practice for Use of a Radiochromic Film Dosimetry System[1]

This standard is issued under the fixed designation 51275; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—References to ISO/ASTM standards were editorially updated in December 2024.

1. Scope

1.1 This is a practice for using radiochromic film dosimetry systems to measure absorbed dose in materials irradiated by photons or electrons in terms of absorbed dose to water. Radiochromic film dosimetry systems are generally used as routine dosimetry systems.

1.2 The radiochromic film dosimeter is classified as a type II dosimeter on the basis of the complex effect of influence quantities (see ASTM 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 ASTM 52628 "Practice for Dosimetry in Radiation Processing" for a radiochromic film dosimetry system. It is intended to be read in conjunction with ASTM 52628.

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

1.4.1 The absorbed dose range is 1 Gy to 150 kGy.

1.4.2 The absorbed dose rate is 1×10^{-2} to 1×10^{13} $Gy \cdot s^{-1}$ (**1-4**).[2]

1.4.3 The photon energy range is 0.1 to 50 MeV.

1.4.4 The electron energy range is 70 keV to 50 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.*

2. Referenced documents

2.1 *ASTM Standards:*[3]

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

E3083 Terminology Relating to Radiation Processing: Dosimetry and Applications

51261 Practice for Calibration of Routine Dosimetry Systems for Radiation Processing

51707 Guide for Estimating Uncertainties 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

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

ICRU Report 85a Fundamental Quantities and Units for Ionizing Radiation

ICRU Report 80 Dosimetry Systems for Use in Radiation Processing

2.3 *ISO Standards:*[5]

12749-4 Nuclear energy – Vocabulary – Part 4: Dosimetry for radiation processing

2.4 *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]

[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. Originally developed as a joint ASTM/ISO standard in conjunction with ISO/TC 85/WG 3.

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

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

[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, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[6] Document produced by Working Group 1 of the Joint Committee for Guides in Metrology (JCGM/WG 1). Available free of charge at the BIPM website (http://www.bipm.org).

JCGM 200:2008, VIM, International vocabulary of metrology – Basis and general concepts and associated terms[7]

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*—reproducible, quantifiable effect produced in the dosimeter by ionizing radiation.

3.1.2.1 *Discussion*—For radiochromic film dosimeters, the absorbance, specific absorbance or specific net absorbance is the dosimeter response.

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

3.1.4 *measurement management system*—a set of interrelated or interacting elements necessary to achieve metrological confirmation and continual control of measurement processes.

3.1.5 *radiochromic film dosimeter*—specially prepared film containing ingredients that undergo change in optical absorbance under ionizing radiation, which can be related to absorbed dose to water.

3.1.6 *reference standard dosimetry system*—dosimetry system, generally having the highest metrological quality available at a given location or in a given organization, from which measurements made there are derived.

3.1.7 *response*—see *dosimeter response*.

3.1.8 *routine dosimetry system*—dosimetry system calibrated against a reference standard dosimetry system and used for routine absorbed dose measurements, including dose mapping and process monitoring.

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

$$k = A_\chi / d \tag{1}$$

3.1.10 *specific net absorbance (Δk)*—net absorbance, ΔA_λ, at a selected wavelength, λ, divided by the optical pathlength, d, through the dosimeter material as follows:

$$\Delta k = \Delta A_\chi / d \tag{2}$$

3.2 Definitions of other terms used in this practice that pertain to radiation measurement and dosimetry may be found in ASTM Practice 52628. Other terms that pertain to radiation measurement and dosimetry may be found in ASTM Terminology E3083 and ISO Terminology 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.

[7] Document produced by Working Group 2 of the Joint Committee for Guides in Metrology (JCGM/WG 2). Available free of charge at the BIPM website (http://www.bipm.org).

4. Significance and use

4.1 The radiochromic film dosimetry system provides a means for measuring absorbed dose based on radiation-induced change in color using spectrophotometers, densitometers or scanned images.

4.2 Radiochromic film 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 Radiochromic film dosimeters are manufactured by various methods to produce freestanding or coated films, which are flexible and transparent. They are generally supplied as small squares, strips, or long rolls or sheets that can be cut into a convenient size for dosimetry purposes. The response of the dosimeters may be influenced by water content, irradiation temperature, post-irradiation time to measurement, and other potential influence quantities that need to be taken into account. Many commercially available dosimeters are supplied in light- and vapor-tight packages, which effectively protect against light and changes in ambient humidity. The dosimeters should be calibrated under irradiation conditions that are similar to those in which they will be used.

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

5.3 The radiation-induced change in absorbance of the radiochromic film depends on the wavelength of the light which is used to make the measurement.

6. Influence quantities

6.1 Factors other than absorbed dose which influence the dosimeter response are referred to as influence quantities. (See ASTM Guide 52701.) See Refs **(2-16)** for examples of the types and magnitudes of the effects. It is recommended to calibrate the dosimetry system under the conditions of use (in-situ calibration) in order to help to account for the influence quantities and reduce their associated uncertainty along with batch to batch variations. Examples of such factors are temperature, humidity, dose rate and dose fractionation.

NOTE 1—Due to the variety of radiochromic dosimeter types the manufacturer should be consulted for specific recommendations regarding influence quantities and their significance for dosimeter use, shipment and storage.

6.2 *Pre-Irradiation Conditions:*

6.2.1 *Dosimeter Conditioning and Packaging*—Dosimeters may be conditioned by the manufacturer to optimize water content in the film, and then sealed in vapor and light tight pouches to maintain that condition.

6.2.2 *Time since Manufacture*—The shelf-life of the different types of radiochromic film dosimeters varies and the manufacturer should be contacted for recommended duration. However, it is recommended that users carry out performance