Designation: E 1275 – 98ε1

An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

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

This standard is issued under the fixed designation E 1275; 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—Footnote 1 was editorially altered in June 1999.

1. Scope

1.1 This practice covers the handling, testing, and procedure for using a radiochromic film dosimetry system to measure absorbed dose in materials irradiated by photons or electrons in terms of absorbed dose in water.

1.2 This practice applies to radiochromic film dosimeters that can be used within part or all of the specified ranges as follows:

1.2.1 The absorbed dose range is 1 Gy to 100 kGy.

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

1.2.3 The radiation energy range for both photons and electrons is 0.1 to 50 MeV.

1.2.4 The irradiation temperature range is –78 to +60°C.

1.3 This practice applies to radiochromic films of various formats, including small pieces used to measure a single dose value, strips used for one-dimensional dose-mapping, and sheets used for two-dimensional dose-mapping. Three-dimensional dose-mapping may be achieved by proper placement of any of these formats.

1.4 *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[3]

E 178 Practice for Dealing with Outlying Observations[4]

E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near Infrared Spectrophotometers[5]

E 456 Terminology Relating to Quality and Statistics[3]

E 668 Practice for Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices[3]

E 925 Practice for the Periodic Calibration of Narrow Band-Pass Spectrophotometers[6]

E 958 Practice for Measuring Practical Spectral Bandwidth of Ultraviolet-Visible Spectrophotometers[6]

E 1026 Practice for Using the Fricke Reference Standard Dosimetry System[3]

E 1204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing[3]

E 1205 Practice for Use of a Ceric-Cerous Sulfate Dosimetry System[3]

E 1261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing[3]

E 1707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing[3]

2.2 *International Commission on Radiation Units and Measurements (ICRU) Reports:*[7]

ICRU Report 14—Radiation Dosimetry: X–Rays and Gamma Rays with Maximum Photon Energies Between 0.6 and 50 MeV

ICRU Report 17—Radiation Dosimetry: X–Rays Generated at Potentials of 5 to 150 kV

ICRU Report 33—Radiation Quantities and Units

ICRU Report 34—The Dosimetry of Pulsed Radiation

ICRU Report 35—Radiation Dosimetry: Electron Beams with Energies Between 1 and 50 MeV

3. Terminology

3.1 *Definitions:*

3.1.1 *analysis wavelength*—wavelength used in a spectrophotometric instrument for the measurement of optical absorbance.

3.1.2 *calibration curve*—graphical representation of the dosimetry system's response function.

[1] This guide is under the jurisdiction of ASTM Committee E-10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.01 on Dosimetry for Radiation Processing.

Current edition, which includes substantial revisions to the last previous edition, was approved June 10, 1998. Published December 1998. Originally published as E 1275–88. International Standard ISO 15557:1998(E) is identical to the last previous edition E 1275–93.

[2] The boldface number in parentheses refer to the list of references at the end of this practice.

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

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

[5] *Annual Book of ASTM Standards*, Vol 14.01.

[6] *Annual Book of ASTM Standards*, Vol 03.06.

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

3.1.3 *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.

3.1.4 *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.

3.1.5 *measurement quality assurance plan*—a documented program for the measurement process that ensures on a continuing basis that the overall uncertainty meets the requirements of the specific application. This plan requires traceability to, and consistency with, nationally or internationally recognized standards.

3.1.6 *net absorbance*, ΔA—change in measured optical absorbance at a selected wavelength determined as the absolute difference between the pre-irradiation absorbance, A_0, and the post-irradiation absorbance, A, as follows:

$$\Delta A = |A - A_0|. \quad (1)$$

3.1.6.1 *Discussion*—In practice, an average pre-irradiation absorbance, $\bar{A}_0$, may be used to determine net absorbance.

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

3.1.8 *response function*—mathematical representation of the relationship between dosimeter response and absorbed dose for a given dosimetry system.

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

$$\Delta k = \Delta A/d. \quad (2)$$

3.2 Definitions of other terms used in this standard that pertain to radiation measurement and dosimetry may be found in Terminology Standard E 170. Definitions in E 170 are compatible with ICRU 33; that document, therefore, may be used as an alternative reference.

4. Significance and Use

4.1 The radiochromic film dosimetry system provides a means of determining absorbed dose in materials. Under the influence of ionizing radiation, chemical reactions take place in the radiochromic film creating or enhancing, or both, optical absorption bands. Absorbance is determined within these radiation-induced absorption bands using a spectrophotometer or photometer (See 5.1.2).

4.2 In the application of a specific dosimetry system, absorbed dose is determined by use of a calibration curve traceable to national standards.

4.3 The absorbed dose determined is usually specified in water. Absorbed dose in other materials may be determined by applying the conversion factors discussed in Guide E 1261.

NOTE 1—For comprehensive discussion of various dosimetry methods applicable to the radiation types and energies discussed in this practice, see ICRU Reports 14, 17, 34, and 35.

4.4 Radiochromic film dosimetry systems are commonly applied in the industrial radiation processing of a variety of products, for example, sterilization of medical devices and processing of foods **(11, 13)**.

5. Apparatus

5.1 *Components of the Dosimetry System*—The following shall be used to determine absorbed dose with radiochromic film dosimetry systems:

5.1.1 *Radiochromic Film Dosimeters*:

5.1.2 *Spectrophotometer or Photometer*, having documentation covering analysis wavelength range, accuracy of wavelength selection, absorbance determination, spectral bandwidth, and stray light rejection. Examples of appropriate wavelengths for analysis for specific dosimetry systems are provided by the manufacturer and in Refs. **(3-14, 19)**.

5.1.3 *Holder*, to position the dosimeter reproducibly in and perpendicular to the measuring light beam.

5.1.4 *Calibrated Thickness Gage*, with a precision of ± 2 % of the film thickness (at a 95 % confidence level), if the film's thickness is to be measured.

NOTE 2—Documentation provided by the manufacturer of the radiochromic film dosimeter with regard to the film thickness and its variability may be substituted for direct measurement of thickness by the user. This information should be verified by the user by analyzing a representative sample of films.

NOTE 3—Some radiochromic film dosimeters contain a substrate which is not radiochromic. With such dosimeters the thickness is not measured.

5.1.5 Packaging materials for radiochromic films, where applicable.

6. Performance Check of Instrumentation

6.1 The performance of the photometer or spectrophotometer shall be checked as specified in Section 7.4, and documented.

6.1.1 When using a spectrophotometer, check and document the accuracy of the wavelength scale and absorbance scale at or near the analysis wavelength(s) at intervals not to exceed one month during periods of use and as specified by the end-user's internal procedures.

6.1.2 When using a photometer, check and document the accuracy of the absorbance scale at intervals not to exceed one month during periods of use and as specified by the end-user's internal procedures.

6.1.3 Compare the information obtained in 6.1.1 or 6.1.2 with the original instrument specifications to ensure adequate performance.

6.2 Check the thickness gage prior to first use and periodically thereafter to assure reproducibility and lack of zero drift. Check and document the calibration of the gage at intervals not to exceed six months. Use gage blocks, traceable to national standards for this purpose.

7. Calibration of the Dosimetry System

7.1 Prior to use, the dosimetry system shall be calibrated in accordance with the user's documented procedure that specifies details of the calibration process and quality assurance requirements. This calibration procedure shall be repeated at regular intervals to ensure that the accuracy of the absorbed dose measurement is maintained within required limits. Detailed calibration procedures are provided in Guide E 1261.