INTERNATIONAL STANDARD

ISO 15559

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Practice for use of a radiochromic optical waveguide dosimetry system

Pratique de l'utilisation d'un système dosimétrique à guide d'ondes optique radiochromique

Reference number
ISO 15559:1998(E)

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.

International Standard ISO 15559 was prepared by the American Society for Testing and Materials (ASTM) Subcommittee E10.01 (as E 1310-94) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 85, *Nuclear energy*, in parallel with its approval by the ISO member bodies.

A new ISO/TC 85 Working Group WG 3, *High-level dosimetry for radiation processing*, was formed to review the voting comments from the ISO "Fast-track procedure" and to maintain these standards. The USA holds the convenership of this working group.

International Standard ISO 15559 is one of 20 standards developed and published by ASTM. The 20 fast-tracked standards and their associated ASTM designations are listed below:

ISO Designation	ASTM Designation	Title
15554	E 1204-93	*Practice for dosimetry in gamma irradiation facilities for food processing*
15555	E 1205-93	*Practice for use of a ceric-cerous sulfate dosimetry system*
15556	E 1261-94	*Guide for selection and calibration of dosimetry systems for radiation processing*
15557	E 1275-93	*Practice for use of a radiochromic film dosimetry system*
15558	E 1276-96	*Practice for use of a polymethylmethacrylate dosimetry system*
15559	E 1310-94	*Practice for use of a radiochromic optical waveguide dosimetry system*
15560	E 1400-95a	*Practice for characterization and performance of a high-dose radiation dosimetry calibration laboratory*
15561	E 1401-96	*Practice for use of a dichromate dosimetry system*

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15562	E 1431-91	*Practice for dosimetry in electron and bremsstrahlung irradiation facilities for food processing*
15563	E 1538-93	*Practice for use of the ethanol-chlorobenzene dosimetry system*
15564	E 1539-93	*Guide for use of radiation-sensitive indicators*
15565	E 1540-93	*Practice for use of a radiochromic liquid dosimetry system*
15566	E 1607-94	*Practice for use of the alanine-EPR dosimetry system*
15567	E 1608-94	*Practice for dosimetry in an X-ray (bremsstrahlung) facility for radiation processing*
15568	E 1631-96	*Practice for use of calorimetric dosimetry systems for electron beam dose measurements and dosimeter calibrations*
15569	E 1649-94	*Practice for dosimetry in an electron-beam facility for radiation processing at energies between 300 keV and 25 MeV*
15570	E 1650-94	*Practice for use of cellulose acetate dosimetry system*
15571	E 1702-95	*Practice for dosimetry in a gamma irradiation facility for radiation processing*
15572	E 1707-95	*Guide for estimating uncertainties in dosimetry for radiation processing*
15573	E 1818-96	*Practice for dosimetry in an electron-beam facility for radiation processing at energies between 80 keV and 300 keV*

Designation: E 1310 – 94

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If not listed in the current combined index, will appear in the next edition.

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

This standard is issued under the fixed designation E 1310; 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.

1. Scope

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

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

1.2.1 The absorbed dose range is from 1 to 10 000 Gy for photons.

1.2.2 The absorbed dose rate is from 0.001 to 1000 Gy/s.

1.2.3 The radiation energy range for photons is from 0.1 to 10 MeV.

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

1.3 *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[2]
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[3]
E 178 Practice for Dealing with Outlying Observations[3]
E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near Infrared Spectrophotometers[4]
E 666 Practice for Calculating Absorbed Dose from Gamma or X Radiation[2]
E 668 Practice for the Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices[2]
E 925 Practice for the Periodic Calibration of Narrow Band-Pass Spectrophotometers[4]
E 958 Practice for Measuring Practical Spectral Bandwidth of Ultraviolet-Visible Spectrophotometers[4]
E 1026 Practice for Using the Fricke Reference Standard Dosimetry System[2]
E 1204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing[2]
E 1205 Practice for Use of a Ceric-Cerous Sulfate Dosimetry System[2]
E 1261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing[2]
E 1275 Practice for Use of a Radiochromic Film Dosimetry System[2]
E 1276 Practice for Use of a Polymethylmethacrylate Dosimetry System[2]

2.2 *International Commission on Radiation Units and Measurements (ICRU) Reports:*[5]

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

3. Terminology

3.1 *Definitions:*

3.1.1 *absorbed dose, D*—the quotient of $d\bar{\varepsilon}$ by dm, where $d\bar{\varepsilon}$ is the mean energy imparted by ionizing radiation to the matter of mass dm (see ICRU Report 33).

$$D = \frac{d\bar{\varepsilon}}{dm}$$

The special name of the unit for absorbed dose is the gray (Gy):

$$1\ \text{Gy} = 1\ \text{J} \times \text{kg}^{-1}$$

Formerly, the special unit for absorbed dose was the rad:

$$1\ \text{rad} = 10^{-2}\ \text{J} \times \text{kg}^{-1} = 10^{-2}\ \text{Gy}$$

3.1.2 *analysis wavelength, λ*—the wavelength used for calibration and routine application.

3.1.3 *calibration curve*—graphical or mathematical relationship between dosimeter response and the absorbed dose for a given dosimetry system; this term is also referred to as the response function.

3.1.4 *calibration facility*—a combination of an ionizing radiation source and its associated instrumentation that provides traceable, uniform, and reproducible absorbed dose rates at specific locations and in a specific material; it may be used to calibrate the response of routine or other types of dosimeters as a function of absorbed dose.

3.1.5 *dosimeter batch*—quantity of dosimeters made from

[1] This practice 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.

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

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

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

[5] Available from International Commission on Radiation Units and Measurements, 7910 Woodmont Ave., Suite 800, Bethesda, MD 20814.

a specific mass of material with uniform composition, fabricated in a single production run under controlled, consistent conditions, and having a unique identification code.

3.1.6 *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.

3.1.7 *measurement quality assurance plan*—a documented program for the measurement process that quantifies the total uncertainty of the measurements (both random and systematic error components); this plan shall demonstrate traceability to national standards, and shall show that the total uncertainty meets the requirements of the specific application.

3.1.8 *net response,* ΔR—the radiation-induced change in the relationship of measured absorbance at a specific wavelength determined by subtracting the pre-irradiation response, R_0, from the post-irradiation response, R_I:

$$\Delta R = R_I - R_0$$

where:

$$R_I = \left[\frac{A_\lambda}{A_{\lambda ref}}\right]_I$$

$$R_0 = \left[\frac{A_\lambda}{A_{\lambda ref}}\right]_0$$

where:

A_λ = optical absorbance at the analysis wavelength, λ, and
$A_{\lambda ref}$ = optical absorbance at a reference wavelength, λref.

A block diagram of an instrument capable of measuring R_I or R_0 is shown in Fig. 1.

3.1.9 *optical waveguide*—a device that contains an optical path at a high index of refraction relative to the material enclosing the optical path.

3.1.10 *radiochromic optical waveguide*—a specially prepared optical waveguide containing ingredients that undergo an ionizing radiation-induced change in photometric absorbance. This change in absorbance can be related to absorbed dose in water **(1, 2)**.[6]

3.1.11 *reference wavelength,* λref—the wavelength selected for comparison with the analysis wavelength. This wavelength is chosen to minimize effects associated with optical coupling and other geometric variations in the dosimeter.

3.1.12 *traceability*—the ability to show that a measurement is consistent with appropriate national standards through an unbroken chain of comparisons.

3.2 Other appropriate terms may be found in Terminology E 170.

4. Significance and Use

4.1 The radiochromic optical waveguide dosimetry system provides a means of measuring absorbed dose in materials. Under the influence of ionizing radiation, chemical reactions take place in the radiochromic optical waveguide creating and/or modifying optical absorbance bands in the visible region of the spectrum. Optical response is determined at selected wavelengths using the equations in 3.1.8. Examples of appropriate wavelengths for the analysis for specific dosimetry systems are provided by their manufacturers and in Refs **(1)** through **(5)**.

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

4.4 These dosimetry systems commonly are applied in the industrial radiation processing of a variety of products, for example, the sterilization of medical devices and radiation processing of foods **(4–6)**.

5. Apparatus

5.1 The following shall be used to determine absorbed dose with radiochromic optical waveguide dosimetry systems:

5.1.1 *Dosimeters*—A batch or portion of a batch of radiochromic optical waveguide dosimeters.

5.1.2 *Spectrophotometer or Photometer*—An instrument, either a spectrophotometer equipped with a special dosimeter holder and associated coupling optics (7), or a modified photometer (Fig. 1), having documentation covering analysis wavelengths, accuracy of wavelength selection, absorbance determination, spectral bandwidth, and stray light rejection.

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

6. Performance Check of Instrumentation

6.1 Check and document the performance of the photometer or spectrophotometer (see Practices E 275, E 925, E 958, and E 1026).

6.1.1 When using a photometer, check and document the precision and bias of the absorbance scale at intervals not to exceed one month during periods of use, or whenever there are indications of poor performance.

6.1.2 When using a spectrophotometer, check and docu-

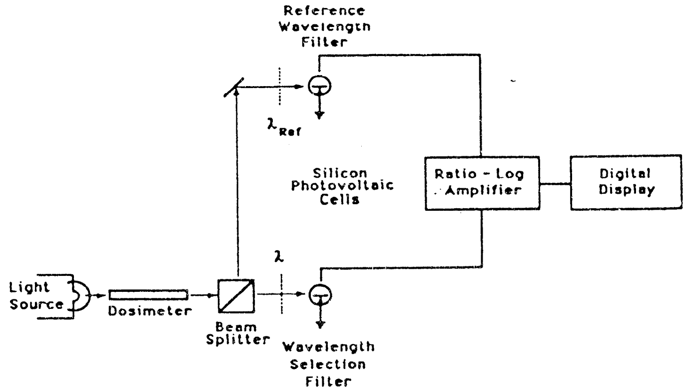

FIG. 1 Block Diagram of the Instrument Described in Section 5

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

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