

INTERNATIONAL  
RECOMMENDATION

**OIML R 127**

Edition 1999 (E)

---

Radiochromic film dosimetry system for ionizing  
radiation processing of materials and products

Systèmes de dosimétrie par film radiochromique pour le traitement  
par rayonnement ionisant de matériaux et de produits

---



## Contents

Foreword .....	3
1 Introduction .....	4
2 Scope .....	4
3 Application .....	5
4 Terminology .....	5
5 Description of the dosimetry system .....	7
6 Metrological requirements .....	7
7 Technical requirements .....	9
8 Practical instructions .....	10
9 Metrological controls .....	10
References .....	12
Annex A Calibration procedure .....	13
Annex B Test procedure .....	15
Annex C Test report format .....	16

## Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D)**, which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective

of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication - reference OIML R 127, edition 1999 (E) - was developed by the OIML Technical Committee TC 15 *Measuring instruments for ionizing radiations*. It was approved for final publication by the International Committee of Legal Metrology in 1998, and will be submitted to the International Conference of Legal Metrology in 2000 for formal sanction.

OIML publications may be obtained from the Organization's headquarters:

Bureau International de Métrologie Légale  
11, rue Turgot - 75009 Paris - France  
Telephone: 33 (0)1 48 78 12 82 and 42 85 27 11  
Fax: 33 (0)1 42 82 17 27  
E-mail: [biml@oiml.org](mailto:biml@oiml.org)  
Internet: [www.oiml.org](http://www.oiml.org)

# Radiochromic film dosimetry system for ionizing radiation processing of materials and products

## 1 Introduction

1.1 The objective of this Recommendation is to harmonize globally the procedures by which a radiochromic film dosimetry system (referred to in this Recommendation as “dosimetry system”) is evaluated when subject to law or regulations. It also provides confidence that the dosimetry system can indicate accurate absorbed dose measurements for facilities utilizing radiation processing of materials and products. In addition, the international marketing of dosimetry systems and affected products is facilitated.

1.2 The evaluation of a dosimetry system is carried out by a national responsible body through a process referred to as metrological control which generally includes pattern evaluation and initial and subsequent verification. If successful, pattern evaluation is provided only once to a manufacturer of a specific type of dosimeter. Verification is necessary by the national responsible body or user for each batch or new supply of dosimeters.

1.3 Pattern evaluation is the primary subject of this Recommendation, which specifies the metrological and technical requirements of the dosimetry system to be evaluated. A manufacturer submits either samples of a batch of dosimeters and a read-out instrument or only samples of a batch of dosimeters for evaluation. In the first case, the manufacturer will have calibrated the dosimeters and read-out instrument prior to their presentation and will also submit the calibration curve or response function that will serve as the basis for the evaluation. In the second case, the national responsible body will use samples of the dosimeters submitted to calibrate the overall dosimetry system including the read-out instrument prior to using that instrument to evaluate other samples of the dosimeters. All calibrations are carried out in a recognized calibration facility.

1.4 The evaluation is conducted according to an overall test procedure, and the results are contained in the test report. The test procedure and test report are specified in this Recommendation. After calibration, the national responsible body evaluates the dosimetry system by randomly selecting dosimeters from the same batch used for the calibration and then irradiates these samples in the same or another recognized calibration facility to predetermined absorbed dose values within the absorbed dose working range of the dosimetry system. The dosimetry system and its calibration curve or response function are used to determine the absorbed dose values. An analysis of absorbed dose readings for several dosimeters at a single irradiation dose level provides a determination of the repeatability of the measurement. A comparison of the average absorbed dose values measured using the calibration curve or response function and the absorbed dose values reported by the calibration facility provides the maximum error of the system.

1.5 The performance requirements for a dosimetry system are the same for verification as for pattern evaluation. This Recommendation indicates three different means of developing documentation that may be acceptable for verification by the national responsible body in which either the manufacturer or the user at the site of application may participate.

## 2 Scope

2.1 This Recommendation provides requirements for defining, testing and verifying the performance of a radiochromic film dosimetry system used for the legal measurements of absorbed dose from ionizing radiation for industrial processing of materials and products. It does not cover nor does it exclude the use of other equivalent means of measurement or determination of absorbed dose for such applications.

2.2 This Recommendation is intended to apply specifically to manufacturers of radiochromic film dosimeters (hereafter referred to as “dosimeters”) and to national bodies responsible for the metrological control of dosimetry systems. It also contains information of interest to users of radiochromic film dosimetry systems.

2.3 The metrological and technical performance requirements of radiochromic film dosimetry systems are covered in this Recommendation; however, the selection and routine use of these and other dosimeters for radiation processing applications are discussed in other standards [1, 2]. Performance better than that prescribed in this Recommendation may be achieved.

2.4 This Recommendation applies to dosimeters irradiated by either photons or electrons within the energy range of 0.1 MeV to 10 MeV. Tests of dosimeters according to this Recommendation are specified to be carried out at a reference temperature and humidity within specified absorbed dose range and absorbed dose-rate range.

Note: The following ranges may be covered using one or more radiochromic film dosimeters:

- absorbed dose range from 10 Gy to 105 Gy [2];
- absorbed dose-rate range from  $10^{-2}$  Gy/s to  $10^{13}$  Gy/s [3, 4];
- irradiation temperature range from  $-78$  °C to  $+60$  °C [5].

2.5 Requirements that may be necessary for personnel safety are not covered in this Recommendation; therefore, users should determine that a dosimetry system meets the safety and labeling requirements in accordance with national regulations.

### 3 Application

3.1 This Recommendation may be applied to any process using ionizing radiation where the desired change in a property or characteristic of a product is related to the absorbed dose in the product.

3.2 National laws or regulations may specify the minimum and maximum absorbed dose for a particular radiation processing application.

3.3 Specific applications of ionizing radiation processing include sterilization of medical devices and products, sterilization of medical waste, and processing of foods and spices for quarantine release, pathogen control, or extension of shelf life. Examples of the use of radiochromic films for dosimetry for various irradiation applications are given in references [6] through [8].

## 4 Terminology

Note: For definitions of terms other than those in this clause that are important to metrology, see reference [9].

### 4.1 Radiochromic film dosimetry system

System used for determining absorbed dose, consisting of radiochromic film dosimeters and associated measurement instrumentation.

### 4.2 Radiochromic film dosimeter

Specially prepared film that undergoes a change in optical absorbance when exposed to ionizing radiation. This change in absorbance may be related to absorbed dose in the surrounding material that is usually referenced as water.

### 4.3 Dosimeter batch

Quantity of dosimeters made from a specific mass of material having a uniform composition, fabricated in a single production run under controlled and consistent conditions, and assigned a unique identification code.

### 4.4 Analysis wavelength

Wavelength used in a read-out instrument for measuring the optical absorbance of a radiochromic film dosimeter.

#### 4.5 Net absorbance, $\Delta A$

Change in measured optical absorbance at the analysis wavelength(s) determined as the absolute difference between the pre-irradiation absorbance,  $A_0$ , and the post-irradiation absorbance,  $A$ , as follows:

$$\Delta A = |A - A_0|$$

#### 4.6 Specific net absorbance, $\Delta k$

Net absorbance,  $\Delta A$ , at the analysis wavelength divided by the thickness,  $t$ , of the radiation sensitive layer of the dosimeter as follows:

$$\Delta k = \frac{\Delta A}{t}$$

#### 4.7 Absorbed dose, $D$

The quotient of  $d\bar{e}$  by  $dm$ , where  $d\bar{e}$  is the incremental mean energy imparted by ionizing radiation to a quantity of matter of mass  $dm$ . The unit for absorbed dose is the gray (Gy), where  $1 \text{ Gy} = 1 \text{ J/kg}$ .

#### 4.8 Electron equilibrium

Condition that exists in material under ionizing irradiation whereby the energies, number, and direction of secondary electrons induced by the radiation are uniform throughout the volume of interest. Thus, for such a volume, the sum of the energies of the secondary electrons entering is equal to the sum of the energies of the secondary electrons leaving that volume.

#### 4.9 Calibration facility

Combination of an ionizing radiation source and associated instrumentation that provide uniform and reproducible absorbed dose, or absorbed dose rates, at specified locations within a specific material. The absorbed dose shall be traceable to national or international standards.

#### 4.10 Calibration curve

Graphical representation of the relationship between dosimeter response and absorbed dose for a given dosimetry system.

#### 4.11 Response function

Mathematical representation of the relationship between dosimeter response and absorbed dose for a given dosimetry system.

#### 4.12 Traceability

Property of the result of a measurement or value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons, all having stated uncertainties.

#### 4.13 Repeatability

The closeness of agreement between the results of successive measurements of the same sample carried out under the same conditions and within a relatively short period of time.

Note: The same conditions would include the same method of measurement, measuring instrument, operator, location, and ambient environmental conditions.

#### 4.14 Maximum permissible errors

Extreme values of an error permitted by specifications, regulations, etc. for a given measuring instrument.

#### 4.15 Absorbed-dose working range

The set of values of absorbed dose for which the error of the dosimetry system is intended to lie within specified limits.

#### 4.16 National responsible body

The organization or agency in a particular country that is responsible for determining whether the dosimetry system meets the performance requirements designated by law or regulation.

#### 4.17 Manufacturer

The producer of the radiochromic film dosimeter to be evaluated, unless the term is otherwise specified.

## 5 Description of the dosimetry system

### 5.1 General

5.1.1 The radiochromic film dosimetry system provides a means of determining absorbed dose in materials. Ionizing radiation causes chemical reactions to take place in an exposed radiochromic film dosimeter that increase or decrease the absorbance at some optical absorption bands. Absorbance is determined at one or more specific analysis wavelength(s) within these radiation-induced absorption bands. Appropriate wavelengths for analysis for specific dosimetry systems are identified by the manufacturer or in published references on the subject.

5.1.2 Absorbed dose is usually specified as that which would be received in water. Absorbed dose in other materials may be determined by applying appropriate conversion factors, as discussed in reference [2].

### 5.2 Major components

#### 5.2.1 Radiochromic film dosimeter

5.2.1.1 The dosimeter is usually 0.01 mm to 0.10 mm thick and is a homogeneous free-standing thin film or a coated layer on an optically clear (and radiation-insensitive) substrate.

5.2.1.2 The optical absorbance of the dosimeter changes at the analysis wavelength(s) when the dosimeter is exposed to ionizing radiation. The optical absorbance of a dosimeter is a function of the thickness of its radiation-sensitive material and of the absorbed dose that it receives.

5.2.1.3 The absorbed dose in the dosimeter is determined by measuring its optical absorbance and using the calibration curve or response function that provides a functional relationship between the absorbed dose and the net absorbance or specific net absorbance. The absorbed dose used for calibration of a dosimetry system shall be traceable to national or international standards.

#### 5.2.2 Instrument for measuring the dosimeter thickness

5.2.2.1 An appropriate instrument is used to measure the thickness of the radiation-sensitive layer of the radiochromic dosimeter. For dosimeters without a

substrate, thickness may be measured mechanically by an instrument such as a thickness gauge. The thickness of some types of dosimeters may be measured optically. The actual thickness, or the mean value and standard deviation of representative samples of the batch, may be provided by the manufacturer or determined by the user.

5.2.2.2 In the case of dosimeters with a substrate, the standard deviation in thickness of the radiation-sensitive layer may be provided by the manufacturer instead of their actual thickness or mean value.

#### 5.2.3 Instrument for measuring optical absorbance

5.2.3.1 A read-out instrument, either a spectrophotometer or a photometer, is used to determine the absorbance or transmittance of the dosimeter at the analysis wavelength specified by the manufacturer. The basic components of such instruments are illustrated in Fig. 1.

5.2.3.2 Optical components include a light source, a spectral grating or bandpass (color) filter for selecting the wavelength(s), a holder for reproducible positioning of the dosimeter, and a photodetector.

5.2.3.3 The data read-out component may be either analog or digital, and the data may be recorded either manually by an operator or automatically by a data handling system.

## 6 Metrological requirements

Note: This clause provides the performance requirements that the dosimetry system shall meet during pattern evaluation.

6.1 For evaluation, the manufacturer shall provide to the national responsible body either samples of a batch of radiochromic film dosimeters and a read-out instrument or only samples of a batch of dosimeters. A calibration curve or response function for the dosimetry system read-out shall be submitted by the manufacturer or determined by the national responsible body and shall be based on an analysis of samples from the same batch of dosimeters. It shall cover the absorbed dose working range. If the read-out instrument is not provided by the manufacturer, its performance criteria shall be specified by the dosimeter's manufacturer (see 7.4). Procedures for performing calibrations are given in Annex A.

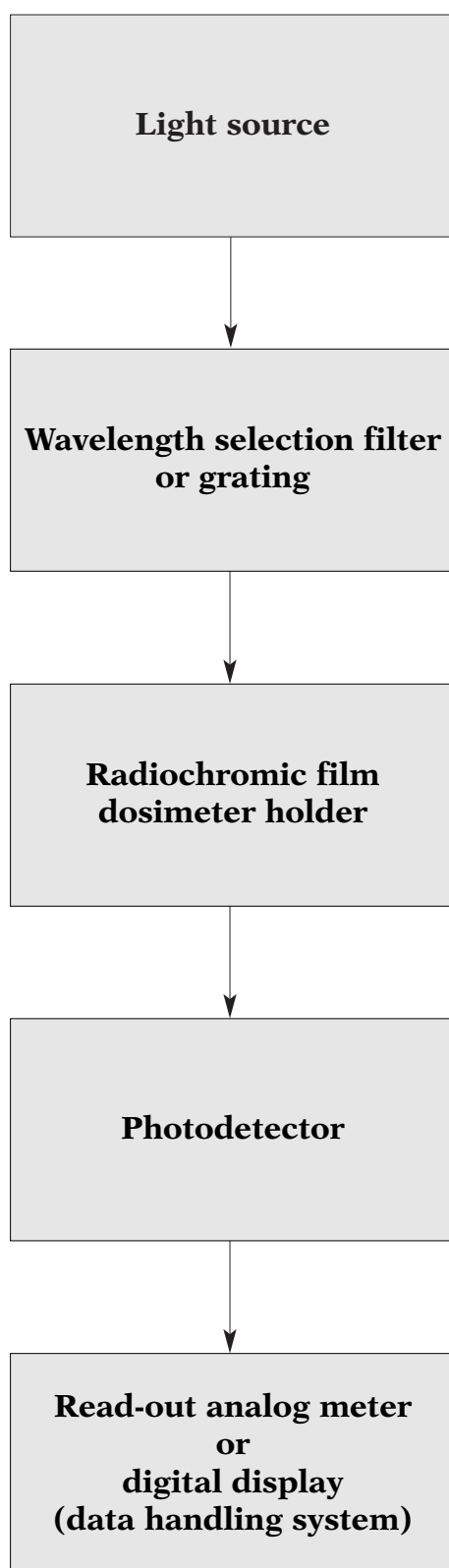


Fig. 1 Diagram of the read-out instrument used in a radiochromic film dosimetry system



## 6.2 Maximum permissible errors and repeatability of absorbed dose

6.2.1 At least 10 dosimeters shall be irradiated in a calibration facility at each of at least three separate absorbed dose levels within the absorbed dose working range. During pattern evaluation, the repeatability and maximum errors of the absorbed dose shall be determined for dosimeters irradiated under the following reference conditions:

- temperature:  $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$  or as specified by the manufacturer;
- relative humidity:  $50\% \pm 10\%$  or as specified by the manufacturer

Note: The reference conditions for relative humidity may be achieved by enclosing the dosimeters in a hermetically sealed package;

- calibration facility: irradiation source having the type of radiation and range of absorbed dose rates as specified by the manufacturer

Note: It has been demonstrated that the expanded uncertainty (calculated for  $k = 2$ ) in absorbed dose delivered in a calibration facility to dosimeters can be within  $\pm 2\%$  [10].

6.2.2 The maximum error in measurement at each of the three absorbed dose levels shall be determined as the difference between the mean absorbed dose value assigned according to the calibration curve and the absorbed dose provided at each level by the calibration facility. The maximum permissible errors of the mean value of absorbed dose determined for each absorbed dose level shall be within  $\pm 6\%$ .

6.2.3 The repeatability of the absorbed dose at each irradiated absorbed dose level as expressed in terms of the relative standard deviation shall not be greater than  $4\%$ .

6.2.4 The test procedure for determining repeatability and maximum errors is given in Annex B.

## 7 Technical requirements

Note: Clause 7 covers information on characteristics and labeling requirements of the dosimeters that shall be provided by the manufacturer to the national responsible body prior to pattern evaluation.

7.1 Dosimeters shall be packaged, and the package shall be marked clearly indicating the product and batch identification. When appropriate, the actual or average thickness of the dosimeter should also be clearly indicated on the package.

7.2 If the thickness of the radiation-sensitive layer of the dosimeter is specified by the manufacturer, then the actual thickness or the mean value and standard deviation of the repeatability of thickness measurements for a specific sample size of a batch shall be provided.

7.3 The manufacturer shall specify the absorbed dose working range of the dosimeter.

7.4 For a read-out instrument not provided by the manufacturer, information on required performance criteria shall be specified by the dosimeter's manufacturer for the instrument to be used in the evaluation as follows:

- for a photometer:
  - waveband for the filter used;
  - absorbance range;
  - repeatability of absorbance measurements within the absorbance range;
- for a spectrophotometer:
  - wavelength of analysis setting and the slit (band) width;
  - absorbance range;
  - repeatability of absorbance measurements within the absorbance range;
- wavelength and absorbance range and repeatability of absorbance to be checked using certified reference materials.

7.5 The read-out instrument used for measuring the absorbance of the dosimeter shall be labeled with or include the following information:

- trade (or instrument manufacturer's) name;
- model and serial number;
- units of measurement (for example, absorbance or transmittance or percent transmittance);
- instructions for setup, adjustment, use, and maintenance.

7.6 The manufacturer shall make available information about the characteristics of the dosimeters, including any effects on the response of the dosimeters caused by irradiation conditions (influence quantities) such as temperature, humidity, atmosphere, and absorbed dose rate.

Note: Influence quantities can be sources of significant error in absorbed dose measurements in radiation processing facilities.

## 8 Practical instructions

Note: This clause provides information for a user to consider prior to selection of a dosimetry system for an application.

8.1 Before using a dosimetry system, all environmental factors related to the specific irradiation application should be considered. If the irradiation conditions are different from those specified for the dosimetry system, the manufacturer or other relevant sources should be consulted before using the dosimetry system. Reference [2] provides guidance on the choice of dosimetry systems.

8.2 Any necessary precautions or warnings for instrument users shall be indicated explicitly in the operating manual and shall be displayed clearly on the read-out instrument when applicable, as may be required by national regulations.

## 9 Metrological controls

Note: This clause provides the steps to be followed by the national responsible body in carrying out pattern evaluation of the dosimetry system. Procedures for consideration and requirements are also given for verification and routine tests of the dosimetry system. In pattern evaluation, the national responsible body selects dosimeters from the batch used to calibrate the dosimetry system and then irradiates them in a calibration facility to predetermined absorbed dose levels. The absorbed doses determined by the dosimetry system compared with the absorbed doses given at the calibration facility provide data for pattern evaluation.

### 9.1 Pattern evaluation

9.1.1 The manufacturer shall provide the national responsible body with samples of a batch of radiochromic film dosimeters and may also provide test data that support an evaluation of whether these dosimeters meet the performance requirements according to this Recommendation.

9.1.2 The radiochromic film dosimeters shall be evaluated using the read-out instrument provided by the manufacturer or a read-out instrument that meets the specifications of the manufacturer as indicated in 7.4. The read-out instrument shall be calibrated according to the requirements of 6.1 and of Annex A.

9.1.3 If the read-out instrument is provided by the manufacturer, its operating manual shall be reviewed by the national responsible body for completeness and clarity of operating instructions, and the read-out instrument shall be inspected visually in conjunction with the manufacturer's specifications to determine whether it complies with the requirements of clause 7.

9.1.4 After calibration of the dosimetry system, the national responsible body shall carry out performance tests using the procedure of Annex B to confirm acceptable conformance to the following requirements:

- maximum permissible errors of absorbed dose measurement (6.2.2);
- repeatability of absorbed dose measurement (6.2.3).

Note: Instead of carrying out these tests, the national responsible body may consider accepting test data submitted by the manufacturer that indicate acceptable conformance.

9.1.5 The results of tests of a dosimetry system carried out at pattern evaluation shall contain, as a minimum, the items of information according to the *Test report format* provided in Annex C. A specific test report form may be developed according to national preference. The manufacturer shall be provided with specific comments about any test failures.

### 9.2 Initial and subsequent verification

9.2.1 The performance requirements for verification either at the site of the manufacturer or at the site of

application shall be the same as for pattern evaluation (9.1.4) except that 5 dosimeters may be used instead of 10 where required in the testing.

9.2.2 Initial verification and subsequent verification, if necessary, of a new supply or batch of radiochromic film dosimeters may be carried out on the basis of information provided by the manufacturer or the user that documents the necessary performance tests (9.1.4) at each of at least three absorbed dose levels covering the working range of the intended application of the dosimeters. The documentation reviewed for verification may be developed using sample sets of a batch or new supply of dosimeters as follows:

- (a) by carrying out with sample sets a calibration of a dosimetry system and verifying that the data obtained for the calibration curve or response function meet the necessary repeatability requirements;
- (b) by using a calibrated dosimetry system to analyze sample sets irradiated in a calibration facility and comparing the measured absorbed doses with those reported for the sets by the calibration facility; or
- (c) by using a calibrated dosimetry system to analyze sample sets irradiated in the user's facility along with transfer standard dosimeters whereby the measured absorbed doses are compared with those values reported for the transfer dosimeters as determined by a recognized calibration facility. The procedures of Annexes A and B should be used as appropriate in developing the documentation that meets the requirements of 9.1.4.

Note: Verification may be carried out by the user utilizing a calibration performed according to the user's quality assurance procedures.

9.2.3 The *Test report format* in Annex C may be modified appropriately to report the results of tests for verification.

9.2.4 The period of validity for initial verification carried out according to 9.2.2 shall be one year unless

documented data provided by the manufacturer support a different period of validity. The period of validity for subsequent verification shall be one year.

### 9.3 Routine tests by a user

9.3.1 The national responsible body may refer users to appropriate methods for using dosimetry systems for specific industrial applications. Some measurement methods may be appropriate for use as quality control of the response of the dosimeter system during radiation processing.

9.3.2 The user shall develop a calibration curve or response function for each specific batch of dosimeters and each read-out instrument used. The calibration should also reflect the specific irradiation conditions of the application.

9.3.3 Tests of the performance of the dosimeter to exposures at the extremes of environmental conditions of humidity and temperature and at the extremes of absorbed dose rates shall be carried out when required for specific applications.

Note: Data on the environmental effects for a specific batch of dosimeters provided by the manufacturer or in relevant publications may be used instead of testing. In some cases, the data provided by the manufacturer on a specific batch of dosimeters may be more current.

9.3.4 A chronological written record for each dosimetry system shall be maintained for a period according to national requirements and shall contain at least the following information:

- results of calibrations;
- results of all routine tests;
- extent of maintenance and repair of the read-out instrumentation;
- identification of major components replaced in the read-out instrumentation.

## References

- [1] ASTM Standard E1275-93, "Practice for use of a Radiochromic Film Dosimetry System", Annual Book of ASTM Standards, Vol. 12.02, ASTM West Conshohocken, PA 19428-2959 (1996).
- [2] ASTM Standard E1261-94, "Practice for Selection and Calibration of Dosimetry Systems for Radiation Processing", Annual Book of ASTM Standards, Vol. 12.02, ASTM, West Conshohocken, PA (1996).
- [3] McLaughlin, W.L.; Humphreys, J.C.; Radak, B.B.; Miller, A. and Olejnik, T.A., "The Response of Plastic Dosimeters to Gamma Rays and Electrons at High Dose Rates", Radiation Physics and Chemistry, 14, pp. 535-550 (1979).
- [4] McLaughlin, W.L.; Humphreys, J.C.; Levine, H.; Miller, A.; Radak, B.B. and Rativanich, N., "The Gamma-Ray Response of Radiochromic Dye Films at Different Absorbed Doses", Radiation Physics and Chemistry, 18, pp. 987-999 (1981).
- [5] Levine, H.; McLaughlin, W.L. and Miller, A., "Temperature and Humidity Effects on the Gamma-Ray Response and Stability of Plastic and Dyed Plastic Dosimeters", Radiation Physics and Chemistry, 14, pp. 551-574 (1979).
- [6] Shaffer, H.L. and Garcia, R.D., "Practical Application of Dosimetry Systems Utilized in Radiation Processing of Medical Devices", Radiation Physics and Chemistry, Vol. 31, pp. 491-496 (1988).
- [7] ASTM Standard E1204-93, "Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing", Annual Book of ASTM Standards, Vol. 12.02, ASTM, West Conshohocken, PA (1996).
- [8] ASTM Standard E1431-91, "Practice for Dosimetry in Electron and Bremsstrahlung Irradiation Facilities for Food Processing", Annual Book of ASTM Standards, Vol. 12.02, ASTM, West Conshohocken, PA (1996).
- [9] *International Vocabulary of Basic and General Terms in Metrology*, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, and OIML, 1993 Edition (ISO).
- [10] Humphreys, J.C.; Hocken, D. and McLaughlin, W.L., "NBS Measurement Services: Dosimetry for High Dose Applications", NIST Special Publication 250-11, US National Institute of Standards and Technology (1988).

## Annex A

### Calibration procedure (Mandatory)

A.1 Select randomly from a single batch a set of at least five dosimeters to be irradiated at each desired absorbed dose level. Use at least five absorbed dose levels per decade of the absorbed-dose working range, with a minimum of five absorbed dose levels if that range is less than one decade. Specify the absorbed dose in terms of absorbed dose in water, or in another material appropriate for the specific application.

A.2 Identify each dosimeter by writing a number on a corner of the dosimeter or by placing it in a numbered envelope.

Note: Improper handling of the dosimeter may affect its analysis. Follow the manufacturer's guidelines for handling the dosimeters.

A.3 Check the dosimeter for defects such as scratches or fingerprints. Dust dosimeters gently, if necessary. Discard any dosimeters that show imperfections which may affect readings.

A.4 Since ultraviolet radiation may cause the film to change color, take necessary precautions to ensure that the handling and reading environment does not cause measurable change in optical absorbance.

Note: Filters placed over fluorescent lights and windows or directly over the film can reduce color development caused by such sources of ultraviolet radiation.

A.5 Check and adjust the read-out instrument according to the instructions given in its operating manual by the instrument's manufacturer (see also 7.4).

A.6 Measure and record the pre-irradiation absorbance,  $A_0$ , of each dosimeter at the selected analysis wavelength and record the specific photodetector and data handling system used. If the dosimeters are pre-packaged and are not to be removed from the package until after irradiation, then an average pre-

irradiation absorbance may be used as determined from at least 10 unirradiated dosimeters from the same batch.

A.7 If necessary, package each dosimeter in order to provide controlled environmental conditions during irradiation.

A.8 Irradiate the dosimeters in a calibration facility under reference conditions as specified in 6.2.1. Photon irradiations shall be carried out under conditions of electron equilibrium.

Note: The definition of electron equilibrium is given in 4.8. For example, in determining the absorbed dose in water for a  $^{60}\text{Co}$  irradiation, electron equilibrium can be achieved by surrounding the dosimeters with 3-mm to 5-mm thick layers of polystyrene or an equivalent polymeric material.

A.9 Measure and record the post-irradiation absorbance,  $A$ , of each dosimeter using the same instrumentation as in A.5.

A.10 If appropriate, measure and record the thickness of the radiation sensitive layer,  $t$ , of each dosimeter, or record the individual or mean value of thickness provided by the manufacturer. Gauge blocks or other standards used to calibrate the thickness measuring instruments shall be traceable to national standards.

Note: Some dosimeters are compressible; therefore, if the film thickness is measured mechanically, care should be taken to minimize compressing the film.

A.11 Calculate the response of each dosimeter, i.e. the net absorbance or specific net absorbance (see 4.5 and 4.6).

A.12 Generate a calibration curve or a response function. Use an analytical form (for example, linear,

polynomial, or exponential) that fits the measured data using standard curve fitting techniques.

A.13 Examine the resulting calibration curve or response function for goodness of fit.

Note: Standard statistical procedures may be used for eliminating outliers.

A.14 Repeat this calibration procedure if any value deviates significantly from the determined curve and if

discarding that value would result in not having sufficient data to define the curve (see also the note under B.6).

A.15 The resulting dosimetry system calibration curve or response function applies only for the batch of dosimeters used in the calibration procedure. A new calibration shall be carried out if a change is made in the batch of dosimeters or any component of the dosimetry system, including repair of the read-out system, that may affect the calibration.



## Annex B

### Test procedure (Mandatory)

B.1 This test shall evaluate the repeatability and maximum errors for absorbed dose determined by the dosimetry system at three absorbed dose levels within the absorbed dose working range of the dosimeter.

B.2 Following the procedures in A.2 through A.7, prepare a set of ten dosimeters for each of the three required dose levels by randomly selecting dosimeters from the same batch from which samples were selected to calibrate the dosimetry system.

B.3 Irradiate the sets of dosimeters in a calibration facility to at least three absorbed dose levels in the low, middle and high regions of the absorbed-dose working range specified by the manufacturer.

Note: The calibration facility does not have to be the same facility used to calibrate the dosimetry system; however, it should meet the requirements of 6.2.1.

B.4 Following the procedures in A.9 through A.11, measure the response of each dosimeter using the photodetector and the data handling system either supplied or specified by the manufacturer.

B.5 Assign an absorbed dose value,  $D$ , corresponding to each measured response using the calibration curve or response function for the dosimetry system.

B.6 Determine the mean absorbed dose,  $\bar{D}$ , and the relative standard deviation,  $\sigma_r$ , for each absorbed dose level using the following equations:

$$\bar{D} = \frac{\sum D_i}{n}$$

$$\sigma = \left[ \frac{\sum (D_i - \bar{D})^2}{n - 1} \right]^{\frac{1}{2}}$$

$$\sigma_r = \frac{\sigma}{\bar{D}} \times 100 \%$$

where:

$D_i$  is an individual absorbed dose value, and

$\bar{D}$  is the average absorbed dose of a number ( $n$ ) of dosimeters at the absorbed dose level.

Note: Standard statistical procedures may be used for eliminating outliers. For example, using Chauvenet's criterion for 10 measurements, any datum shall be rejected if it deviates from the mean value by more than 1.96  $\sigma$ .

B.7 The maximum errors of  $\bar{D}$  and the value of  $\sigma_r$  at each absorbed dose level shall meet the requirements of 6.2.2 and 6.2.3, respectively.

**Annex C**  
**Test report format**  
**(Mandatory)**

A test report intended for use in the *OIML Certificate System* and for other purposes shall include the following information:

Report No. .... OIML Recommendation No. .... Edition (year) .....

C.1 Name and address of the testing laboratory(ies):

.....  
.....  
.....  
.....

C.2 Location at which tests were performed (if other than indicated in C.1):

.....  
.....  
.....  
.....

C.3 Name and address of the manufacturer:

.....  
.....  
.....  
.....

C.4 Name and address of applicant (if other than the manufacturer):

.....  
.....  
.....  
.....

C.5 Identification of the radiochromic film (pattern) tested:

- name of manufacturer .....
- product number .....
- batch number .....



C.6 Identification of the read-out instrument used in testing, either:

spectrophotometer ..... , or photometer .....

- trade (or instrument maker's) name .....
- model number .....
- serial number .....
- review of the operating manual including instructions for set-up, calibration and use:  
acceptable .....; deficient .....

Comments: .....  
.....  
.....

- wavelength ..... or waveband .....
- absorbance range ..... and reproducibility .....

Comments: .....  
.....  
.....

- units of measurement: absorbance .....; transmittance or percent transmittance .....; other .....

Comments: .....  
.....  
.....

C.7 Summary of the results of the pattern evaluation tests carried out

C.7.1 Reference conditions of testing:

- absorbed dose rate ( $Gy \cdot s^{-1}$  in water) .....
- ambient temperature of irradiation volume ..... °C
- relative humidity surrounding the dosimeter ..... %
- atmosphere surrounding the dosimeter .....

Comments: .....  
.....  
.....

C.7.2 Identification of the calibration curve or response function of the dosimetry system

Absorbed-dose working range: .....

Date and location of calibration: .....

Comments: .....  
.....  
.....

C.7.3 Maximum errors and repeatability of absorbed dose

Measurements	Absorbed dose levels (values)		
	1	2	3
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
$\bar{D}$			
$\sigma_r$			

- Maximum error (difference in the mean absorbed dose determined by the calibration curve or response function and that provided by the calibration facility) for each absorbed dose level:

1 ....., 2 ....., 3 .....

pass .....; fail ..... with respect to maximum permissible errors (see 6.2.2)

Comments: .....  
 .....  
 .....  
 .....

- Repeatability for absorbed dose levels (see 6.2.3):

1 ....., 2 ....., 3 .....

pass .....; fail .....

Comments: .....  
 .....  
 .....  
 .....

C.8 Brief statement of the conclusions as to whether the tested dosimeters or dosimetry system meet the requirements of this Recommendation:

.....  
.....  
.....  
.....  
.....  
.....

C.9 Person(s) responsible for the testing:

Signature .....	Signature .....
Title .....	Title .....
Date .....	Date .....

