Standard Practice for Dosimetry in Electron Beam and X-Ray (Bremsstrahlung) Irradiation Facilities for Food Processing[1]

This standard is issued under the fixed designation ISO/ASTM 51431; 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 practice outlines the installation qualification program for an irradiator and the dosimetric procedures to be followed during operational qualification, performance qualification and routine processing in facilities that process food with high-energy electrons and X-rays (bremsstrahlung) to ensure that product has been treated within a predetermined range of absorbed dose. Other procedures related to operational qualification, performance qualification and routine processing that may influence absorbed dose in the product are also discussed. Information about effective or regulatory dose limits for food products, and appropriate energy limits for electron beams used directly or to generate X-rays is not within the scope of this practice (see ASTM Guides F1355, F1356, F1736, and F1885).

NOTE 1—Dosimetry is only one component of a total quality assurance program for adherence to good manufacturing practices used in the production of safe and wholesome food.

NOTE 2—ISO/ASTM Practice 51204 describes dosimetric procedures for gamma irradiation facilities for food processing.

1.2 For guidance in the selection and calibration of dosimetry systems, and interpretation of measured absorbed dose in the product, see ISO/ASTM Guide 51261 and ASTM Practice E666. For the use of specific dosimetry systems, see ASTM Practices E1026 and E2304, and ISO/ASTM Practices 51205, 51275, 51276, 51310, 51401, 51538, 51540, 51607, 51650 and 51956 For discussion of radiation dosimetry for electrons and X-rays also see ICRU Reports 35 and 14. For discussion of radiation dosimetry for pulsed radiation, see ICRU Report 34.

1.3 While gamma radiation from radioactive nuclides has discrete energies, X-rays (bremsstrahlung) from machine sources cover a wide range of energies, from low values (about 35 keV) to the energy of the incident electron beam. For information concerning electron beam irradiation technology and dosimetry, see ISO/ASTM Practice 51649. For information concerning X-ray irradiation technology and dosimetry, see ISO/ASTM Practice 51608.

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:*[2]

E170 Terminology Relating to Radiation Measurements and Dosimetry

E666 Practice for Calculating Absorbed Dose From Gamma or X Radiation

E1026 Practice for Using the Fricke Dosimetry System

E2232 Guide for Selection and Use of Mathematical Methods for Calculating Absorbed Dose in Radiation Processing Applications

E2303 Guide for Absorbed-Dose Mapping in Radiation Processing Facilities

E2304 Practice for Use of a LiF Photo-Fluorescent Film Dosimetry System

F1355 Guide for Irradiation of Fresh Agricultural Produce as a Phytosanitary Treatment

F1356 Practice for Irradiation of Fresh and Frozen Red Meat and Poultry to Control Pathogens and Other Microorganisms

F1736 Guide for Irradiation of Finfish and Aquatic Invertebrates Used as Food to Control Pathogens and Spoilage Microorganisms

F1885 Guide for Irradiation of Dried Spices, Herbs, and Vegetable Seasonings to Control Pathogens and Other Microorganisms

2.2 *ISO/ASTM Standards:*[2]

51204 Practice for Dosimetry in Gamma Irradiation Facilities for Food Processing

51205 Practice for Use of a Ceric-Cerous Sulfate Dosimetry System

[1] This practice is under the jurisdiction of ASTM Committee E61 on Radiation Processingand is the direct responsibility of Subcommittee E61.04 on Specialty Application, and is also under the jurisdiction of ISO/TC 85/WG 3.

Current edition approved by ASTM Oct. 1, 2004. Published May 15, 2005. Originally published as E 1431–91. Last previous ASTM edition E 1431–98$^{\varepsilon 1}$. ASTM E 1431–91 was adopted by ISO in 1998 with the intermediate designation ISO 15562:1998(E). The present International Standard ISO/ASTM 51431:2005(E) is a major revision of the last previous edition ISO/ASTM 51431:2002(E), which replaced ISO 15562.

[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.

51261 Guide for Selection and Calibration of Dosimetry Systems for Radiation Processing
51275 Practice for Use of a Radiochromic Film Dosimetry System
51276 Practice for Use of a Polymethylmethacrylate Dosimetry System
51310 Practice for Use of a Radiochromic Optical Waveguide Dosimetry System
51400 Practice for Characterization and Performance of a High-Dose Radiation Dosimetry Calibration Laboratory
51401 Practice for Use of a Dichromate Dosimetry System
51538 Practice for Use of the Ethanol-Chlorobenzene Dosimetry System
51539 Guide for Use of Radiation-Sensitive Indicators
51540 Practice for Use of a Radiochromic Liquid Dosimetry System
51607 Practice for Use of the Alanine-EPR Dosimetry System
51608 Practice for Dosimetry in an X-ray (Bremsstrahlung) Facility for Radiation Processing
51631 Practice for Use of Calorimetric Dosimetry Systems for Electron Beam Dose Measurements and Dosimeter Calibrations
51649 Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies Between 300 keV and 25 MeV
51650 Practice for Use of a Cellulose Triacetate Dosimetry System
51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing
51956 Practice for Thermoluminescence Dosimetry (TLD) Systems for Radiation Processing

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

ICRU Report 14 Radiation Dosimetry: X Rays and Gamma Rays with Maximum Photon Energies Between 0.6 and 50 MeV
ICRU Report 34 The Dosimetry of Pulsed Radiation
ICRU Report 35 Radiation Dosimetry: Electron Beams with Energies Between 1 and 50 MeV
ICRU Report 37 Stopping Powers for Electrons and Positrons
ICRU Report 60 Fundamental Quantities and Units for Ionizing Radiation

3. Terminology

3.1 *Definitions:*

3.1.1 *absorbed dose, D*—quantity of ionizing radiation energy imparted per unit mass of a specified material. The SI unit of absorbed dose is the gray (Gy), where 1 gray is equivalent to the absorption of 1 joule per kilogram of the specified material (1 Gy = 1 J/kg). The mathematical relationship is the quotient of $d\bar{\varepsilon}$ by dm, where $d\bar{\varepsilon}$ is the mean incremental energy imparted by ionizing radiation to matter of incremental mass dm (see ICRU 60).

$$D = d\bar{\varepsilon}/dm \tag{1}$$

3.1.1.1 *Discussion*—The discontinued unit for absorbed dose is the rad (1 rad = 100 erg/g = 0.01 Gy). Absorbed dose is sometimes referred to simply as dose. Water is frequently selected as the specified material for defining absorbed dose. In practice, dosimeters are most often calibrated in terms of dose to water. That is, the dosimeter measures the dose that water would absorb if it were placed at the location of the dosimeter. Water is a convenient medium to use because it is universally available and understood, and its radiation absorption and scattering properties are close to those of tissue. The requirement of tissue-equivalency historically originates from radiation-therapy applications. However, to determine the temperature increase in an irradiated material, it is necessary to know the absorbed dose in that material. This may be determined by applying conversion factors in accordance with ISO/ASTM Guide 51261.

3.1.2 *absorbed-dose mapping (for a process load)*—measurement of absorbed dose within a process load using dosimeters placed at specified locations to produce a one-, two- or three-dimensional distribution of absorbed dose, thus rendering a map of absorbed-dose values.

3.1.3 *average beam current*—time-averaged electron beam current.

3.1.3.1 *Discussion*—For a pulsed machine, the averaging shall be done over a large number of pulses.

3.1.4 *beam length*—dimension of the irradiation zone along the direction of product movement, at a specified distance from the accelerator window (see Fig. 1).

3.1.4.1 *Discussion*—*(1)* This term usually applies to electron irradiation. *(2)* Beam length is therefore perpendicular to beam width and to the electron beam axis. *(3)* In case of a low-energy, single-gap electron accelerator, beam length is equal to the active length of the cathode assembly in vacuum. *(4)* In case of product that is stationary during irradiation, 'beam length' and 'beam width' may be interchangeable.

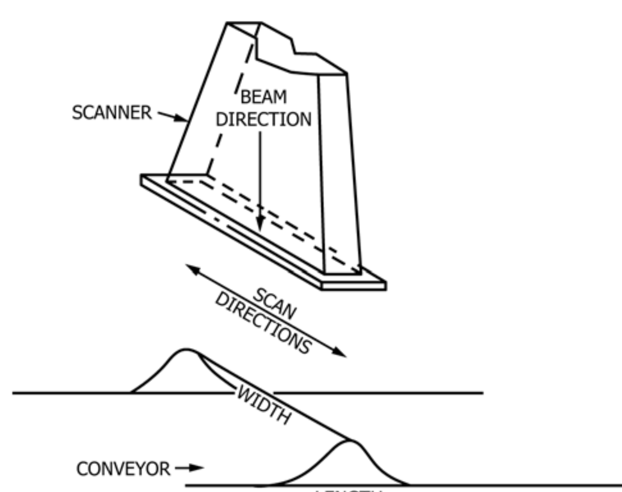

FIG. 1 Diagram showing beam length and width for a scanned beam using a conveyor system

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