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Standard Guide for Irradiation of Insects for Sterile Release Programs[1]

This standard is issued under the fixed designation E 1940; 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 guide outlines dosimetric procedures to be followed for the radiation sterilization of live insects for use in pest management programs. The primary use of irradiated, reproductively sterile insects is in the Sterile Insect Technique, where large numbers of sterile insects are released into the field to mate with and thus control pest populations of the same species. A secondary use of irradiated insects is as benign "hosts" for rearing insect parasitoids. If followed, the procedures outlined in this guide will help to ensure that insects processed with ionizing radiation from gamma, electron, or X-ray sources receive absorbed doses within a predetermined range. Information on effective dose ranges for specific applications of insect sterilization, or on methodology for determining effective dose ranges, is not within the scope of this guide.

NOTE 1—Dosimetry is only one component of a total quality control program to ensure that irradiated insects are adequately sterilized and fully competitive or otherwise suitable for their intended purpose.

1.2 This guide covers dosimetry in the irradiation of insects for these types of irradiators: self-contained dry-storage ^{137}Cs or ^{60}Co irradiators, larger-scale gamma irradiators, and electron accelerators. Additional, detailed information on dosimetric procedures to be followed in installation qualification, process qualification, and routine product processing can be found in Practice E 1608 (X-ray, bremsstrahlung facilities), Practice E 1649 (electron beam facilities), and Practice E 1702 (large-scale gamma facilities).

1.3 The absorbed dose for insect sterilization is typically within the range of 20 Gy to 600 Gy.

1.4 This guide refers, throughout the text, specifically to reproductive sterilization of insects. It is equally applicable to radiation sterilization of invertebrates from other taxa (for example, Acarina, Gastropoda) and to irradiation of live insects or other invertebrates for other purposes (for example, inducing mutations), presuming the absorbed dose is within range specified in 1.3.

1.5 This guide also covers the use of radiation-sensitive indicators for the visual and qualitative indication that the insects have been irradiated.

1.6 *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 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[2]
E 1026 Practice for Using the Fricke Reference Standard 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 1538 Practice for Use of the Ethanol-Chlorobenzene Dosimetry System[2]
E 1539 Guide for the Use of Radiation-Sensitive Indicators[2]
E 1540 Practice for Use of a Radiochromic Liquid Dosimetry System[2]
E 1607 Practice for Use of the Alanine-EPR Dosimetry System[2]
E 1608 Practice for Dosimetry in an X-Ray (Bremsstrahlung) Facility for Radiation Processing[2]
E 1649 Practice for Dosimetry in an Electron Beam Facility for Radiation Processing at Energies Between 300 keV and 25 MeV[2]
E 1702 Practice for Dosimetry in a Gamma Irradiation Facility for Radiation Processing[2]
E 1707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing[2]
E 1956 Practice for use of a Thermoluminescence Dosimetry (TLD) System for Radiation Processing

[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.

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

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

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

ICRU 14 Radiation Dosimetry: X-rays and Gamma Rays with Maximum Photon Energies Between 0.6 and 50 MeV
ICRU 17 Radiation Dosimetry: X-rays Generated at Potentials of 5 to 150 kV
ICRU 33 Radiation Quantities and Units
ICRU 34 The Dosimetry of Pulsed Radiation
ICRU 35 Radiation Dosimetry: Electron Beams with Energies Between 1 and 50 MeV

2.3 *NCRP Publications:*[5]

NCRP Report No. 69, Dosimetry of X-Ray and Gamma-Ray Beams for Radiation Therapy in the Energy Range 10 keV to 50 MeV, December 1981.

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^{-1}, which is equivalent to 100 rad). The mathematical relationship is the quotient of $d\bar{\epsilon}$ by dm, where $d\bar{\epsilon}$ is the mean incremental energy imparted by ionizing radiation to matter of incremental mass dm (see ICRU 33).

$$D = d\bar{\epsilon}/dm$$

3.1.1.1 *Discussion*—The discontinued unit for absorbed dose is the rad (1 rad = 1 cGy = 100 erg per gram). Absorbed dose is sometimes referred to simply as dose.

3.1.2 *absorbed-dose mapping*—measurement of absorbed-dose within 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 *absorbed-dose rate*—the absorbed dose in a material per incremental time interval, that is, the quotient of dD by dt (see ICRU 33).

$$\dot{D} = dD/dt \text{ (SI unit: Gy} \cdot \text{s}^{-1}\text{)}$$

3.1.3.1 *Discussion*—The absorbed-dose rate can be specified in terms of average value of $\dot{D}$ over long-time intervals, for example, in units of Gy · min^{-1} or Gy · h^{-1}.

3.1.4 *calibration*—the comparison of a measurement system or device of known accuracy that is traceable to national standards to detect, correlate, report, or eliminate by adjustment any variation from the required performance limits of the unverified measurement system or device.

3.1.5 *canister*—a durable, reusable container, usually an aluminum or steel cylinder, used to house factory-reared insects (in packaging containers) during the radiation process.

3.1.5.1 *Discussion*—Canisters are not used in some applications in which the packaging container is sufficiently rigid and the design of irradiator is appropriate.

3.1.6 *dose uniformity ratio*—ratio of maximum to minimum absorbed dose within the irradiated factory-reared insects. This concept is also referred to as the "max/min ratio".

3.1.6.1 *Discussion*—The central plane/minimum dose ratio is not used in this guide.

3.1.7 *dosimeter*—a device that, when irradiated, exhibits a quantifiable change in some property of the device which can be related to absorbed dose in a given material using appropriate analytical instrumentation and techniques.

3.1.7.1 *Discussion*—A dosimeter shall exhibit the reproducible and quantifiable properties that allow it to be calibrated and compared to national standards.

3.1.8 *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.

3.1.9 *factory-reared insects*—insects that are reared *en masse* in a laboratory or factory setting for use, following reproductive sterilization through irradiation, as live animals in pest management programs.

3.1.10 *irradiator turntable*—device used to rotate the canister during the radiation process so as to improve the dose uniformity ratio.

3.1.10.1 *Discussion*—An irradiator turntable is often referred to as a turntable. Some irradiator geometries, for example, with an annular array of radiation sources surrounding the product, may not need a turntable.

3.1.11 *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 specified application. This plan requires traceability to, and consistency with, nationally or internationally recognized standards.

3.1.12 *measurement traceability*—the ability to demonstrate by means of an unbroken chain of comparisons that a measurement is in agreement within acceptable limits of uncertainty with comparable nationally or internationally recognized standards.

3.1.13 *packaging container*—a container such as a paper cup with lid, plastic bag, or plastic bottle that is used to hold factory-reared insects during irradiation and, typically, during subsequent shipment from the irradiation facility to the release site.

3.1.14 *process load*—volume of material with a specified loading configuration irradiated as a single entity.

3.1.15 *radiation-sensitive indicator*—material such as a coated or impregnated adhesive-back (or adhesive-front) substrate, ink, or coating which may be affixed to or printed on the irradiated sample and which undergoes a visual change when exposed to ionizing radiation (see Guide E 1539).

3.1.15.1 *Discussion*—Radiation-sensitive indicators are often referred to as" indicators." Radiation-sensitive indicators cannot be classified as a "label" under certain trade association guidelines. Indicators may be used to show that products have been exposed to ionizing radiation. They can be used to provide a visual and qualitative indication of radiation exposure and can be used to distinguish between irradiated and

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

[5] Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Ave., Bethesda, MD 20814, USA.