

A Survey of Physical Dosimetry to Date and in the Near Future: Part 1. Review of Standards and Regulatory Issues

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This article summarizes the status of the relevant standards and current regulatory issues for use of physical dosimetry devices for the occupational worker in the United States. Included is a summary of relevant standards from the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the American National Standards Institute (ANSI), the United States Nuclear Regulatory Commission NUREG-Series, the National Voluntary Laboratory Accreditation Program (NVLAP), the Department of Energy Laboratory Accreditation Program (DOELAP), and the U.S. Military Specifications and Standards (MIL-STD). Proposed changes to ANSI N13.11-1993, "American National Standard for Dosimetry-Personnel Dosimetry Performance Criteria for Testing," are listed. The strategic changes that the United States Nuclear Regulatory Commission (NRC) is making in rulemaking activities related to dosimetry and standards are given. The status of Measurement Program Description (MPD) C.18, "Implementation of Electronic Dosimetry for Primary Dosimetry," from the Council on Ionizing Radiation Measurements and Standards (CIRMS) is given.

Introduction

Physical dosimetry devices are essential to the field of low-level radiation exposure. For external radiation exposure, physical dosimetry devices worn by the occupational worker directly measure the whole-body, extremity, and eye dose equivalents. To date, these devices are the legal and practical way to determine the personnel radiation dose of record. These devices are subject to voluntary standards and specific legal regulations. The transition to new physical dosimetry systems or other dosimetry methodologies, such as biodosimetry, will require the modification of current standards and regulations. The current standards are summarized in two tables that categorize the standards into different subject areas. Additionally, important changes in the standards and in U.S. regulatory programs are discussed.

Standards and Regulatory Status

Several international standards serve to provide guidance on the characterization, performance, and use of physical dosimetry devices. Tables I and II provide an abbreviated list of the most commonly used standards for physical dosimetry.¹⁻⁵ These standards have three common principles. First, they are consensus standards in which the views of all interested parties, such as manufacturers, vendors, users, consumer groups, testing laboratories, governments, engineering professionals, and

research organizations, are taken into account. Second, they are intended to provide global solutions that satisfy industries and customers worldwide. Third, they are voluntary.

Standards are living documents that evolve with progress in the field. Of particular relevance to this article is a proposed draft revision to ANSI N13.11, the standard referenced in the National Voluntary Laboratory Accreditation Program (NVLAP) accreditation process for whole-body dosimetry. According to ANSI N13.11 committee member Craig Yoder, "the goal was to adopt current International Organization for Standardization (ISO) guidance where possible and to incorporate Department of Energy (DOE) needs so that we can have one standard—maybe two test programs, but one standard." Mr. Yoder provided Table III, which outlines the proposed changes. In summary, the proposed changes to ANSI N13.11 provide for a proficiency test that is more inclusive of the range of qualities encountered in practical situations. The past criteria were established on the principle that each measurement is important to an individual; satisfactory performance is no longer based solely on a group statistic with little regard for the frequency of large biases.

In the United States, occupational radiation workers are subject to the legal requirements in state and federal codes. State codes are written to be in compliance with federal codes and to embellish them in those areas not covered. Federal regulation is overseen by the Nuclear Regulatory Commission (NRC) and guided by the U.S. Code of Federal Regulations (CFR). At the eighth Annual Meeting of the Council on Ionizing Radiation Measurements and Standards (CIRMS) in October 1999, Dr. Ronald Zelac from the NRC announced several strategic changes in the NRC's rulemaking activities related to dosimetry and standards.⁶

The NRC intends to incorporate voluntary standards into rulemaking. Dr. Zelac explained that Public Law 104-113, the National Technology and Transfer Act of 1995 (with guidance in the Office of Management and Budget [OMB] Circular A-119), promotes participation by federal agencies in the development and use of standards. This law specifies that agency staff members participate as authorized representatives. The NRC will encourage greater involvement of licensees and industry in developing codes, standards, and guides that can be endorsed by the NRC. The expected benefits are (1) the adoption of acceptable criteria and methods of appropriate specificity, (2) increased agreement among licensees so that fewer case-by-case reviews are required, (3) better compliance because licensees know what is expected of them, and (4) a shortened revision process because those who help produce a standard should not object if it becomes a regulation.

Dr. Zelac also announced a proposed change in 10CFR20 that attempts to broaden licensee options for personnel dosimetry usage. To this end, a definition of "dosimeter of record" will be

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TABLE I
SUMMARY OF DOSIMETRY STANDARDS: PART I

Personnel whole-body dosimetry ANSI N13.11: 1993	American National Standard for Dosimetry-Personnel Dosimetry Performance Criteria for Testing
Quality assurance, accreditation, and certification standards NVLAP PB90-242298 NISTIR 89-4125: 1989	Program Handbook, Personnel Radiation Dosimetry
NVLAP NIST Handbook 150: 1994	Procedures and General Requirements
NVLAP NIST Handbook 150-4: 1994	Ionizing Radiation Dosimetry
DOE 5480.15: 1987	U.S. Department of Energy-Department of Energy Laboratory, Accreditation Program for Personnel Dosimetry
DOE/EH-0026: 1986	Handbook for the Department of Energy Laboratory Accreditation Program for Personnel Dosimetry System
DOE/EH-0027: 1989 ANSI Z1.4-1993	Department of Energy Standard for the Performance Testing of Personnel Dosimetry Systems Sampling Procedures and Tables for Inspection by Attributes
Environmental dosimetry ANSI N13.29: Draft 11/14/94 ANSI N13.37: Draft 6/93	American National Standard for Dosimetry-Environmental Dosimetry Performance-Criteria for Testing American National Standard for Environmental Thermoluminescent Dosimeters of Radioactive Sources and Associated Instrument Quality Control (<i>Note: This standard is intended to take the place of N545</i>)
Extremity dosimetry ANSI N13.32 1995	American National Standard for Dosimetry-Extremity Dosimetry Performance-Criteria for Testing
System characterization, type testing, environmental criteria IEC 61066 Ed. 1.0 b: 1991 ISO4037-1,2; 1996, 1997	Thermoluminescence dosimetry systems for personal and environmental monitoring X and γ reference radiation for calibrating dosimeters and dose-rate meters and for determining their response as a function of photon energy: Part 1. Radiation characteristics and production methods. -Part 2. Dosimetry for radiation protection over the energy ranges from 8 keV to 13 MeV and 4 MeV to 9 MeV
ISO 8529: 1989	Neutron reference radiations for calibrating neutron-measuring devices used for radiation protection purposes and for determining their response as a function of neutron energy
ANSI/ANS 6.1.1-1991 ISO 6980: 1996	Neutron and γ Ray Fluence-to-Dose Factors References β radiations for calibrating dosimeters and dose-rate meters and for determining their response as a function of β -radiation energy
ANSI N42.17A-1989 (R1994)	Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions
ANSI N42.17C-1989 (R1994)	Radiation Instrumentation-Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Extreme Environmental Conditions
IEC 68-1	Environmental Testing

added to Part 20, and the specific references to the type of personnel dosimeter (film and thermoluminescent dosimeters) will be removed from Parts 34, 36, and 39. These changes could allow U.S. licensees to use electronic and other dosimetry devices as the primary dosimeter to monitor personnel exposure. In the author's opinion, there is a broader issue to resolve. Approval of the dosimetry device for a specified range of operation needs to be separated from the certification of use, operation, and processing of the device.

Also discussed at the CIRMS meeting was the progress on Measurement Program Description (MPD) C.18, Implementation of Electronic Dosimetry for Primary Dosimetry. As part of this initiative, started in 1998, Sergio Lopez of MGP Instruments is chairing the Electronic Dosimetry Type Test Committee (EDTTC).

The EDTTC will produce two documents. The first document, "Electronic Dosimeter Test Criteria," will list about 70 test criteria, including all relevant information regarding each test.

This document is intended to provide a consistent method for testing any electronic dosimeter (i.e., other MGP Instruments models as well as other manufacturers' models). The second document, "Type Test Results of the MGPI DMC 2000S Electronic Dosimeter," will be the completed test report for the DMC 2000S. In addition to listing all information included in the first document, this will also include all test results. This test report can serve as a reference for demonstration of regulatory compliance for the DMC 2000S.⁷

This test plan would not only ensure compliance with applicable standards but would also cover practical applications and needs not currently covered by any of the standards. Furthermore, under this plan, some of the critical dosimeter parameters would be tested to failure to establish the limitations of the device and predict its behavior under abnormal conditions.⁶

This work will allow users to make valid comparisons among different dosimeter types and to make sound decisions regarding the use of electronic dosimetry. It will ultimately eliminate

TABLE II
SUMMARY OF DOSIMETRY STANDARDS: PART 2

Electronic and direct reading dosimeters ANSI N13.27: 1997 Draft	American National Standard Performance Requirements for Pocket-Sized Alarm Dosimeters and Alarm Ratemeters
ANSI N13.2-1981 (R1992)	Dosimeters and Alarm Ratemeters, Performance Requirements for Pocket-Sized Alarm
IEC 61283 Ed. 1.0 b: 1995	Radiation protection instrumentation—Direct reading personal dose equivalent (rate) monitors X-, γ -, and high-energy β -radiation
ANSI N42.20: 1995	Performance Criteria for Active Personnel Radiation Monitors
IEC 61526 Ed. 1.0 b: 1998	Radiation protection instrumentation—Measurement of personal dose equivalents Hp(10) and Hp(0.07) for X-, γ -, and β -radiations—Direct reading personal dose equivalent and/or dose equivalent rate dosimeters
IEC 61525 Ed. 1.0 B: 1996	Radiation protection instrumentation—X-, γ -, high-energy β and neutron radiations—Direct reading personal dose equivalent and/or dose equivalent rate monitors
NUREG CR-6354 (7/95)	Performance Testing of Electronic Personnel Dosimetry Systems
Capacitor-type dosimeters ISO 11934: 1997	X- and γ -radiation—Indirect or direct reading capacitor-type pocket dosimeters
United States military specifications and standards MIL-STD-167-1	Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)
MIL-STD-1189	Standard Department of Defense Bar Code Symbology (for guidance only)
MIL-STD-1399-070	Interface Standard for Shipboard Systems—D.C. Magnetic Field Environment
MIL-STD-1399-300A	Interface Standard for Shipboard Systems—Electric Power, Alternating Current
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility
MIL-STD-462	Test Method Standard for Measurement of Electromagnetic Interference Characteristics
MIL-STD-471	Maintainability Verification/Demonstration/Evaluation
MIL-HDBK-781	Reliability Test Methods, Plans and Environments for Engineering Development, Qualification, and Production
MIL-S-901	Shock Tests, High Impact, Shipboard Machinery, Equipment and Systems, Requirements for

TABLE III
SUMMARY OF PROPOSED CHANGES TO ANSI N13.11

1. Categories have been consolidated to reduce the number of dosimeters required for general purpose use. The separate X-ray, γ -ray, and angular test categories now used have been combined into one.
2. The variety of X-ray and γ -ray energies that can be used for the test has been expanded to include any narrow or wide series ISO or NIST technique including the X-rays from americium-241. Each dosimeter will likely be irradiated to a different quality, which differs from the current practice of varying the quality each month.
3. The pass criteria for protection doses have been lowered to 0.4 to be consistent with those of DOELAP.
4. A new pass condition exists to ensure that limited number of dosimeters have unsatisfactory errors. Only one dosimeter can have a bias that exceeds the pass criterion of 0.4. This is consistent with new ISO guidance.
5. Tests for the mixture of β particles and photons will allow the use of low-energy X-rays when a high-energy β source is used. In the past, only γ -rays were mixed with β particles. This change makes the standard compatible with current DOE practices.
6. A krypton-85 source can be used in place of thallium-204 to be consistent with ISO guidance.
7. Neutron tests will include a high- and low-energy spectrum from californium-252. These will be mixed with X-rays and γ -rays. Currently, only γ -rays are mixed with the neutron irradiations.
8. Angular testing will be standard in the photon protection category test when the average energy is >70 keV.
9. The processor can request that the testing laboratory adjust the stated delivered dose by the offset between the phantom surface where the dose is defined and the sensitive elements of the dosimeter, which is spaced in front of the phantom.
10. Standard uses current NIST specified conversion factors put out by NVLAP.

ISO, International Organization for Standardization; NIST, National Institute of Standards and Technology; DOELAP, Department of Energy Laboratory Accreditation Program; NVLAP, National Voluntary Laboratory Accreditation Program.

from the market dosimeters that do not meet these criteria because they will no longer be considered adequate. The adoption of comprehensive, uniform testing methods is the only means by which to ensure that the quality of the devices and compliance with standards are maintained.

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2. International Electrotechnical Commission (IEC), available at <http://www.tec.ch/>.
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4. Nuclear Regulatory NUREG-Series, available at <http://www.nrc.gov/>.
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A Survey of Physical Dosimetry to Date and in the Near Future: Part 2. Review of Commercially Available Products

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This article summarizes the status of physical dosimetry for the occupational worker. The review of commercially available physical dosimetry systems was limited to the following technologies: thermoluminescent dosimeters, electronic personnel dosimeters, optically stimulated luminescence dosimeters, and direction ion storage dosimeters. Product reviews were limited to the top models and largest commercial manufacturers in each category. The physical principles of each dosimeter type are discussed. Information was gathered from journal literature, by direct experience, and by inviting six commercial vendors to present their newest technologies. Each system was found to have strengths and weaknesses. Many of the technologies presented by major vendors were still in development and thus could be considered near-future systems.

Introduction

The physical dosimetry industry is presently very dynamic. Several new technologies and materials have been proposed over the past several years. As low as reasonably achievable principles push levels of detection lower and make real-time monitoring more desirable. Changes in standards are in the planning stage but will eventually demand greater dosimeter capabilities. The battlefield emphasis has changed from measuring high exposures from nuclear detonation to measuring low-level exposures from terrorist attacks. The threat of radiation-related litigation is necessitating the monitoring of individuals on the battlefield, which will require that lower cost and logistically simpler devices be used. Greater emphasis on data management and record keeping will require that dosimetry systems integrate these capabilities into their system.

Review of Current Physical Dosimetry Technology for Occupational Workers

Film and thermoluminescent dosimeter (TLD) methodologies are the most widely accepted to date; these methods are specifically referenced in the Code of Federal Regulations and have been used for over 30 years. Film is not discussed in this article because of space limitations.

In thermoluminescence, ionizing radiation interacts with a crystal, which then ejects electrons from its atoms. The number of ejected electrons is proportional to the absorbed radiation dose. Some of these free electrons fall into traps created by defects introduced into the crystal. If the traps are deep enough, these electrons will remain there forever. The number of trapped electrons is therefore a measure of the absorbed dose since

initialization (emptying all the traps). The number of trapped electrons is measured by heating the material to a temperature high enough to release all of the trapped electrons. The energy of the released electrons is higher than that of the atomic electrons. When these released electrons return to their atomic sites and become atomic electrons, they give up some of their excess energy in the form of luminescence. The amount of luminescence is proportional to the number of electrons that were initially ejected by the ionizing radiation and therefore to the absorbed dose. When properly calibrated, the luminescence intensity is a measure of the absorbed dose.¹

Two of the largest and oldest commercial manufacturers of TLD systems are Bicon RMP (Solon, Ohio) and Panasonic (Matsushita Electric Corp., Secaucus, New Jersey). Both companies offer a variety of products to fill diverse customer needs. Bicon's most popular whole-body system uses a four-chip lithium fluoride dosimeter that is heated with hot nitrogen gas or purified hot air. Panasonic's most popular whole-body system uses a four-chip dosimeter (two chips of lithium borate and two chips of calcium sulfate) that is heated by a flash lamp. Both systems measure beta particles, photons, and albedo neutrons.

Bicon's newest dosimeter, model 8840/8841, uses a four-element, high-sensitivity, copper-doped lithium fluoride material, a Monte Carlo optimized holder for improved photon energy discrimination, and a neural network algorithm for dose calculation. Panasonic's newest product is an improved reader, model UD7900M, which has a thermal flux sensor that allows near real-time monitoring of thermal profile and simultaneous comparison with multiple other reader parameters. Bicon and Panasonic do not offer dosimetry processing services, but they do sell dosimetry processing equipment, dosimeters, and materials to other processors.

The optically stimulated luminescent (OSL) dosimeter mechanism is identical to the TLD mechanism with one exception. In OSL, the trapped electrons are released using light exposure (laser or light emitting diode [LED]) rather than heat application. OSL was first suggested as a dosimetry tool in the 1950s and 1960s.²

Several OSL methods exist for dosimetry with aluminum oxide. All use the same basic steps to determine the radiation dose absorbed by the aluminum oxide dosimeter—namely, stimulation with a pure light source followed by the quantitative measurement of the resultant luminescence emitted by the dosimeter.³ Akselrod et al.² provide a useful historical summary and detailed explanation of delayed optical stimulated luminescence (DOSL) and pulsed optical stimulated luminescence (POS�).

DOSL occurs at room temperature. A light source, such as a helium-cadmium laser emitting 442-nm light, transfers trapped electrons from the dosimetric centers to shallow traps, which are emptied quickly by the thermal energy present at room

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temperature. The stimulation time depends on the desired sensitivity and energy output of the laser. With a 100-mW laser, stimulation times of less than 1 second will result in very good dosimetry with good reanalysis capability. After stimulation, electrons vacate the shallow traps and combine with the luminescence centers. The resultant luminescence lasts for several seconds with the luminescence of very large radiation doses lasting over 30 seconds. Generally, a delay of 0.5 to 1 second between stimulation and luminescence measurement is introduced to allow the dosimeter to be relocated from the laser beam to the photomultiplier housing. This approach simplifies mechanical design and avoids the need to use optical filters to protect the photomultiplier tube from the laser light. DOSL is the simplest OSL method from a design perspective.

POSL is a very fast luminescence process involving the direct transfer of trapped dosimetric electrons to the luminescence centers. While DOSL uses shallow traps as intermediaries, POSL avoids the delay by measuring luminescence produced by electrons moving from the dosimetric traps directly to the luminescence centers. Because the fast luminescence decays in a few microseconds, the measurement process is very fast and the stimulation can be rapidly repeated or pulsed. Pulsing enhances sensitivity and results in a better signal-to-noise ratio for a given stimulation energy. Prompt OSL measures the luminescence during stimulation, as the stimulation light does not prevent electrons from recombining with the luminescence. Pulsed OSL requires advanced optical filtration to separate the stimulation light from the luminescence. Pulsed methods can avoid this complexity by using fast timing systems to coordinate the stimulation and luminescence measurement equipment.

POSL is currently being used commercially by the Landauer Corporation (Glenwood, Illinois) in their OSL dosimeter called Luxel. The Luxel dosimeter essentially uses three filtered aluminum oxide positions for the beta and photon measurements, CR-39 for the neutron measurement, and one additional aluminum oxide area for imaging. Currently, Landauer offers only dosimetry processing services, but it has plans to begin selling dosimetry processing equipment, dosimeters, and materials to other processors.

Electronic dosimeters typically use silicon photodiodes (PIN diodes) or Geiger-Mueller detectors with a complex filter for energy compensation.⁴ This article discusses silicon PIN diodes only. PIN diodes can operate in pulse or current modes. In pulse mode, a reverse bias is applied to the diode so that the diode operates similarly to a parallel plate ionization chamber. In current mode, the charge migrates due to the self-bias of the detector and is converted into a current flow. Silicon is neither an air nor a tissue equivalent material below 300 keV. Above 300 keV, silicon and air have similar mass energy absorption coefficients in current mode. Operating in pulse mode increases the sensitivity but also increases the over-response compared with the cesium-137 response.

There are four common techniques used to make the response of PIN diodes tenable at energies below 300 keV. (1) The most cost-effective commercial practice is to use a single diode with a simple filter to flatten the energy response; this has the major disadvantage of sacrificing low-energy photon response below 70 keV. (2) An algorithm based on the photon spectrum of a single diode can be used to flatten the energy response to 18

keV.⁵ (3) Olsher and Eisen⁴ describe a technique using a composite filter of two or more materials together with several openings whose individual area is in the range of 15% to 25% of the diode's active area. One of the openings is centered over the diode's active area and the others are located at the periphery of the active area to preserve a good response to radiation incident to the dosimeter at angles of $\pm 45^\circ$. (4) Finally, it is also possible to use multiple diodes in parallel with individual filters to produce an excellent energy and angular response. Two of the largest manufacturers using this technique are Siemens (Munich, Germany) and MGP Instruments (Atlanta, Georgia). Both of these companies offer an extensive product list.

Siemens' newest whole-body electronic dosimeters are the electronic personnel dosimeter (EPD) Mark 2 and the EPD-N. The EPD Mark 2 is a three-PIN diode whole-body dosimeter for measuring beta and photon fields (Hp[0.07] and Hp[10]). The EPD-N is based on the EPD Mark 2 design, but replaces the shallow dose Hp(0.07) quantity with a neutron-detection capability designated Hp(N).

MGP's newest whole-body dosimeters are the DMC 2000 XB and the SOR 2000. The DMC 2000 is a three-PIN diode whole-body dosimeter for measuring beta and photon fields (Hp[0.07] and Hp[10]). The SOR 2000 is a military dosimeter designed to be worn under protective clothing by an individual (soldier) involved in operations in a nuclear, biological, and chemical zone. It monitors residual gamma and neutrons and has a built-in backup passive silicon detector, which may still be read after the nuclear flash following a nuclear or thermonuclear blast.

The direction ion storage (DIS) dosimeter by RADOS (Baltimore, Maryland) uses a modified Analog-EEPROM memory cell.⁶ The oxide layer surrounding the typical floating gate in the memory cell is modified so that the surface of the floating gate is in direct contact with the surrounding air (or any other gas). The memory cell is surrounded by a conductive wall so that an ion chamber is effectively formed between the wall and the floating gate. The floating gate is initially charged to a preset value to "zero" the memory cell. As photon radiation or charged particle radiation interacts with the wall or gas inside the chamber, charged particles are formed. These particles easily migrate toward the charged floating gate, lowering the charge. The information stored is read without disturbing the stored charge by measuring the channel conductivity of the transistor. Thus, the DIS dosimeter can be read at any time during use to determine the cumulative dose up to that point. RADOS has also developed a neutron-capable DIS dosimeter. The DIS dosimeter badge contains five elements: a deep-dose low-level ion chamber, a deep-dose intermediate-level ion chamber, a deep-dose high-level MOSFET, a shallow-dose low-level ion chamber, and a shallow-dose high-level ion chamber. The neutron version of the DIS eliminates the deep-dose high-level MOSFET element and the shallow-dose capability. It has four elements consisting of two ranges of gamma- and neutron-sensitive detectors and two ranges of detectors that are sensitive only to gamma.

Film, TLD, and OSL are clearly categorized as "passive" rather than "active" dosimetry systems. The author has never found a formal definition of a passive dosimeter, but some general comments can be made about passive and active systems. Passive implies that the radiation-sensitive elements do not require en-

ergy to store or measure the deposited energy during the radiation exposure. The readout of a passive dosimeter requires the removal of all or part of the stored energy. If the removal of energy is small and predictable, re-reads may be possible. In general, passive dosimeters are thought to be the most reliable because they (1) are less susceptible to environmental stimuli such as radio frequency waves, microwaves, magnetic fields, and electrostatic fields; (2) they do not need to be powered to operate; and (3) they require no operational parts during irradiation. Passive dosimeters are integrating devices that rely on superposition and give only cumulative dose information.

Active devices are inherently more versatile because they provide real-time information and are dose-rate devices. They lend themselves to remote reading, dose control, and alarm features. Active devices do not have to be processed to be read; instead, each device is its own reader. Electronic dosimetry readers take the already processed dose information from each device for the real-time storage, analysis, and control of the aggregate data. Electronic dosimetry readers also control individual features on each electronic dosimeter.

Generally, the prices per unit for passive dosimeters are lower than for active devices, but require more expensive readers to process them. Active dosimeters require a replacement battery and a calibration check every 9 to 12 months.

The DIS dosimeter cannot be clearly categorized as active or passive. It cannot be considered a true passive system because it is a charged device like a pocket ion chamber. However, reading the dosimeter does not remove any of the stored charge. This allows the DIS dosimeter to have many of the dose-rate features of an active dosimeter.

The choice of which dosimeter is best depends on the needs of the user. It is not a simple question that can be answered by one criterion. All dosimetry systems must meet the |B|+S limitations

in each of the National Voluntary Laboratory Accreditation Program (NVLAP) categories upon blind proficiency testing according to ANSI N13.11-1993. Remarkably, vendors of dosimetry systems often do not have this information on their new products but rely on customers to acquire it during NVLAP accreditation. Manufacturers do not need to go through NVLAP accreditation to blind test their final product in NVLAP categories. Another requirement is to make sure that any environmental factor encountered during the dosimeter's storage and use will not affect its operation. When choosing a dosimeter, serious engineering and economic analyses must be done on each system that meets all the listed operational requirements. It is also important to include the status and reputation of the vendor in the analysis. Will the vendor be around in the future? Is there a prior relationship and established track record? Is the vendor vertically integrated, and does it have the manufacturing capacity to adequately meet all dosimetry needs? These factors and questions should be considered before a dosimetry system is acquired and used.

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