U.S. NUCLEAR REGULATORY COMMISSION

June 2011
Revision 1

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.4

(Draft was issued as DG-8036, dated April 2010)

PERSONNEL MONITORING DEVICE—DIRECT-READING POCKET DOSIMETERS

A. INTRODUCTION

This guide provides a method acceptable to the U.S. Nuclear Regulatory Commission (NRC) staff for use in complying with the agency's regulations on direct-reading pocket dosimeters. The guide includes specific performance standards for personnel monitoring but not for area monitoring.

The regulatory requirements for the use of personnel monitoring devices are mainly established in Title 10, of the *Code of Federal Regulations*, Part 20, "Standards for Protection against Radiation" (10 CFR Part 20) (Ref. 1), which requires licensees to determine and record occupational exposures to demonstrate compliance with dose limits for adults (including declared pregnant women), an embryo/fetus, and minors and to supply and direct the use of individual monitoring devices. In addition, 10 CFR Part 34, "Licenses for Industrial Radiography and Radiation Safety Requirements for Industrial Radiographic Operations" (Ref. 2), includes a specific provision in 10 CFR 34.47, "Personnel Monitoring," that requires the use of a direct-reading pocket dosimeter or an electronic personnel dosimeter for industrial radiographer personnel monitoring. Also, NUREG-1556, "Consolidated Guidance about Materials Licenses," Volume 2, "Program-Specific Guidance about Industrial Radiography Licenses," issued August 1998 (Ref. 3), provides guidance for the use of pocket dosimeters in industrial radiographic operations.

This regulatory guide contains information collection requirements covered by 10 CFR Part 20 and 10 CFR Part 34 that the Office of Management and Budget (OMB) approved under OMB control numbers 3150-0014 and 3150-0007, respectively. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. The OMB has determined that NRC's Regulatory Guides are not "major" rules under the Congressional Review Act.

The NRC issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff needs in reviewing applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions—1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

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B. DISCUSSION

In addition to guidance on direct-reading dosimeters, the previous version of this guide included guidance on indirect pocket dosimeters. However, this guide excludes such dosimeters because they are rarely used. The direct-reading dosimeter, also known as a pocket dosimeter, self-reading pocket dosimeter, and pocket electroscope, provides individuals with an immediate reading of their exposure to x rays and gamma rays. Although this dosimeter was originally designed to measure x-ray and gamma-ray exposures, it can also respond to beta radiation above 1 million electron volts. Neutron-sensitive versions have also been developed.

Direct-reading dosimeters are still in operation because they are compact and reusable, allowing individuals to determine their exposure at any time with reasonable accuracy on a daily or a single entry dose assessment, which is an important advantage when working in high-radiation fields. However, their readings may be affected by shock; are subject to drift, especially in conditions of high humidity; are temperature dependent in some applications; and may be difficult to read under certain work conditions, such as in low light. Therefore, this type of dosimeter has been supplanted in some industries by electronic dosimeters, which perform the same functions with greater reliability and accuracy, as well as provide many additional important capabilities (Ref. 4).

The NRC staff provided guidance on direct-reading dosimeters in Regulatory Guide 8.4 in 1973, endorsing American National Standards Institute (ANSI) N13.5-1972, "Performance Specifications for Direct Reading and Indirect Reading Pocket Dosimeters for X- and Gamma Radiation" (Ref. 5). ANSI N13.5-1972 was reaffirmed in 1989, but there has not been a revision since its inception. The standard refers to obsolete technical practices as well as outdated requirements and is no longer endorsed in this guide.

ANSI developed a related standard for pocket dosimeters, ANSI N322-1977, "American National Standard Inspection and Test Specifications for Direct and Indirect Reading Quartz Fiber Pocket Dosimeters" (Ref. 6), which was updated in 1997 as ANSI N322-1997, "Inspection, Test, Construction, and Performance Requirements for Direct Reading Electrostatic/Electroscope Type Dosimeters" (Ref. 7).

Although ANSI N322-1977, and its update, ANSI N322-1997, provide related guidance for direct-reading dosimeters, the NRC staff has not endorsed them in their entirety because several sections are not relevant to licensee activities necessary to comply with the NRC regulations. However, some of their recommendations for direct-reading dosimeters that are still applicable to NRC licensees are endorsed by the staff and are included in Section C below. This revision also references NUREG-1556, Volume 2, which includes guidance on direct-reading dosimeters used by industrial radiographers.

C. REGULATORY POSITION

In accordance with 10 CFR 20.1501, "General," licensees must ensure that dosimeters are calibrated for the radiation measured. In addition, 10 CFR 34.47 has additional dosimeter requirements for industrial radiographers. NUREG-1556, Volume 2, includes specific guidance for industrial radiography licensees using direct-reading dosimeters.

In general, all licensees should ensure that pocket dosimeters are well maintained, clean, and free of contamination; calibrated at specified frequencies; and checked periodically for proper operation, following the manufacturer's recommended procedures. Specifically, licensees should perform the following tasks for pocket dosimeters:

1. Criteria for Selecting Pocket Dosimeters

Licensees should check pocket dosimeters before initial use and after being subject to possible damage from being dropped or from other causes. Licensees should check pocket dosimeters at a maximum test interval of 12 months for correct response. Retest should be performed if the dosimeter fails its initial calibration. Although 10 CFR 34.47(c) requires that radiography licensees check pocket dosimeters at periods not to exceed 12 months, and NUREG-1556, Volume 2, recommends the same interval, licensees should check more frequently based on the working environment and conditions. If adjustment is necessary, licensees should follow manufacturer instructions.

2. Response Check Criteria

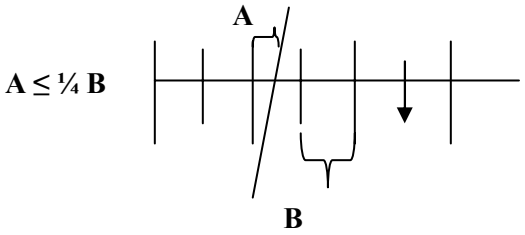
The licensee should reject the dosimeter if it fails to read within ±20 percent of the calibrated exposure from a source traceable to the National Institute of Standards and Technology on two consecutive tests.[1] In addition, licensees should follow the manufacturer's recommendations to reject for the following testing:

a. Loss of hermetic seal—This can be evidenced by cracks in optics, scale fading, or presence of moisture in the viewing window.

b. Excessive geotropism—A special characteristic of direct-reading dosimeters is the effect of gravity on the indicator (geotropism). This effect is observed as the fiber-image shift when the instrument is held horizontally and rotated about its optical axis. With the dosimeter charged to midscale and held horizontally, read the dosimeter with the scale upright and horizontal, rotated 90 degrees each direction, and with the scale inverted. The change in reading should not exceed ±5 percent of maximum scale value.

c. Excessive drift or charge leakage—The discharge of the dosimeter in the absence of a radiation environment above normal background (usually 0.02 milliroentgen per hour (mR/h)) should be measured. A fully charged dosimeter should discharge no more than 5 percent of full scale in 48 hours.

Fiber alignment to scale markings—The image of the fiber should appear as a line parallel to the scale markings within one-fourth of a minor scale division over the entire scale; that is, with the charging potential adjusted so that the image of the fiber coincides with the bottom of any major scale division marking, the distance between the image of the fiber and the top of that same major division marking should not be greater than one-fourth the distance between two adjacent minor division markings.



[1] As required by 10 CFR 34.47(c), pocket dosimeters for radiography licensees must read within ±20 percent of the true radiation exposure. NUREG-1556, Volume 2, as well as this guide, recommend the same percentage. However, licensees could use more conservative criteria.

d. Change in reading after charging—Upon the completion of charging and adjusting the dosimeter to a scale reading of 0, the pressure on the dosimeter charging switch should be released. The dosimeter should then be removed from the charging receptacle. The charging electrode of the dosimeter should then be electrically shorted to the barrel of the dosimeter, and the scale reading again observed. The net difference between the initial setting with the dosimeter fully depressed on the charger and the final reading should not exceed 5 percent of full scale for dosimeters with ranges up to and including 1,290 microcoulombs/kilogram (μC/kg) (5 R) and 2 percent of full scale for dosimeters with ranges greater than 1,290 μC/kg (5 R).

e. Radiation response—The dosimeter should be fully charged and then exposed to a source of radiation of the specified energy, with the axis of the dosimeter perpendicular to the axis of the beam, to deliver an exposure equal to 50 percent of the full-scale reading, at a rate at least a factor of 1,000 below the maximum exposure rate. The reading obtained should be within ±20 percent of the true exposure delivered.

3. Use of Dosimeters

Licensees should store pocket dosimeters in an area with a low radiation background and charge and reset them in accordance with the manufacturer's recommendations. In order to ensure full-scale reading capability, any pocket dosimeter that will be used during a particular shift, should be recharged or reset at the start of that shift, so that the dosimeter will be capable of reading the dose accrued, while also accounting for the charge leakage that normally occurs.

Licensee instructions should include how and where pocket dosimeters are to be stored when not in use. The storage place should be dry, with a low radiation background and cool room temperature so that the devices will not be affected by adverse environmental conditions.

a. Training

All users should receive training in the use of personnel monitoring equipment. Training may include such elements as the proper method of charging, reading, and recording such readings from the pocket dosimeter; proper location of the pocket dosimeter during specific radiation exposure conditions; and proper handling of the dosimeter and action to be taken if it is found to be off scale.

b. Comparison of Dose Readings

Licensees should compare the total doses recorded by the pocket dosimeter for a given period with the dose recorded by the worker's primary personnel dosimetry, such as thermoluminescent dosimetry or optically stimulated luminescence dosimeters, and investigate the reasons for differences greater than 25 percent for gamma- and x-ray dose measurements and 50 percent for neutron dose measurements and when either device exceeds 100 millirem of accumulated exposure.

c. Mixed Radiation Fields

Direct-reading pocket dosimeters normally used for gamma dose measurements may be used in a mixed neutron and gamma radiation field for neutron dose measurements to comply with the personnel monitoring and recordkeeping requirements of 10 CFR Part 20, provided that all of the following conditions are met:

(1) The neutron dose equivalent rate and the gamma exposure rate at the point of personnel exposure are known.
(2) The neutron-to-gamma ratio is essentially constant during the period of personnel exposure.
(3) The degree of response of the dosimeter to the neutron flux density is known.

If the response to the neutron flux density is negligible, the gamma exposure indicated by the dosimeter may be accepted. To determine the neutron dose equivalent, multiply the indicated gamma exposure by the neutron-to-gamma ratio.

If the response to the neutron flux is significant, and the gamma dose is known, then the neutron component is the total response of the neutron-gamma dosimeter minus the gamma dose. The neutron dose is the neutron component adjusted by the appropriate neutron dose calibration factor.

d. Off-scale Reading

If the individual's pocket dosimeter is found to be off-scale, and the possibility of radiation exposure cannot be ruled out as the cause, the individual's personnel dosimeter should be sent for processing within 24 hours.[2] The radiation protection manager/radiation safety officer or their designee should determine whether the individual should resume work associated with the licensed activities. The results of this determination must be included in the records maintained by the licensee.[3] The pocket dosimeter should also be checked for proper functioning and calibration.

4. Records

Personnel should be instructed that direct-reading dosimeters should be read, and the exposures recorded at the beginning and the end of each shift, and records should be maintained in accordance with 10 CFR 34. 83.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

In some cases, applicants or licensees may propose or use a previously established acceptable alternative method for complying with specified portions of the NRC's regulations. Otherwise, the methods described in this guide will be used in evaluating compliance with the applicable regulations for license renewal applications.

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[2] As required by 10 CFR 34.47(d), if pocket dosimeters for radiography licensees are found to be off scale, the individual's personnel dosimeter must be sent for processing within 24 hours.

[3] As required by 10 CFR 34.47(d).

REFERENCES[4]

1. 10 CFR Part 20, "Standards for Protection against Radiation," U.S. Nuclear Regulatory Commission, Washington, DC.

2. 10 CFR Part 34, "Licenses for Industrial Radiography and Radiation Safety Requirements for Industrial Radiographic Operations," U.S. Nuclear Regulatory Commission, Washington, DC.

3. NUREG-1556, "Consolidated Guidance about Materials Licenses," Volume 2, "Program-Specific Guidance about Industrial Radiography Licenses," U.S. Nuclear Regulatory Commission, Washington, DC, August 1998.

4. Frame, P.W., "A History of Radiation Detection Instrumentation," *Health Physics*, 88:613–637, 2005.

5. ANSI N13.5-1972, "Performance Specifications for Direct Reading and Indirect Reading Pocket Dosimeters for X- and Gamma Radiation," American National Standards Institute, Washington, DC, 1972.[5]

6. ANSI N322-1977, "American National Standard Inspection and Test Specifications for Direct and Indirect Reading Quartz Fiber Pocket Dosimeters," American National Standards Institute, Washington, DC, 1977.

7. ANSI N322-1997, "Inspection, Test, Construction, and Performance Requirements for Direct Reading Electrostatic/Electroscope Type Dosimeters," American National Standards Institute, Washington, DC, 1997.

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[4] Publicly available NRC published documents are available electronically through the Electronic Reading Room on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. The documents can also be viewed on-line or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail pdr.resource@nrc.gov.

[5] Copies of American National Standards may be purchased from the American National Standards Institute (ANSI), 1819 L Street, NW, 6th floor, Washington, DC 20036; telephone (202) 293-8020. Purchase information is available through the ANSI Web site at http://webstore.ansi.org/ansidocstore/.