U.S. NUCLEAR REGULATORY COMMISSION

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Proposed Revision 2 to Regulatory Guide RG 4.13

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ENVIRONMENTAL DOSIMETRY – PERFORMANCE SPECIFICATIONS, TESTING, AND DATA ANALYSIS

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes an approach that is acceptable to the staff of the U.S. Nuclear Regulatory Commission (NRC) to meet regulatory requirements for performing surveys and evaluations of public dose in the unrestricted area and the controlled area of a licensed facility from direct radiation using environmental dosimetry.

RG 4.13 endorses the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.37-2014, "Environmental Dosimetry—Criteria for System Design and Implementation" (Ref. 1), which provides environmental dosimeter performance specifications, testing criteria and data analysis methods for passive environmental dosimetry systems, such as thermoluminescence dosimeters (TLDs) and optically stimulated luminescence dosimeters (OSLs).

Applicability

This RG applies to all facilities licensed under the following regulations.

- Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 2),
- 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants" (Ref. 3),
- 10 CFR Part 70, "Part 70—Domestic Licensing of Special Nuclear Material" (Ref. 4), and
- 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste" (Ref. 5).

Applicable Regulations

- 10 CFR Part 20, "Standards for Protection Against Radiation" (Ref. 6).
    - 10 CFR 20.1301, "Dose limits for individual members of the public," establishes the dose limits for members of the public.
    - 10 CFR 20.1302, "Compliance with dose limits for individual members of the public," provides acceptable methods used to demonstrate compliance with the dose limits.
- 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."
    - 10 CFR 50.36a, "Technical specifications on effluents from nuclear power reactors," establishes the requirement that licensees keep releases of radioactive material as low as is reasonably achievable (ALARA) and establishes the expectation that radioactive materials released to unrestricted areas meet the numerical limiting conditions for operation in Appendix I, to 10 CFR Part 50, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."
    - 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 64, "Monitoring Radioactivity Releases," establishes design criteria for monitoring the plant environment for radioactivity that may be released from the plant.
    - 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion, "As Low As Is Reasonably Achievable, for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," Section B, provides the criterion that an appropriate surveillance and monitoring program be established to provide data on measurable levels of radiation in the environment.
- 10 CFR Part 52
    - 10 CFR Part 52.0, "Scope; applicability of 10 CFR Chapter I, provisions," states that the regulations referenced in 10 CFR Chapter I are applicable to 10 CFR Part 52 licensees (e.g., 10 CFR Part 20).
- 10 CFR Part 70
    - 10 CFR 70.59, "Effluent monitoring reporting requirements," requires licensees to provide information because the Commission may require them to estimate maximum potential annual radiation doses to the public resulting from effluent releases.
- 10 CFR Part 72
    - 10 CFR Part 72.104, "Criteria for radioactive materials in effluent and direct radiation from an independent spent fuel storage installations (ISFSI) or Monitored Retrievable Storage Facilities (MRS)," incorporates the U.S. Environmental Protection Agency (EPA) standards in 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations" (Ref. 7), and 40 CFR Part 191, "Environmental Radiation

Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste" (Ref. 8).

- 40 CFR Part 190 (10 CFR 20.1301(e) requires that NRC licensees subject to the standards set forth in 40 CFR Part 190 shall comply with those standards)
    - 40 CFR 190.10, "Standards for formal operations," establishes the EPA standards for the annual dose equivalent not to exceed 25 millirem (mrem) (0.25 millisievert (mSv)) to the whole body, 75 mrem (0.75 mSv) to the thyroid, and 25 mrem (0.25 mSv) to any other organ.

Related Guidance

- RG 4.1, "Radiological Environment Monitoring for Nuclear Power Plants" (Ref. 9), provides guidance on for use in establishing and conducting a comprehensive environmental monitoring program at nuclear power plants.
- NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors" (Ref. 10), provides guidance on standard radiological effluent controls for pressurized water reactors.
- NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors" Generic Letter 89-01, Supplement No. 1 (Ref. 11), provides guidance on standard radiological effluent controls for boiling water reactors.
- RG 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste" (Ref. 12), provides guidance on (1) measuring, evaluating, and reporting plant-related radioactivity (excluding background radiation) in effluents and solid radioactive waste shipments from NRC licensed facilities, (2) assessing and reporting the public dose from facility operations, and (3) complying with 40 CFR 190 in accordance with the requirements of 10 CFR 20.1301(e).

Purpose of Regulatory Guides

The NRC issues RGs to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated events, and to provide guidance to applicants. RGs are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs 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.

Paperwork Reduction Act

This RG provides guidance for implementing the information collections in 10 CFR Parts 50, 52, 70 and 72 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), under control numbers 3150-0011, 3150-0151, 3150-0009 and, 3150-0132. Send comments regarding this information collection to the Information Services Branch, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of

Information and Regulatory Affairs, NEOB-10202 (3150-0011, 3150-0151, 3150-0009, 3150-0132), Office of Management and Budget, Washington, DC 20503.

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless the document requesting or requiring the collection displays a currently valid OMB control number.

B. DISCUSSION

Reason for Revision

This revision of the guide (Revision 2) provides updated NRC guidance on an acceptable dosimetry program by endorsing ANSI/HPS N13.37-2014. The 2014 ANSI/HPS standard provides up-to-date environmental dosimetry system design criteria and dosimeter laboratory test protocols and data-analysis methods suitable to assess potential facility-related radiation doses.

The NRC modified the title of Revision 2 to RG 4.13 from the title used for Revision 1. The NRC is changing the title to more clearly indicate the content of the RG, which includes data-analysis methods suitable to assess potential facility-related radiation doses, and to broaden the scope beyond thermoluminescence dosimetry to include other types of dosimetry.

Background

RG 4.1, "Radiological Environmental Monitoring for Nuclear Power Plants," provides an overall description of an environmental monitoring program for nuclear power plants. It includes guidance for evaluating direct radiation measurements to determine the dose contribution from plant operation to members of the public in the general environment.

Revision 1 to RG 4.13, "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications," issued in July 1977 (Ref. 13), endorsed the American National Standards Institute (ANSI) N545-1975, "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications)" standard (Ref. 14).

ANSI N545-1975 provides a conceptual description of two methods for analyzing environmental data, but it does not provide specific data analysis techniques for either method. The two methods are based on two assumptions:

(1) Background radiation levels are the same at any location but may vary from year to year.

The background radiation levels are assumed to be the same, regardless of the monitoring location. Therefore, dosimetry measurements can be made at control locations (i.e., at a site remote from a nuclear facility) and compared to the dose rate at indicator locations near the monitored facility.

(2) Background radiation levels are constant at each location but may vary between locations.

The background dose rate at each location is constant (i.e., from preoperational time periods to operational time periods). Dosimetry measurements can be made at a monitoring location and compared to previous (e.g., preoperational) measurements at the same location.

Revision 1 to RG 4.13 established the regulatory position that ANSI N545-1975 is a generally acceptable method of performing direct radiation surveys in the environment of NRC-licensed facilities, subject to additional dosimeter performance specifications listed in Revision 1. ANSI N545-1975, Appendix C, "Interpretation of Field Exposures to Isolate Contributions Attributable to Man-Made Radiation Sources (Such as Nuclear Power Plant)," provides a conceptual description of two data-analysis methods, but it does not provide a data-analysis procedure. Operating experience showed that the dosimetry performance specifications in Revision 1 were difficult to meet and unnecessarily burdensome.

In 1980, the NRC provided guidance on an acceptable method of complying with the EPA 40 CFR 190 requirements. The agency described the method in NUREG-0543, "Methods for Demonstrating LWR Compliance with the EPA Uranium Fuel Cycle Standard (40 CFR Part 190)," issued February 1980 (Ref. 15). NUREG-0543 states conditions under which conformance with 10 CFR Part 50, Appendix I, provide reasonable assurance of conformance with 40 CFR Part 190. NUREG-0543 states that, in comparing 10 CFR Part 50, Appendix I, to 40 CFR Part 190, the only potentially significant exposure pathway that is not addressed is the direct radiation pathway.

NUREG-0543 indicated that, for most facilities with offsite direct radiation doses exceeding 5 mrem (0.05 mSv) per year, it is necessary to determine the magnitude and distribution of off-site direct radiation doses. Under these conditions, NUREG-0543 assumed that a reasonable assurance exists that no individual would receive a significant dose (i.e., greater than 1 mrem (0.01 mSv) per year per reactor) from radioactive liquid effluent release pathways. Therefore, only doses to individuals via airborne gaseous effluent pathways and doses resulting from direct radiation need consideration in determining compliance with EPA's regulations in 40 CFR Part 190. After the direct radiation dose fields were characterized, the dose resulting from direct radiation was added to the doses resulting from liquid and gaseous effluents to establish compliance with 40 CFR Part 190.

Since the publication of NUREG-0543 in 1980, some light-water reactors (LWRs) have begun storing substantial amounts of radioactive material outside the heavily shielded areas of the nuclear power plants (e.g., spent fuel assemblies in independent spent fuel storage installations (ISFSIs) and low-level radioactive waste, such as steam generators and reactor heads). The additional storage of this waste has the potential for increasing the direct radiation levels and dose to members of the public in the unrestricted area and the controlled area of a licensed facility.

In 1991, the NRC revised 10 CFR Part 20 to include a new requirement in 10 CFR 20.1302 stating that licensees shall perform, as appropriate, surveys of radiation levels in the unrestricted area and the controlled area of a licensed facility to demonstrate compliance with the dose limits for individual members of the public.

Subsequently, ANSI N545-1975 was withdrawn and replaced with ANSI/Health Physics Society (HPS) N13.37-2014, "Environmental Dosimetry—Criteria for System Design and Implementation." ANSI/HPS N13.37-2014 provides revised environmental dosimetry performance specifications and data analysis methods to comply with 10 CFR Part 20 that are based on the premise that the background radiation at each location is constant. Appendix A of this RG provides a summary of ANSI N13.37-2014 data-analysis methods.

ANSI N13.37-2014 introduced four important terms:

(1) The "minimum quantifiable dose" (MQD) is the smallest amount of dose that can be accurately measured with less than or equal to a 7 percent coefficient of variation. The MQD is used to evaluate the adequacy of a dosimeter system design.

(2) The "minimum differential dose" (MDD) is the smallest amount of dose that can be detected and attributed to a facility's operation (e.g., the incremental dose above background). The MDD is a nominal 5 to 6 mrem (0.05 to 0.06 mSv) per quarter or 10 to 12 mrem (0.01 to 0.12 mSv) per year.

(3) The FRD is the actual amount of dose detected (above natural background) attributed to the facility. If the FRD is less than the MDD, the FRD is "not detected."

(4) The "extraneous dose" is the extra dose accumulated on a dosimeter before and after field deployment. Extraneous dose is due to radiation sources other than those at the field monitoring location, such as natural background (when the dosimeter is not deployed), and dose received from manmade sources in transit such as medical isotopes or facility sources such as nitrogen-16 (N-16) shine when the dosimeter is not deployed. To determine the field dose, the extraneous dose is subtracted from the gross field dosimeter.

It should be recognized that facilities using passive environmental dosimeters such as TLDs and OSLs for environmental measurements may not be able to measure very low doses below the minimum detectable dose. In those situations additional calculations or measurements may be performed by the licensees.

Harmonization with International Standards

The NRC has a goal of harmonizing its guidance with international standards, to the extent practical. The International Commission on Radiological Protection and the International Atomic Energy Agency have issued a significant number of standards, guidance, and technical documents, and recommendations that address good practices in most aspects of radiation protection. The NRC encourages licensees to consult these international documents noted throughout this guide and to implement the good practices, where applicable.

The International Electrotechnical Commission (IEC) issued international standard IEC 62387:2012, "Radiation Protection Instrumentation—Passive Integrating Dosimetry Systems for Personal and Environmental Monitoring of Photon and Beta Radiation" (Ref. 16). ANSI N13.37-2014 and RG 4.13, Revision 2, are generally consistent with the IEC standard for dosimetry system performance specifications and complement and supplement the technical guidance in IEC 62387. However, although the performance criteria are generally comparable, by focusing specifically on passive environmental monitoring dosimetry systems, the ANSI/HPS N13.37-2014 testing approach may be a simpler approach than the one described in IEC 62387. Additionally, ANSI/HPS N13.37-2014 extends beyond IEC 62387:2012 in providing guidance for deployment and data analysis of environmental monitoring dosimetry systems.

Generally, it should be noted that some of the recommendations issued by these international organizations do not correspond to the requirements specified in the NRC's regulations. In such cases, the NRC's requirements take precedence.

Documents Discussed in Staff Regulatory Guidance

This RG endorses the use of one or more codes or standards developed by external organizations, and other third party guidance documents. These codes, standards and third party guidance documents may contain references to other codes, standards or third party guidance documents ("secondary references"). If a secondary reference has itself been incorporated by reference into NRC regulations as a requirement, then licensees and applicants must comply with that standard as set forth in the regulation. If the secondary reference has been endorsed in a RG as an acceptable approach for meeting an NRC requirement, then the standard constitutes a method acceptable to the NRC staff for meeting that regulatory requirement as described in the specific RG. If the secondary reference has neither been incorporated by reference into NRC regulations nor endorsed in a RG, then the secondary reference is neither a legally-binding requirement nor a "generic" NRC approved acceptable approach for meeting an

NRC requirement. However, licensees and applicants may consider and use the information in the secondary reference, if appropriately justified, consistent with current regulatory practice, and consistent with applicable NRC requirements.

C. STAFF REGULATORY GUIDANCE

This section describes an approach that is acceptable for performing surveys and evaluations of public dose in the unrestricted area and the controlled area of a licensed facility from direct radiation using environmental dosimetry.

The guidance included in ANSI/HPS N13.37-2014 is endorsed without exception for meeting the purpose of this guide, as stated in the introduction.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] subject to 10 CFR Part 20 may use this guide and information regarding the NRC's plans for using this regulatory guide.

Use by Applicants and Licensees

Applicants and licensees may voluntarily[2] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described or referenced in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations.

Licensees may use the information in this regulatory guide for actions which do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59, "Changes, Tests, and Experiments." Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

The NRC staff does not intend or approve any imposition of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action that would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order, generic communication, or rule requiring the use of this regulatory guide.

During regulatory discussions on plant specific operational issues, the NRC staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this revised regulatory guide, and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements.

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[1] In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52, and the term "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

[2] In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

REFERENCES [3]

1. American Nuclear Standards Institute/Health Physics Society N13.37-2014, "Environmental Dosimetry—Criteria for System Design and Implementation."[4]

2. *U.S. Code of Federal Regulations* (CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities," Chapter I, Title 10, "Energy."

3. CFR Part 52, "Licenses, Certifications, and Approvals For Nuclear Power Plants," Chapter 1, Title 10, "Energy."

4. CFR, "Domestic Licensing of Special Nuclear Material," Part 70, Chapter I, Title 10, "Energy."

5. CFR, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-level Radioactive Waste, and Reactor-related Greater Than Class C Waste," Part 72, Chapter I, Title 10, "Energy."

6. CFR, "Standards for Protection against Radiation," Part 20, Chapter 1, Title 10, "Energy."

7. Environmental Protection Agency (EPA), CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," Chapter I, Title 40, "Protection of Environment." [5]

8. EPA, CFR Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes," Title 40, "Protection of Environment."

9. U.S. Nuclear Regulatory Commission (NRC), Regulatory Guide (RG) 4.1, "Radiological Environmental Monitoring for Nuclear Power Plants," Washington DC.

10. NRC, NUREG-1301, (1991) "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, Generic Letter 89-01, Supplement No. 1," Washington DC (ADAMS Accession No. ML091050061).

11. NRC, NUREG-1302, (1991), "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors, Generic Letter 89-01, Supplement No. 1," Washington DC (ADAMS Accession No. ML091050059).

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3 Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at http://www.nrc.gov/reading-rm/doc-collections/ and through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. The documents can also be viewed online or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD. For problems with ADAMS, contact the PDR staff at 301-415-4737 or (800) 397-4209; fax (301) 415-3548; or e-mail pdr.resource@nrc.gov.

4 Copies of American National Standards Institute (ANSI) standards may be purchased from ANSI, 1819 L Street, NW, Washington, DC 20036, on their Web site at http://webstore.ansi.org/; telephone (202) 293-8020; fax (202) 293-9287; or e-mail storemanager@ansi.org. Copies of the Health Physics Society (HPS) products may be purchased from HPS, 1313 Dolley Madison Boulevard, Suite 402 McLean, Virginia 22101 Phone: 703-790-1745.

5 Copies of EPA Library Services may be obtained through their Web site: http://www.epa.gov/libraries/library_services.html.

12. NRC, RG 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," Washington, DC.

13. NRC, RG 4.13, Revision 1, (1977) "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications," Washington, DC (ADAMS Accession No. ML003739935).

14. American National Standards Institute (ANSI) N545-1975, "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications)."

15. NRC, NUREG-0543, (1980), "Methods for Demonstrating LWR Compliance with the EPA Uranium Fuel Cycle Standard (40 CFR Part 190)," Washington DC (ADAMS Accession No. ML081360410).

16. International Standard of the International Electrotechnical Commission (IEC) 62387:2012 "Radiation Protection Instrumentation – Passive integrating dosimetry systems for personal and Environmental Monitoring of Photon and Beta Radiation."[6]

[6] Copies of International Electrical Commission (IEC) documents may be obtained through their Web site: http://www.iec.ch/ or by writing the IEC Central Office at P.O. Box 131, 3 Rue de Varembé, 1211 Geneva, Switzerland, Telephone +41 22 919 02 11.

Bibliography

Regulatory Guides

RG 4.8, "Environmental Technical Specifications for Nuclear Power Plants," December 1975 (ADAMS Accession No. ML003739900) (Withdrawn; see 74 FR 21017; May 6, 2009).

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NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants: A Guidance Manual for Users of Standard Technical Specifications," October 1978 (ADAMS Accession No. ML091050057).

NRC, NUREG-1301, (1991) "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, Generic Letter 89-01, Supplement No. 1," Washington, DC (ADAMS Accession No. ML091050061).

NRC, NUREG-1302, (1991), "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors, Generic Letter 89-01, Supplement No. 1," Washington, DC (ADAMS Accession No. ML091050059).

NUREG/CR-3775, "Quality Assurance for Measurements of Ionizing Radiation," June 1984 (ADAMS Accession No. ML101390303).

Generic Letters (GLs)

GL 79-41, "Compliance with 40 CFR [Part] 190, EPA Uranium Fuel Cycle Standard," September 17, 1979 (available at https://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1979/gl79041.html.)

GL 79-70, "Environmental Monitoring for Direct Radiation," December 21, 1979 (available at https://www.nrc.gov/reading-rm/doc-collections/gen-comm/gen-letters/1979/gl79070.html.)

Branch Technical Positions

Branch Technical Position on Environmental Monitoring, "An Acceptable Radiological Environmental Monitoring Program," Revision 0, March, 1978 (ADAMS Accession No. ML093380781).

Branch Technical Position on Environmental Monitoring, "An Acceptable Radiological Environmental Monitoring Program," Revision 1, November 1979 (ADAMS Accession No. ML12187A692).

National Standards

ANSI N545-1975, "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications)" (http://webstore.ansi.org/).

ANSI/HPS N13.11-2009, "Personnel Dosimetry Performance – Criteria for Testing" (http://webstore.ansi.org/).

Associated Documents

Darois, E.L., and Rashidifard, N.S. (Radiation Safety & Control Services, Inc.), "Characterization of Neutron and Gamma Fields and Dosimetry Response from Spent Fuel in Transit and Stored at ISFSI Facilities," Radiological Effluents and Workshop, San Diego, CA, June 23–25, 2015 (ADAMS Accession No. ML15362A644).

APPENDIX A

SUMMARY OF ANSI N13.37-2014 DATA-ANALYSIS METHODS

Appendix A provides a summary of ANSI N13.37-2014 data analysis methods for information only. This summary is not intended to substitute for use of ANSI N13.37-2014. Licensees should review the standard and use it as the basis for the environmental dosimetry program. ANSI/HPS N13.37-2014 provides revised environmental dosimetry performance specifications and data analysis methods based on the premise that the background radiation at each location is constant.

1. Performance Specifications

Dosimeter design criteria (with testing performed under laboratory conditions) should be such that uniformity and reproducibility criteria are sufficient to meet a coefficient of variation (CV) of less than or equal to 7.5 percent for individual groups of 10 dosimeters and an average CV over several dosimeter test groups of less than or equal to 5 percent.

2. Data Analysis

Data-analysis methods should be able to detect a facility-related dose (FRD) (e.g., approximately 5 to 6 millirem (mrem) (0.05 to 0.06 millisievert (mSv)) per quarter or approximately 10 to 12 mrem (0.10 to 0.12 mSv) per year). If the calculated minimum differential dose (MDD) is less than 5 mrem (0.05 mSv) per quarter or 10 mrem (0.10 mSv) per year, the MDD should be set at 5 mrem (0.05 mSv) per quarter and 10 mrem (0.10 mSv) per year to avoid false positives at such low doses. The following summarizes the data-analysis method:

a. Determine the dosimetry system's MDD.

   1. For each monitored location, determine the historical baseline background dose rate and standard deviation (normalized to a standard monitoring period (e.g., 91 days)).

      Note that, if the baseline background dose rates are determined after facility operations have begun, a professional health physics staff's evaluation and judgment will be needed to determine the baseline background dose rates.

   2. For each location, calculate the standard deviation of the historical baseline background dose data. Select the standard deviation at the location that has the 90th-percentile highest standard deviation. The systemwide environmental dosimetry MDD is established as equal to 3 standard deviations (3σ) above the baseline background dose rate (at that 90th-percentile location).

      Note that use of a 3σ value increases the MDD by approximately 1 mrem (0.01 mSv) but helps to avoid false positives because of the relatively large number (approximately 40) of dosimeters deployed in a typical environmental monitoring program.

b. Analyze current monitoring period (e.g., quarter) gross field dosimeter readings.

   1. Perform a qualitative review of the field dosimeter results to identify and remove any obvious data outliers and investigate any apparent discrepancies.

Note that the review is performed before removal of extraneous dose from the field dosimeter readings. The extraneous dose is the additional dose accumulated on a dosimeter other than the dose received at the field monitoring location (e.g., before or after field deployment). The method used to determine the extraneous dose has been the least understood process over historical environmental measurements. The extraneous dose is not simply the average dose on control dosimeters stored in a lead vault. American National Standards Institute (ANSI)/Health Physics Society (HPS) N13.37-2014, "Environmental Dosimetry—Criteria for System Design and Implementation," describes, in detail, proper methods for determining extraneous dose.

2. Calculate the average field dosimeter reading at each monitored location (assuming that two or more dosimeters were used at each location).

3. Normalize the average field dosimeter readings at each location to a standard monitoring period (e.g., 91-day quarterly period).

4. Calculate the standard deviation and the CV at each field location. This information will be used later to identify outliers for investigation.

c. Determine the extraneous dose. Note that this analysis assumes that control dosimeters were stored in a lead storage vault during the deployment period. In addition, note that the concept of "control dosimeters" is different that the concept of "control locations."

1. The extraneous dose is the dose accrued in the time before deployment and after deployment. Extraneous dose is NOT simply the dose on control dosimeters stored in a lead vault/pig. Control dosimeters stored in a lead vault contain both extraneous dose and storage dose (i.e., the dose accrued while in the lead storage vault). Storage dose is not part of the extraneous dose and, therefore, must be subtracted from the dose on the control dosimeter to determine the extraneous dose.

2. Calculate the amount of extraneous dose by subtracting the storage dose from the gross dose on the control dosimeters. Note that the typical storage dose in a lead storage vault is approximately 7 mrem (0.07 mSv) per quarter from high-energy cosmic radiation.

d. Determine the net field doses.

1. Calculate the gross (uncorrected) field dosimeter average dose, standard deviation, and CV. Investigate the cause of any CV greater than 10 percent. Remove any dosimeter reading from the data set that has a justifiable reason for being an outlier. The following are justifications for the removal of outlier dosimeter data:

a. abnormal high or low readings on some chips as compared to those on other chips (high standard deviation among chips);

b. dosimeters that have been lost and later recovered;

c. dosimeters that were annealed at a different time and were not issued with the remaining group of dosimeters;

d. a sealed plastic bag ripped open and exposed to weather conditions;

e. dosimeters that were damaged by vandalism; and

f. known processing problems (bad glow curves, a dosimeter history that suggests poor quality or damage, and poor quality control results).

2. Subtract the extraneous dose from each of the gross field dosimeter results to get the net field dose at each location.

3. Calculate the normalized net field dose at each location to a standard monitoring period (e.g., a 91-day quarter).

4. Perform a qualitative comparison of the normalized net field doses to the baseline background dose for each monitored location. Identify outliers and investigate anomalies.

5. Remove justifiable outliers from the data set, and document the bases for removing the outliers.

e. Determine the quarterly FRDs.

1. For each monitored location, first calculate the sum of the baseline background dose plus the dosimetry system's quarterly MDD (approximately 5 to 6 mrem) (0.05 to 0.06 mSv). Note that the normalized net field dosimeter results at each location must be greater than the MDD value to detect an FRD.

2. For each monitored location, subtract the sum of the baseline background dose and the quarterly MDD from the current quarter normalized field dose.

a. If the value is negative, there is no detectable FRD.
b. If the value is positive, FRD is detected.

3. If a quarterly FRD is detected, calculate the amount of the FRD. To do so, subtract the baseline background dose from the normalized net field dose. Once a positive FRD is identified, only subtract the baseline background dose, not the 3σ standard deviation.

4. Investigate and document the source of any apparent detectable FRD.

f. Determine the annual FRDs.

1. For each monitored location, first calculate the annual net field doses by summing the normalized net field doses from each monitoring period (e.g., quarterly).

2. For each monitored location, subtract the sum of the baseline background dose and the quarterly MDD from the annual normalized field dose.

a. If the value is negative, there is no detectable FRD.
b. If the value is positive, FRD is detected.

3. If an annual FRD is detected, calculate the amount of the FRD. To do so, subtract the baseline background dose from the normalized annual net field dose. Once a positive FRD is identified, only subtract the baseline background dose, not the 3σ standard deviation.

3. Quality Assurance

ANSI/HPS N13.37-2014 describes the following quality assurance methods that are suitable for performing quality assurance:

- end-user quality assurance checks/measures
- annual audits of the end user by independent assessors
- annual blind spike testing
- triennial audits of the processor

A processor laboratory accreditation program is not necessary unless the quality assurance program routinely identifies unsatisfactory results.