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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 4.13

PERFORMANCE, TESTING, AND PROCEDURAL SPECIFICATIONS FOR THERMOLUMINESCENCE DOSIMETRY: ENVIRONMENTAL APPLICATIONS

A. INTRODUCTION

Section 20.105, "Permissible levels of radiation in unrestricted areas," of 10 CFR Part 20, "Standards for Protection Against Radiation," provides limits on levels of radiation in unrestricted areas resulting from possession, use, or transfer of NRC-licensed radioactive material. Section 20.201, "Surveys," of 10 CFR Part 20 further requires that a licensee conduct surveys as may be necessary to comply with the regulations of 10 CFR Part 20 including, when appropriate, the measurement of levels of radiation.

Paragraph IV.B(2) of 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," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that licensees establish appropriate surveillance and monitoring programs to provide data on measurable levels of radiation and radioactive materials in the environment.

General Design Criterion 64, "Monitoring radioactivity releases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires that nuclear power plant designs provide means for monitoring the plant environs for radioactivity that may be released as the result of normal operations, including anticipated operational occurrences, and as the result of postulated accidents.

Thermoluminescence dosimetry (TLD) is widely used to measure levels of X and gamma radiation in the environs of NRC-licensed nuclear facilities. This guide provides minimum acceptable performance criteria for TLD systems used for this purpose. It also provides procedures for calibration, field application, and reporting. It does not apply to TLD systems used for the purpose of determining occupational exposure.

B. DISCUSSION

Working Group 9 of the Health Physics Society Standards Committee for American National Standards Institute (ANSI) Committee N13 on Radiation Protection has prepared a standard that specifies minimum acceptable performance of TLDs used for environmental measurements; outlines methods to test for compliance; and provides procedures for calibration, field application, and reporting. This standard was approved by the N13 Committee. It was subsequently approved and designated N545-1975, by ANSI on August 20, 1975.[1]

The specification of performance criteria of thermoluminescence dosimetry and the verification of the actual performance require appropriate statistical concepts and techniques. Because wide applicability is intended, ANSI N545-1975 as well as the provisions and clarifications given below in the regulatory position are confined to simple statistical concepts and prescribe no specific statistical techniques. In fact, the implementation of some specifications by rigorous statistical methods may prove difficult for some users of the guide. Therefore, good approximate statistical methods are acceptable.

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* Lines indicate substantive changes from previous issue.

[1] ANSI N545-1975, "Performance, Testing, and Procedural Specification for Thermoluminescence Dosimetry (Environmental Applications)" may be obtained from the American National Standards Institute, 1430 Broadway, New York, New York 10018.

No specific criteria for good approximation are prescribed. However, the user should judge whether the sample size is adequately large for the approximation and whether the distribution of the measurements is sufficiently close to that assumed in the analysis. Problems relating to underlying distributions can be avoided by the use of nonparametric methods. Some of the specifications that are stated in terms of standard deviations can be reformulated in nearly equivalent specifications for tolerance limits for which simple nonparametric methods are available. Such reformulations are also acceptable. A. Hald[1] and W. J. Conover[2] are useful reference sources for parametric and nonparametric methods, respectively.

If every TLD is individually calibrated, the population parameters for certain errors can be computed directly, and statistical inference is not needed for specifications relating to these errors.

Comments received on this guide and subsequent discussions of these comments have indicated a need for the following emphasis on, or clarification of, sections of the guide and ANSI N545-1975 in order to avoid misinterpretations:

a. In this guide, the expression *environs of NRC-licensed facilities* includes both the term *environment* as defined in ANSI N545-1975 and the phrase *unrestricted areas* as defined in 10 CFR Part 20.

b. In Section 2, "Definitions," of ANSI N545-1975, the distinction between *thermoluminescence dosimeter (TLD)* and *thermoluminescence (TL) phosphor* should be noted. As defined in ANSI N545-1975, a *TLD* can, and usually does, contain multiple *TL phosphors* or otherwise provides for multiple readings of the exposure. When multiple readings are used for the measurement of the response of a TLD, that response is an average of the individual readings. ANSI N545-1975 refers to these average values rather than to the individual readings.

c. Regulatory position 3 of this guide and Section 3.3 of ANSI N545-1975 refer to the overall error in the total field exposure. No method is specified for interpreting field exposures to isolate contributions attributable to a nuclear facility, and no limit is specified on the error associated with estimates of the exposure attributable to the facility.

d. Section 6.3.1 of ANSI N545-1975 specifies field exposure at a height of 1 meter above the ground; however, Section 6.3.3 permits exposure at other heights.

e. Section 7.2 of ANSI N545-1975 permits the requirements of Section 4 of the standard to be satisfied by reference to prior documents. Test results provided by vendors are examples of such documents. Therefore, when requirements of Section 4 of the standard can be met by reference to test results provided by a vendor or other source, additional tests by a licensee are not needed.

f. The appendixes to ANSI N545-1975 are not a part of the ANSI standard or of this regulatory guide, which endorses the standard. However, the appendixes do provide useful information on the topics covered.

C. REGULATORY POSITION

The requirements and recommendations for performance specifications, testing procedures, calibration procedures, field procedures, and reporting procedures that are included in ANSI N545-1975 are generally acceptable to the NRC staff as the basis for using thermoluminescence dosimetry for the measurement of X and gamma radiation in the environs of NRC-licensed facilities subject to the following additional provisions and qualifications.

1. Section 3, "Performance Specifications," of ANSI N545-1975 should be supplemented by the following statement: "Subsection 4.2.4 shall apply also to the subsections 3.1 and 3.3."

2. Instead of Section 3.1 of ANSI N545-1975, the following should be used: "The performance of the TLD system shall be determined under laboratory conditions and in a known radiation field with an exposure equal to that resulting from an exposure rate of 10 μR/hr during the field cycle. Ninety-five percent of the measurements shall fall within 10% of the known exposure."

3. Instead of Section 3.3 of ANSI N545-1975, the following should be used: "Ninety-five percent of the final values (after all appropriate corrections to the measurements are applied, including those for errors expected under field conditions) shall differ from the correct value by less than 30% of the correct value."

4. Instead of Section 4.3.1 of ANSI N545-1975, the following should be used: "Uniformity shall be determined by giving TLDs from the same batch an exposure equal to that resulting from an exposure rate of 10 μR/hr during the field cycle. The response obtained shall have a relative standard deviation (coefficient of variation) of less than 7.5%."

5. Instead of Section 4.3.2 of ANSI N545-1975, the following should be used: "Reproducibility shall be determined by giving one TLD repeated exposures equal to that resulting from an exposure rate of 10 μR/hr during the field cycle. The responses shall have

[1] A. Hald, *Statistical Theory with Engineering Applications*, John Wiley & Sons, Inc., 1952.

[2] W. J. Conover, *Practical Nonparametric Statistics*, John Wiley & Sons, Inc., 1971.

a relative standard deviation (coefficient of variation) of less than 3.0%."

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant or licensee proposes an acceptable alternative method, the staff is using and will continue to use the method described herein in evaluating an applicant's or licensee's capability for and performance in complying with specified portions of the Commission's regulations until this guide is revised as a result of suggestions from the public or additional staff review.

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