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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.14

PERSONNEL NEUTRON DOSIMETERS

A. INTRODUCTION

Section 20.202, "Personnel Monitoring," of 10 CFR Part 20, "Standards for Protection Against Radiation," requires that licensees supply personnel monitoring equipment and require its use by specified individuals. This guide provides guidance acceptable to the NRC staff on the use of personnel neutron dosimeters where exposure to neutrons occurs.

B. DISCUSSION

The American National Standards Institute has approved a standard entitled "Personnel Neutron Dosimeters (Neutron Energies Less than 20 MeV)" and designated ANSI N319-1976.[1] This standard gives performance criteria, use factors, and dosimetry system calibration criteria for neutron dosimetry systems. Accuracy criteria are not included among the performance criteria, however.

This guide supplements the standard by adding an accuracy requirement. The guide also provides substitutes for certain of the standard's performance requirements because data from a test performed by the Battelle Pacific Northwest Laboratory showed that the requirements of the standard could not be met by NTA film or thermoluminescence dosimeter systems. A copy of the Battelle data is available by writing to the Occupational Health Standards Branch, Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

One problem in neutron dosimetry is that neutron dosimeters are less sensitive than gamma dosimeters. Section 20.202 of the NRC regulations requires personnel monitoring if a worker is likely to receive a whole body dose of more than about 300 millirems in a quarter year. Many neutron dosimeters have difficulty measuring neutron doses of this magnitude. The problem is even more severe in a mixed radiation field where neutrons contribute only a portion of the 300 millirems. Thus the regulations may require personnel monitoring when the neutron dose is less than 300 millirems in a quarter, but the standard only requires the dosimeters to detect 300 millirems per quarter (paragraph 4.1 of the standard). This problem is discussed in regulatory position C.1.

C. REGULATORY POSITION

ANSI N319-1976, "Personnel Neutron Dosimeters (Neutron Energies Less than 20 MeV),"[1] provides guidance acceptable to the NRC staff on the use of personnel neutron dosimeters, as supplemented and modified below.

1. When Neutron Dosimeters Should Be Worn

Neutron dosimeters should be worn whenever the neutron dose equivalent is likely to exceed 300 mrem in a quarter (the minimum sensitivity required of a neutron dosimeter in paragraph 4.1 of the standard). If personnel monitoring is required by §20.202 because of the total radiation exposure but the neutron dose equivalent is not likely to exceed 300 mrem in a quarter, the following alternatives are acceptable with regard to personnel neutron dosimetry:

a. Using higher sensitivity dosimeters. The licensee may use a dosimeter with a sensitivity greater than that required in the standard. Albedo neutron dosimeters generally are believed to be more sensitive than required by the standard. Film may be acceptable if fading due to humidity can be controlled, if the neutron spectrum has a small proportion of neutrons below the neutron energy threshold of the film (about 0.7 MeV), and if the tracks are counted on a large area of film.

[1]Copies may be obtained from the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

*Lines indicate substantive changes from previous issue.

b. Calculated neutron dose equivalent to supplement neutron dosimeter. A licensee may use a personnel neutron dosimeter but may substitute a calculated neutron dose equivalent for the measured dose equivalent if the measured dose equivalent cannot be reliably determined because of the lack of sensitivity of the dosimeter. Calculated dose equivalents may be based on measured neutron/gamma ratios or on neutron dose equivalents measured with portable or fixed monitoring instruments and known personnel occupancy times. More information on determining neutron dose equivalents by neutron/gamma ratios is given in Regulatory Guide 8.4, "Direct-Reading and Indirect-Reading Pocket Dosimeters."

c. Calculated neutron dose equivalent in place of neutron dosimeter. If the individual is not likely to receive a neutron dose equivalent in excess of 100 mrem in a quarter but would still have to have some sort of monitoring under §20.202 (e.g., gamma monitoring), a personnel neutron dosimeter may be omitted. The neutron dose equivalent should then be estimated by the methods in regulatory position C.1.b above. This procedure is discussed in more detail in regulatory position C.3 of Regulatory Guide 8.4.

d. Neutron dose equivalent much smaller than gamma dose equivalent. If the neutron whole body dose equivalent is not likely to exceed 10% of the gamma plus x-ray dose equivalent, neutron dosimeters may be omitted and the neutron dose equivalent may be assumed equal to zero.

e. Negligible neutron dose equivalent. If the neutron dose equivalent is not likely to exceed 30 mrem per quarter, or 10 mrem per quarter for individuals under 18 years of age, neutron dosimeters may be omitted and the neutron dose equivalent assumed equal to zero. The determination that an individual is not likely to receive a neutron dose equivalent of 30 mrem per quarter should not be based on previous NTA film badge readings since NTA film is not suffficiently sensitive to detect this dose equivalent rate.

2. Performance Requirements

Section 4 of the standard contains several performance requirements on the dosimetry system.

Instead of paragraph 4.1 of the standard on lower limit of detection, the following should be used:

"The lower limit of detection of the dosimetry system shall not exceed 300 mrem per quarter. The quarterly lower limit of detection (LLD) in mrems at the 95% confidence level is defined as

$$LLD = 4.66\sqrt{N}\,S$$

where N is the number of dosimetry exchange periods in a quarter and S is the standard deviation of the normal background in mrems for a single reading." (This definition of LLD was chosen to be consistent with the NRC position previously stated in Tables 1 and 3 of Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants." The basis for the definition is given in USERDA report HASL-300, p. D-08-01.)

Instead of the 10% limit on the standard deviation in paragraph 4.4 of the standard on precision, a limit of 30% should be used.

The following accuracy requirement should be added: "When exposed to an unmoderated californium-252 source, the average accuracy of a set of 10 dosimeters exposed in the range from 100 mrems to 3 rems should be ±50%."

The tests necessary to verify that the dosimetry system meets the requirements in the standard may be performed by the licensee or by someone selected by him. The tests may be performed on a system just once to demonstrate that it can meet the requirements of Section 4 of the standard.

In the case of film, each different type of packaging should be considered a different system to be tested separately. Tests should also be repeated any time changes are made in the dosimetry system (i.e., processing the dosimeters differently). A licensee following the recommendations of this guide should maintain records to show that his neutron dosimeters have been tested and meet the performance requirements of Section 4 of the standard.

3. Meeting the Fading Requirements of the Standard

To meet the fading requirements in paragraphs 5.3 and 5.4 of the standard, the licensee should irradiate four dosimeters with a neutron dose equivalent of at least 0.5 rem. The dosimeters should then be stored for an entire dosimeter exchange period at a humidity similar to that expected in normal use. The dosimeters should then be read to verify that, on the average, they meet the fading criterion (paragraph 5.3 of the standard). If humidity is a significant cause of fading, the test should be performed during a period of high humidity.

4. Dosimetry System Calibration

Section 6 of the standard gives suggestions on dosimetry system calibration. Calibration of dosimeter response may be performed by the exposure of the dosimeter and a reference monitoring instrument in the actual locations where significant neutron exposure occurs. The spherical (Hankins) "rem-meter," the Anderson-Braun rem counter, or other similar instruments may be used as reference monitoring instruments. These monitoring instruments should be calibrated by sources whose calibration is traceable to the National Bureau of Standards.

Calibrations of dosimeter response may also be performed by the dosimeter processor. The processor should use a calibration factor applicable to the dose spectrum delivered to the individuals wearing the dosimeters. The calibration may be performed by the licensee or by someone selected by him, and records describing the dosimeter calibration should be maintained by the licensee. The dosimeter calibration should be repeated any time the licensee has reason to believe the neutron spectrum has changed and the previous calibration might not be valid.

5. Maintaining Body Contact

Albedo neutron systems usually require close body contact at all times during usage. Sizable errors can occur if close body contact is not maintained. Albedo neutron dosimeters should have a means to maintain this necessary close contact with the body.

D. IMPLEMENTATION

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

Except in those cases in which the applicant proposes an acceptable alternative method for complying with §20.202 of the Commission's regulations, the method herein will be used in the evaluation of submittals in connection with license applications docketed after November 1, 1977.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before November 1, 1977, the pertinent portions of the application will be evaluated on the basis of this guide.