U.S. NUCLEAR REGULATORY COMMISSION

August 1981

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.28
(Task OH 804-4)

AUDIBLE-ALARM DOSIMETERS

A. INTRODUCTION

Section 20.201, "Surveys," of 10 CFR Part 20, "Standards for Protection Against Radiation," states that licensees must make or cause to be made such surveys to evaluate radiation hazards as may be necessary for the licensee to comply with the regulations of Part 20. Section 20.202, "Personnel Monitoring," requires the use of appropriate personnel monitoring equipment to determine whether any radiation dose is being or has been received. Licensees sometimes supplement such monitoring equipment with electronic pocket dosimeters that have an audible alarm to warn workers that they may be receiving more exposure to radiation than they had expected or had planned.

This guide discusses a program for the appropriate use of audible-alarm dosimeters, including certain conditions under which they should not be relied upon to perform their intended function. The guide also discusses performance specifications that the dosimeters should meet if they are used.

In this guide, the term "audible-alarm dosimeters" refers to electronic dosimeters that alarm when either a preset integrated exposure or a preset exposure rate is reached; these dosimeters generally sound a short "beep" every time an exposure of 1 milliroentgen is accumulated. The term audible-alarm dosimeters also includes "chirpers," those devices that sound a brief "chirp" or "beep" every time some small exposure is received; these "chirpers" usually emit a hundred or more chirps per milliroentgen.

B. DISCUSSION

Several types of work lend themselves to the advantageous use of audible-alarm dosimeters. For example, audible-alarm dosimeters may be effectively used during nuclear power plant maintenance operations. The alarm can warn workers that they are being exposed unexpectedly. The alarm can tell a worker who has reached a preset dose level to leave the area. The alarms can also tell a worker where to stand while doing a job to receive the least exposure. Although a survey with a survey meter is required before work starts, the audible-alarm dosimeter can help a worker recall the locations of "hot spots" and help the worker better locate the centers and boundaries of any "hot spots."

In medical institutions, audible-alarm dosimeters have been found to be very useful as a training aid to demonstrate where and when radiation exposure is being received.[1] In certain situations, moving to a slightly different location will greatly reduce exposure. Thus, audible-alarm dosimeters can be useful in programs to maintain occupational exposures to radiation as low as is reasonably achievable (ALARA).

In industrial radiography, an audible-alarm dosimeter can provide warning to a radiographer that he or she is approaching an exposed source. Ideally, the radiographer's survey meter should have provided a warning, but, in many radiography overexposures, the radiographer did not use the survey meter or else used the meter but did not draw appropriate conclusions from the meter readings.

In low-level waste disposal, an audible-alarm dosimeter can quickly warn a worker that a particular package is more than normally radioactive and should receive especially cautious handling.

Audible-alarm dosimeters are not generally substitutes for conventional survey meters.[2] The dosimeters provide a complementary function. They provide some redundancy or "defense in depth" where (1) the operator fails to perform

[1] Joel E. Gray, "Radiation Awareness and Exposure Reduction with Audible Monitors," *American Journal of Roentgenology*, vol. 133, p. 1200, December 1979.

[2] An exception to this statement, however, can be found in Standard Technical Specification 6.12.1, "High Radiation Area," for nuclear power plants. The specification allows an audible-alarm dosimeter to be substituted for a survey meter after the dose rates in the area have been measured with a survey meter and the workers in the area have been informed of the measured dose rates.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

The guides are issued in the following ten 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
10. General

Copies of issued guides may be purchased at the current Government Printing Office price. A subscription service for future guides in specific divisions is available through the Government Printing Office. Information on the subscription service and current GPO prices may be obtained by writing the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Publications Sales Manager.

a survey, (2) the operator fails to make a fully adequate survey, or (3) the survey meter has malfunctioned, unknown to the operator. An audible-alarm dosimeter is especially useful when workers cannot hold survey meters because they need both hands to perform a job or when workers cannot continually look at the survey meter because the operation they are performing requires them to look elsewhere. The alarm dosimeter also provides continuous feedback to users about where and when they are receiving a radiation dose. Used in the manner described above, alarm dosimeters can be a valuable part of a licensee's educational program or ALARA program and can complement the conventional survey meter.

The main difficulties that arise with the use of audible-alarm dosimeters are related to their occasional unreliability and their improper use. A worker wearing an audible-alarm dosimeter that has stopped working may have a false indication of safety. Unaware that the audible-alarm dosimeter is not working, the worker may neglect other precautions such as performing radiation surveys. In such a case, the worker could be unaware of radiation exposure levels. The possibility of depending on an alarm dosimeter that is not working can be diminished by using a modern audible-alarm dosimeter designed for severe industrial use and by following procedures for avoiding misuse. These subjects are discussed in the regulatory position.

To evaluate the reliability of audible-alarm dosimeters now commercially available, the NRC contracted with Battelle-Pacific Northwest Laboratories for performance testing of such dosimeters. The results of these tests are reported in NUREG/CR-0554, "Pocket-Sized Electronic Dosimeter Testing,"[3] January 1979, written by Oscar Mulhern, William Bartlett, and C. D. Hooker, and NUREG/CR-1452, "Further Testing of Pocket-Sized Electronic Dosimeters,"[3] April 1980, written by Robert A. Fox, C. D. Hooker, and B. T. Hogan. The authors of NUREG/CR-1452 have prepared another report, NUREG/CR-2019, "Third-Phase of Pocket-Sized Electronic Dosimeter Testing," that is expected to be published in August 1981. The authors of these reports were rather critical of the performance of the audible-alarm dosimeters that they tested. A careful reading of their conclusions reveals that the failure of any dosimeter models to survive the water-immersion test and audibility test under very noisy conditions was an important factor in reaching their conclusions.

It appears that the criteria against which the instruments were tested were unduly stringent and that the Battelle testers may be requiring more of the instruments than is necessary for certain uses. It is difficult to justify requiring the instruments to operate after immersion in water if the instruments will not be used in heavy rain or if their being dropped in water is unlikely. The sound levels may not be adequate for many noisy industrial environments and consequently should not be used in these environments. Conversely, some medical users complained that the dosimeters were too loud and had to be modified to reduce the sound level. Certain dosimeter models did not survive drop tests of 4 to 8 feet, but other models did. Certain models had weak mounting clips or switches that were so easily accessible that they were inadvertently moved. These defects should be easily apparent to a potential purchaser and therefore avoidable. Thus, it must be concluded that although the dosimeter models tested are not perfect and cannot meet all environmental conditions, a potential purchaser can find models that will be adequately reliable for a wide variety of uses. Thus, the NRC staff believes that many commercially available audible-alarm dosimeters are adequate to perform a valuable function if they are not subjected to inappropriate use as described in the regulatory position.

In addition to the results of these studies, the American National Standards Institute (ANSI) Committee N13, "Radiation Protection," sponsored by the Health Physics Society, has developed a standard on acceptable performance specifications for audible-alarm dosimeters. The standard entitled "Performance Specifications for Pocket-Sized Alarming Dosimeters/Ratemeters" was approved by ANSI in April 1981 and designated ANSI N13.27.[4] Regulatory Guide 8.28 endorses, with one exception, the performance specifications for dosimeters indicated in this standard.

C. REGULATORY POSITION

The NRC staff approves of the use of audible-alarm dosimeters if they are used as part of a carefully controlled program that ensures proper use of the alarm dosimeters. The program should contain guidance on the selection of appropriate dosimeters, their proper use, and what constitutes misuse.

1. Selection of Appropriate Dosimeters

The radiation protection staff should be given the responsibility for selecting dosimeters appropriate for the conditions to be encountered.

Audible-alarm dosimeters should meet the performance specifications indicated in ANSI N13.27-1981, "Performance Specifications for Pocket-Sized Alarming Dosimeters/Ratemeters," except that dosimeters to be used in quiet locations need not meet the loudness specification of the standard (paragraph C.2). Only dosimeters designed for severe industrial use (those that can pass the 1.2 meter drop test described in paragraph A.3 of the standard) should be used.

Audible-alarm dosimeters with an appropriate chirp rate should be selected. Thus, audible-alarm dosimeters that will not chirp excessively at the anticipated exposure levels should be selected. For example, dosimeters that chirp 50 times or more per 1 milliroentgen dose are not suitable for use in industrial radiography or nuclear reactor maintenance

[3] Copies are available at current rates through the Distribution Services Section, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, or from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

[4] Copies are available from the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

because they will chirp so frequently that they will be annoying to the user.

2. Proper Use

The radiation protection staff should be responsible for assigning audible-alarm dosimeters only when the working environment is suitable for their use and when the users have been instructed in proper use of the dosimeters and can be trusted to use the dosimeters as instructed. Proper use includes the following:

a. Audible-alarm dosimeters should not be substituted for a survey meter.[2] Instead, they are a *complementary* warning device.

b. A program should prohibit the use of a dosimeter in the following adverse situations:

(1) *Alarm Inaudible.* Alarm dosimeters should not be used when the alarm may not be heard, such as (a) in a high noise environment, (b) when the user has a pronounced hearing loss, (c) when the user is wearing mufflers over the ears, or (d) when the sound from the dosimeter would be muffled by heavy clothing worn over the dosimeter.

(2) *Alarm Too Loud.* Audible-alarm dosimeters with a loud sound level should not be used in quiet environments where the dosimeter might create a disturbance or become annoying, thereby causing the user to shut it off.

(3) *Dosimeter Soaked with Water.* Alarm dosimeters should not be used when immersion in water or soaking of the dosimeter, such as from rain, is possible. Tests have shown that immersion in water stops all alarm dosimeters from working. Complete drying of dosimeters and replacing the batteries will allow some but not all dosimeters to resume proper operation.

(4) *Dosimeter Affected by Chemicals.* Alarm dosimeters should not be used when a salt or corrosive chemical-laden atmosphere is present. Salt water quickly caused all audible-alarm dosimeters tested to malfunction.

c. Each day, before use, audible-alarm dosimeters should be tested for adequate battery strength and should be checked with a radiation source for proper operation.

d. Care should be taken to avoid dropping alarm dosimeters. If a dosimeter is dropped, its proper operation should be verified with a radiation source before using the dosimeter again.

3. Misuse of Dosimeters

The program should permit the radiation protection staff to take the dosimeter away from a worker immediately on observing that the worker is misusing the dosimeter (e.g., using the alarm dosimeter as a substitute for the survey meter in violation of operating procedures or handling the alarm dosimeter roughly). In addition, the program should allow any worker to discontinue using an audible-alarm dosimeter if the worker finds use of the dosimeter inappropriate. The use of alarm dosimeters should always be optional, never mandatory.

D. IMPLEMENTATION

This section provides information to applicants on the NRC staff's plans for using this regulatory guide.

If an applicant plans to use audible-alarm dosimeters as part of the radiation protection program, the selection and use of the audible-alarm dosimeters will be evaluated on the basis of this guide unless the applicant has proposed an acceptable alternative method for complying with the specified portions of the Commission's regulations.

VALUE/IMPACT STATEMENT

1. THE ACTION

1.1 Description

The action, issuance of Regulatory Guide 8.28, "Audible-Alarm Dosimeters," is intended to provide guidance on the selection of reliable audible-alarm dosimeters and on the appropriate use of such dosimeters by industrial radiographers, nuclear power plant workers, and others as a supplemental warning of exposure to radiation.

1.2 Need

At times in the past, industrial radiographers have attempted to improve safety by using audible-alarm dosimeters. For the most part these attempts were unsuccessful for two reasons. First, commercially available audible-alarm dosimeters often were not rugged enough to operate reliably under adverse field conditions.* Second, radiographers using these audible-alarm dosimeters placed less reliance on the use of survey meters. A survey meter reading not heeded coupled with the radiographer depending on an audible-alarm dosimeter that was not working has often created a dangerous situation.

The guidance is intended to allow licensees to select reliable audible-alarm dosimeters and to provide dosimeter manufacturers with criteria they may use in designing their products. Because reliability and use of alarm dosimeters are so interconnected, both performance criteria and programs for dosimeter use will be treated in the same guide.

1.3 Value/Impact

1.3.1 NRC Operations

Approximately one man-year of staff time has been required to develop and review the guide. A technical assistance contract ($77,000) with Battelle-Pacific Northwest Laboratories was awarded for testing commercially available alarm dosimeters. Their first report was received in March 1979 and published as NUREG/CR-0554, "Pocket-Sized Electronic Dosimeter Testing."** A followup report was published in April 1980 as NUREG/CR-1452, "Further Testing of Pocket-Sized Electronic Dosimeters."** A final report, NUREG/CR-2019, "Third-Phase of Pocket-Sized Electronic Dosimeter Testing," is expected to be published in late 1981.

*Comments from some users were given in Attachment 1 to the value/impact statement issued with Draft Guide OH 804-4, "Audible-Alarm Dosimeters," in August of 1979. Copies are available for public inspection or copying for a fee in the U.S. Nuclear Regulatory Commission Public Document Room, 1717 H Street NW., Washington, D.C.

**Copies are available at current rates through the Distribution Services Section, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, or from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

1.3.2 Industry

The guidance will allow licensees (including industrial radiographers, nuclear power plant personnel, low-level radioactive waste disposal facility personnel, and others) to select an audible-alarm dosimeter suitable for their needs and to avoid using dosimeters that are not likely to perform adequately. The guidance will also alert licensees to situations where the use of audible-alarm dosimeters is not appropriate. This will assist licensees in conducting adequate surveys and using appropriate personnel monitoring equipment.

The guidance will also provide dosimeter manufacturers with criteria to use in designing suitable dosimeters.

An impact of publishing performance specifications is that the market potential for dosimeters not meeting the specifications will be greatly reduced. Manufacturers of those dosimeters would probably have to redesign their dosimeters.

1.3.3 Workers

The use of reliable audible-alarm dosimeters can be beneficial to workers if good dosimeters are used in appropriate situations. Warning of high radiation levels can reduce the frequency of radiation overexposures and can reduce occupational exposure to radiation when radiation levels are higher than expected.

1.3.4 ANSI

The draft guide on audible-alarm dosimeters was based on the May 11, 1979, version of a draft standard developed by the American National Standards Institute (ANSI) Committee N13, "Radiation Protection," sponsored by the Health Physics Society. The development of NRC guidance proceeded in parallel with the ANSI standard, but the NRC did not wait for issuance of the ANSI standard before publishing the draft guide for public comment.

The active guide, Regulatory Guide 8.28, endorses, with one exception, ANSI N13.27-1981, "Performance Specifications for Pocket-Sized Alarming Dosimeters/Ratemeters," that was approved by ANSI in April 1981.

2. TECHNICAL APPROACH

2.1 Value/Impact of the Use of Audible-Alarm Dosimeters in Industrial Radiography

It is believed that the careful use of audible-alarm dosimeters in industrial radiography would reduce workers' collective dose, but it is not possible to estimate the size of the reduction. In some cases increased dose could result from reliance on an alarm dosimeter that is not working in place of a survey meter.

The alarm dosimeter would be of use in avoiding accident situations. It is not known how much of the collective dose in radiography is caused by accidents, but it is probably no more than 10 percent of the total dose.

Thus, accidents by NRC-licensed radiographers could account for 310 of 3100 man-rems. (The collective dose resulting from overexposures totals about 100 man-rems annually, but not all accidents lead to overexposures.) Assuming the alarm dosimeters could reduce the 310 man-rems by 50 percent, the dosimeters might save 155 man-rems per year.

To accomplish this saving, the industry would have to buy 1500 alarm dosimeters per year (assuming a 2-year life) at a cost of $100 per unit. Thus, the annual equipment cost would be $150,000 per year. The cost of maintaining the dosimeters would be at least $50,000 per year for a total cost of $200,000 per year.

This cost might save 155 man-rems that might be caused by accidents and perhaps more in normal operations.

2.2 Value/Impact of the Use of Audible-Alarm Dosimeters in Nuclear Power Plant Maintenance or Repair

Audible-alarm dosimeters generally have a different function in nuclear power plant maintenance or repair than in industrial radiography. Rather than warning of an accident, they warn when a preset dose limit has been reached. As such, they allow a more precise measurement of a worker's exposure during the course of a job than would otherwise be possible. Thus, the dosimeters allow the worker to work in the radiation area without receiving an overexposure. Used in this way, the purpose is not to reduce the collective man-rem from a job, but to spread it over enough workers that an overexposure to anyone would be avoided. The dosimeter's value to the licensee is that it allows better use of manpower.

A savings of man-rems is possible during maintenance or repair work when the size of the area being worked in is large, when the dose rates in the area vary, and when the area contains "hot spots." An audible-alarm dosimeter with a "chirper" type alarm will immediately warn a worker that he or she is in an area with high doses rates. This warning allows avoidance of the area when possible. Unfortunately, the savings in collective dose from this application will depend so strongly on the particular situation that an estimate of dose savings cannot be made for the general situation. It is only possible to calculate a savings when the specific circumstances of an individual situation are known.

The value of this guide to the licensee is that it should prevent the use of audible-alarm dosimeters where their use would not be safe and that it should help licensees select dosimeters having adequate performance characteristics for their intended use where their use is desirable.

2.3 Value/Impact of the Use of Audible-Alarm Dosimeters in Other Activities

An informative description of the use of audible-alarm dosimeters in medical institutions has been written by Dr. Joel E. Gray ("Radiation Awareness and Exposure Reduction with Audible Monitors," *American Journal of Roentgenology*, vol. 133, p. 1200, December 1979). Gray found that audible-alarm dosimeters were useful as a training aid to demonstrate where and when radiation exposure is being received.

3. PROCEDURAL APPROACH

3.1 Procedural Alternatives

There are four possible procedural approaches for publishing this guidance:

a. Regulation
b. Regulatory guide developed by the staff
c. Regulatory guide adopting an ANSI standard
d. NUREG-series report or other less formal presentation of the criteria

3.2 Value/Impact of Procedural Alternatives

A regulation is not a suitable alternative for publishing this guidance because the use of alarm dosimeters is optional.

A regulatory guide is the recommended procedural alternative because a guide allows considerable flexibility in its application.

Regulatory Guide 8.28 endorsing an ANSI standard has been selected because the ANSI standard represents the work of a group of experts on the performance of these instruments.

A NUREG-series report or other less formal presentation has not been selected because the performance criteria and recommendations on the use of alarm dosimeters would really be guidance and not background information. The subject also seems important enough to warrant issuance of a regulatory guide.

4. SUMMARY AND CONCLUSIONS

Regulatory Guide 8.28 has been prepared. It endorses, with certain exceptions, ANSI N13.27-1981.