



American National Standard
ANSI/HPS N13.41-2024

Criteria for Performing Multiple Dosimetry

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Foreword

(This foreword is not part of American National Standard HPS N13.41-2024.)

When monitoring personnel for exposure to radiation originating outside of the body, normal practice is to locate a single dosimeter at a location that gives a reasonably accurate but conservative estimate of the dose received. To do so, the dosimeter is placed at the location of maximum exposure. However, this practice can greatly over-estimate the effective dose to the individual. Therefore, the use of more than one dosimeter should be considered in order to arrive at a more realistic effective dose.

While it may be necessary to use multiple dosimeters throughout an individual's monitoring period, a more likely practice may be to use multiple dosimeters for specific operations or activities. The results obtained would then be added to the doses measured during the remainder of the monitoring period with the single dosimeter.

This standard provides criteria for when and how to use multiple dosimeters under conditions incident to routine activities in the presence of ionizing radiation. It also contains the recommended methodology for determining the effective dose from external sources when the use of multiple dosimeters has been deemed necessary by radiation protection professionals.

In 2007, the International Commission on Radiological Protection (ICRP) released Publication 103, "2007 Recommendations of the ICRP." The concepts regarding effective dose contained in ICRP Publication 103 form the basis for the recommendations in this standard. However, provisions for application under ICRP Publications 60 and 26 guidance are included as well.

Suggestions for improvement of this standard are welcome. Send suggestions by e-mail to Amy Wride-Graney at the Health Physics Society: awride-graney@burkinc.com.

The 2017 version of this standard is a re-affirmation of the 2011 version, performed under the authority of the Health Physics Society Accredited Standards Committee (ASC) N13, Radiation Protection. This standard was re-affirmed with only non-substantive (editorial and formatting) changes. More specifically, the terminology to "personal dose equivalent" was corrected in Sections 1, 2 and 6 for consistency with the definition given in Section 3 and with terminology used elsewhere throughout the standard. No changes to reflect current revisions of referenced standards in Section 9 were made in order to maintain this standard's reaffirmation status.

The 2024 version of this standard accounts for the potentially diverse technical bases for developing compartment weighting factors. Of particular interest was Table A-1, which inaccurately identified and allocated certain tissues and organs in certain parts of the body. A requirement for external dosimetry programs using multiple dosimetry to have a documented basis for the compartment weighting factors has been added. Example dose calculations have been provided as Appendix B.

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Criteria for Performing Multiple Dosimetry

1. Introduction

For uniform external exposures of the whole body, the International Commission on Radiological Protection (ICRP) acknowledges the use of personal dose equivalent as determined from dosimeters worn on the torso of the body as an acceptable means of assessing the effective dose from external radiation sources (ICRP, 2007). However, radiation fields may vary spatially as a result of job- or location-specific conditions. Conditions which may contribute to this variability include: Source geometry (e.g., point sources, line sources, plane sources, or non-uniform deposition patterns), source-to-worker distance and general orientation of the worker with respect to the source, and the presence of equipment or other barriers which may provide non-uniform radiation shielding of the worker. Other pertinent factors are the energy and/or composition of the radiation field, and changes in these as a result of interactions of radiation with matter in the working environment.

Data from radiation surveys are essential for assessing how these factors affect radiation field variability with respect to a worker, and for determining the need for more than one dosimeter. The following are just a few examples of conditions which may indicate such a need:

- (1) Work in close proximity to point or line sources of radiation that presents greater exposure potential for the hands and varying exposure potential over the torso;
- (2) Maintenance work at facilities where variation in source geometry or partial local shielding exist as a result of structures, equipment, and other barriers;

- (3) Operations performed in the vicinity of radiation shielding leaks (e.g., pin holes, cracks), or work involving the use of partial (shadow) shields;
- (4) Work on reactor, accelerator, and laboratory components, or handling of radioactive waste when the materials in question contain radioactivity that is not uniformly distributed; or
- (5) Work while using protective clothing or leaded garments which may result in non-uniform exposures between protected and unprotected parts of the body.

"Multiple dosimetry" is the practice of placing more than one dosimeter on an individual's body to determine the doses at various regions of the torso, head, arms, and legs. This practice may be implemented for a number of reasons, including demonstration of compliance with federal and state regulations or administrative requirements, identification of the location of highest exposure, evaluating the effectiveness of radiation control measures before and after a particular activity, other circumstances when a single measurement may not provide sufficient information for dose control purposes, or to estimate the effective dose from non-uniform external sources.

Multiple dosimeters may be used to monitor different areas of the body (extremities included) when variations in the radiation field result in significant variations of dose over the body. The significance of the variation is dependent upon the organs exposed (i.e., blood-forming organs, lens of the eye, etc.) and the applicable regulatory dose limits.

The criteria presented in this standard provide guidance for when to monitor with

multiple dosimeters, where to place multiple dosimeters when their use is deemed necessary, and the interpretation and recording of results after the dosimeters are processed or evaluated. This standard also

provides examples of how to develop a technical basis for assigning doses based on multiple dosimetry, as well as examples based on current available standards and definitions.

2. Scope

The final decision on the use of multiple dosimeters for external dosimetry purposes instead of a strategically-placed single dosimeter is left to the judgment of radiation protection professionals. However, once multiple dosimeter use has been deemed appropriate, this standard contains criteria applicable to routine occupational activities for when and how to use them to monitor the body and extremities of individuals exposed to external sources of ionizing radiation. Such conditions may be encountered at medical, research, commercial, weapons disposition, fuel processing, power reactors and other sites. In addition, recommendations for selecting dosimeter types, placement of dosimeters on the body, interpretation of multiple dosimeter results, and recording of dose information are presented. A program that is compliant with this standard includes the requirements of the standard, but not necessarily its recommendations.

This standard does not address the cases of internal deposition of radioactive materials, external contamination of the body, or

working conditions that do not permit job pre-planning. Sudden or unexpected changes in the radiation environment as might occur during accidents are also beyond the scope of this standard. Fetal monitoring is not addressed because it represents a special case not necessarily related to non-uniform irradiation. (Fetal monitoring is for the purpose of estimating the dose to a separate entity, the fetus, and demonstrating an appropriate rate of equivalent dose accumulation for the period of gestation. Since it is not an example of multiple dosimetry, it is not addressed herein.) Finally, skin exposures where the area of irradiation is less than 10 cm² (e.g., from a hot particle) are not addressed.¹

This standard assumes that dosimeter assemblies worn for multiple dosimetry purposes are calibrated and processed to provide an estimate of personal dose equivalent. Specific guidance on dosimeter processing methodologies, calibrations, and performance criteria are included only by reference.

¹ The National Council on Radiation Protection and Measurements, in NCRP Report No. 106, *Limit for Exposure to "Hot*

Particles" on the Skin, provides guidance on assessing the radiation exposure of small skin areas.

3. Definition of Terms

In this standard, definitions given by the American Nuclear Society (1986), the International Commission on Radiation Units and Measurements (1980, 1993), the International Commission on Radiological Protection (1984, 1990, 2007), and the National Council on Radiation Protection and Measurements (1985) apply, supplemented by those given below.

Absorbed Dose. Mean energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The unit of absorbed dose is the gray (Gy) or rad. One rad is equal to 0.01 Gy.

Compartments. Areas of the body which are of dosimetric importance for purposes of multiple dosimetry.

Compartment Factors (W_c). Factors used to weight the results from dosimeters placed over various compartments in order to relate the fractional risk to the organs underlying the dosimeters to the total risk from uniform irradiation of the whole body.

Dose Limitation. A user-defined dose quantity of interest for which limits have been established to control radiation exposures. Examples of dose limitations may include regulatory limits, ALARA (As Low As is Reasonably Achievable) goals, administrative limits that could account for doses already received, Planned Special Exposure limits, or others. The principle of dose limitation is to limit stochastic effects to an acceptable level, and to prevent deterministic effects (ICRP 1991).

Dosimeter. A device, instrument or system that measures or evaluates, either directly or indirectly, the quantities exposure, kerma, absorbed dose or dose equivalent, or their time derivatives (rates), or related quantities of ionizing radiation.

Dosimetry System. A system used to assess equivalent dose from external radiation. This system includes the selection, placement, and processing of the dosimeters; interpretation and recording of results; and the means by which the quality of results is assured.

Effective Dose (E). The tissue-weighted sum of equivalent doses in all specified tissues and organs of the body. It is the product of the equivalent dose in an organ or tissue (H_T) and the tissue weighting factor (w_T) applicable to each of the body organs or tissues that are irradiated. Or:

$$E = \sum w_T H_T$$

Equivalent Dose (H_T). A protection quantity that indicates the energy absorbed in a tissue or organ, T , given by:

$$H_T = \sum w_R D_{T,R}$$

Where $D_{T,R}$ is the mean absorbed dose from radiation, R , in a tissue or organ, and w_R is the radiation weighting factor. The unit of equivalent dose is the sievert (Sv) or the rem. One rem is equal to 0.01 Sv.

Extremity. The hand, the arm, the leg, or the foot. The extremity compartment thus includes the left hand, the right hand, the left lower arm, the right lower arm, the left lower leg, the right lower leg, the left foot and the right foot. Inclusion of the elbow and knee as part of the definition of extremity, and thus their inclusion in the extremity compartment, depends on the regulations being followed.

Lens of the Eye. A tissue of concern from a dosimetric and regulatory point of view because of the potential for radiation-induced cataracts. The lens of the eye is located at a depth of 300 mg cm⁻².

Multiple Dosimetry. The practice of using more than one dosimeter to monitor different