ANSI/HPS N13.32-2008

American National Standard

Performance Testing of Extremity Dosimeters

Approved: November 2008

American National Standards Institute, Inc.

Published by

Health Physics Society
1313 Dolley Madison Blvd.
Suite 402
McLean, VA 22101

Printed in the United States of America

Foreword

(This foreword is not a part of the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.32-2008.)

This American National Standard provides a procedure for testing the performance of extremity personnel dosimetry systems used to monitor the personnel exposure to the extremities from ionizing radiation. This is the first revision of the original standard, HPS N13.32-1995. Testing the performance of personnel dosimeters has been an active part of evaluation and quality assurance of personnel dosimetry systems.

By ANSI policy, standards must be reviewed and, if necessary, revised every few years. The Health Physics Society working group that reviewed this standard held to three major objectives during revision: (1) as far as possible, maintain an approach to testing consistent with the practical application of extremity dosimeter systems without excluding current and developing techniques; (2) attempt to achieve a measure of consistency with related national and international standards; and (3) base major changes in the approach and content of the standard on scientific fact.

The group identified 12 major issues for consideration. The following paragraphs describe how the group resolved these issues. Some of the issues are treated in greater detail in the appendices, which were written to provide greater insight and convenience. The working group made the most significant changes in the areas of test categories and test criteria.

The working group attempted to harmonize the test categories with those in the whole-body dosimetry testing standard, ANSI/HPS N13.11-2001. Particularly, the photon test categories in the protection level dose range were combined so that the previous test categories for low-energy and high-energy photons, Categories II and III, are now both included in test Category II for photons. In addition, the number of x-ray fields available for testing in the photon category was increased from four x-ray fields and one high-energy photon field to six x-ray fields and two high-energy photon fields. The beta category now included as Category III remains unchanged except for the addition of ^{85}Kr as a replacement for ^{204}Tl.

The working group considered the inclusion of a neutron-testing category based on the recommendation in the *Journal of the ICRU*, Volume 1, No. 3 (2001), “Determination of Operational Dose Equivalent Quantities for Neutrons.” At this time, though, the working group felt that the theoretical basis of neutron dosimetry to extremities has not reached a sufficient level of national and international agreement to promote the practice of neutron extremity dosimetry by including a testing category.

At the request of the dosimetry community, one additional test category was added to evaluate response to the beta/photon mixtures (new Category IV). This category was added to accommodate test participants submitting dosimeters with the ability to interpret H_p (0.07) in mixed fields or for dosimeters that are energy/exposure field-independent. If a test participant chooses to test in this category, then that participant will not be told which exposure fields (test sources) were used in any of the categories (Categories I through IV), with the exception that the participant would be told which dosimeters were exposed in the high-dose category (Category I). However, if the participant chooses the “General” subcategory in Category I he or she will not be told whether the irradiating field was ^{137}Cs or M150. This is referred to as *blind testing*. There is no option to only blind-test in Category IV.

Normal testing, as in the previous version of the standard, is not done blindly and includes only Categories I through III. In this case, the testing source is identified to the participant beforehand for the purpose of allowing him or her to apply a specific correction factor to determine a more accurate personal dose (dose equivalent). It is intended that this methodology would be consistent with the methodology for normal processing of personnel dosimeters. That is, the processor would have knowledge of the worker’s exposure field and be able to use this information during the determination of the dose equivalent.

The working group modified the ratios of delivered doses for the mixture category to approximate fields more normally found in the industry. The ratios of contributing shallow doses from betas and photons were modified to range from 1:1 to 5:1 (beta:photons).

The working group also considered adding a photon mixture category comprising irradiations in high- and low-energy photon fields. However, based on the response of dosimetry materials to photons with energies above 100 keV, and with the addition of high-energy, broad-spectrum x-ray testing fields, the group considered the testing provided in Category II to be adequate for mixed photon fields.

The selection method for irradiation levels remains unchanged from the previous version of this standard (i.e., the choice of the use of logarithms to increase the number of irradiations at the lower personal dose equivalents).

The working group agreed to the adoption of the personal dose equivalent at 0.07 mm depth or in mass thickness 7 mg cm^{-2}. Research has shown that the dose rate at 0.07 mm used for beta particles incident on the slab phantom is applicable for use with the rod and pillar phantoms (ISO 2006). In selecting personal dose equivalent at 0.07 mm, the working group chose to exclude a discussion of lens dose equivalent (LDE). The group concluded that it was inappropriate to include LDE dose as part of a standard addressing extremity dose.

Conversion coefficients for photons, listed in ISO 4037-3 (ISO 1999), were used with digitized spectra of the National Institutes of Standards and Technology (NIST) x-ray beams to determine coefficients to convert air kerma to personal dose equivalent for the x-ray testing fields. Considering the uncertainties in estimating the extremity exposure in the field, the added uncertainty from this difference in computed conversion factors from air kerma to dose is insignificant.

For practical purposes, the polymethylmethacrylate (PMMA) rod phantom will continue to be used for testing of finger dosimeters.

The working group considered several different designs in selecting a pillar phantom for testing of wrist/ankle dosimeters. They conducted an experiment to determine the differences in the amount of backscatter among designs. Extremity dosimeters were irradiated on a solid PMMA pillar, a water-filled PMMA pillar, an aluminum-core PMMA pillar, and a Styrofoam pillar. Only small differences in dosimeter response were observed among these phantom designs. Therefore, for practical reasons, a solid PMMA phantom, of the same dimensions, was chosen to replace the aluminum-core PMMA phantom described in the previous version of this standard. The study is summarized in Appendix A6.

In the Unites States, performance test criteria for personal extremity dosimeter systems have historically used a systematic approach (i.e., testing the performance of a group of dosimeters rather than basing the test on individual dosimeter results). This philosophy was continued in the current revision of the standard, and as before there are no individual dosimeter failure criteria to pass. However, the approach to determining group failure criteria has been modified. In the past, group failure criteria were based on (1) not exceeding the tolerance level (L) by the performance index, defined as the sum of the absolute value of the bias ($|B|$) and standard deviation (S) of 15 dosimeters irradiated in a single test category and (2) not exceeding individual limits on the $|B|$ and S in a single test category. In this revision of the standard a new testing model was adopted in which the performance index is redefined as the square root of the sum of the squares of the B and S, consistent with current theory in statistical quality control (see Wheeler and Chambers 1992, in Appendix I of this standard). The resulting performance index is compared to a criteria limit determined by either (1) setting the new performance model's area of acceptable performance equivalent to the previous model's area of acceptable performance or (2) limiting the acceptable values of B and S to historical levels.

There are several notable differences in the two models that could affect the evaluation of performance of dosimetry systems compared to past results. For the high-dose test category, the limit was chosen so the area of acceptable performance was equal to the previous area of acceptable performance (i.e., by equating the area of the triangle formed by $L = |B| + S$ to the area of the half-circle formed by $L^2 = B^2 +$

S^2)). This is illustrated in Fig. D1 and results in (1) lowering the maximum allowable individual S and $|B|$ from 0.30 in the old model to 0.24 in the new model and (2) two identical small areas on the graph where the allowable sum of the $|B|$ and S would be greater than 0.30. The probability that a dosimeter system would perform in the affected area of acceptable performance is extremely small. Further, the maximum $|B| + S$ in these small areas for the quadrature model was determined to be 0.34, which is only slightly above the value of 0.30 for $|B| + S$ allowed by the previous model. For the protection level categories, the quadrature model was also adopted and the limit was chosen so the maximum acceptable individual value of the $|B|$ and S would be 0.35, consistent with the previous testing criteria. The maximum $|B| + S$ for the protection level categories was determined to be 0.495, which is only slightly less than the value of 0.50 for $|B|+S$ allowed by the previous model. This is illustrated in Fig. D2.

The performance criterion for the General Beta test (Category IVC in the previous version of the standard and Category IIIA in the current version of the standard) was modified from having no limit on $|B|$ and S in the previous version to a value of 0.35 in the current version as a result of applying the quadrature model to all categories.

The working group modified the required ancillary tests to further distinguish between type tests and periodic performance tests. The requirements for the lower limit of detection (LLD) and angular response testing were removed from this standard because they constitute one-time tests that should be performed upon the initial implementation or modification of a dosimeter system. Recommended protocols for those studies are described in the attached appendices. In addition to those studies, the working group modified the standard to also recommend the study of uncertainty for each dosimeter system. Based on the *U.S. Guide to the Expression of Uncertainty in Measurements*, guidance is given in the appendices for the approach to uncertainty analysis (see ANSI/NCSL 1997, in Appendix 1 of this standard).

Suggestions for improving this standard are welcome. Suggestions should be sent to the Health Physics Society, 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101.

This standard was consensus-balloted and approved by the ANSI-accredited HPS N13 Committee on November 6, 2007. At the time of balloting, the HPS N13 Committee had the following membership:

Chairperson	Tracy Ikenberry
American College of Occupational and Environmental Medicine	Bryce Breitenstein
American Industrial Hygiene Association	Irene Patrek
American Iron and Steel Institute	Anthony LaMastra
American Mining Congress	Scott C. Munson
American Nuclear Insurers	Bob Oliveira
American Nuclear Society	Nolan E. Hertel
Conference of Radiation Control Program Directors	Shawn Seeley
Council on Ionizing Radiation Msmts & Standards (CIRMS)	Chris Soares
Council on Radionuclides and Radiopharmaceuticals, Inc. (CORAR)	Leonard Smith
Health Physics Society	Sandy Perle
	William Harris, Jr. (alternate)
Institute of Electrical and Electronic Engineers	Lou Costrell
National Council on Radiation Protection and Measurements	Constantine Maletskos
Nuclear Energy Institute	Ralph L. Andersen
Paper, Allied-Industrial, Chemical & Energy Workers Union (PACE)	Mark Griffon
	Dave Ortlieb (alternate)
U.S. Department of Commerce	Timothy F. Mengers
	Janna P. Shupe (alternate)
U.S. Department of Energy	Robert Loesch
	Joel Rabovsky (alternate)
U.S. Department of Defense	John Esterl
U.S. Environmental Protection Agency	Mike Boyd
	Bonnie Gitlin (alternate)
U.S. Nuclear Regulatory Commission	Donald A. Cool
U.S. Navy	Cdr. Brendan Glennon
Individual Member	John A. Auxier
Individual Member	Tracy Ikenberry
Individual Member	Ronald L. Kathren
Individual Member	Joseph P. Ring
Individual Member	L. Max Scott
Individual Member	Kenneth Swinth
Individual Member	A. N. Tschaeche
Individual Member	Toshihide Ushino