

## THE STATUS OF ANSI N13.11 - THE DOSIMETER PERFORMANCE TEST STANDARD

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The standard designated ANSI N13.11<sup>1</sup> was issued in 1983 and is the basis for the dosimeter performance test associated with the National Voluntary Laboratory Accreditation Program (NVLAP)<sup>2</sup>. The standard is important because the Nuclear Regulatory Commission requires that all licensees use personnel dosimeters processed by NVLAP-accredited processors<sup>3</sup>. The standard has undergone review and modifications have been recommended. Historical information concerning the development and utilization of the present standard, ANSI N13.11-1983, is presented. Details associated with the review of the standard (e.g., policy, group selection) are then given. Finally, the modifications recommended by the review group are discussed.

## ANSI N13.11-1983

Development. The Conference of Radiation Control Program Directors appointed a task force in 1973 to implement its recommendation for establishing a continuing personnel dosimetry performance test program. The task force convinced the Health Physics Society Standards Committee (HPSSC) to develop a standard for personnel dosimeter performance. In 1975, a Health Physics Society (HPS) working group accepted the task of writing the standard. In 1976, a draft standard was completed and submitted for comment. The draft was published for trial use and comment in 1978. The University of Michigan conducted a pilot test program based on that draft standard. Modifications were made to the draft as a result of the pilot program and the present version of the standard was issued in 1983.

Description. The standard defines tests involving beta, gamma, and neutron irradiations. The specific test categories, irradiation ranges, and tolerance levels are presented in Table 1. The standard requires 15 test dosimeters per category. In order to pass the category test, the calculated bias (B) plus standard deviation (S) for the 15 dosimeters must be less than or equal the tolerance level(L); i.e.,

$$|B| + S \leq L.$$

The tolerance levels for the various tests are given in Table 1. Dosimeters are mounted on polymethyl methacrylate (PMMA) slab phantoms for irradiation. The absorbed dose at 1 cm depth must be used to report doses for the accident test cases. The shallow (0.007 cm) and deep (1 cm) dose equivalent must be reported for the other test cases as specified in the table.

Performance Test Results. The standard is the basis for the performance tests required by the NVLAP. The National Institute of Standards and Technology (NIST) administers NVLAP and NIST certification requires passing an on-site assessment as well as the performance test program<sup>4</sup>. The performance test results obtained during 1985-1990 by about 70 processors are shown in Table 2.

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From the table, it is seen that 94% pass the performance tests. Category 4 ( $^{137}\text{Cs}$ ) has had only one failure in 257 tests. Category 1 (Accidents, x-ray) has the lowest passing rate (84%). It can be concluded that the test is not difficult. That conclusion is strengthened when the allowable tolerance levels of 0.30 (categories 1-2) and 0.50 (categories 3-8) are compared with values in Table 2.

### Review of ANSI N13.11-1983

Policy. It is the general policy of ANSI and the HPSSC to have their standards reviewed every five years. Historically, that has not happened. The HPSSC has, in recent years, made a renewed push to carry out this policy.

Selection of Review Group. The HPSSC issued a call for volunteers to participate as members of the N13.11 review work group in September, 1986<sup>5</sup>. The review group members were selected by the HPSSC from among the volunteers and were notified of their selection in February, 1987. The review group consists of the nine voting members and five consultants listed in Table 3. It should be recognized that the HPSSC originally selected four consultants. Bob Devine was added later because his computational expertise was needed by the group.

Group Activity. The review group published a call for comments on ANSI N13.11-1983 in the HPS Newsletter<sup>6</sup>. At the first meeting, the group listened to formal presentations by several persons familiar with the standard. The group received a disappointingly small amount of input by mail, phone, and personal contact. Group members and consultants, chosen on the basis of their expertise in areas associated with the standard, provided significant comments. From all these sources of input, the group identified 16 different issues (see Table 4) which had to be resolved prior to the rewriting of the standard. The issues, 10 of which resulted in suggested modifications, were resolved in a series of 10 meetings over a period of more than 3 years. The total effort involved over 400 person-days. The standard has been revised and plans were to have it sent to the HPSSC before the end of FY 1991. The revisions are the product of the review group as a whole and do not necessarily coincide with the views of any individual group member.

### Suggested Modifications to ANSI N13.11-1983

The modifications suggested by the review group are presented in this section. Table 5 shows the proposed new ANSI N13.11 test categories, test irradiation ranges, and tolerance levels. The reader is reminded that the proposed modifications have not yet undergone complete review and approval by the HPSSC and ANSI. Therefore, the final published version could differ from that presented here.

SI Units. Traditional units (e.g., rad, rem) are used in ANSI N13.11-1983. The modified version will follow HPS guidance and use the International System of Units (SI) with traditional units in parentheses. For example, 1 mSv (100 mrem).

Lower Limit of Detection (LLD). It is estimated that over 80% of all dosimeters processed read zero (or below minimum detectable) doses. Consequently, it is important to know the LLD. The LLD will be calculated according to a prescribed method for each category (3-8) in which the processor is tested. The LLD does not apply to categories 1, 2, or 9. The calculations, which the processor must keep on file, do not require the processor to expose any additional dosimeters. There is no performance criterion for the LLD, but it is suggested that a good value is about one-half of

the lower limit of the test range used in this standard.

Distance from Source. It will be made clear that the distance from the source means the distance from the center of the source to the center of the front face (i.e., surface nearest source) of the phantom. Allowable distances will not change for x-rays, photons, or neutrons. The minimum allowable distance for beta exposure is changed from 35 cm to 30 cm to allow use of the Physikalisch-Technische Bundesanstalt (PTB) irradiator and sources.

X-ray Category. The new NIST beam codes will replace the ones currently in the standard. Category 3 will be divided into 3A and 3B as shown in Table 5. Category 3B is designed for testing processors at facilities which do not have significant numbers of photons below 50 keV (e.g., nuclear power plants).

Conversion Factors and Dose Reporting Convention. This subject area is complicated by four major factors: (1) the effective dose equivalent<sup>7</sup> is used in dose limitation, but is not measurable; (2) NIST now calibrates in terms of air kerma instead of Roentgens; (3) angular dependence must now be considered; and (4) calculations for existing factors are related to the ICRU sphere, but the tests are done using PMMA slabs.

Dose and dose equivalent reporting will be linked to the methodology of the International Commission on Radiation Units and Measurements (ICRU) Report 39<sup>8</sup>. It will be different in that our "person" will be a tissue equivalent slab as opposed to the ICRU sphere<sup>9</sup>. Testing will continue to be done with dosimeters mounted on PMMA slabs and the terminology will remain the same (e.g., the term deep dose equivalent will still be used, but it will actually mean the individual dose equivalent, penetrating). The only obvious difference to the processor should be that the values of the conversion factors<sup>10,11</sup> will be different from those in ANSI N13.11-1983.

Tolerance Levels and Performance Criteria. The performance criterion will be changed from

$$|B| + S \leq L \text{ to } |B| + S - E \leq L$$

where E is the estimated fractional uncertainty in the delivered dose or dose equivalent. It is expected that E will be < 0.05. The tolerance level, L, is 0.30 for categories 1 and 2 and it is 0.50 in all other categories. The standard deviation, S, and the bias, B, are to be calculated as described in ANSI N13.11-1983.

As it is now, a processor could pass the performance test with B=0 and S=0.50 or vice versa. Either way, that wouldn't be good dosimetry. Consequently, a separate limit of 0.35 has been established for B and for S. This means that, for example, a processor reporting B=0.07 and S=0.36 would fail even though  $|B| + S - E \leq 0.50$ . As indicated in Table 5, this separate limit does not apply to categories 1, 2, 5C, 7, 9, or the neutron-only portion of 8.

The lowest dose equivalent to be given in categories 3 and 4 is 0.30 mSv (30 mrem). The dose equivalent selection process (random based on the logarithms of the test range limits) will be modified to assure that no processor gets more than one test dosimeter out of any set of 15 exposed to values between 0.30-0.50 mSv (30-50 mrem). This action will help assure that processors are not inadvertently discriminated against by having to measure several very low dose equivalent values.

Beta Category.  $^{204}\text{Tl}$  will be added to category 5. This addition will be accomplished by restructuring the test to include 3 categories as shown in Table 5. Category 5A is the same as category 5 in ANSI N13.11-1983. Category 5B is  $^{204}\text{Tl}$ . Category 5C is a general one and will offer a challenge to the dosimetrist. It will include both 5A ( $^{90}\text{Sr} + ^{90}\text{Y}$ ) and 5B ( $\text{Tl}^{204}$ ); e.g., 7 dosimeters could be exposed to 5A irradiations and 8 exposed to 5B irradiations. Note that 5C does not have a separate limit on B and S.

Neutron Category.  $^{241}\text{AmBe}$  will be added to category 8 as 8B. A lead filter will be used to cut out the associated low energy photons. As seen in Table 5, category 8A ( $\text{D}_2\text{O}$ -moderated  $^{252}\text{Cf}$ ) is the same as category 8 in ANSI N13.11-1983. Both 8A and 8B will be enhanced with  $^{137}\text{Cs}$  gammas such that the neutron-to-gamma dose equivalent ratio varies from 3/1 to 1/3. The 1983 standard only requires the total dose equivalent (i.e., neutron + gamma) to be reported. The proposed standard will require separate reporting of the neutron dose equivalent, but the separate limits on B and on S will not apply in that case (see Table 5).

Mixtures. As shown in Table 5, category 6 involves mixtures of x-rays (category 3) and  $^{137}\text{Cs}$  photons (category 4). Details are not included in Table 5; however, category 6A will be a mixture of categories 4 and 3A. Similarly, 6B will be a mixture of 4 and 3B. If a processor participates in 3B (but not 3A), there would be no reason to expect that processor to participate in 6A.

Category 7 involves mixtures of betas (category 5) and photons (category 4). Although not shown specifically in Table 5, category 7A will be a mixture of categories 4 and 5A. Likewise, 7B will be a mixture of 4 and 5B. There will not be a category 7C (i.e., no combination of 4 and 5C).

Angular Dependence. Testing for angular dependence will be introduced as category 9. It involves only categories 3B and 4; i.e., x-rays (beam codes M100, M150, H150) and  $^{137}\text{Cs}$  photons. The angles for testing (both vertically and horizontally) will be  $0^\circ$ ,  $\pm 40^\circ$ , and  $\pm 60^\circ$ . The dose equivalent range will be 1-100 mSv (0.1-10 rem). The tolerance level will be 0.50, but there will not be a separate limit on B or on S. The shallow dose equivalent reporting does not apply to  $^{137}\text{Cs}$  exposures. Due to the limited irradiation categories, this test will not introduce any real difficulty for most dosimeters. However, processors should consider the possibility of having angular dependence testing introduced into other test categories (e.g., neutron or beta) in the future.

It should be noted that the review group consensus is that the appropriate response to irradiation at nonperpendicular angles of incidence is not isotropic, but somewhat bell-shaped in the frontal half-plane like the effective dose equivalent as a function of angle. Obtaining such a response might require major modifications in the design of some dosimeters.

## Summary

The modified standard hasn't been approved by ANSI yet, but changes have been proposed. They include angular dependence testing, use of  $^{204}\text{Tl}$  and  $^{241}\text{AmBe}$  sources, different allowable beta exposure distances, calculation of LLD, use of new NIST beam codes, adoption of new conversion factors and dose equivalent reporting conventions, and putting a separate limit on B and on S.

Table 1. ANSI N13.11-1983 Test Categories,  
Test Irradiation Ranges, and Tolerance Levels

Test Category	Test Range	Tolerance Levels	
		Deep	Shallow
1. Accidents, x-ray <sup>a</sup>	10 - 500 rad	0.3	No test
2. Accidents, <sup>137</sup> Cs	10 - 500 rad	0.3	No test
3. X-rays <sup>b</sup>	0.03 - 10 rem	0.5	0.5
4. <sup>137</sup> Cs	0.03 - 10 rem	0.5	No test
5. Betas ( <sup>90</sup> Sr+ <sup>90</sup> Y)	0.15 - 10 rem	No test	0.5
6. Photon mixtures (3 + 4)	0.05 - 5 rem	0.5	0.5
7. Photon/beta mixtures (4 + 5)	0.20 - 5 rem	0.5	0.5
8. D <sub>2</sub> O-moderated <sup>252</sup> Cf/ <sup>137</sup> Cs	0.15 - 5 rem	0.5	No test

<sup>a</sup> NBS technique MFI

<sup>b</sup> NBS techniques LG, LI, LK, MFC, MFI

Table 2. NVLAP Performance Test Results (1985-1990)

Category	Avg.  B  + S <sup>a</sup>	Attempted/Passed	% Pass
1. Accidents, x-ray	0.15	191/161	84
2. Accidents, <sup>137</sup> Cs	0.13	228/213	93
3. X-rays	0.19	209/192	92
4. <sup>137</sup> Cs	0.14	257/256	99+
5. Betas	0.18	238/228	96
6. Photon mixtures	0.18	201/191	95
7. Photon/beta mixtures	0.15	249/235	94
8. Neutron/photon mixtures	0.14	<u>183/175</u>	<u>96</u>
		1756/1651	94

<sup>a</sup> Average among those passing tests.

**Table 3. ANSI N13.11 Review Group**

**Members**

1. Doug Carlson - Department of Energy
2. Brian Colby - American Nuclear Insurers
3. Don Jones - Lawrence Livermore National Laboratory  
(Pacific Gas & Electric)\*
4. Harley Piltingsrud - Public Health Service
5. Sami Sherbini - Nuclear Regulatory Commission
6. Steve Sims - Oak Ridge National Laboratory, Chairman
7. Chris Soares - National Institute of Standards and Technology
8. Stan Waligora - Environmental Dimensions, Inc.
9. Gary Zeman - AT & T Bell Laboratories  
(Defense Nuclear Agency)

**Consultants**

1. Bob Devine - Los Alamos National Laboratory
2. Elizabeth Donnelly - Atlan-Tech, Inc.  
(San Onofre Nuclear Generating Station)
3. Bill King - Victoreen, Inc.  
(Harshaw)
4. Bob Pollock - Radon Environmental Monitoring  
(Siemens Gammasonics)
5. Pete Roberson - University of Michigan  
(Pacific Northwest Laboratories)

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\* If the person's employer at the time of selection to the group was different than the current employer listed above, the former employer is shown in parentheses.

**Table 4. 16 Issues for Resolution**

1. SI Units
2. Lower Limit of Detection
3. Distance from Source
4. X-ray Category
5. Conversion Factors and Dose Reporting Convention
6. Tolerance Levels and Performance Criteria
7. Beta Category
8. Neutron Category
9. Mixtures
10. Angular Dependence
- 
11. Philosophy
12. Photon Category
13. Extremity Dose Category
14. Phantom
15. Blind Test
16. Environmental Concerns

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- Notes:
- a. The issues are identified only by title in this table. They are, however, a series of comments and questions of a technical nature related to each area of concern.
  - b. The resolution of issues 1-10 resulted in suggested modifications to the standard. Issues 11-16 were considered in detail, but did not result in substantive changes.

Table 5. Proposed ANSI N13.11 Test Categories,  
Test Irradiation Ranges, and Tolerance Levels

Test Category	Test Range	Tolerance Levels		Additional Limit on  B  and S
		Deep	Shallow	
1. Accidents, x-ray <sup>a</sup>	0.1 - 5 Gy	0.30	No test	None
2. Accidents, <sup>137</sup> Cs	0.1 - 5 Gy	0.30	No test	None
3. X-rays				
A. General <sup>b</sup>	0.3 - 100 mSv	0.50	0.50	0.35
B. High energy techniques <sup>c</sup>				
4. <sup>137</sup> Cs	0.3 - 100 mSv	0.50	No test	0.35
5. Beta particles				
A. <sup>90</sup> Sr + <sup>90</sup> Y	1.5 - 100 mSv	No test	0.50	0.35
B. <sup>204</sup> Tl				0.35
C. General (A,B)				None
6. Photon mixtures (3 + 4)	0.5 - 50 mSv	0.50	0.50	0.35
7. Photon/beta mixtures (4 + 5)	2 - 50 mSv	0.50	0.50	None
8. Neutron/ <sup>137</sup> Cs mixtures				
A. D <sub>2</sub> O-moderated <sup>252</sup> Cf	1.5 - 50 mSv	Total 0.50	No test	0.35
B. <sup>241</sup> AmBe		Neutron 0.50		None
9. Photons/varied $\angle$ of incidence <sup>d</sup>	1 - 100 mSv	0.50	0.50	None

<sup>a</sup> NIST technique M150.

<sup>b</sup> M30, M60, M100, M150, H150.

<sup>c</sup> M100, M150, H150.

<sup>d</sup> Combination of categories 3B and 4.

## References

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