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PILOT TEST OF ANSI DRAFT STANDARD N13.29 ENVIRONMENTAL DOSIMETRY – PERFORMANCE CRITERIA FOR TESTING

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ABSTRACT

American National Standards Institute Draft N13.29 describes performance tests for environmental radiation dosimetry providers. If approved, it would be the first step toward applying the types of performance testing now required in personnel dosimetry to environmental radiation monitoring. The objective of this study was to pilot test the draft standard, before it undergoes final balloting, on a small group of dosimetry providers that were selected to provide a mix of facility types, thermoluminescent dosimeter designs and monitoring program applications. The first phase of the pilot test involved exposing dosimeters to laboratory photon, beta, and x-ray sources at routine and accident dose levels. In the second phase, dosimeters were subjected to ninety days of simulated environmental conditions in an environmental chamber that cycled through extremes of temperature and humidity. Two out of seven participants passed all categories of the laboratory testing phase, and all seven passed the environmental test phase. While some relatively minor deficiencies were uncovered in the course of the pilot test, the results show that draft N13.29 describes useful tests that could be appropriate for environmental dosimetry providers. An appendix to this report contains recommendations that should be addressed by the N13.29 working group before draft N13.29 is submitted for balloting.

TABLE OF CONTENTS

Introduction 1

Participant Selection 1

Phase 1. Laboratory Testing 2

- Methods 2
- Quantities 3

Phase 1. Results 4

- Participant Reports 4
- Calculation of Performance 4

Phase 1. Discussion 6

Phase 2. Field Testing 7

- Methods 8

Phase 2. Results 9

Phase 2. Discussion 10

Summary and Conclusions 10

References 12

Tables 1-13 13

Figures 1-16 26

Appendix A. Recommended Modifications to Draft N13.29 36

Appendix B. Examples of Instructions and Response Forms 41

INTRODUCTION

Passive environmental dosimeters are widely used to assess the radiation dose to the general public from nuclear or radiological facilities and to demonstrate compliance with regulations on public dose limits. Over 21,000 sites worldwide are currently being monitored with such devices, including U. S. Department of Energy (DOE) facilities and Nuclear Regulatory Commission (NRC) licensed sites (Klemic et al. in press). There is presently no required performance testing or accreditation program in the U. S. for environmental dosimetry providers, a potential weakness should the estimates for radiation dose to the general public from a radiological facility be challenged. In contrast, personnel dosimetry providers for DOE sites are required to pass performance tests in the DOE Laboratory Accreditation Program (DOELAP), and those providers for NRC sites must pass the National Voluntary Laboratory Accreditation Program (NVLAP).

American National Standards Institute (ANSI) Draft Standard N13.29 provides the criteria and procedures for determining performance of processors engaged in environmental radiation dosimetry using passive dosimeters. It is analogous to ANSI N13.11 (ANSI 1993), which is the basis for personnel dosimetry testing. ANSI Draft N13.29 was developed by a group of experts appointed by the Health Physics Society Standards Committee in 1991. It was approved for pilot testing in February 1996 and an independent panel reviewed three proposals submitted to the DOE Office of Environment, Safety and Health (EH). The Environmental Measurements Laboratory's (EML) proposal for collaboration between EML, the National Institute of Standards (NIST) and Brookhaven National Laboratory (BNL) was selected in March 1997.

The objective of this pilot study is to test the draft standard on a small group of processors before it undergoes final balloting to become an American National Standard. The standard calls for two phases of testing. Phase one is the laboratory testing of the dosimeters and consists of three categories: accident (using ^{137}Cs and $^{90}Sr/^{90}Y$ sources), routine (^{137}Cs and $^{90}Sr/^{90}Y$), and energy (H40 and H100 x-ray sources). Phase two involves testing the dosimeters under real and simulated field conditions. We report here on the results of the pilot test, and our recommended modifications are presented in Appendix A.

PARTICIPANT SELECTION

Seven participants were selected to provide a mix of facility types, thermoluminescent dosimeter (TLD) designs, environmental monitoring program applications, and experience levels. The participants represented three DOE national laboratories, the NRC, one nuclear power plant, and two commercial dosimetry providers. They routinely perform fence-line, off-site, on-site, and/or remediation monitoring. TLDs used were LiF:Mg,Ti, CaF:Dy, $Li_2B_4O_7$, $CaSO_4$, and Al_2O_3:C. Dosimeter designs included five commercially available badge-type dosimeters (three

manufactured by Panasonic and two by Harshaw), and two "in-house" designed packages containing loose chips. The dosimeter types are summarized in Table 1. The letters A-G identified participants throughout the pilot test.

PHASE 1. LABORATORY TESTING

METHODS

Each participant submitted a total of 34 dosimeters to EML in August 1997. These included two control dosimeters to measure the dose accumulated in transit and storage, two spare dosimeters, and five dosimeters to be irradiated in each of the following subcategories: accident photon, accident beta, routine photon, routine beta, energy H40 x-ray, and energy H100 x-ray. Draft N13.29 allows the processor to choose which subcategories to be tested in, but for purposes of the pilot test all participants were tested in all categories. There were no mixture categories, but the radiation sources were not revealed except for the accident category.

Upon receipt at EML, all dosimeters were stored in a steel vault where the background radiation was reduced by about 75% to an air-kerma level of 14 nGy h^{-1}. Dosimeters were logged in and scanned for surface contamination, sorted and tagged. Doses to be delivered were assigned by generating a random number using the log of the dose between 0.01 to 0.5 Gy for the accident category, and 0.2 to 10.0 mSv for the other categories. Five separate randomly selected doses were required for each category, with no more than one per category being < 0.3 mSv.

Five packets were made up for each subcategory, each containing one dosimeter from each of the participants. Forty-one EML LiF:Mg,Ti quality control (QC) dosimeters (Klemic 1996) were prepared to provide verification of photon and x-ray irradiations and were included in the packets. Separate packets containing the control and spare dosimeters were kept with the dosimeters at all times. In October, all of the dosimeters were transported by car to NIST. Doses that may have been received in transit would be recorded on the control dosimeters also, and, consequently, subtracted out at the end of the test.

Irradiations for the laboratory phase were performed at NIST during the week of October 20^{th}-24^{th}, 1997. For the ^{137}Cs irradiations, two horizontal-beam sources were used. Radiation from both units was collimated into a circular beam. The first unit delivered an air-kerma rate of 3.459 μGy s^{-1} at 195 cm with a useful beam diameter of 37 cm. Irradiations were performed on the second unit at both 195 cm, air-kerma rate of 33.145 μGy s^{-1}, and at 300 cm, air-kerma rate of 13.93 μGy s^{-1}. The useful beam diameters were 31 cm and 50 cm, respectively. For the ^{90}Sr/^{90}Y irradiations, a collimated point-like source delivered an absorbed-dose rate of 1.854 mrad s^{-1}, which had a uniform (± 5%) circular beam diameter of 15 cm at 50 cm. The 100 kV and 300 kV x-ray generators were used for the energy category, with uniform circular beam diameters of

15 cm and 50 cm at 100 cm and 220 cm, respectively. The combined total uncertainty for delivered dose or exposure was estimated at 1.0%, 3.2%, and 1.0% for the ^{137}Cs, ^{90}Sr/^{90}Y and x-ray sources, respectively. Uncertainty statements are on file at the NIST.

Five of the seven participant dosimeters in each packet were irradiated simultaneously along with an EML QC dosimeter. They were mounted on a single-plane, low-mass fixture using double-sided adhesive tape, and distances were measured to the front face of the fixture (see Figure 1). Two of the dosimeters in each packet were large cylindrical environmental packages that proved problematic for laboratory irradiations. Their large size necessitated separate irradiations and unique fixtures. Since the position of the dosimeter inside these packages was not fixed, special care was used in their setup. Distances were measured to the approximate center of these dosimeters (see Figure 2).

Seventy-five separate shots were required to irradiate all dosimeters in all categories. The QC dosimeters were read out and analyzed at EML. Results for all but one of the subcategories were as expected. The QC TLDs for a few of the H40 x-ray shots were lower than expected, indicating a possible problem with some of the H40 x-ray irradiations. When two of the participants also reported questionable results for the H40 irradiations, it was decided that it was in the best interest to repeat that subcategory test.

NIST installed a new 100 kV x-ray generator in November of 1997. The H40 irradiations were repeated in February 1998 after the beam was mapped with film and an ion chamber. Each participant submitted nine dosimeters to EML where the same procedures were followed to scan, sort, and tag the dosimeters. They were shipped to NIST along with EML QC dosimeters for irradiation on February 20th. Sixteen shots were required to irradiate all the dosimeters. They were returned to EML and then to the participants on February 26th. EML QC TLDs showed no unexpected results for the retest.

QUANTITIES

For the routine and energy categories, Draft N13.29 uses the quantities ambient dose equivalent H*(10) and directional dose equivalent H'(0.07). H*(10) is defined as the dose to an ICRU tissue sphere at a depth of 10 mm, and H'(0.07) is the dose at a depth of 0.07 mm (refer to Draft N13.29 for precise definitions). Conversion factors given in the draft were used to convert the NIST delivered air-kerma K_a in Gy to the appropriate quantities in Sv. For the ^{137}Cs subcategories, H* (10) and H' (0.07) are equal. For the x-ray categories, H*(10) and H'(0.07) are not equal but both are applicable. For the routine beta irradiations, only the quantity H'(0.07) is defined.

For the accident categories, Draft N13.29 uses the quantities penetrating absorbed dose in tissue, D(10), and the shallow absorbed dose in tissue, D(0.07), since it is recognized that for

high (accident level) doses the dose-equivalence is not applicable. The conversion factors are the same ones used for H*(10) and H'(0.07), but the units are Gy.

PHASE 1. RESULTS

PARTICIPANT REPORTS

Along with their dosimeters, participants received a response form and the option to report results electronically. Only those dosimeters used in the accident category and as controls were identified. Apparent inconsistencies in one report prompted a request that all participants recheck their results. In an actual performance test such corrections would not be solicited, emphasizing the need for a careful evaluation of results prior to submission.

Some confusion was shown with regard to reporting quantities. Because dose-equivalent quantities are not used routinely by all the participants, the response form allowed air-kerma to be reported along with ambient and directional dose equivalent if needed. It was recognized that since the irradiation source is not revealed in the routine categories, it might not be possible to determine the appropriate conversion factor. However, for the dosimeters exposed to beta irradiations only H'(0.07) or D(0.07) are defined. Out of the seven participants, four reported D(0.07) for the accident beta subcategory, and three reported H'(0.07) for the routine beta subcategory. Another participant reported H'(0.07) for the H40 x-ray but not for the routine beta subcategory. One participant (A) reported air kerma and also used the ^{137}Cs conversion factor to report "cesium dose equivalent" in mSv for all dosimeters.

CALCULATION OF PERFORMANCE

The pilot test investigators subtracted control results for three participants who had not already done so, another action that would not be performed during formal testing. Results were evaluated according to the N13.29 performance criteria, which states that to pass the following conditions must be met:

$$|B| + S \leq 0.50$$
$$|B| \leq 0.35$$
$$S \leq 0.35$$

In the above equations, B is the "bias" of the values of the "performance quotient" P_i, defined as:

$$P_i \equiv \frac{measured\_dose - delivered\_dose}{delivered\_dose} \quad \text{(of the i}^{th}\text{ of n=5 test dosimeters)}$$

with

$$B \equiv \overline{P} = \sum_{i=1}^{n=5} \frac{P_i}{n}$$

where the sum is extended over all five (n) values of P_i for a given subcategory.

The standard deviation, S, is defined as:

$$S \equiv \sqrt{\frac{\sum_{i=1}^{n} (P_i - B)^2}{(n-1)}}$$

For a laboratory to pass the first phase, its bias and standard deviation must each be less than or equal to 0.35, while their sum must be less than or equal to the tolerance level 0.50.

A summary of the performance results is shown in Table 2 and Figure 3 for all categories. In the figure, points within the dashed triangle meet the tolerance level of 0.50 on the sum of the bias and standard deviation. The additional separate limit of 0.35 on both the bias and standard deviation corresponds to the vertical and horizontal lines at the corners of the triangle. To pass, both criteria must be met.

Results for the individual subcategories are tabulated in Tables 3-10 and are shown visually in Figures 4-9. In the tables, the NIST delivered doses are shown in the first two rows in terms of the appropriate quantities. The participants' reported results are shown in the next seven rows. When both air-kerma (K_a) and dose equivalent values were reported, the dose equivalent values were used for the calculations and are shown in the tables. Values reported only in air-kerma are shown in italics. The performance quotient, bias, and standard deviation were calculated for each participant and are shown in the next three columns. The overall performance rating of "pass" or "fail" is shown in the last column, applying the tolerance levels 0.50 (L1) and 0.35 (L2) described above. An asterisk indicates cases where there was no reported value in a particular quantity. There are two tables for each of the x-ray categories since both H*(10) and H'(0.07) are appropriate and are not equal.

PHASE 1. DISCUSSION

The laboratory tests described in N13.29 cover a range of sources and dose levels that some environmental dosimetry providers may not have experience in. In an actual performance test, participants would probably choose to omit those categories that are not relevant to their applications. For purposes of pilot testing the draft standard as thoroughly as possible, all dosimeters were subjected to every test. This must be taken into consideration when analyzing performance in this pilot test. As Table 2 shows, there was only one category where all of the participants passed. Two participants passed in all categories.

The routine photon category corresponds to the source and dose levels most often used for calibrating environmental dosimeters. This category is also the closest to the laboratory tests applied in the International Intercomparisons of Environmental Dosimeters (Klemic et al. 1995), which many of the participants have experience in. Perhaps for these reasons, this category is the one all of the participants passed. In the accident photon category, while the source is familiar, the doses delivered are much higher than those encountered in most environmental monitoring programs and high readings and possible residual signals may have presented a new challenge to some participants. In the accident photon category, six participants passed. (It should be noted that without the request to recheck results, in both the routine and accident photon categories there would have been one additional failure. One participant made a transcription error and another made an error in applying conversion factors. No changes were permitted after a preliminary report revealed the delivered doses, although participant B determined that they would have passed the accident category if they had not transposed some dosimeter results in their report.)

The x-ray irradiations are new to most participants, and it is known that the response of most TLDs to very low energy photons is significantly different from the higher energies routinely used for calibration. To accurately measure low energy photons, a low-energy calibration source could be used or correction factors applied. However, this requires knowledge of the irradiation source which is not divulged according to the procedures of Draft N13.29.

The three dosimeters that passed the H40 x-ray category were capable of energy discrimination by using element ratios with filters in a badge-type design. For these participants, it was possible to deduce the irradiation source and then apply appropriate correction or conversion factors. Two of the dosimeters that did not pass also apparently had this capability, but the processors do not routinely apply these techniques, presumably because they are not required for their applications. Dosimeters using loose chips without special filters did not pass the H40 x-ray category.

In the H100 x-ray category, the performance of the loose chip dosimeters was different. Both of the loose chip dosimeters that failed in H40 passed in H100. The two badge-type

dosimeters with unused energy discrimination capabilities, which failed the H40 irradiations, also did not pass in the H100 x-ray test. The rest of the badge-type dosimeters passed the H100 test.

Beta irradiations are new to many participants, and in the routine category many did not report the appropriate quantity. Of the three who did report directional dose equivalent for the routine beta case, all passed. Among the others, two were dosimeters that were not designed to measure beta and had never been tested with beta irradiations, and two were apparently capable of beta discrimination in theory. Measured values were reported in these cases but they were not in directional dose equivalent quantities, so they could not be compared to the delivered dose, and, therefore, could not pass the performance criteria. However, this suggests that performance may be improved with appropriate calibrations or procedural modifications. For the accident beta category, the source was revealed and five participants were able to report the shallow absorbed dose; of these, three passed.

The choice of quantities remains a difficult issue in the field of environmental dosimetry. Based on data from the International Intercomparisons of Environmental Dosimeters, most processors prefer physical quantities to dose-equivalent quantities. ANSI Draft N13.29 uses dose-equivalent quantities since the purpose of environmental dosimetry is ultimately to assess the dose to a person. Furthermore, environmental dosimetry programs may be used to verify compliance with regulations on dose limits to the public, which are specified in terms of dose-equivalent values.

Most of the participants in the pilot test are not routinely using dose-equivalent quantities in their environmental monitoring programs. Since the sources in the routine and energy categories of Draft N13.29 are not revealed, the selection of the appropriate conversion factor could be a problem. For some of the participants, deducing the irradiation source with a dosimeter designed for energy and beta discrimination solved this problem. Among the participants using dosimeters without this capability, one simply chose to apply the ^{137}Cs factor in all cases, while another was limited to reporting in air kerma for the routine and energy categories. Perhaps in a real performance test a participant using a dosimeter without energy discrimination would elect to be tested only in the ^{137}Cs categories and the problem would be solved.

PHASE 2. FIELD TESTING

The second phase of ANSI Draft 13.29 involves exposing dosimeters to simulated field conditions, using an environmental chamber, and actual environmental conditions at an outdoor field site. Because of limited funding, only the environmental chamber tests were included in this pilot test. Draft N13.29 requires that a dosimetry provider pass the Laboratory Test Phase prior to beginning the second phase of tests. However, for purposes of the pilot test, this was not enforced.

The simulated field tests require exposing dosimeters to extremes of temperature (-20 and +50°C) and relative humidity (RH, 20% and 90%) in an environmental chamber using 15-day cycles for a total period of 90 days. Lighting is to be provided by two 40-W fluorescent bulbs. The environmental test dosimeters are removed from the chamber and irradiated at the beginning, middle, and end of the 90-day period using a ^{137}Cs source. The value of interest is the delivered ^{137}Cs dose. The natural environmental radiation field (measured by control dosimeters) is subtracted as background.

METHODS

Each participant submitted 22 dosimeters to EML in December 1997. These included two spare dosimeters and five control dosimeters. The remaining 15 dosimeters from each laboratory were divided into three groups of five dosimeters, designated for irradiation at the beginning, middle (45 days) and end (90 days) of the environmental tests. Each dosimeter was assigned a different dose between 0.5 and 10.0 mSv, based on a random selection of the logarithm of the ambient dose equivalent. As in the first phase of tests, dosimeters were logged in, scanned for surface contamination, sorted and tagged. Dosimeters were transported to BNL, about 70 miles east of EML.

In January 1998, group one dosimeters from each participant were irradiated using BNL's ^{137}Cs point source. Dosimeters were mounted on a thin Lucite track at a distance of 1.0 m from the center of the dosimeters to the source (see Figure 10). Dosimeters assigned to each dose level were irradiated in a single shot. EML QC dosimeters and a NIST calibrated reference ionization chamber verified each irradiation. The QC TLDs were not subjected to the environmental chamber tests and were read out within a few days of the irradiations.

All 22 dosimeters from each participant were suspended from a steel rack using plastic cable ties and placed in a 91 x 91 x 101 cm environmental chamber, where lighting was provided by two 40-W fluorescent bulbs. The distance from the lamp to the dosimeters was about 0.3 m, resulting in an illuminance to the dosimeters of about 2500-2800 lux. Two EML pressurized ionization chambers (PICs) continuously monitored the background radiation dose near the environmental chamber, with servicing required every 2 weeks. A microprocessor-based digital control system was used to control the temperature and humidity in the chamber (see Figure 11). The set point and actual parameters were logged on a PC and recorded on 12-day chart paper. Cycling between the extremes of temperature and humidity occurred over a period of 24 h.

For the first test cycle, the temperature in the chamber was reduced to –20°C (humidity controls were turned off). During this time the fluorescent bulbs dimmed considerably. After 15 days at –20°C, conditions were ramped up to +50°C and 20% RH, where they were held constant for 15 days. The RH was then ramped up to 90% and held for 15 days at +50°C. After about 7 days at these settings, the outlet valve for the water supply became blocked and the humidity conditions did not meet the set point; for the second half of the 15-day period the humidity averaged 72% rather than the desired value of 90% (see Figure 12). The temperature and RH

were then ramped down to 20°C and 20%, and the dosimeters were removed from the chamber. Repairs were made to the outlet valve for the water supply, and a float on the water reservoir was replaced.

Group two dosimeters from each participant were removed from the rack and irradiated. The same procedures were used for irradiating the dosimeters and for quality assurance. The following day, the dosimeters were returned to the wire rack in the environmental chamber and the cycles of temperature and humidity conditions were repeated. The humidity instrumentation for the chamber again required servicing during the second 90% RH cycle.

At the end of the last cycle (total 90 days), group three dosimeters from each participant were removed from the wire grid and irradiated. The dosimeters were then returned to the participants for processing and analysis. Assigned doses and information as to when the test dosimeters were irradiated were not revealed to the processing laboratories.

PHASE 2. RESULTS

Measured values of temperature and humidity (Figure 12) show that desired parameters were met for most of the test cycle. Deviations may be seen because of the humidity malfunctions described above and a brief power outage after the middle set of irradiations.

Background radiation recorded by the EML PIC is shown in Figure 13 and illustrates expected natural variations due to precipitation and atmospheric effects as well as facility contributions from BNL. The average dose in air was found to be 55.5 ± 3.3 nGy h^{-1}. The combined total uncertainty was determined by taking two times the quadratic sum of type A and type B uncertainties according to the International Organization for Standardization recommendations (1995).

The delivered ^{137}Cs doses and participants' reported results are shown in the Tables 11-13. The combined total uncertainty in the delivered doses is estimated at 3% at the 95% confidence level, and includes the uncertainty in the calibration of the ^{137}Cs source and assumed approximations for uncertainty in dosimeter positioning. For this phase of tests, all participants reported their results in ambient dose equivalent. The bias and standard deviation were calculated as described for Phase 1, using n = 5 to determine performance separately for irradiations performed at the beginning, middle, and end of the simulated environmental tests. The performance measures are shown in the last three columns of the tables and plotted in Figures 14-16. Points within the dashed lines pass the performance criteria.

PHASE 2. DISCUSSION

All participants passed the second phase of simulated environmental tests. As Figures 14-16 show, in all but one case the participants' dosimeters showed a negative average bias while the QC dosimeters are in good agreement with the delivered doses. Since phase one tests showed both positive and negative bias, it appears that the environmental chamber conditions resulted in some signal and/or trap fading that would not occur under laboratory conditions. However, in all cases the fading was less than 25% and all participants easily passed this phase of testing.

SUMMARY AND CONCLUSIONS

American National Standards Institute Draft N13.29 describes performance tests for environmental dosimetry processors using passive dosimeters. If approved it would be the first step toward applying the types of performance testing now required in personnel radiation monitoring to the field of environmental dosimetry. The purpose of this project was to pilot test Draft N13.29 on a small group of dosimetry providers in order to uncover potential deficiencies before it undergoes final balloting. The processors participating in the test represented a wide range of facility types and thermoluminescent dosimeter designs.

The first phase of the pilot test involved laboratory testing categories using photon, beta, and x-ray sources and routine and accident dose levels. Two out of seven participants passed in all categories, and there was one category where everyone passed. The low energy x-ray (H40) and beta categories had the lowest passing rate. The second phase of the pilot test involved subjecting dosimeters to simulated environmental conditions using an environmental chamber. All participants passed the second phase of tests. Another set of tests required by the standard that would involve an outdoor field exposure was not included in the pilot study.

The results indicate that Draft N13.29 describes useful and rigorous tests that would be appropriate for the testing of environmental dosimetry providers. Such tests would provide verification for programs that assess radiation dose to the general public. Appendix A contains recommendations that should be addressed before Draft N13.29 is submitted for final balloting.

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TABLE 1

DOSIMETER TYPES USED IN PILOT TEST OF ANSI DRAFT N13.29

Participant Identification	Dosimeter Type	Manufacturer	TLD Material
A	Loose chips in unique design	Harshaw TLD100	^{nat}LiF:Mg,Ti
B	Commercial badge	Panasonic 814	$Li_2B_4O_7$, $CaSO_4$, $CaSO_4$*
C	Commercial badge	Harshaw 8807	CaF:Dy ^{7}LiF:Mg,Ti
D	Commercial badge	Panasonic 814	$Li_2B_4O_7$, $CaSO_4$, $CaSO_4$ *
E	Loose chips in unique design	Victoreen 2600-80	Al_2O_3:C
F	Commercial badge	Harshaw 8807	CaF:Dy ^{7}LiF:Mg,Ti
G	Commercial badge	Panasonic 801	$Li_2B_4O_7$ (2) ** $CaSO_4$ (2) *

*Behind lead filter
**Behind plastic window

TABLE 2

SUMMARY OF PERFORMANCE IN LABORATORY TESTING PHASE

Category		Number Who Passed (out of 7 total)
Accident:	Photon	6
	Beta	3
Routine:	Photon	7
	Beta	3
Energy:	x-ray H40	3
	x-ray H100	5

TABLE 3

PHOTON ACCIDENT CATEGORY (in absorbed dose)

	Accident Cs 1 (mGy)	Accident Cs 2 (mGy)	Accident Cs 3 (mGy)	Accident Cs 4 (mGy)	Accident Cs 5 (mGy)	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered Dose									
D(10)= D(0.07)	32.4	219.6	373.2	19.2	72.0				
K_a	*27.0*	*183.0*	*311.0*	*16.0*	*60.0*				
Participants Reported Results									
A*	32.5	218	358	18.4	68.9	-0.027	0.022	0.049	pass
B*	28.08	0.51	216.52	2.23	369.6	0.340	2.149	2.489	fail
C*	40.397	277.129	481.210	24.197	85.588	0.249	0.037	0.287	pass
D	29.03	208.50	359.58	16.56	63.06	-0.091	0.045	0.135	pass
E	28.88	192.51	327.94	16.11	61.52	-0.132	0.021	0.153	pass
F	33.086	230.033	389.171	19.763	74.088	0.034	0.011	0.045	pass
G	42.6	294	498	22.8	92	0.291	0.062	0.353	pass
QC	32.01	202.30	331.14	19.57	70.02	-0.042	0.053	0.095	pass

*Investigators subtracted control-dosimeter results.

TABLE 4

BETA ACCIDENT CATEGORY (in shallow absorbed dose)

	Accident Beta 1 (mGy)	Accident Beta 2 (mGy)	Accident Beta 3 (mGy)	Accident Beta 4 (mGy)	Accident Beta 5 (mGy)	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered									
D(0.07)	55.8	227.8	51.2	117.1	23.3				
Participants Reported Results									
A	**	**	**	**	**	**	**	**	fail
B	**	**	**	**	**	**	**	**	fail
C*	44.185	182.92	39.714	98.535	18.427	-0.199	0.025	0.224	pass
D	50.73	189.55	53.21	116.11	24.82	-0.033	0.096	0.129	pass
E	27.31	106.2	25.55	52.21	12.00	-0.517	0.027	0.544	fail
F	53.476	206.071	47.489	107.265	22.086	-0.069	0.022	0.091	pass
G	10.4	165	34.6	85.2	17.2	-0.390	0.238	0.628	fail

*Investigators subtracted control-dosimeter results.
** No values reported in D(0.07).

TABLE 5

PHOTON ROUTINE CATEGORY (in ambient dose equivalent, with air kerma, K_a, shown in italics)

	Routine Cs 1	Routine Cs 2	Routine Cs 3	Routine Cs 4	Routine Cs 5	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered									
H*(10) = H(0.07) (mSv)	2.35	0.40	0.80	0.32	5.30				
K_a (mGy)	1.96	0.33	0.67	0.27	4.42				
Participants Reported Results									
A* (mSv)	2.28	0.38	0.80	0.32	5.07	-0.030	0.019	0.049	pass
B* (mSv)	2.09	0.36	0.70	0.28	4.60	-0.120	0.019	0.139	pass
C* (mGy)	*2.254*	*0.378*	*0.783*	*0.318*	*5.635*	*-0.183*	*0.053*	*0.236*	pass
D (mSv)	2.07	0.36	0.74	0.28	4.75	-0.106	0.022	0.129	pass
E (mSv)	2.58	0.427	0.846	0.298	5.923	0.053	0.078	0.131	pass
F (mSv)	2.356	0.412	0.798	0.326	5.486	0.015	0.021	0.036	pass
G (mSv)	2.42	0.420	0.864	0.330	5.72	0.052	0.027	0.079	pass
QC (mSv)	2.43	0.42	0.82	0.34	5.61	0.044	0.017	0.061	pass

*Investigators subtracted control-dosimeter results.

TABLE 6

BETA ROUTINE CATEGORY (in directional dose equivalent)

	Routine Beta 1	Routine Beta 2	Routine Beta 3	Routine Beta 4	Routine Beta 5	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered									
H' (0.07) (mSv)	0.34	6.54	0.62	9.02	0.91				
Participants Reported Results									
A	*	*	*	*	*	*	*	*	fail
B	*	*	*	*	*	*	*	*	fail
C	*	*	*	*	*	*	*	*	fail
D (mSv)	0.38	6.45	0.64	8.53	0.83	-0.001	0.080	0.081	pass
E	*	*	*	*	*	*	*	*	fail
F (mSv)	0.315	5.782	0.554	8.180	0.808	-0.100	0.017	0.117	pass
G (mSv)	0.386	5.82	0.501	7.51	0.703	-0.112	0.145	0.257	pass

* No values reported in H’(0.07)

TABLE 7

ENERGY CATEGORY H40 X-RAY, (in ambient dose equivalent, with air-kerma, in italics)

	H40 1	H40 2	H40 3	H40 4	H40 5	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered									
H*(10) (mSv)	0.29	4.86	1.16	3.80	1.29				
K_a (mGy)	*0.25*	*4.15*	*0.99*	*3.25*	*1.10*				
Participants Reported Results									
A* (mSv)	0.45	7.2	1.7	5.6	1.8	0.47	0.056	0.529	fail
B* (mSv)	0.102	1.015	0.314	1.043	0.298	-0.73	0.055	0.787	fail
C* (mGy)	*0.454*	*6.992*	*1.652*	*5.149*	*1.747*	*0.67*	*0.094*	*0.763*	fail
D (mSv)	0.28	5.25	1.26	3.86	1.26	0.02	0.056	0.081	pass
E	**	**	**	**	**	**	**	**	**
F (mSv)	0.296	4.889	1.272	4.056	1.379	0.05	0.037	0.089	pass
G (mSv)	0.238	3.67	0.867	2.77	0.927	-0.25	0.040	0.286	pass
QC (mSv)	0.32	4.84	1.32	4.27	1.38	0.09	0.057	0.143	pass

*Investigators subtracted control-dosimeter results.
** No values reported in H*(10) or K_a.

TABLE 8

ENERGY CATEGORY H40 X-RAY (in directional dose equivalent)

	H40 1	H40 2	H40 3	H40 4	H40 5	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
NIST Delivered									
H'(0.07) (mSv)	0.32	5.23	1.25	4.10	1.39				
K_a (mGy)	*0.25*	*4.15*	*0.99*	*3.25*	*1.10*				
Participants Reported Results									
A	*	*	*	*	*	*	*	*	*
B	*	*	*	*	*	*	*	*	*
C	*	*	*	*	*	*	*	*	*
D (mSv)	0.30	5.67	1.36	4.17	1.36	0.025	0.061	0.087	pass
E (mSv)	0.81	14.47	3.74	12.44	9.49	2.644	1.800	4.445	fail
F (mSv)	0.319	5.265	1.370	4.368	1.486	0.051	0.040	0.091	pass
G (mSv)	0.256	3.96	0.934	2.99	1.00	-0.246	0.036	0.282	pass

*No values reported in H’(0.07).

TABLE 9

ENERGY CATEGORY H100 X-RAY (in ambient dose equivalent, with air-kerma, in italics)

	H100 1	H100 2	H100 3	H100 4	H100 5	Bias	S	|B|+S	Performance (L1=0.5 L2+0.35)
NIST Delivered									
H*(10) (mSv)	5.39	1.56	1.83	1.03	0.22				
K_a (mGy)	*3.15*	*0.91*	*1.07*	*0.60*	*0.13*				
Participants Reported Results									
A* (mSv)	4.38	1.27	1.51	0.80	0.17	-0.202	0.028	0.231	pass
B* (mSv)	2.43	0.71	0.84	0.47	0.10	-0.545	0.004	0.549	fail
C* (mGy)	*4.528*	*1.25*	*1.483*	*0.832*	*0.175*	*0.386*	*0.033*	*0.419*	fail
D (mSv)	5.55	1.59	1.73	0.92	0.18	-0.059	0.092	0.151	pass
E (mSv)	5.319	1.536	1.936	1.099	0.234	0.031	0.041	0.072	pass
F (mSv)	5.807	1.671	1.937	1.100	0.232	0.065	0.014	0.079	pass
G (mSv)	4.67	1.22	1.58	0.857	0.214	-0.138	0.065	0.203	pass
QC (mSv)	5.13	1.51	1.7	0.99	0.22	-0.039	0.022	0.061	pass

*Investigators subtracted control-dosimeter results.

TABLE 10

ENERGY CATEGORY H100 X-RAY (in directional dose equivalent)

	H100 1	H100 2	H100 3	H100 4	H100 5	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
				NIST Delivered					
H'(0.07) (mSv)	5.01	1.45	1.70	0.95	0.21				
K_a (mGy)	*3.15*	*0.91*	*1.07*	*0.60*	*0.13*				
				Participants Reported Results					
A	*	*	*	*	*	*	*	*	-
B	*	*	*	*	*	*	*	*	-
C	*	*	*	*	*	*	*	*	-
D (mSv)	4.99	1.43	1.56	0.82	0.16	-0.093	0.093	0.186	pass
E	*	*	*	*	*	*	*	*	
F (mSv)	5.400	1.554	1.802	1.023	0.216	0.066	0.014	0.079	pass
G (mSv)	4.34	1.13	1.47	0.797	0.199	-0.138	0.066	0.204	pass

* No values reported in H’(0.07).

TABLE 11

ENVIRONMENTAL CHAMBER: BEGINNING ^{137}Cs IRRADIATIONS (mSv)

	Beg. 1 (mSv)	Beg. 2 (mSv)	Beg. 3 (mSv)	Beg. 4 (mSv)	Beg. 5 (mSv)	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
Delivered Dose (mSv)									
Delivered H*(10)	0.61	1.25	0.85	3.18	0.51				
Participants Reported Values and Performance Test Results									
A	0.73	1.3	0.98	3.1	0.59	0.105	0.095	0.201	pass
B	0.507	1.069	0.708	2.652	0.398	-0.173	0.025	0.198	pass
C	0.466	0.984	0.673	2.548	0.412	-0.209	0.017	0.226	pass
D	0.526	1.062	0.739	2.796	0.452	-0.130	0.016	0.146	pass
E	0.47	1.055	0.682	2.51	0.388	-0.206	0.030	0.236	pass
F	0.581	1.170	0.772	2.781	0.457	-0.086	0.032	0.118	pass
G	0.544	1.140	0.731	2.780	0.446	-0.117	0.021	0.138	pass
QC	0.61	1.28	0.87	3.24	0.52	0.018	0.007	0.025	pass

TABLE 12

ENVIRONMENTAL CHAMBER: MIDDLE ^{137}Cs IRRADIATIONS (mSv)

	Mid 1 (mSv)	Mid 2 (mSv)	Mid 3 (mSv)	Mid 4 (mSv)	Mid 5 (mSv)	Bias	S	|B|+S	Performance (L1=0.5 L2=0.35)
Delivered Dose (mSv)									
Delivered H*(10)	1.80	4.52	0.56	1.13	0.98				
Participants Reported Values and Performance Test Results									
A	1.6	3.7	0.54	1.1	0.88	-0.093	0.061	0.155	pass
B	1.512	3.785	0.459	0.935	0.803	-0.173	0.011	0.184	pass
C	1.390	3.549	0.438	0.876	0.754	-0.225	0.006	0.231	pass
D	1.567	3.909	0.525	0.996	0.819	-0.124	0.034	0.158	pass
E	1.582	3.874	0.496	1.051	0.768	-0.135	0.053	0.188	pass
F	1.590	4.077	0.489	1.036	0.871	-0.109	0.020	0.129	pass
G	1.550	4.260	0.517	1.040	0.950	-0.079	0.040	0.119	pass
QC	1.83	4.57	0.57	1.16	1.00	0.016	0.007	0.023	pass

TABLE 13

ENVIRONMENTAL CHAMBER: END ^{137}Cs IRRADIATIONS (mSv)

	End 1 (mSv)	End 2 (mSv)	End 3 (mSv)	End 4 (mSv)	End 5 (mSv)	Bias	S	$\lvert B \rvert + S$	Performance (L1=0.5 L2=0.35)
Delivered Dose (mSv)									
Delivered H*(10)	0.88	1.66	1.33	2.85	1.88				
Participants Reported Values and Performance Test Results									
A	0.87	1.5	1.3	2.6	1.8	-0.053	0.039	0.092	pass
B	0.763	1.465	1.132	2.512	1.705	-0.123	0.020	0.143	pass
C	0.715	1.357	1.098	2.404	1.547	-0.177	0.012	0.189	pass
D	0.800	1.455	1.160	2.496	1.680	-0.116	0.015	0.131	pass
E	0.845	1.528	1.269	2.950	1.894	-0.026	0.046	0.071	pass
F	0.803	*	1.295	2.695	1.794	-0.054	0.027	0.081	pass
G	0.863	1.500	1.250	2.770	1.720	-0.059	0.034	0.093	pass
QC	0.92	1.75	1.37	3.01	1.98	0.047	0.009	0.056	pass

*Dosimeter missing

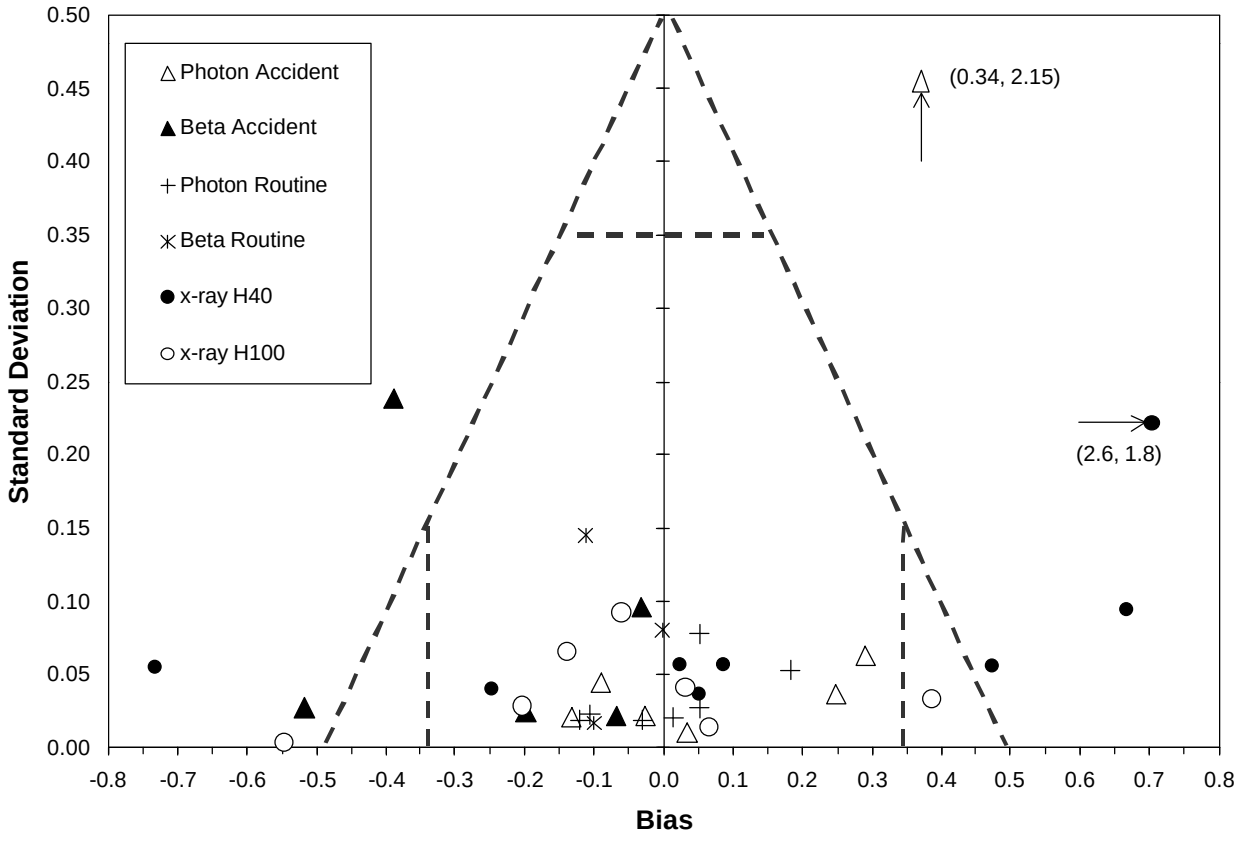

Figure 3. Plot of bias and standard deviation for all participants and all categories. Points within the dashed triangle meet the tolerance level of 0.50 on the sum of the bias and standard deviation. The additional limit of 0.35 in the bias and standard deviation corresponds to the vertical and horizontal lines at the corners of the triangle. To pass, both criteria must be met. Two points that are off-scale are indicated with arrows.

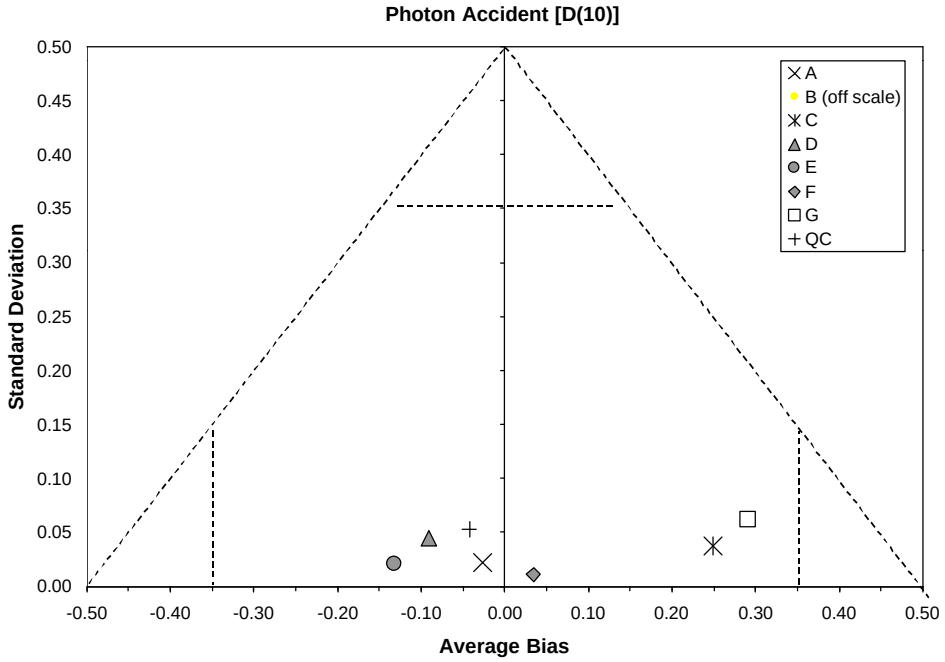

Figure 4. Plot of bias and standard deviation in Accident Photon category. Six out of seven were within the performance criteria (dashed lines).

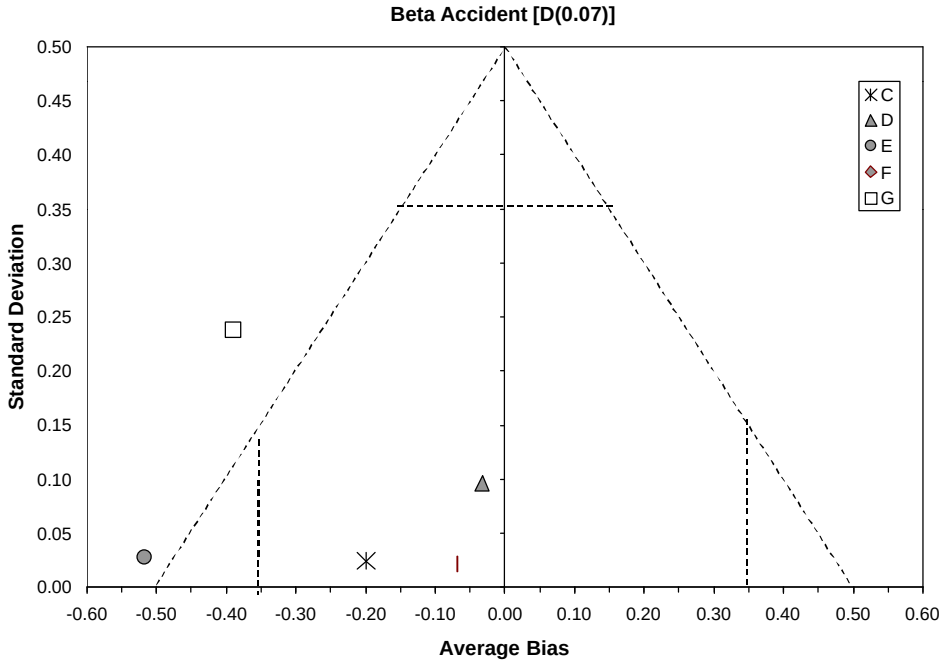

Figure 5. Plot of bias and standard deviation for those reporting D(0.07) in the Accident Beta category. Three out of five were within the performance criteria (dashed lines), and the two other participants did not report the appropriate quantity.

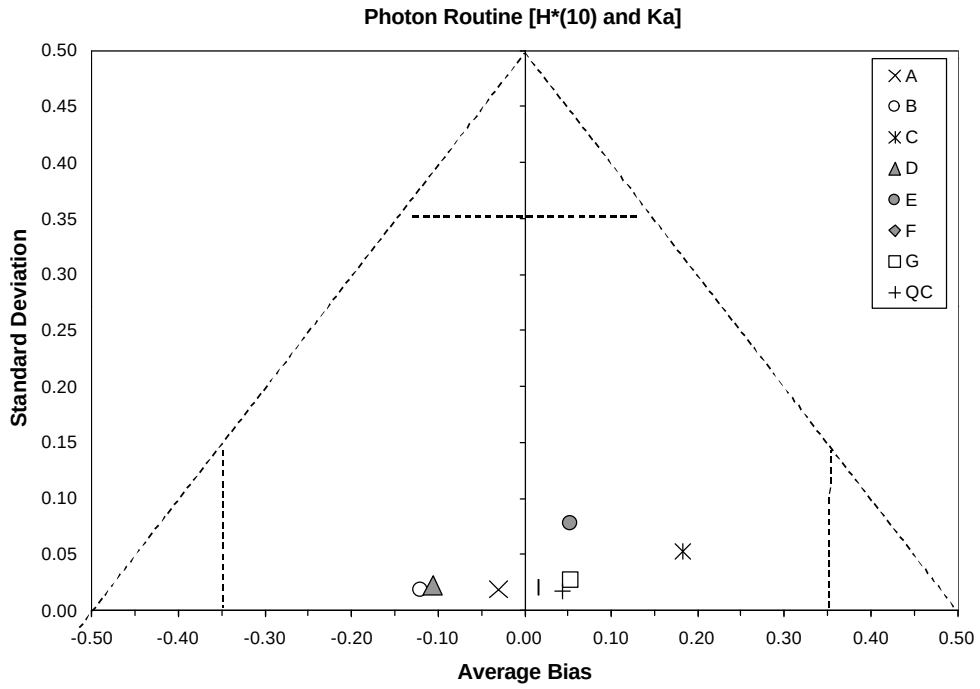

Figure 6. Plot of bias and standard deviation in the Routine Photon category. All seven were within the performance criteria (dashed lines).

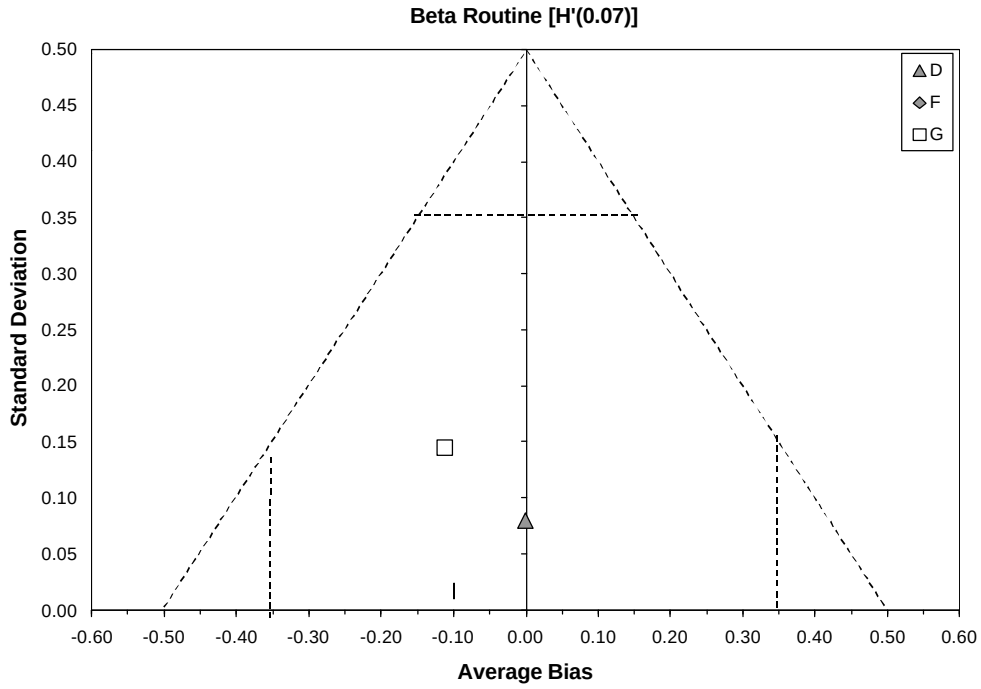

Figure 7. Plot of bias and standard deviation for participants reporting H’(0.07) in the Routine Beta category. Three were within the performance criteria (dashed lines), while the other four participants did not report the appropriate quantity.

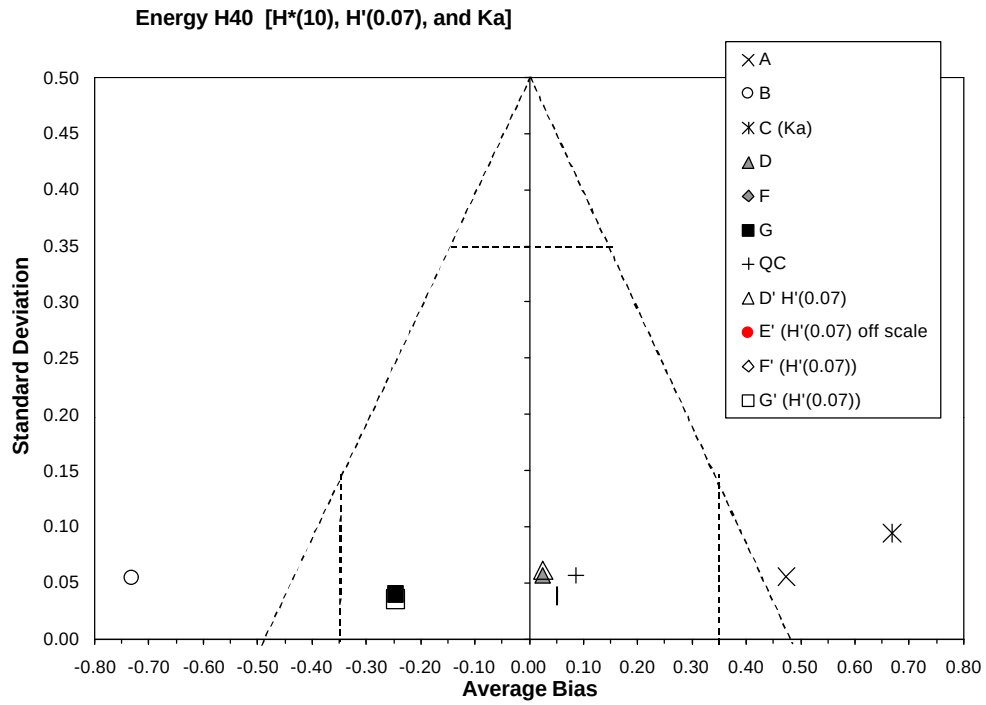

Figure 8. Plot of bias and standard deviation for the Energy H40 x-ray category. Values were given in H*(10) unless otherwise noted. Three out of seven were within the performance criteria (dashed lines).

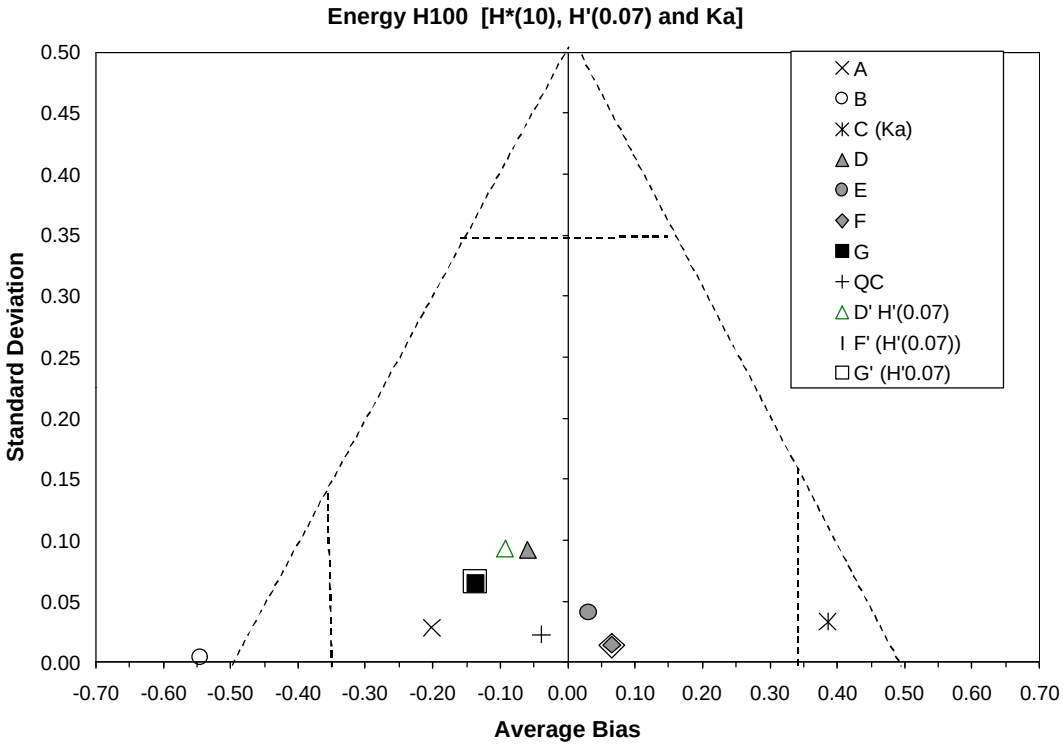

Figure 9. Plot of bias and standard deviation in Energy H100 x-ray category. Values were given in H*(10) unless other wise noted. Five out of seven were within the performance criteria (dashed lines).

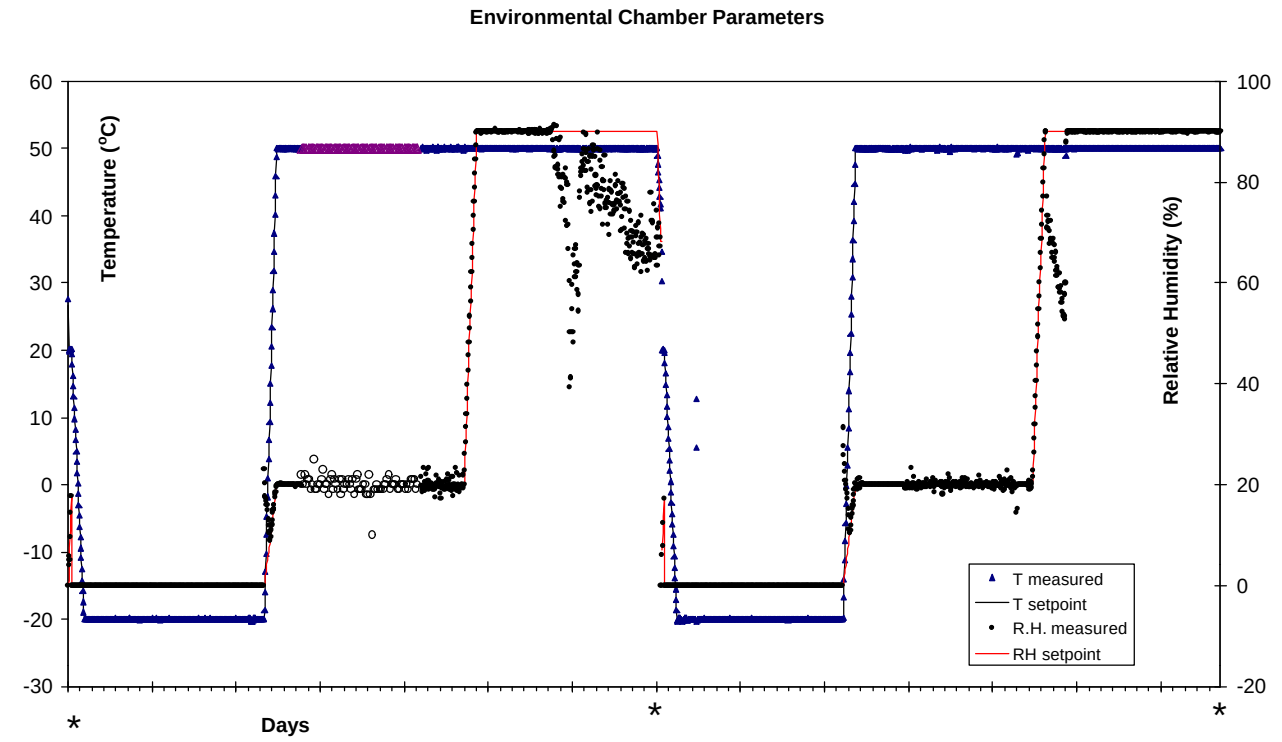

Figure 12. Plot of conditions in the environmental test chamber logged hourly on a PC. The measured and set point temperature is plotted on the left axis and the relative humidity is on the right axis. Asterisks on the x-axis indicate when ^{137}Cs irradiations were performed. Open circles are values taken from circular chart paper since the log file was incomplete.

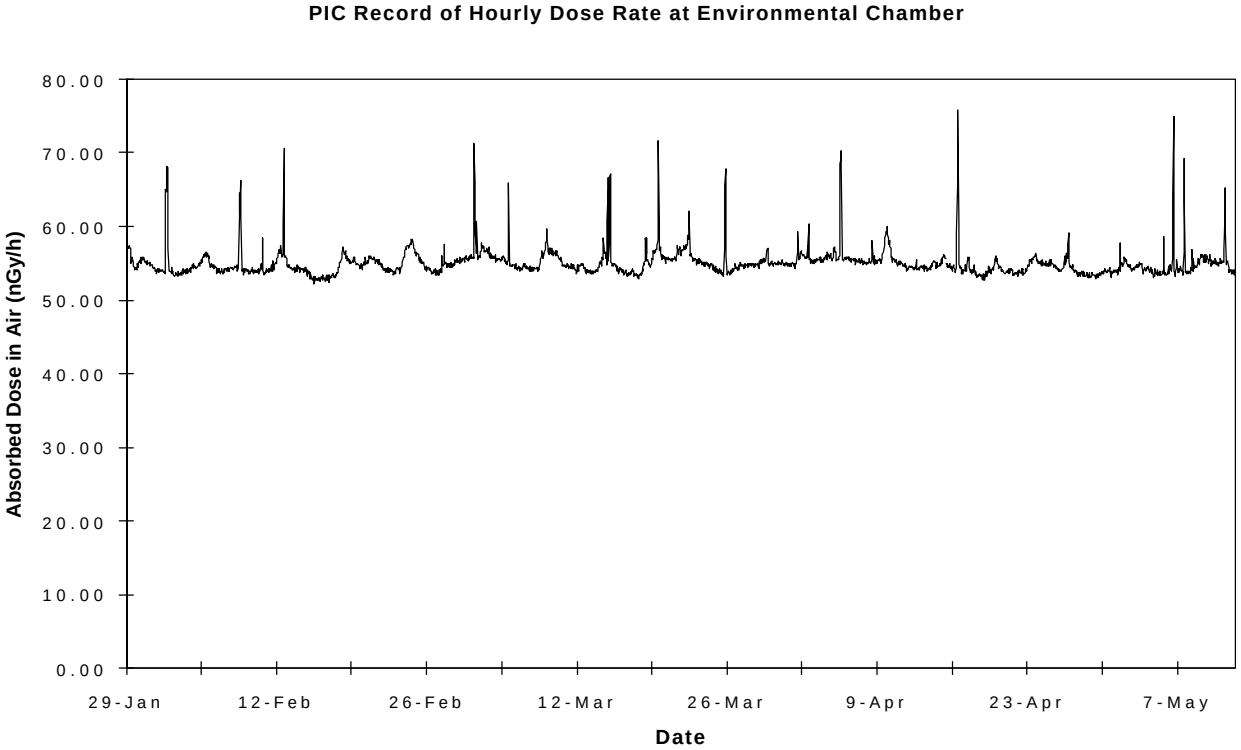

Figure 13. Plot of absorbed dose rate in air measured by an EML pressurized ionization chamber located near the environmental test chamber.

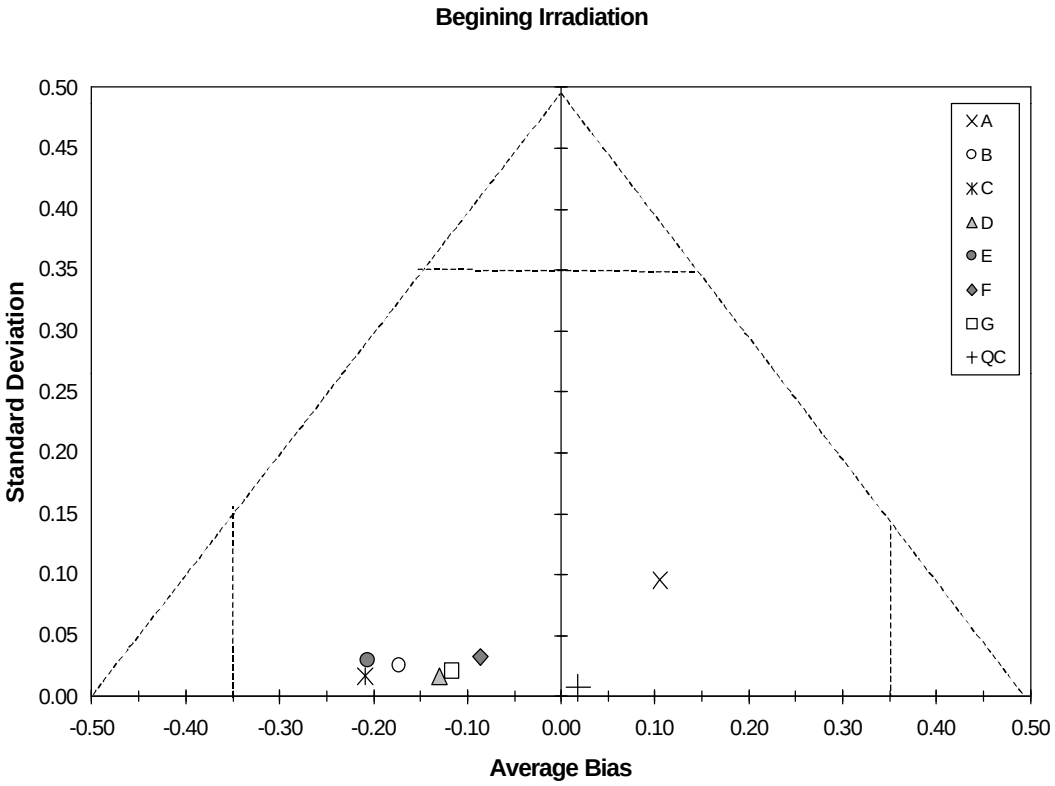

Figure 14. Plot of the bias and standard deviation for dosimeters irradiated before the environmental chamber test began. All participants were within the ANSI N13.29 performance criteria indicated with dashed lines.

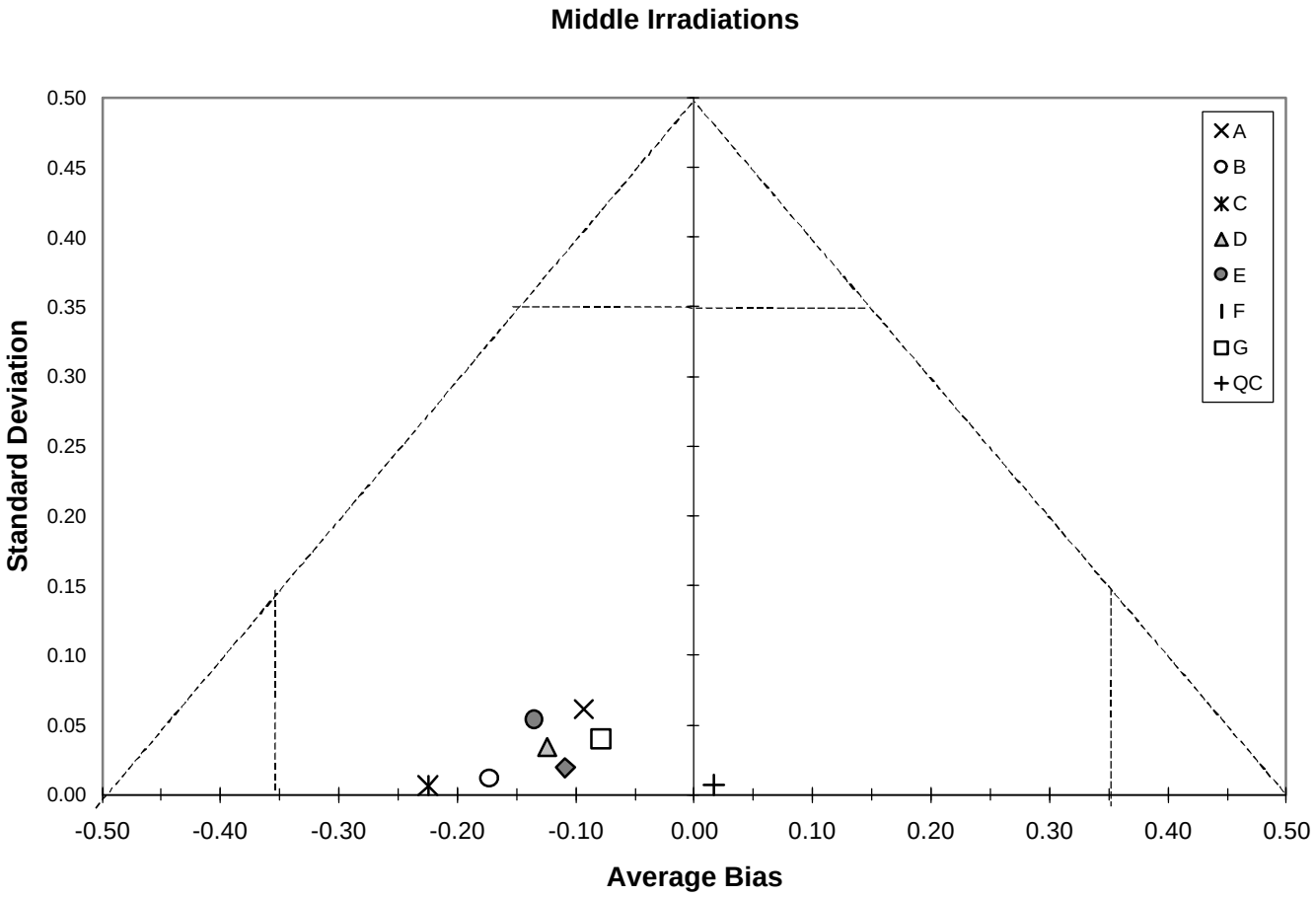

Figure 15. Plot of the bias and standard deviation for dosimeters irradiated after 45 days of environmental test conditions. All participants were within the ANSI N13.29 performance criteria indicated with dashed lines.

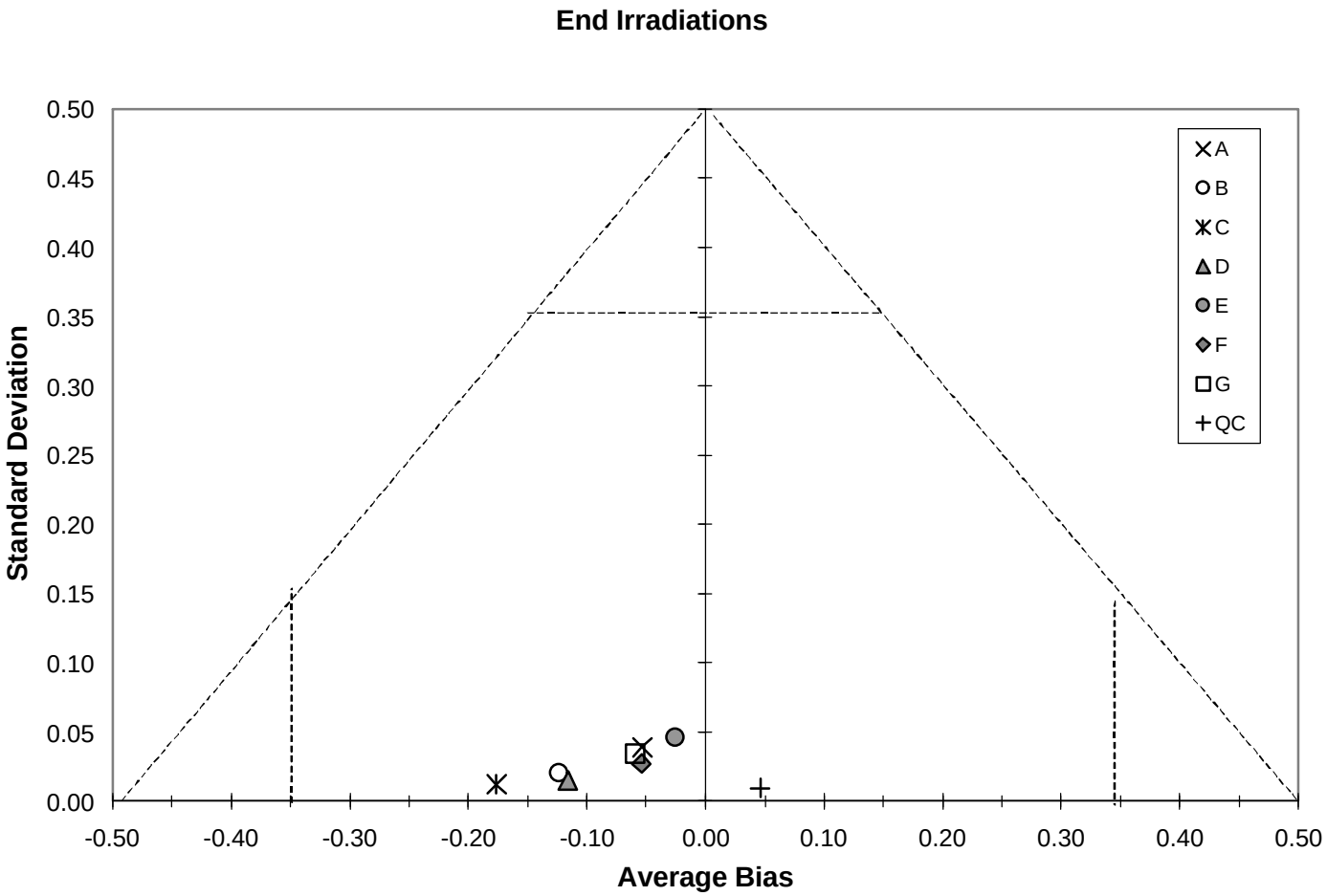

Figure 16. Plot of the bias and standard deviation for dosimeters irradiated after 90 days of environmental test conditions. All participants were within the ANSI N13.29 performance criteria indicated with dashed lines.

APPENDIX A:

RECOMMENDED MODIFICATIONS TO DRAFT N13.29

The purpose of this project was to thoroughly test Draft N13.29 by carrying out all of the procedures it specifies. Some problems with the specifications in Draft N13.29 were discovered in the course of the pilot test. In some cases ambiguities or omissions left procedural details open to interpretation. Wherever possible such occurrences were discussed with the N13.29 working group chair to determine the intention of the standard. Also, during the course of the pilot test, preliminary results were presented at scientific conferences where specialists in the field provided feedback. The most significant findings and comments are summarized here. It is recommended that the working group consider these before Draft N13.29 is submitted for final balloting.

Definitions, administrative procedures, and performance specifications

The definition of absorbed dose should be modified to explicitly define D(10) and D(0.07) which are referred to on page 40 as "penetrating absorbed dose and shallow dose," presumably in tissue. [Based on equation 8 on page 35 and equation 9 on page 36, it would seem the intended quantity is D*(10) and D'(0.07), respectively.]

Lines 19-23 on page 26 are inconsistent with the first paragraph on page 27 and should be deleted.

Performance criteria listed in Table 1 and the text on page 44 do not agree. The text specifies additional separate criteria of 0.35 for the absolute value of the bias and standard deviation, while the last column of the table specifies no additional limits.

Footnote "a" in Table 3 should read "1 rem = 10^{-2} Sv".

The intended value of n to be used in the calculation of the bias and standard deviation for the phase 2 tests should be stated explicitly. For the pilot test, separate values were calculated for irradiations at the beginning, middle, and end, using n=5 for each case. However, it would also have been possible to calculate one value for the entire phase two tests using n=15.

Draft N13.29 does not address what instructions are to be given to the test participants. Some participants did not subtract control dosimeter results in the first phase of tests or had problems with the dose equivalent quantities. For the energy x-ray categories the quantities H'(0.07) and H*(10) are not equal but both are applicable; it is not clear if participants are required to report both or what the passing requirements are. A sample of the instructions and response forms given to the pilot test participants is included in Appendix B. It is recommended that the working group use these as a reference to clarify the intent of the standard.

Table 3 should include units (presumably Sv Gy^{-1}).

Based on the results of the performance tests in all categories, the working group may wish to reconsider the tolerance levels that are required. The pilot test results show that while there was a greater spread in the bias, in all but one case the standard deviation was less than 15%.

Laboratory test protocol

Laboratory test protocol on page 30 states that for collimated beams the central beam axis shall coincide with a line through the center of the face of the dosimeter. This does not allow for the most likely possibility of irradiating more than one dosimeter at a time, or for positioning an assymetrical dosimeter off-center. It is also not clear how the testing laboratory could verify that mutual interference between dosimeters is <2% since the geometry would be dependent on the test dosimeters received.

Some dosimetry providers use additional packaging during field deployment for protection from environmental insults and vandalism. Draft N13.29 does not specify if such environmental packages should be used during laboratory tests. After consultation with the ANSI N13.29 chair the environmental packages were included in the pilot test; the standard should be modified to clarify the procedure.

On page 35, lines 17-19 state that 3 mm of PMMA is needed for charged particle equilibrium. However, it is not clear if the testing laboratory is to add 3 mm if the submitted dosimeters do not have it or if this is to be taken as an instruction to the dosimetry provider being tested. On page 35, line 15, "the ^{137}Cs source" should be replaced with "all photon sources," and if it is appropriate, "for the ^{137}Cs source" could be inserted at the end of the sentence in line 19.

Environmental test protocol

On page 32 Draft N13.29 requires that at least two environmental monitoring instruments be maintained at the environmental chamber to continuously measure and record a quantity from

which ambient dose rates may be determined. This represents a large commitment of resources for data that is not used since the control dosimeters account for all background including any unplanned doses. It is recommended that the working group consider deleting the following lines from N13.29 or specify how this data is to be used:

Page 32, lines 12-14
Page 32, lines 19-23
Page 33, lines 23-25
Page 34, lines 4-6

Page 33 lines 9-13 call for an illumination of 3000 lux, to be provided by two 40-watt fluorescence (cool white) bulbs placed 1 m above the dosimeters in the environmental chamber for the entire 90-day cycle. Attempts to implement these lighting specifications showed they were ambiguous and problematic. Light intensity is an important factor in environmental dosimetry performance, as was demonstrated during the 11th International Intercomparison of Environmental Dosimeters when one dosimeter failed the field test because of light leakage but was able to pass the laboratory tests (Klemic et al. in press). It is recommended that the working group re-evaluate its specifications for lighting parameters in consideration of the following findings:

- Illuminance measurements with a light meter revealed that two bare 40-watt cool white fluorescent bulbs provide about 1300 lux at a distance of 1 m. A special fixture required for operation in wet environments reduced the intensity further.

- Bulb manufacturers that were consulted warned that fluorescent bulbs might not operate at low temperatures. Measurements showed that at -20^{o}C the intensity drops by a factor of 2.7, and returns to full brightness at 0^{o}C.

- Furthermore, an illumination of 3000 lux does not approximate outdoor conditions; at noon on a cloudy day the outdoor illuminance was found to be five times higher.

- Table 2 footnote “b” uses a different quantity for light intensity.

Draft N13.29 specifies a low humidity setting of 10% RH that proved difficult to achieve in practice. The working group chair approved of using 20% RH for the pilot test, and it is suggested that the standard be modified to 20% RH.

The RH for the –20°C cycle is left unspecified without explanation. It may be worth noting in the standard that the humidity control on an environmental chamber is shut off for the low temperature setting.

The first paragraph on page 34 should be rewritten to clarify if the doses delivered at the middle and end of the environmental tests are the same or different from those used at the beginning. Different doses were used for the pilot test.

The pilot test only included the environmental chamber tests. The outdoor test was not performed because of limited funding. Performing both tests in an actual accreditation test would require a significant commitment of time and resources and would involve some redundancy. It is recommended that the working group reconsider the goals of each test and address the needs for both types of test.

COMMENTS FROM OTHERS

The following comments were received from environmental dosimetry providers at conferences and users meetings where preliminary results of the pilot test were presented.

The definition of "environment" given in ANSI Draft N13.29 is limiting and is inconsistent with that used in federal regulations. That is, it should explicitly include indoor areas where the public has access.

Beta irradiations are not appropriate for this standard since dose limits to the public are defined in terms of total effective dose equivalent (TEDE) which does not include a shallow dose.

Delivered doses should be extended to lower values to reflect realistic environmental levels.

A neutron category should be included because neutron sky-shine is the biggest contribution to the boundary dose at accelerator facilities.

The word "radiological" should be removed from the definition of environment to be consistent with 10CFR834.

To be consistent with ANSI N13.11, “all known sources of error” should exclude the error of conversion factors (see page 40, line 20; page 41, line 13; page 42, lines 2 and 20; page 43, line 15).

Acknowledgements: Thanks to the following specialists who were among those that provided comments: J. Liu (Stanford Linear Accelerator), S. Walker (Los Alamos National Laboratory), M. Lantz (Arizona Power).

APPENDIX B

EXAMPLES OF INSTRUCTIONS AND RESPONSE FORMS

Instructions for reporting results

Please read out your dosimeters according to your usual procedures. The net results are to be reported on the enclosed forms Table B1 and Table B2. With the exception of the Accident Category, the sources used for irradiation are not to be divulged to the participants until the test results are reported. The sources and dosimeters used for the Accident Category are shown in Table 2.

If you prefer to submit your results electronically, please create an Excel file that exactly corresponds to Tables B1 and B2, with a separate worksheet for each table. The Excel file may be submitted by email or diskette, but please mail or fax a hard copy for verification. Results should be reported to EML within 30 days of receipt of dosimeters.

Reporting quantities

ANSI N13.29 uses the quantities ambient dose equivalent, **H*(10),** and directional dose equivalent, **H′(0.07)** for all categories except the accident category. If possible, participants should report their results in these quantities. However, it is recognized that some of the participants in this pilot study are not presently using dose equivalent quantities, and for categories where the irradiation sources are not divulged, it will not be possible for those participants to convert to the dose equivalent quantities.

Therefore, participants should report their results for Tables 1 and 2 in the column corresponding to the quantity that their dosimeters measure. Results may be reported in more than one column where applicable.

(The accident category uses the quantity absorbed dose, D(10) and D(0.07). All participants should be able to report this quantity using the conversion factors given in ANSI Draft N13.29 sections 3.7.1, 3.7.2 and Table 3.)

Additional comments

Please include any comments you have on your experience in this test, or on the content or wording of the Draft Standard N13.29. If you have any questions feel free to contact Gladys Klemic at (630) 252-2440 or (630) 252-2374 or klemic@eml.doe.gov.

Table B1. All Categories Except Accident Category			
Participant **A** Lab ID Number	H*(10) (mSv)	H=(0.07) (mSv)	Air Kerma (mGy)
275 CONTROL			
691 CONTROL			
542			
568			
354			
235			
390			
593			
316			
500			
552			
619			
241			
351			
393			
736			
215			
505			
387			
533			
374			
626			
389			
583			

Table B2. Accident Category				
Participant **A** Lab ID Number	Source	D(10) (mGy)	D(0.07) (mGy)	Air kerma (mGy)
406	^{137}Cs			
431	^{137}Cs			
292	^{137}Cs			
399	^{137}Cs			
318	^{137}Cs			
411	$^{90}Sr/^{90}Y$			
405	$^{90}Sr/^{90}Y$			
438	$^{90}Sr/^{90}Y$			
458	$^{90}Sr/^{90}Y$			
747	$^{90}Sr/^{90}Y$			

Pilot Test ANSI Draft N13.29 -- Phase 2 -- Environmental Chamber Tests

Instructions for reporting results

Please read out your dosimeters according to your usual procedures. Please be sure to subtract the controls from the other results. The net results are to be reported on the enclosed form Table B3. If you prefer, results may be submitted electronically. Results should be reported to as soon as possible, and within 30 days of receipt of dosimeters. Please use the address or fax number below for reporting results.

Reporting Quantities

Since for this phase of the pilot test the source is ^{137}Cs it should be possible for everyone to report results in H*(10). (The results in air kerma may also be reported if desired.)

Additional Comments

Please include any comments you have on your experience in this test, or on the content or wording of the Draft Standard N13.29. If you have any questions feel free to contact Gladys Klemic at (630) 252-2440 or (630) 252-2374 or klemic@eml.doe.gov.

Send Results to:

Ms. Gladys Klemic
c/o U.S. Department of Energy
New Brunswick Laboratory
9800 South Cass Avenue, Bldg. 350
Argonne, IL 60439-4899

Fax: (630) 252- 6256

Table B3. Environmental Chamber Test Results		
Participant **A** ID #	H*(10) (mSv)	Air Kerma (mGy)
691 control		
701 control		
316 control		
321 control		
708 control		
609		
771		
634		
715		
460		
562		
722		
336		
346		
385		
313		
782		
375		
795		
755		
760		
418		