OAK RIDGE NATIONAL LABORATORY

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Nuclear Accident Dosimeter Processing with Attenuation Filters

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MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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NUCLEAR ACCIDENT DOSIMETER PROCESSING

WITH ATTENUATION FILTERS

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ABSTRACT

An evaluation of the Martin Marietta Energy Systems, Inc., Personnel Nuclear Accident Dosimeters was undertaken to determine if they could meet DOE 5480.11 requirements for photon dose assessment. Dosimeters were irradiated with a ^{137}Cs source to doses ranging from 0.5 to 10,000 rad and processed using transmission filters to prevent photomultiplier tube saturation. Dose equivalent responses were found to meet the requirements using dosimeter reader number 55. Use of reader number 11 revealed a problem with current procedures. While performing a normal calibration with transmission filters in place it was discovered that there was a high noise component in the calibration signal, resulting in a poor calibration. Dosimeters processed with reader number 11 using a 1% transmission filter determined element 3 response 30% below expectations. The low element 3 response resulted in a significantly lower dose calculation for affected dosimeters. Another factor affecting overall response was an excessive supralinearity correction applied to dosimeters exposed between 100 and 1,000 rad.

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1. INTRODUCTION

DOE 5480.11 states that Personnel Nuclear Accident Dosimeters (PNADs) shall be capable of determining gamma dose delivered within a range of 10 to 1,000 rad with an accuracy of ±20%, without dependance on data gained from nearby Fixed Nuclear Accident Dosimeters (FNADs). This experiment assesses the capability of the PNADs and the photon dosimeter portion of the FNADs used by the Centralized External Dosimetry System (CEDS) to report photon dose up to 10,000 rad.

The CEDS uses the routine-issued personnel thermoluminescent dosimeter (TLD) as a PNAD and a component of the FNAD. TLDs exposed to relatively high radiation doses emit excessive light resulting in saturation of photomultiplier tubes (PMTs) found in the dosimeter readers. Saturation of PMTs may result in a loss of dosimeter system response and damage to the tubes. Light attenuating optical filters are often used to prevent saturation of PMTs when LiF dosimeters are processed after receiving a relatively high radiation dose.

CEDS Procedure 3-1-500, "Personnel Nuclear Accident Dosimetry,"[1] calls for the use of optical filters to prevent PMT saturation while reading dosimeters recording high doses. The procedure calls for using a 10% transmission filter when processing dosimeters exposed to radiation doses of 50 to 500 rad, and a 1% transmission filter when exposed to greater than 500 rad. In the event of an accidental exposure of individuals from a criticality accident or misuse of a large source, the dose to and the population of affected individuals may not be known. If the dose is unknown, an appropriate filter may not be used. This experiment will determine the ability to accurately measure and report doses in the range of 0.5 to 10,000 rad using the Harshaw/Bicron TLD System 8800 Reader and Model 8805 dosimeter card with light attenuating optical filters. Evaluating use of filters over a wide range of dose will indicate whether they can be used in the event of a casualty prior to a full understanding of its severity.

2. EQUIPMENT AND MATERIALS

The following equipment and materials will be needed to complete this experiment:

- 90 Harshaw/Bicron 8805 dosimeter cards in holders on a lucite phantom
- Optical filters for each TLD reader:
  - 10% transmission
  - 1% transmission
- Radiation source:
  - Collimated beam ^{137}Cs
- TLD processing equipment and services:
  - CEDS TLD readers 11 and 55 (Harshaw TLD System 8800 Dosimeter Readers)

2.1 DOSIMETER DESCRIPTION

CEDS uses the Harshaw Model 8805 4-element dosimeter cards with holders providing filtration of incident radiation based on the element position.[2] Elements 1 and 3 responses are used also as a basis for determining deep and shallow doses, respectively. Elements 1, 2, and 3 are composed of TLD 700 (LiF:Mg,Ti), and element 4 is composed of TLD 600 (LiF:Mg,Ti). TLD 600 contains Lithium with an isotopic composition of 95.6% ^{6}Li and 4.4% ^{7}Li, TLD 700 is composed of approximately 99.99% ^{7}Li. Elements are held in place by a teflon covering. Figure 1 is an illustration of the dosimeter with the associated holder.

3. METHOD

In this experiment, 15 groups of 6 PNADs were annealed at 300°C and exposed to ^{137}Cs photons (E = 662 keV) using the Department of Energy Laboratory Accreditation Program (DOELAP) irradiation protocols.[3] Once irradiated, dosimeters were evenly divided and processed in accordance with CEDS Procedure 3-1-500, "Personnel Nuclear Accident Dosimetry," using dosimeter readers 11 and 55. Equal numbers of dosimeters exposed to 500 rem or less were processed using both 1% and 10% transmission filters. Dosimeters exposed to greater than 500 rem were processed using a 1% transmission filter. Each TLD was annealed 7 days prior, and processed 24 hours post exposure.

4. EVALUATION OF RESULTS

A complete summary of data and graphs is provided on the attached Data and Graph Pages. The data consists of the individual element readings from each dosimeter, the algorithm step case, and reported doses. Reported doses are given prior to and after various correction factors have been applied. The data is divided by the input parameters chosen for the dose assessment algorithm. Input parameters determine which step case would be used to calculate dose for an identified step. Reported doses

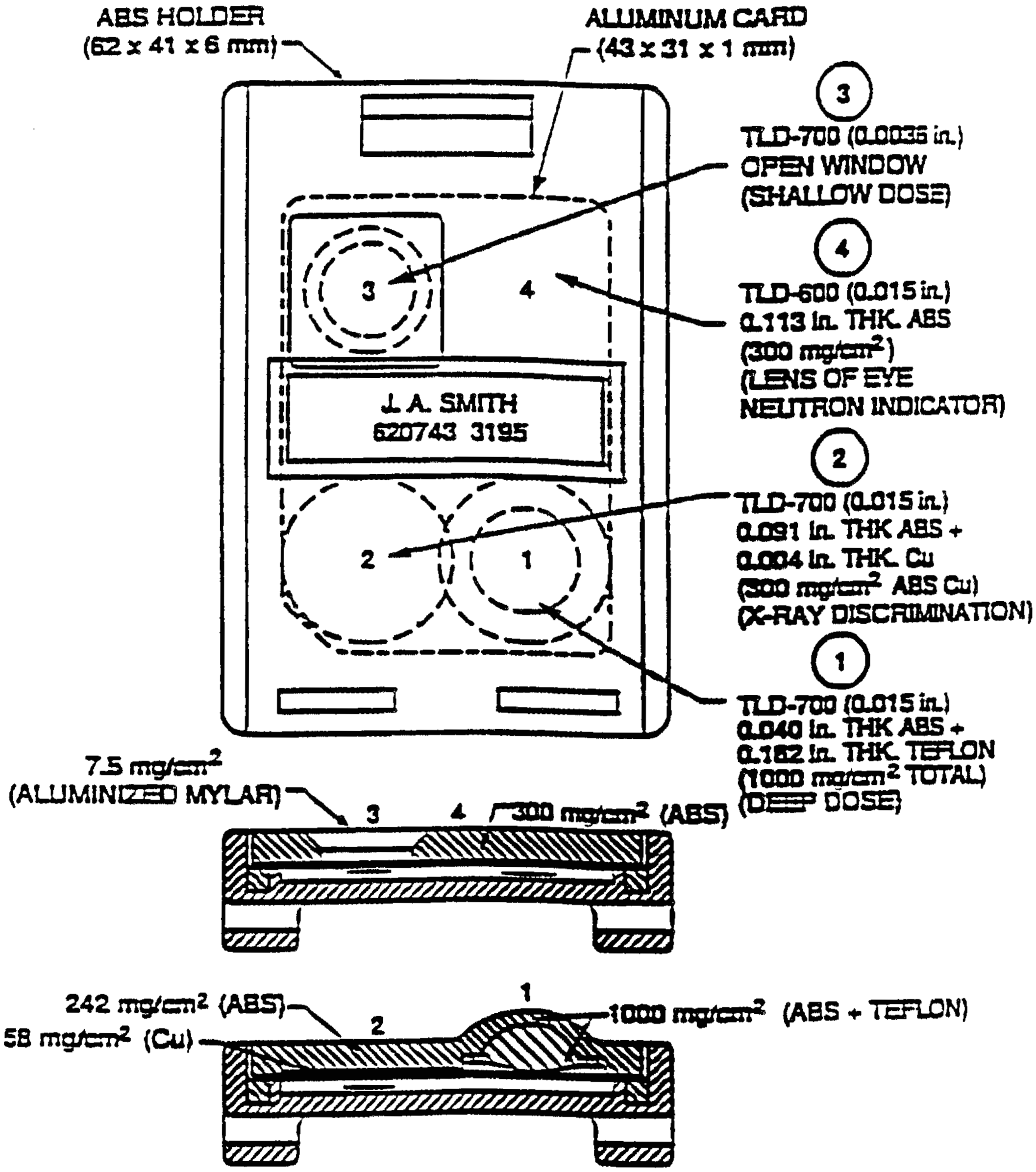

Fig. 1. CEDS beta-gamma dosimeter assembly configuration. *Source*: Centralized External Dosimetry System, "Technical Basis for the Centralized External Dosimetry System," p. 4-11, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn., Oct. 4, 1991.

were calculated with the algorithm methodology used for routine dose assessment.[2] Dosimeters identified to Step 12 had doses calculated using the method described in the revision of the June 19, 1989 algorithm dated January 26, 1992. The graphs used in this report were produced from attached data. Deep radiation dose refers to that dose deposited behind 1,000 mg/cm^2 ABS plastic (element 1 position). Shallow dose is measured beneath 7.50 mg/cm^2 mylar foil (element 3 position).

The algorithm methodology employed to calculate radiation dose by CEDS measures the response of four elements in each TLD. Based on their position, elements are shielded with materials chosen for their ability to attenuate ionizing radiation. Ratios of element responses are used to determine the source of ionizing radiation to which the dosimeter was exposed. The ratios determine the algorithm step used to calculate dose. Since many sources of radiation may exhibit similar characteristics, the user may choose to assume specific sources for some conditions and assign a step case. The step case is chosen based on the most likely sources encountered by an individual at the site. In the event of a ^{137}Cs exposure, as in this experiment, the algorithm is designed to determine the field as high energy photons and use Step 9 to calculate dose. The algorithm steps[2] and step cases identified while processing dosimeters for this experiment dose are as follows:

Step 9: High Energy Photons. Two cases were assumed for this experiment. Step case 9a assumes the high energy photon source is pure ^{137}Cs. Step case 9c assumes a mixture of sources including ^{137}Cs, H150, and M150 X-rays.

Step 10: Beta Component Mixed with High Energy Photons. Step case 10b assumes the beta component is either ^{90}Sr/Y or ^{204}Tl, and the high energy photons are contributed by a mixture of sources including ^{137}Cs, H150, and M150 X-rays.

Step 11: Beta Component Mixed with Low Energy Photons. Step case 11b assumes the beta component is either ^{90}Sr/Y or ^{204}Tl, mixed with low energy photons.

Step 12: Photons of Various Energies. Step 12 is the algorithm default step. It assumes there are photons of various energies in the field exposed. If no other step is identified based on the ratios of element response, the algorithm will default to Step 12 for dose calculation.

Table 1 gives a statistical performance assessment of dosimeter results. The combined performance of results from readers 11 and 55 meets the requirements of DOE Order 5480.11 in 2 of 4 cases. Combined results using the 1% transmission filter and choosing Step cases 9c, 10c, and 11c do not meet the performance requirements for PNADs or FNADs. The results from reader 11 using a 1% transmission filter fail to meet the performance requirements regardless of the step cases chosen. Table 1 presents average dosimeter performance for deep dose determined using the routine CEDS methodology. Performance is measured as the average bias associated with all dosimeters in the group of interest. The bias (B) is the difference between the reported and delivered dose divided by the delivered dose. Performance of both readers using a 10% transmission filter yielded acceptable results. Graphs of average dosimeter bias from individual readers can be found on the Graph Pages.

Table 1. Dosimeter average deep dose performance using routine CEDS dose calculation methods for doses ranging from 10 - 10,000 rad

Filter and Algorithm Step Case	Dosimeter Reader 11 Performance	Dosimeter Reader 55 Performance	Combined Performance
10% Trans. Filter Step 9a, 10b, 11b	-0.018	-0.041	-0.030
1% Trans. Filter Step 9a, 10b, 11b	-0.241	-0.066	-0.153
10% Trans. Filter Step 9c, 10c, 11c	-0.088	-0.133	-0.110
1% Trans. Filter Step 9c, 10c, 11c	-0.267	-0.142	-0.205

A review of the graphs comparing supralinearity and nonsupralinearity-corrected dosimeter response demonstrates decreased performance for supralinearity-corrected (SL) dose in the range of 100 to 1,000 rad. The doses reported without supralinearity correction yield a lower absolute bias for dosimeters irradiated from 100 to 1,000 rad. If the supralinearity correction is removed for these dosimeters, overall performance would improve. Removing the supralinearity correction at doses in this range allowed the CEDS PNADs and FNADs to pass the acceptance criteria in most cases. Note, however, in Table 2 the continued poor performance of reader 11 with the 1% filter.

Table 2. Dosimeter average deep dose performance quotient eliminating supralinearity correction for doses of 100 to 1,000 rad

Filter and Algorithm Step Case	Dosimeter Reader 11 Performance	Dosimeter Reader 55 Performance	Combined Performance
10% Trans. Filter Step 9a, 10b, 11b	0.043	0.012	0.028
1% Trans. Filter Step 9a, 10b, 11b	-0.189	-0.003	-0.096
10% Trans. Filter Step 9c, 10c, 11c	-0.051	-0.066	-0.058
1% Trans. Filter Step 9c, 10c, 11c	-0.218	-0.083	-0.151

Figure 2 illustrates the relative response of dosimeters processed with reader 55 using nonsupralinearity-corrected reported dose. Figure 3 illustrates nonsupralinearity-corrected relative element 1 response of these same dosimeters. Figure 3 agrees with previously-recorded findings demonstrating a supralinearity effect starting at approximately 100 rad, with an increase beyond 1,000 rad.[4,5]

The reported doses calculated in this study were performed using a methodology based on response of the multiple elements located in the TLD. As seen in the Data Pages and in Table 3, more than one algorithm step was identified while reading the

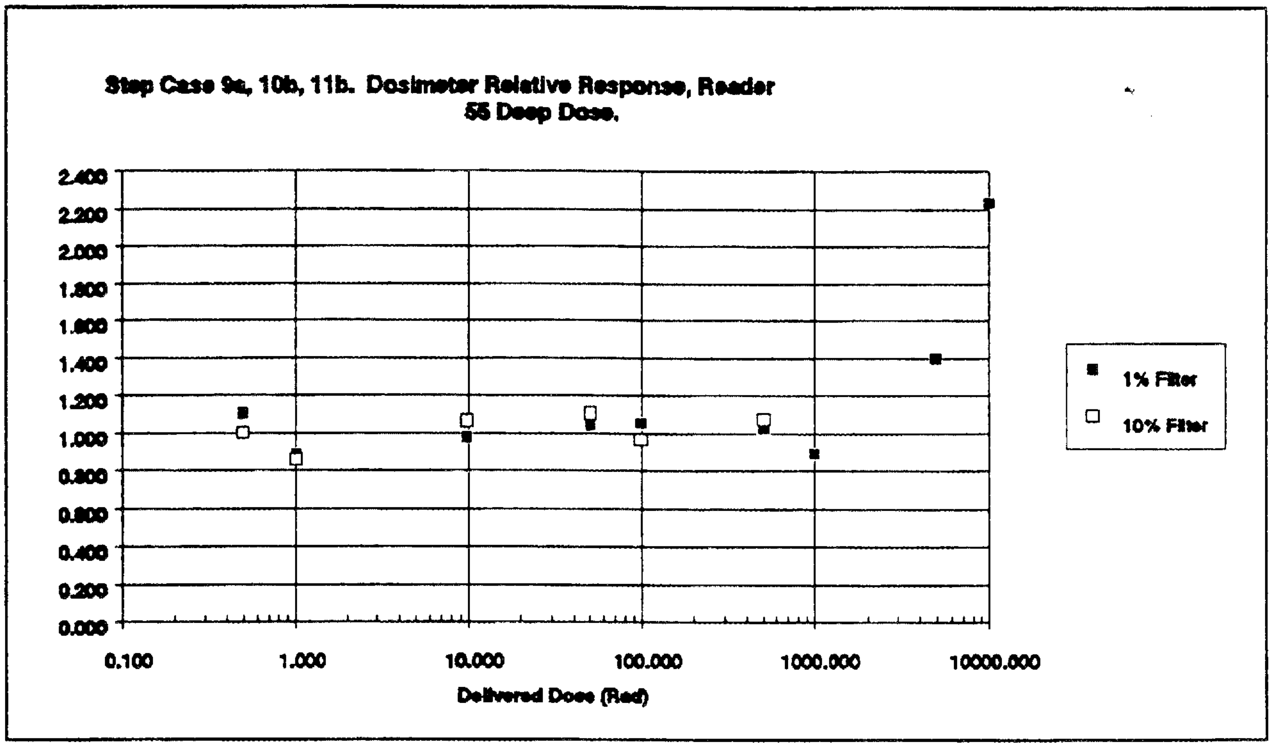

Fig. 2. Nonsupralinearity-corrected dosimeter response (Reported/Delivered Dose) using the current dose assessment method for deep dose.

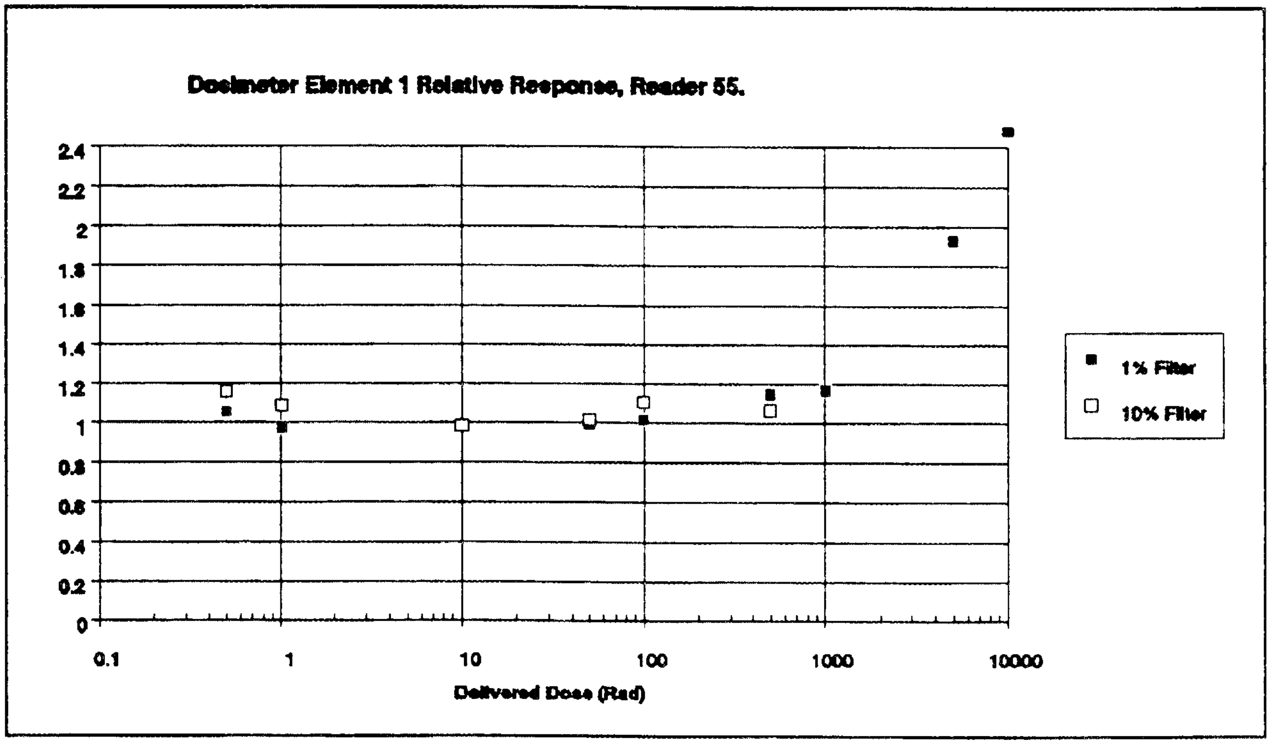

Fig. 3. Element 1 average relative response prior to algorithm application.

Table 3. Step case determinations based on element ratios[2]

Transmission Filter - Reader Number	Step Case 9	Step Case 10	Step Case 11	Step Case 12
1% - 11	8	1	0	18
1% - 55	21	0	0	6
10% - 11	16	0	0	2
10% - 55	13	1	1	3
1% - Both	29	1	0	24
10% - Both	29	1	1	5

dosimeters. Calculation of dose using steps other than Step 9 results in a higher statistical spread than the uncorrected element 1 response. This is due to differences in the method of dose calculation.

A frequency of step case identification is found in Table 3. A significant number of step case misidentifications (other than Step 9) occurred with reader 11 while using the 1% transmission filter. The rate is much higher than that found with reader 11 using the 10% filter, or data obtained with reader 55 using either the 1% or 10% filter. The step identified determines what factors will be used to calculate dose. If more than one step is identified, a higher standard deviation in the reported dose than found with individual element readings will result. Most misidentifications resulted in calculating dose using algorithm Step 12. Calculating dose with Step 12 resulted in reported average bias 0.249 lower than using Step case 9c (Step 9c already has a 10% negative bias), mostly due to the use of element 3 response in calculation of deep and shallow dose for Step 12.

A factor in the high rate of Step 12 identification and the subsequent poor results obtained from reader 11 with a 1% filter, is an unusually low element 3 (L3) response. This resulted in ratios of L3/L2 and L3/L1 less than 0.7, a ratio not anticipated for a ^{137}Cs exposure. The proper L3/L2 and L3/L1 ratios for Step 9 identification would have been in the range 0.7<L3/L2:L3/L1<1.1. Ideally the value would be 1.0. Ratios less than the

0.7 value implies measured deep dose (measured at 1,000mg/cm^2 density thickness) was over 30% higher than shallow dose (7mg/cm^2)! Ratios of L3/L1 and L3/L2 below 0.7 have not been previously found with any dosimeters irradiated with ^{137}Cs. Nearly all of the misidentified dosimeters processed with reader 11 using the 1% filter had their dose calculated using Step 12 as a result of a low L3/L1 and/or L3/L2 ratio. Calculating dose using Step 9 would significantly improve deep dose performance, as element 3 results would not be used. Shallow dose would still be adversely affected.

A ratio of L3/L2 or L3/L1 less than 0.7 is an unusual occurrence for exposure to photons of this energy. Further study of the dosimeter calibration process has uncovered a likely cause. Prior to reading dosimeters, a calibration was performed with the transmission filters in place. Using transmission filters reduces the calibration signal to 1% of its usual value. Reducing the calibration signal to 1% of its original value raises the relative contribution of PMT noise to the total signal.

The typical response of element 3 on a calibration card irradiated to 500 mr* is about 50 - 60 nc. The photomultiplier tube noise during a routine calibration is relatively insignificant, with a maximum specification of about 0.5 nc. If the calibration is performed with a 1% transmission filter in place, the significance of PMT noise is greatly increased. During this experiment, the noise level of the element 3 PMT in reader 11 was approximately 0.25 nc, and element 3 PMT of reader 55 was 0.05 nc. Use of a 1% transmission filter reduced the calibration signal to only 1% of the usual value. At this level, about 33% of the total signal used for element 3 calibration in reader 11 will be noise. Table 4 lists the average percentage of PMT noise in the calibration signal for all calibration cards read with a 1% filter in both readers. Reader 55 element 3 had a PMT noise contribution of only 8.1%. For this reason, reader 55 results were not as significantly affected.

The high noise component resulted in a higher than actual nc/mrad calibration factor, yielding a lower reported response for the affected elements. A noise contribution of 30% for element 3 would account for the unusually low L3/L1 and L3/L2 ratios seen with reader 11 using a 1% filter. Elements 1, 2, and 4 did not display this effect because the dose response of these elements from the calibration cards was a much larger percentage of the calibration signal. Elements 1, 2, and 4 have a larger mass than

Table 4. Percent PMT noise contribution to reader calibration card results using the 1% transmission filter

	Element 1	Element 2	Element 3	Element 4
Reader 11	4.7%	3.6%	30.7%	3.4%
Reader 55	4.2%	3.3%	8.1%	1.5%

element 3, with dose response a factor of 3 to 6 higher. The higher dose response combined with a lower PMT noise for these element positions resulted in a lower percentage of the total calibration signal contributed by noise. Reader 55 element 3 noise only contributed 8% of the total signal. For this reason, the L3/L2 and L3/L1 ratios seen with reader 55 did not cause the algorithm to calculate dose with Step 12 (L3/L2 or L3/L1 less than 0.7).

5. REGULATORY REQUIREMENTS

The Radiological Controls Manual (DOE/EH-0256T) states that DOE 5480.11 specifies the requirements for a Nuclear Accident Dosimetry Program. These requirements can be found in Paragraphs 5480.11.9.q.(1-3). In summary, the requirements for gamma dosimetry are as follows:[6]

1. The gamma ray components of FNADs shall be capable of measuring fission gamma radiation in the presence of neutrons with an accuracy of approximately ± 20%. The gamma dose recording range of these dosimeters shall be 10 to 10,000 rem.

2. The gamma ray components of PNADs shall be capable of determining gamma dose from 10 to 10,000 rad with an accuracy of ± 20%.

This experiment exposed the dosimeters to ^{137}Cs without exposure to neutrons to test the light attenuating filters. Table 5 presents the results for the dose range required in DOE 5480.11.

Table 5. Nuclear accident dosimeter performance within dose range requirements of DOE 5480.11

Step Case and Filters Used	Reader 11 (10 - 1krad/ 10 - 10krad)	Reader 55 (10 - 1krad/ 10 - 10krad)	Combined Results (10 - 1krad/ 10 - 10krad)
Step Case 9a, 10b, 11b; 1% Filter	-0.328/-0.289	-0.118/-0.082	-0.223/-0.186
Step Case 9c, 10c, 11c; 1% Filter	-0.343/-0.304	-0.183/-0.148	-0.263/-0.226
Step Case 9a, 10b, 11b; 1& 10% Filter*	-0.079/-0.111	-0.093/-0.064	-0.086/-0.087
Step Case 9c, 10c, 11c; 1 & 10% Filter*	-0.151/-0.166	-0.162/-0.133	-0.156/-0.150

*The 10% transmission filter was used for dosimeters exposed to 500 rad or less.

Results from reader 55 indicate that the PNADs are capable of meeting the requirements of DOE 5480.11 for measurement of gamma dose when processed using a 1% transmission filter. The results from reader 11 are poor, but this is due to faulty element 3 readings. Table 6 demonstrates the effectiveness of using a 1% filter for doses within the dose range of interest when the PMT noise is not a significant factor. Results are calculated by forcing the algorithm to use Step case 9c (only element 1 response used for dose calculation). Table 6 also lists results obtained using current supralinearity corrections, and those with supralinearity correction applied only to dosimeters exposed greater than or equal to 5,000 rad. These results indicate an excessive supralinearity correction for doses less than or equal to 1,000 rad.

A review of the attached data and graphs illustrates that the dosimetry system is capable of accurately reading dose as low as 0.5 rem with a 1% transmission filter installed. The ability to accurately record dose at a level of 0.5 rem indicates that low doses can be measured with a 1% filter in place. This would allow for use of a 1% filter when reading dosimeters immediately after an accident, and before the extent of dose is fully understood, without losing important dosimetry results.

Table 6. Nuclear accident dosimeter performance exposed from 10 - 10,000 rad using Step case 9c for dose calculation

	Reader 11 Performance Quotient / Standard Deviation	Reader 55 Performance Quotient / Standard Deviation	Combined Performance Quotient / Standard Deviation
Current supralinearity correction method	-0.114 / 0.137	-0.087 / 0.125	-0.090 / 0.118
Supralinearity correction applied only for dose greater than 1,000 rad	-0.039 / 0.071	-0.001 / 0.100	-0.028 / 0.081

6. SUMMARY

Light attenuating filters are an essential component for dosimetry programs providing LiF TLD nuclear accident dosimetry. Attenuation filters reduce the light transmitted from TLDs after high doses of radiation, preventing PMT damage and loss of signal. This experiment demonstrates that acceptable dosimetry results can be obtained using light attenuation filters if an appropriate calibration procedure is employed. A problem with the current calibration procedure was discovered when processing dosimeters with a 1% transmission filter.

The current procedure calls for calibration of the reader using routine calibration cards with the filters installed. The filters reduced the calibration signal to a level at which PMT noise became significant. The element 3 PMT noise from reader 11 calibrated with a 1% filter comprised approximately 30% of the calibration signal. This caused the recorded response of element 3 to be about 30% low. The net effect of low element 3 readings was that L3/L1 and L3/L2 ratios were below values expected for high energy photons by the dose assessment algorithm. The low ratios adversely affected the dose calculation, resulting in a much lower than actual reported dose.

The low reported dose resulted in failure to achieve the performance requirements of DOE 5480.11 for nuclear accident dosimetry using reader 11 with a 1% transmission filter. Results obtained with a 1% filter using reader 55, and from other element readings with reader 11, demonstrate the performance requirements can be achieved if the system is properly calibrated.

The current PMT noise specifications are acceptable under routine conditions, but become a problem when using a 1% transmission filter. To avoid this problem the calibration signal can be increased, filters may be inserted after routine calibration, or the PMT noise can be subtracted during the calibration procedure. Problems exist with all methods. If the calibration signal is increased, calibration cards will have to be maintained at all times which have been exposed to relatively high doses. High doses will lead to degradation in card response and a high turnover of calibration cards. Inserting filters after the calibration has been performed may affect the calibration, and subtraction of the PMT noise from calibration results using the 1% filter could affect the statistics associated with the signal response.

The dose assessment algorithm used by CEDS includes a supralinearity correction which starts to take effect with doses greater than 100 rad. The correction applied is a function of the reported dose. Based on the results of this study, the supralinearity correction used for calculating dose is greater than that observed over some dose ranges. When the correction was applied for doses between 100 and 1,000 rad, the performance of the dosimetry system suffered. At this time there is no supralinearity correction in CEDS procedures for doses greater than 1,000 rad. In the event of an accident resulting in exposures at this level, our documentation would not support calculation of doses. For this report, the supralinearity correction used for doses between 400 and 1,000 rad was extended for dosimeters irradiated greater than or equal to 5,000 rad with acceptable results.

7. FUTURE WORK

This study, though limited in scale, indicated a need for more work in two areas. The calibration failure of reader 11 with a 1% transmission filter demonstrated that otherwise acceptable background noise can be excessive in some cases. Although use of a 1% transmission filter is an unusual event, a need for change in the calibration procedure is indicated. The supralinearity correction should be investigated to determine if changes are necessary for doses greater than or equal to 100 rad. In addition, CEDS procedures or the dose assessment algorithm should be updated to allow for supralinearity correction of doses greater than 1,000 rad.

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6. *Radiation Protection for Occupational Workers*, DOE 5480.11, U.S. Department of Energy, 1988.

Appendix A

DATA TABLES

Cs-137 Exposures processed with a 1% Transmission Filter

Step Cases 9a, 10b chosen

				Uncorrected Dose (REM)				Fade Corrected Dose (REM)				Final Reported Dose (REM) Supralinearity (SL) Corrected			
HBG No.	PC	Del. H (RAD)	Step Case	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
163192	ORNL	0.500	12	0.319	0.320	-0.362	-0.361	0.318	0.319	-0.364	-0.363	0.318	0.319	-0.364	-0.363
169357	ORNL	0.500	10b	0.458	0.565	-0.084	0.130	0.457	0.563	-0.087	0.126	0.457	0.563	-0.087	0.126
163171	ORNL	0.500	9a	0.537	0.534	0.074	0.069	0.535	**0.535**	0.070	**0.070**	0.535	**0.535**	0.070	0.070
120347	Y-12	0.500	9a	0.560	0.505	0.119	0.011	0.558	**0.558**	0.115	**0.115**	0.558	**0.558**	0.115	0.115
148334	Y-12	0.500	9a	0.556	0.556	0.113	0.113	0.554	0.555	0.109	0.109	0.554	0.555	0.109	0.109
125810	Y-12	0.500	9a	0.554	0.555	0.107	0.110	0.552	0.553	0.104	0.107	0.552	0.553	0.104	0.107
101848	ORNL	1.000	9a	0.965	0.842	-0.035	-0.158	0.962	**0.962**	-0.038	**-0.038**	0.962	**0.962**	-0.038	-0.038
115243	ORNL	1.000	9a	1.049	0.907	0.049	-0.093	1.045	**1.045**	0.045	**0.045**	1.045	**1.045**	0.045	0.045
103935	ORNL	1.000	9a	1.062	0.935	0.062	-0.065	1.058	**1.058**	0.058	**0.058**	1.058	**1.058**	0.058	0.058
122005	Y-12	1.000	12	0.594	0.644	-0.406	-0.356	0.592	0.642	-0.408	-0.358	0.592	0.642	-0.408	-0.358
120084	Y-12	1.000	9a	1.006	0.958	0.006	-0.042	1.002	**1.002**	0.002	**0.002**	1.002	**1.002**	0.002	0.002
164108	Y-12	1.000	9a	1.031	0.971	0.031	-0.029	1.028	**1.028**	0.028	**0.028**	1.028	**1.028**	0.028	0.028
164158	ORNL	10	12	6.68	3.91	-0.332	-0.609	6.66	**6.66**	-0.334	**-0.334**	6.66	**6.66**	-0.334	-0.334
163064	ORNL	10	12	6.60	4.49	-0.340	-0.551	6.57	**6.57**	-0.343	**-0.343**	6.57	**6.57**	-0.343	-0.343
118605	ORNL	10	9a	9.48	6.88	-0.052	-0.312	9.45	**9.45**	-0.055	**-0.055**	9.45	**9.45**	-0.055	-0.055
172225	Y-12	10	9a	10.44	8.46	0.044	-0.154	10.40	**10.40**	0.040	**0.040**	10.40	**10.40**	0.040	0.040
116862	Y-12	10	9a	9.35	8.98	-0.065	-0.102	9.32	**9.32**	-0.068	**-0.068**	9.32	**9.32**	-0.068	-0.068
134996	Y-12	10	9a	9.54	9.24	-0.046	-0.076	9.51	**9.51**	-0.049	**-0.049**	9.51	**9.51**	-0.049	-0.049
109374	ORNL	50	12	35.93	20.13	-0.281	-0.597	35.81	**35.81**	-0.284	**-0.284**	35.81	**35.81**	-0.284	-0.284
131712	ORNL	50	12	34.71	19.62	-0.306	-0.608	34.59	**34.59**	-0.308	**-0.308**	34.59	**34.59**	-0.308	-0.308
183625	ORNL	50	12	36.13	22.26	-0.277	-0.555	36.02	**36.02**	-0.280	**-0.280**	36.02	**36.02**	-0.280	-0.280
178419	Y-12	50	9a	52.57	42.97	0.051	-0.141	52.39	**52.39**	0.048	**0.048**	52.39	**52.39**	0.048	0.048
113169	Y-12	50	9a	51.70	42.66	0.034	-0.147	51.53	**51.53**	0.031	**0.031**	51.53	**51.53**	0.031	0.031
148557	Y-12	50	9a	52.11	46.75	0.042	-0.065	51.94	**51.94**	0.039	**0.039**	51.94	**51.94**	0.039	0.039

Step Cases 9a, 10b chosen, Continued

HBG No.	PC	Del. H (RAD)	Step Case	Uncorrected Dose (H) Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Fade Corrected Dose Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Final Reported Dose Supralinearity (SL) Corrected Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
141826	ORNL	100	12	63.66	37.01	-0.363	-0.630	63	**63**	-0.365	**-0.365**	63	**63**	-0.365	-0.365
106867	ORNL	100	12	67.51	41.55	-0.325	-0.585	67	**67**	-0.327	**-0.327**	67	**67**	-0.327	-0.327
112514	ORNL	100	12	70.92	38.34	-0.291	-0.617	71	**71**	-0.293	**-0.293**	71	**71**	-0.293	-0.293
102232	Y-12	100	9a	104	87	0.038	-0.126	103	**103**	0.034	**0.034**	99	**99**	-0.015	-0.015
169589	Y-12	100	9a	103	87	0.034	-0.135	103	**103**	0.031	**0.031**	98	**98**	-0.018	-0.018
176760	Y-12	100	9a	108	93	0.079	-0.074	108	**108**	0.075	**0.075**	102	**102**	0.024	0.024
106752	ORNL	500	12	341	230	-0.319	-0.540	340	**340**	-0.321	**-0.321**	267	**267**	-0.466	-0.466
141637	ORNL	500	12	338	238	-0.324	-0.524	337	**337**	-0.326	**-0.326**	266	**266**	-0.469	-0.469
135744	ORNL	500	9a	514	390	0.028	-0.220	512	**512**	0.025	**0.025**	382	455	-0.236	-0.091
145458	Y-12	500	12	347	341	-0.306	-0.318	346	**346**	-0.308	**-0.308**	270	**270**	-0.459	-0.459
160239	Y-12	500	9a	608	495	0.216	-0.010	606	**606**	0.212	**0.212**	446	536	-0.109	0.071
175433	Y-12	500	9a	590	550	0.180	0.100	588	**588**	0.176	**0.176**	434	520	-0.133	0.040
133138	ORNL	1000	12	742	532	-0.258	-0.468	740	**740**	-0.260	**-0.260**	535	652	-0.465	-0.348
115883	ORNL	1000	12	716	513	-0.284	-0.487	713	**713**	-0.287	**-0.287**	518	629	-0.482	-0.371
101960	ORNL	1000	9a	1132	814	0.132	-0.186	1129	**1129**	0.129	**0.129**	788	986	-0.212	-0.014
128334	Y-12	1000	12	696	702	-0.304	-0.298	693	700	-0.307	-0.300	504	617	-0.496	-0.383
114575	Y-12	1000	12	777	749	-0.223	-0.251	774	**774**	-0.226	**-0.226**	558	681	-0.442	-0.319
177226	Y-12	1000	9a	1200	1155	0.200	0.155	1196	**1196**	0.196	**0.196**	831	1043	-0.169	0.043
167861	ORNL	5000	12	6081	3834	0.216	-0.233	6061	**6061**	0.212	**0.212**	3652	5107	-0.270	0.021
167309	ORNL	5000	12	5807	4356	0.161	-0.129	5788	**5788**	0.158	**0.158**	3502	4882	-0.300	-0.024
112841	ORNL	5000	9a	8681	6052	0.736	0.210	8653	**8653**	0.731	**0.731**	5048	7233	0.010	0.447
170445	Y-12	5000	12	5566	5209	0.113	0.042	5548	**5548**	0.110	**0.110**	3369	4684	-0.326	-0.063
130213	Y-12	5000	12	5197	4483	0.039	-0.103	5180	**5180**	0.036	**0.036**	3165	4379	-0.367	-0.124
131453	Y-12	5000	9a	10215	8871	1.043	0.774	10181	**10181**	1.036	**1.036**	5853	8480	0.171	0.696
109498	ORNL	10000	12	12953	7836	0.295	-0.216	12910	**12910**	0.291	**0.291**	7262	10695	-0.274	0.069
140551	ORNL	10000	12	16193	8965	0.619	-0.104	16139	**16139**	0.614	**0.614**	8895	13301	-0.110	0.330
163950	ORNL	10000	12	14344	8369	0.434	-0.163	14297	**14297**	0.430	**0.430**	7968	11815	-0.203	0.182
170459	Y-12	10000	9a	22251	20512	1.225	1.051	22178	**22178**	1.218	**1.218**	11873	18143	0.187	0.814
124196	Y-12	10000	9a	26287	22314	1.629	1.231	26201	**26201**	1.620	**1.620**	13813	21350	0.381	1.135
100290	Y-12	10000	9a	18653	17291	0.865	0.729	18592	**18592**	0.859	**0.859**	10115	15272	0.012	0.527

Cs-137 Exposures Processed with 1% Transmission Filter

Step Cases 12, 9c, 10c chosen.

HBG No.	PC	Del. H (RAD)	Step Case	Uncorrected Dose (H) Rep. Hd	Uncorrected Dose (H) Rep. Hs	Uncorrected Dose (H) PQ Hd	Uncorrected Dose (H) PQ Hs	Fade Corrected Dose Rep. Hd	Fade Corrected Dose Rep. Hs	Fade Corrected Dose PQ Hd	Fade Corrected Dose PQ Hs	Final Reported Dose Supralinearity (SL) Corrected Rep. Hd	Final Reported Dose Supralinearity (SL) Corrected Rep. Hs	Final Reported Dose Supralinearity (SL) Corrected PQ Hd	Final Reported Dose Supralinearity (SL) Corrected PQ Hs
169357	X-10	0.500	10c	0.458	0.663	-0.084	0.326	0.457	0.661	-0.087	0.322	0.457	0.661	-0.087	0.322
163192	X-10	0.500	12	0.319	0.320	-0.362	-0.361	0.318	0.319	-0.364	-0.363	0.318	0.319	-0.364	-0.363
163171	X-10	0.500	9c	0.485	0.475	-0.030	-0.050	0.483	**0.483**	-0.034	**-0.034**	0.483	0.483	-0.034	-0.034
120347	Y-12	0.500	9c	0.505	0.449	0.011	-0.101	0.504	**0.504**	0.007	**0.007**	0.504	**0.504**	0.007	0.007
148334	Y-12	0.500	9c	0.502	0.495	0.005	-0.011	0.501	**0.501**	0.002	**0.002**	0.501	**0.501**	0.002	0.002
125810	Y-12	0.500	9c	0.500	0.493	0.000	-0.013	0.498	**0.498**	-0.003	**-0.003**	0.498	**0.498**	-0.003	-0.003
101848	X-10	1.000	9c	0.872	0.749	-0.128	-0.251	0.869	**0.869**	-0.131	**-0.131**	0.869	**0.869**	-0.131	-0.131
115243	X-10	1.000	9c	0.947	0.806	-0.053	-0.194	0.944	**0.944**	-0.056	**-0.056**	0.944	**0.944**	-0.056	-0.056
103935	X-10	1.000	9c	0.959	0.831	-0.041	-0.169	0.956	**0.956**	-0.044	**-0.044**	0.956	**0.956**	-0.044	-0.044
122005	Y-12	1.000	12	0.594	0.644	-0.406	-0.356	0.592	0.642	-0.408	-0.358	0.592	0.642	-0.408	-0.358
120084	Y-12	1.000	9c	0.908	0.851	-0.092	-0.149	0.905	**0.905**	-0.095	**-0.095**	0.905	**0.905**	-0.095	-0.095
164108	Y-12	1.000	9c	0.931	0.863	-0.069	-0.137	0.928	**0.928**	-0.072	**-0.072**	0.928	**0.928**	-0.072	-0.072
164158	X-10	10	12	6.68	3.91	-0.332	-0.609	6.66	**6.66**	-0.334	**-0.334**	6.66	**6.66**	-0.334	-0.334
163064	X-10	10	12	6.60	4.49	-0.340	-0.551	6.57	**6.57**	-0.343	**-0.343**	6.57	**6.57**	-0.343	-0.343
118605	X-10	10	9c	8.56	6.12	-0.144	-0.388	8.53	**8.53**	-0.147	**-0.147**	8.53	**8.53**	-0.147	-0.147
172225	Y-12	10	9c	9.43	7.52	-0.057	-0.248	9.40	**9.40**	-0.060	**-0.060**	9.40	**9.40**	-0.060	-0.060
116862	Y-12	10	9c	8.44	7.98	-0.156	-0.202	8.41	**8.41**	-0.159	**-0.159**	8.41	**8.41**	-0.159	-0.159
134996	Y-12	10	9c	8.61	8.22	-0.139	-0.178	8.59	**8.59**	-0.141	**-0.141**	8.59	**8.59**	-0.141	-0.141
109374	X-10	50	12	35.93	20.13	-0.281	-0.597	35.81	**35.81**	-0.284	**-0.284**	35.81	**35.81**	-0.284	-0.284
131712	X-10	50	12	34.71	19.62	-0.306	-0.608	34.59	**34.59**	-0.308	**-0.308**	34.59	**34.59**	-0.308	-0.308
183625	X-10	50	12	36.13	22.26	-0.277	-0.555	36.02	**36.02**	-0.280	**-0.280**	36.02	**36.02**	-0.280	-0.280
178419	Y-12	50	9c	47.47	38.20	-0.051	-0.236	47.32	**47.32**	-0.054	**-0.054**	47.32	**47.32**	-0.054	-0.054
113169	Y-12	50	9c	46.69	37.93	-0.066	-0.241	46.54	**46.54**	-0.069	**-0.069**	46.54	**46.54**	-0.069	-0.069
148557	Y-12	50	9c	47.06	41.56	-0.059	-0.169	46.91	**46.91**	-0.062	**-0.062**	46.91	**46.91**	-0.062	-0.062

Step Cases 12, 9c, 10c chosen, Continued.

HBG No.	PC	Del. H (RAD)	Step Case	Uncorrected Dose (H) Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Fade Corrected Dose Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Final Reported Dose Supralinearity (SL) Corrected Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
141826	X-10	100	12	64	37	-0.363	-0.630	63	**63**	-0.365	**-0.365**	63	**63**	-0.365	-0.365
106867	X-10	100	12	68	42	-0.325	-0.585	67	**67**	-0.327	**-0.327**	67	**67**	-0.327	-0.327
112514	X-10	100	12	71	38	-0.291	-0.617	71	**71**	-0.293	**-0.293**	71	**71**	-0.293	-0.293
102232	Y-12	100	9c	94	78	-0.063	-0.223	93	**93**	-0.066	**-0.066**	93	**93**	-0.066	-0.066
169589	Y-12	100	9c	93	77	-0.066	-0.231	93	**93**	-0.069	**-0.069**	93	**93**	-0.069	-0.069
176760	Y-12	100	9c	97	82	-0.026	-0.176	97	**97**	-0.029	**-0.029**	97	**97**	-0.029	-0.029
106752	X-10	500	12	341	230	-0.319	-0.540	340	**340**	-0.321	**-0.321**	267	**267**	-0.466	-0.466
141637	X-10	500	12	338	238	-0.324	-0.524	337	**337**	-0.326	**-0.326**	266	**266**	-0.469	-0.469
135744	X-10	500	9c	464	347	-0.071	-0.307	463	**463**	-0.074	**-0.074**	348	411	-0.304	-0.177
145458	Y-12	500	12	347	341	-0.306	-0.318	346	**346**	-0.308	**-0.308**	270	**270**	-0.459	-0.459
160239	Y-12	500	9c	549	440	0.098	-0.120	547	**547**	0.094	**0.094**	406	485	-0.188	-0.030
175433	Y-12	500	9c	533	489	0.066	-0.022	531	**531**	0.062	**0.062**	395	471	-0.210	-0.058
133138	X-10	1000	12	742	532	-0.258	-0.468	740	**740**	-0.260	**-0.260**	535	652	-0.465	-0.348
115883	X-10	1000	12	716	513	-0.284	-0.487	713	**713**	-0.287	**-0.287**	518	629	-0.482	-0.371
101960	X-10	1000	9c	1023	724	0.023	-0.276	1019	**1019**	0.019	**0.019**	718	892	-0.282	-0.108
128334	Y-12	1000	12	696	702	-0.304	-0.298	693	700	-0.307	-0.300	504	617	-0.496	-0.383
114575	Y-12	1000	12	777	749	-0.223	-0.251	774	**774**	-0.226	**-0.226**	558	681	-0.442	-0.319
177226	Y-12	1000	9c	1083	1027	0.083	0.027	1080	**1080**	0.080	**0.080**	757	944	-0.243	-0.056
167861	X-10	5000	12	6081	3834	0.216	-0.233	6061	**6061**	0.212	**0.212**	3652	5107	-0.270	0.021
167309	X-10	5000	12	5807	4356	0.161	-0.129	5788	**5788**	0.158	**0.158**	3502	4882	-0.300	-0.024
112841	X-10	5000	9c	7841	5380	0.568	0.076	7815	**7815**	0.563	**0.563**	4601	6547	-0.080	0.309
170445	Y-12	5000	12	5566	5209	0.113	0.042	5548	**5548**	0.110	**0.110**	3369	4684	-0.326	-0.063
130213	Y-12	5000	12	5197	4483	0.039	-0.103	5180	**5180**	0.036	**0.036**	3165	4379	-0.367	-0.124
131453	Y-12	5000	9c	9226	7887	0.845	0.577	9195	**9195**	0.839	**0.839**	5335	7676	0.067	0.535
109498	X-10	10000	12	12953	7836	0.295	-0.216	12910	**12910**	0.291	**0.291**	7262	10695	-0.274	0.069
140551	X-10	10000	12	16193	8965	0.619	-0.104	16139	**16139**	0.614	**0.614**	8895	13301	-0.110	0.330
163950	X-10	10000	12	14344	8369	0.434	-0.163	14297	**14297**	0.430	**0.430**	7968	11815	-0.203	0.182
170459	Y-12	10000	9c	20096	18236	1.010	0.824	20030	**20030**	1.003	**1.003**	10823	16424	0.082	0.642
124196	Y-12	10000	9c	23741	19838	1.374	0.984	23663	**23663**	1.366	**1.366**	12593	19328	0.259	0.933
100290	Y-12	10000	9c	16847	15372	0.685	0.537	16791	**16791**	0.679	**0.679**	9221	13825	-0.078	0.383

Cs-137 Exposures Processed with 10% Transmission Filter

Step cases 9a, 10b, 11b chosen

				Uncorrected Dose (H)				Fade Corrected Dose				Final Reported Dose Supralinearity (SL) Corrected			
HBG No.	PC	Del. H (RAD)	Step Case	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
110629	X-10	0.500	12	0.326	0.325	-0.349	-0.350	0.325	**0.325**	-0.351	**-0.351**	0.325	**0.325**	-0.351	**-0.351**
102178	X-10	0.500	12	0.327	0.322	-0.347	-0.357	0.325	**0.325**	-0.349	**-0.349**	0.325	**0.325**	-0.349	**-0.349**
121861	X-10	0.500	9a	0.560	0.572	0.121	0.143	0.559	0.570	0.117	0.140	0.559	0.570	0.117	0.140
152337	Y-12	0.500	11b	0.388	0.439	-0.225	-0.121	0.386	0.438	-0.227	-0.124	0.386	0.438	-0.227	-0.124
121203	Y-12	0.500	9a	0.539	0.525	0.079	0.049	0.538	**0.538**	0.075	**0.075**	0.538	**0.538**	0.075	**0.075**
138927	Y-12	0.500	9a	0.575	0.571	0.150	0.142	0.573	**0.573**	0.147	**0.147**	0.573	**0.573**	0.147	**0.147**
162421	X-10	1.000	9a	1.118	1.048	0.118	0.048	1.114	**1.114**	0.114	**0.114**	1.114	**1.114**	0.114	**0.114**
110668	X-10	1.000	9a	1.080	1.082	0.080	0.082	1.077	1.078	0.077	0.078	1.077	1.078	0.077	0.078
102972	X-10	1.000	9a	1.101	1.118	0.101	0.118	1.097	1.114	0.097	0.114	1.097	1.114	0.097	0.114
125480	Y-12	1.000	12	0.637	0.623	-0.363	-0.377	0.635	**0.635**	-0.365	**-0.365**	0.635	**0.635**	-0.365	**-0.365**
151146	Y-12	1.000	10b	0.905	1.268	-0.095	0.268	0.902	1.263	-0.098	0.263	0.902	1.263	-0.098	0.263
113507	Y-12	1.000	9a	1.037	1.046	0.037	0.046	1.034	1.043	0.034	0.043	1.034	1.043	0.034	0.043
163925	X-10	10	9a	10.52	9.67	0.052	-0.033	10.48	**10.48**	0.048	**0.048**	10.48	**10.48**	0.048	0.048
160623	X-10	10	9a	10.40	10.30	0.040	0.030	10.37	**10.37**	0.037	**0.037**	10.37	**10.37**	0.037	0.037
139160	X-10	10	9a	10.41	10.14	0.041	0.014	10.38	**10.38**	0.038	**0.038**	10.38	**10.38**	0.038	0.038
106014	Y-12	10	9a	10.73	10.05	0.073	0.005	10.69	**10.69**	0.069	**0.069**	10.69	**10.69**	0.069	0.069
175296	Y-12	10	9a	10.63	10.12	0.063	0.012	10.60	**10.60**	0.060	**0.060**	10.60	**10.60**	0.060	0.060
127728	Y-12	10	9a	10.63	10.73	0.063	0.073	10.59	10.69	0.059	0.069	10.59	10.69	0.059	0.069
122584	X-10	50	9a	53.09	46.50	0.062	-0.070	52.91	**52.91**	0.058	**0.058**	52.91	**52.91**	0.058	0.058
140479	X-10	50	9a	52.21	48.62	0.044	-0.028	52.03	**52.03**	0.041	**0.041**	52.03	**52.03**	0.041	0.041
123418	X-10	50	9a	52.76	50.57	0.055	0.011	52.58	**52.58**	0.052	**0.052**	52.58	**52.58**	0.052	0.052
111246	Y-12	50	9a	55.26	49.54	0.105	-0.009	55.07	**55.07**	0.101	**0.101**	55.07	**55.07**	0.101	0.101
180874	Y-12	50	9a	58.65	52.42	0.173	0.048	58.46	**58.46**	0.169	**0.169**	58.46	**58.46**	0.169	0.169
136361	Y-12	50	9a	52.81	54.12	0.056	0.082	52.63	53.94	0.053	0.079	52.63	53.94	0.053	0.079

Step cases 9a, 10b, 11b chosen, Continued.

				Uncorrected Dose (H)				**Fade Corrected Dose**				**Final Reported Dose Supralinearity (SL) Corrected**			
HBG No.	PC	Del. H (RAD)	Step Case	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
139468	X-10	100	9a	105	97	0.052	-0.035	105	**105**	0.048	**0.048**	100	**100**	-0.002	-0.002
164234	X-10	100	9a	111	96	0.105	-0.042	110	**110**	0.102	**0.102**	105	**105**	0.049	0.049
163583	X-10	100	9a	107	100	0.069	-0.004	107	**107**	0.065	**0.065**	101	**101**	0.014	0.014
126683	Y-12	100	12	68	63	-0.316	-0.374	68	**68**	-0.318	**-0.318**	68	**68**	-0.318	-0.318
115558	Y-12	100	9a	113	101	0.130	0.005	113	**113**	0.127	**0.127**	107	**107**	0.073	0.073
125126	Y-12	100	9a	110	102	0.104	0.024	110	**110**	0.101	**0.101**	105	**105**	0.048	0.048
145525	X-10	500	9a	590	539	0.179	0.078	588	**588**	0.175	**0.175**	433	520	-0.133	0.040
177295	X-10	500	9a	612	587	0.223	0.174	610	**610**	0.219	**0.219**	448	539	-0.104	0.078
169224	X-10	500	9a	595	584	0.191	0.169	593	**593**	0.187	**0.187**	437	525	-0.126	0.050
121704	Y-12	500	12	374	358	-0.253	-0.284	372	**372**	-0.255	**-0.255**	284	**284**	-0.432	-0.432
178817	Y-12	500	9a	618	595	0.235	0.191	616	**616**	0.231	**0.231**	452	544	-0.096	0.088
120753	Y-12	500	9a	629	611	0.259	0.222	627	**627**	0.255	**0.255**	460	554	-0.080	0.109
														-0.202	

Cs-137 Exposures Processed with 10% Transmission Filter.

Step cases 9c, 10c, 11c chosen.

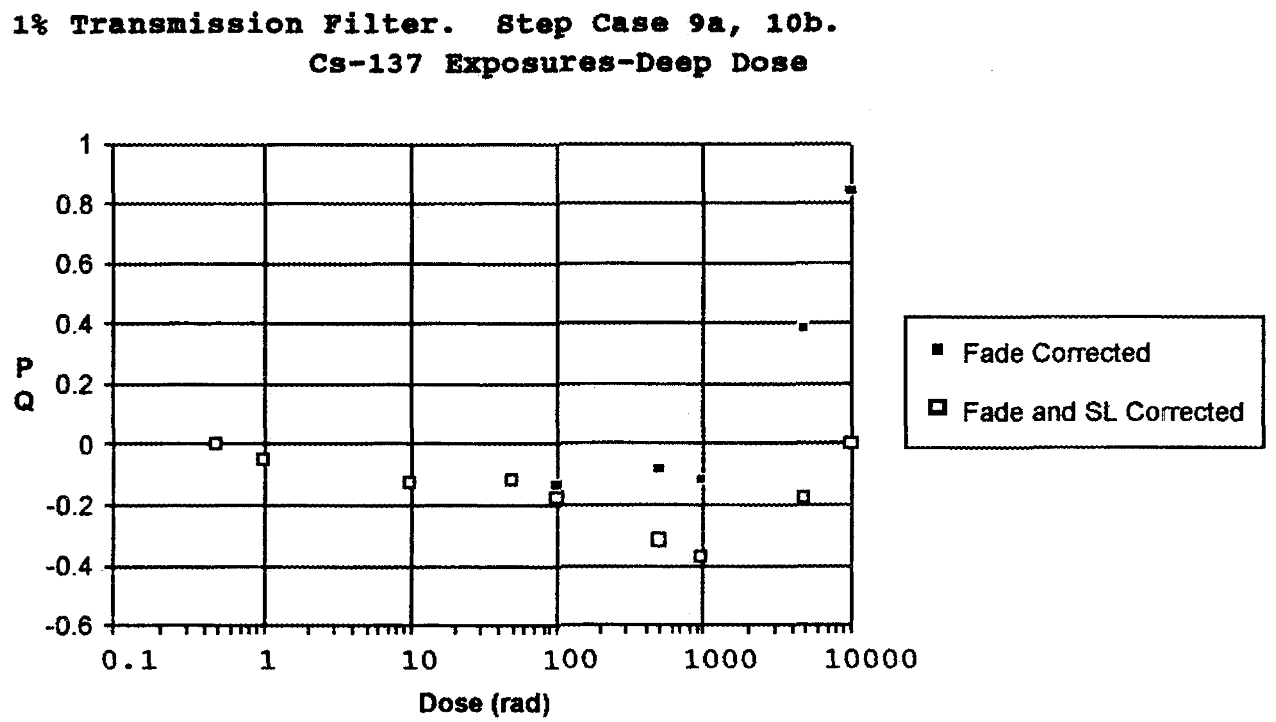
HBG No.	PC	Del. H (RAD)	Step Case	Uncorrected Dose (H) Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Fade Corrected Dose Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	Final Reported Dose Supralinearity (SL) Corrected Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
110629	X-10	0.500	12	0.326	0.325	-0.349	-0.350	0.325	0.325	-0.351	-0.351	0.325	0.325	-0.351	-0.351
102178	X-10	0.500	12	0.327	0.322	-0.347	-0.357	0.325	0.325	-0.349	-0.349	0.325	0.325	-0.349	-0.349
121861	X-10	0.500	9c	0.506	0.508	0.012	0.016	0.504	0.507	0.009	0.013	0.504	0.507	0.009	0.013
152337	Y-12	0.500	11c	0.388	0.516	-0.225	0.033	0.386	0.515	-0.227	0.029	0.386	0.515	-0.227	0.029
121203	Y-12	0.500	9c	0.487	0.466	-0.026	-0.067	0.486	0.486	-0.029	-0.029	0.486	0.486	-0.029	-0.029
138927	Y-12	0.500	9c	0.519	0.508	0.039	0.015	0.518	0.518	0.036	0.036	0.518	0.518	0.036	0.036
162421	X-10	1.000	9c	1.009	0.932	0.009	-0.068	1.006	1.006	0.006	0.006	1.006	1.006	0.006	0.006
110668	X-10	1.000	9c	0.976	0.962	-0.024	-0.038	0.973	0.973	-0.027	-0.027	0.973	0.973	-0.027	-0.027
102972	X-10	1.000	9c	0.994	0.994	-0.006	-0.006	0.991	0.991	-0.009	-0.009	0.991	0.991	-0.009	-0.009
125480	Y-12	1.000	12	0.637	0.623	-0.363	-0.377	0.635	0.635	-0.365	-0.365	0.635	0.635	-0.365	-0.365
151146	Y-12	1.000	10c	0.905	1.554	-0.095	0.554	0.902	1.549	-0.098	0.549	0.902	1.549	-0.098	0.549
113507	Y-12	1.000	9c	0.937	0.930	-0.063	-0.070	0.934	0.934	-0.066	-0.066	0.934	0.934	-0.066	-0.066
163925	X-10	10	9c	9.50	8.60	-0.050	-0.140	9.47	9.47	-0.053	-0.053	9.467	9.467	-0.053	-0.053
160623	X-10	10	9c	9.39	9.15	-0.061	-0.085	9.36	9.36	-0.064	-0.064	9.362	9.362	-0.064	-0.064
139160	X-10	10	9c	9.40	9.02	-0.060	-0.098	9.37	9.37	-0.063	-0.063	9.372	9.372	-0.063	-0.063
106014	Y-12	10	9c	9.69	8.94	-0.031	-0.106	9.65	9.65	-0.035	-0.035	9.655	9.655	-0.035	-0.035
175296	Y-12	10	9c	9.60	8.99	-0.040	-0.101	9.57	9.57	-0.043	-0.043	9.570	9.570	-0.043	-0.043
127728	Y-12	10	9c	9.60	9.54	-0.040	-0.046	9.57	9.57	-0.043	-0.043	9.567	9.567	-0.043	-0.043
122584	X-10	50	9c	47.94	41.34	-0.041	-0.173	47.79	47.79	-0.044	-0.044	47.79	47.79	-0.044	-0.044
140479	X-10	50	9c	47.15	43.23	-0.057	-0.135	46.99	46.99	-0.060	-0.060	46.99	46.99	-0.060	-0.060
123418	X-10	50	9c	47.65	44.96	-0.047	-0.101	47.49	47.49	-0.050	-0.050	47.49	47.49	-0.050	-0.050
111246	Y-12	50	9c	49.90	44.04	-0.002	-0.119	49.74	49.74	-0.005	-0.005	49.74	49.74	-0.005	-0.005
180874	Y-12	50	9c	52.97	46.60	0.059	-0.068	52.80	52.80	0.056	0.056	52.80	52.80	0.056	0.056
136361	Y-12	50	9c	47.69	48.12	-0.046	-0.038	47.54	47.96	-0.049	-0.041	47.54	47.96	-0.049	-0.041

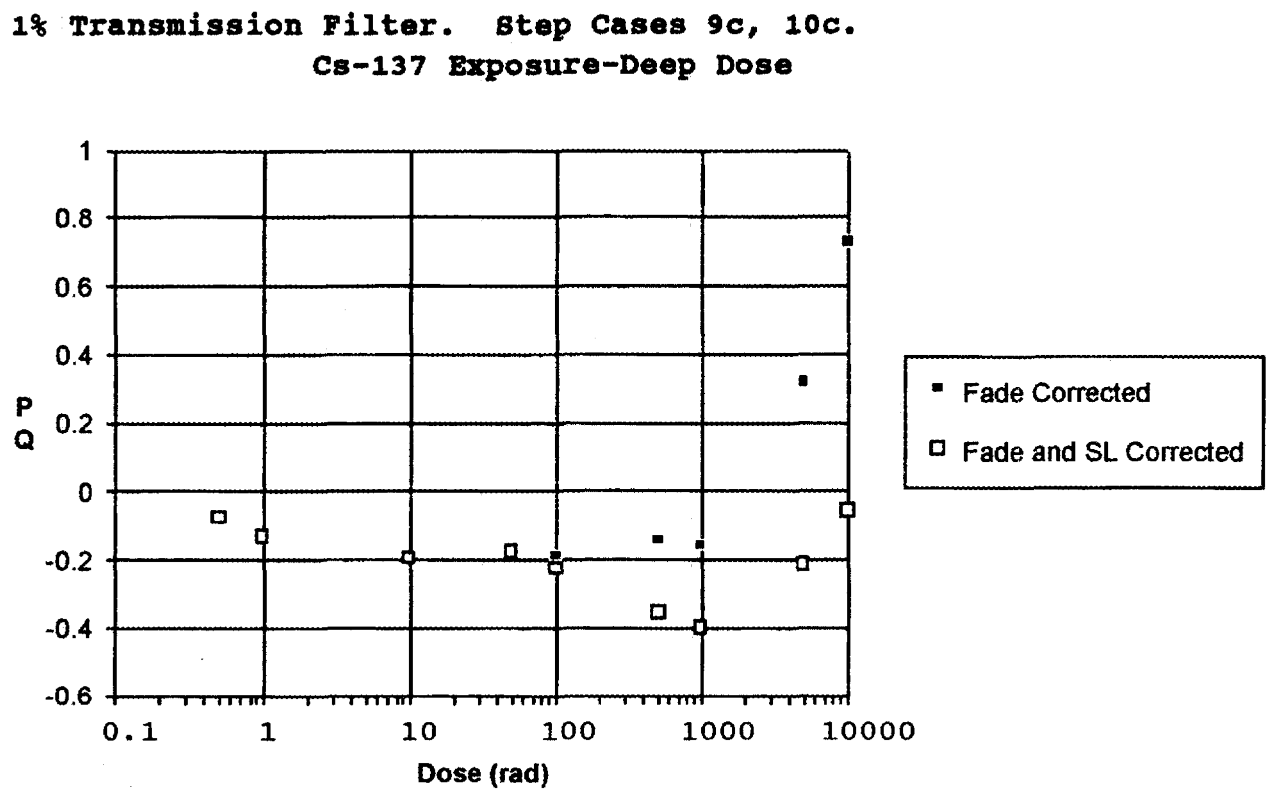
Step cases 9c, 10c, 11c chosen, Continued.

HBG No.	PC	Del. H (RAD)	Step Case	**Uncorrected Dose (H)** Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	**Fade Corrected Dose** Rep. Hd	Rep. Hs	PQ Hd	PQ Hs	**Final Reported Dose Supralinearity (SL) Corrected** Rep. Hd	Rep. Hs	PQ Hd	PQ Hs
139468	X-10	100	9c	95	86	-0.050	-0.142	95	**95**	-0.053	**-0.053**	95	**95**	-0.053	-0.053
164234	X-10	100	9c	100	85	-0.002	-0.148	99	**99**	-0.005	**-0.005**	99	**99**	-0.005	-0.005
163583	X-10	100	9c	97	89	-0.035	-0.115	96	**96**	-0.038	**-0.038**	96	**96**	-0.038	-0.038
126683	Y-12	100	12	68	63	-0.316	-0.374	68	**68**	-0.318	**-0.318**	68	**68**	-0.318	-0.318
115558	Y-12	100	9c	102	89	0.021	-0.106	102	**102**	0.017	**0.017**	97	**97**	-0.031	-0.031
125126	Y-12	100	9c	100	91	-0.003	-0.089	99	**99**	-0.006	**-0.006**	99	**99**	-0.006	-0.006
145525	X-10	500	9c	533	479	0.065	-0.041	531	**531**	0.062	**0.062**	395	**471**	-0.211	-0.059
177295	X-10	500	9c	552	522	0.105	0.043	551	**551**	0.101	**0.101**	408	**488**	-0.184	-0.025
169224	X-10	500	9c	538	519	0.075	0.039	536	**536**	0.072	**0.072**	398	**475**	-0.204	-0.050
121704	Y-12	500	12	374	358	-0.253	-0.284	372	**372**	-0.255	**-0.255**	284	**284**	-0.432	-0.432
178817	Y-12	500	9c	558	529	0.116	0.059	556	**556**	0.112	**0.112**	412	**492**	-0.176	-0.015
120753	Y-12	500	9c	568	543	0.137	0.086	567	**567**	0.133	**0.133**	419	**502**	-0.162	0.003

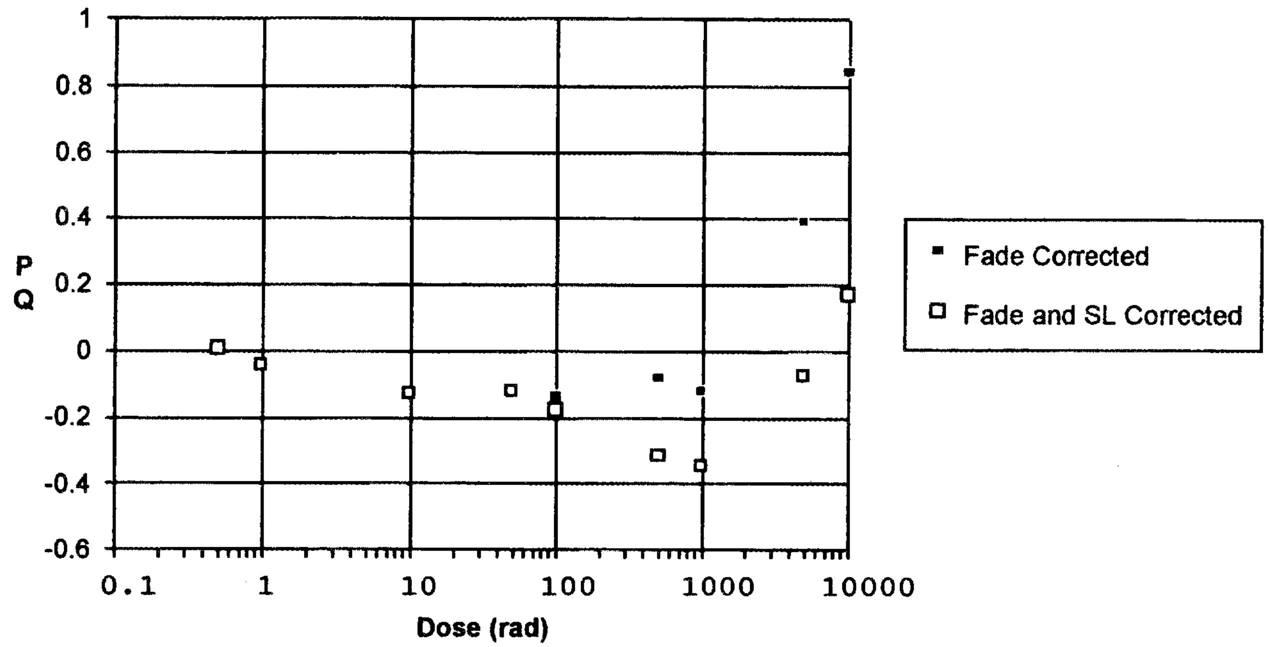
Appendix B

GRAPH CHARTS

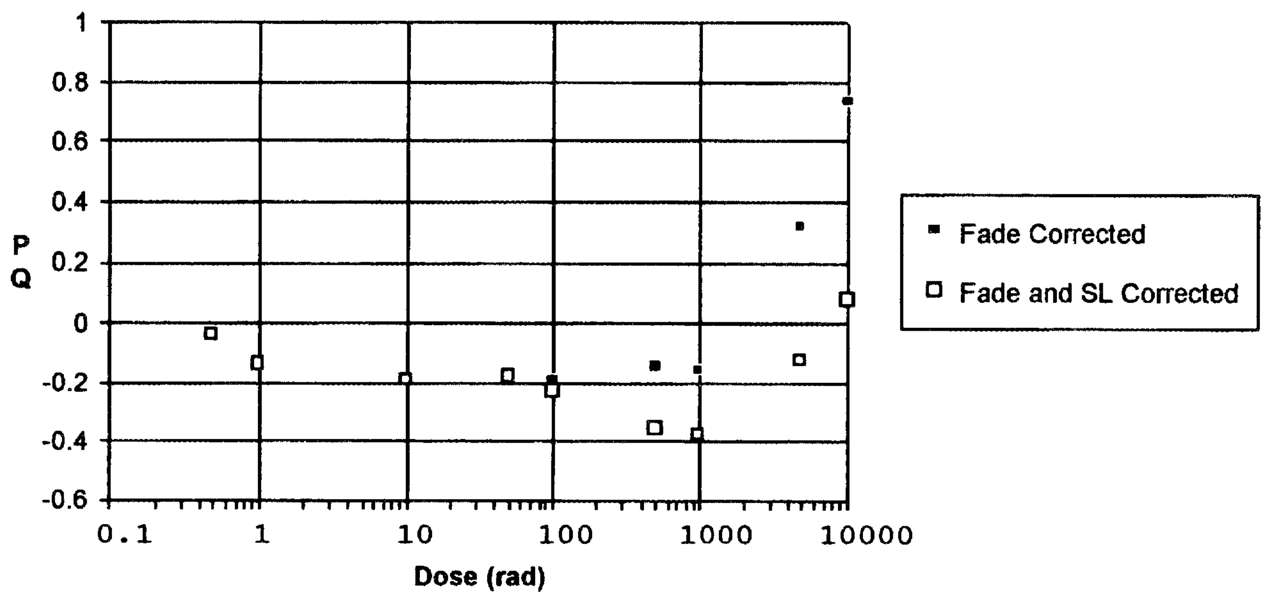

1% Transmission Filter. Step Case 9a, 10b.
Cs-137 Exposures-Deep Dose
PQ
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.1
1
10
100
1000
10000
Dose (rad)
Fade Corrected
Fade and SL Corrected


1% Transmission Filter. Step Cases 9c, 10c.
Cs-137 Exposure-Deep Dose
PQ
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.1
1
10
100
1000
10000
Dose (rad)
Fade Corrected
Fade and SL Corrected

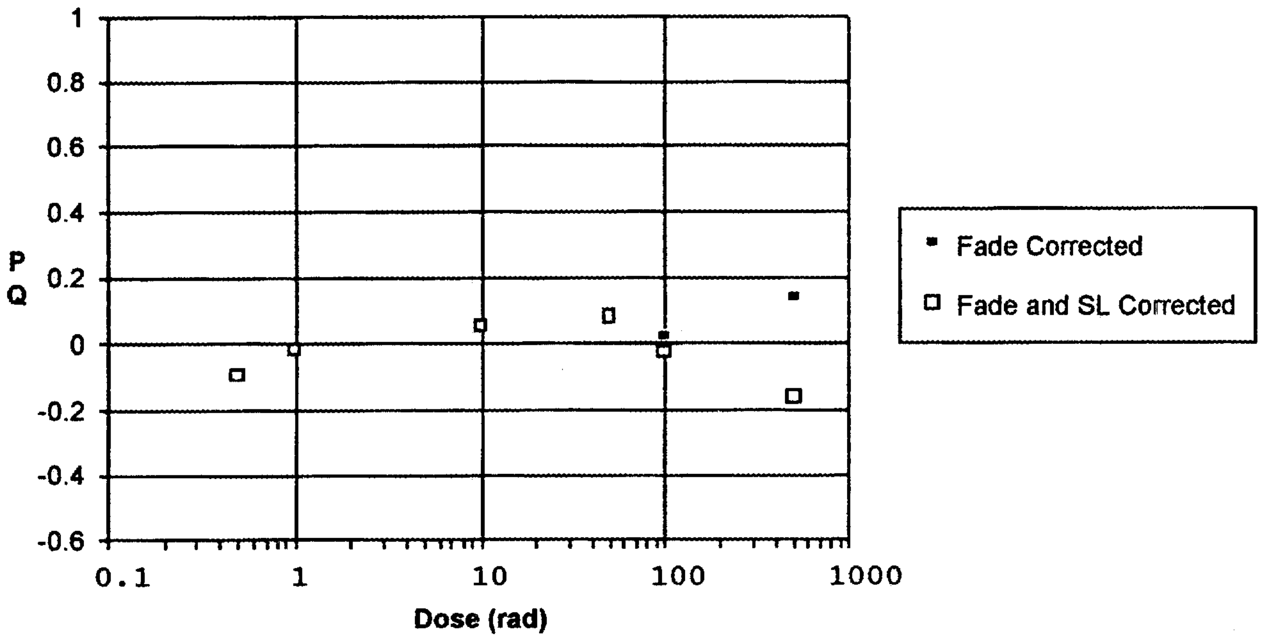
1% Transmission Filter. Step Case 9a, 10b.
Cs-137 Exposures-Shallow Dose



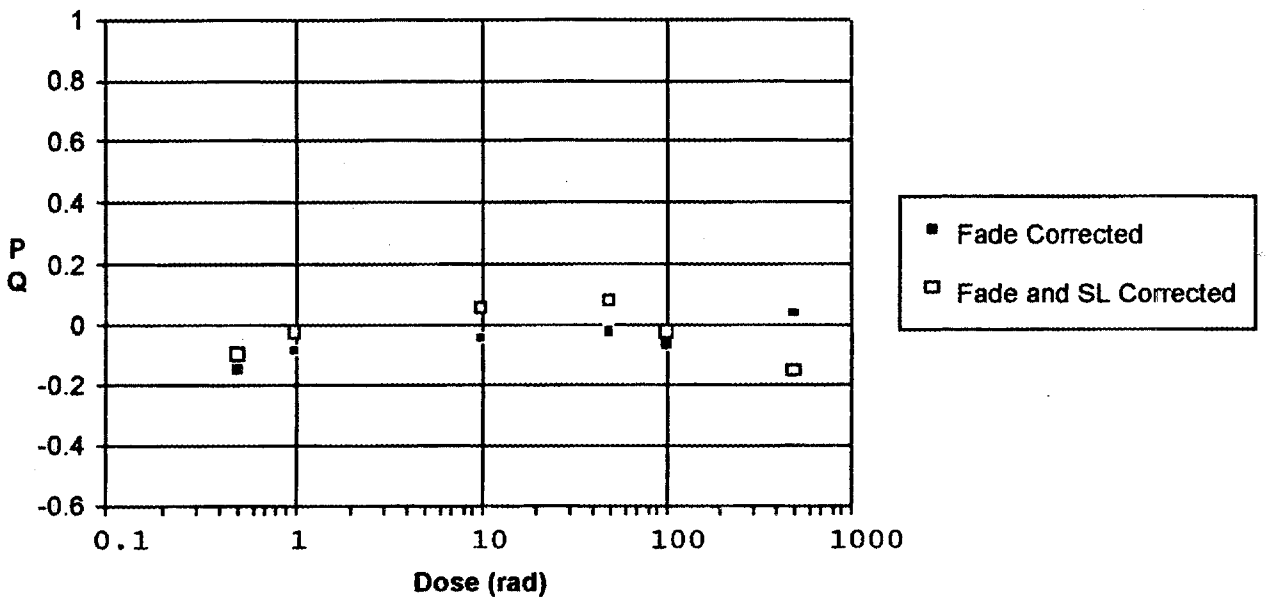
1% Transmission Filter. Step Cases 12, 9c, 10c.
Cs-137 Exposures-Shallow Dose

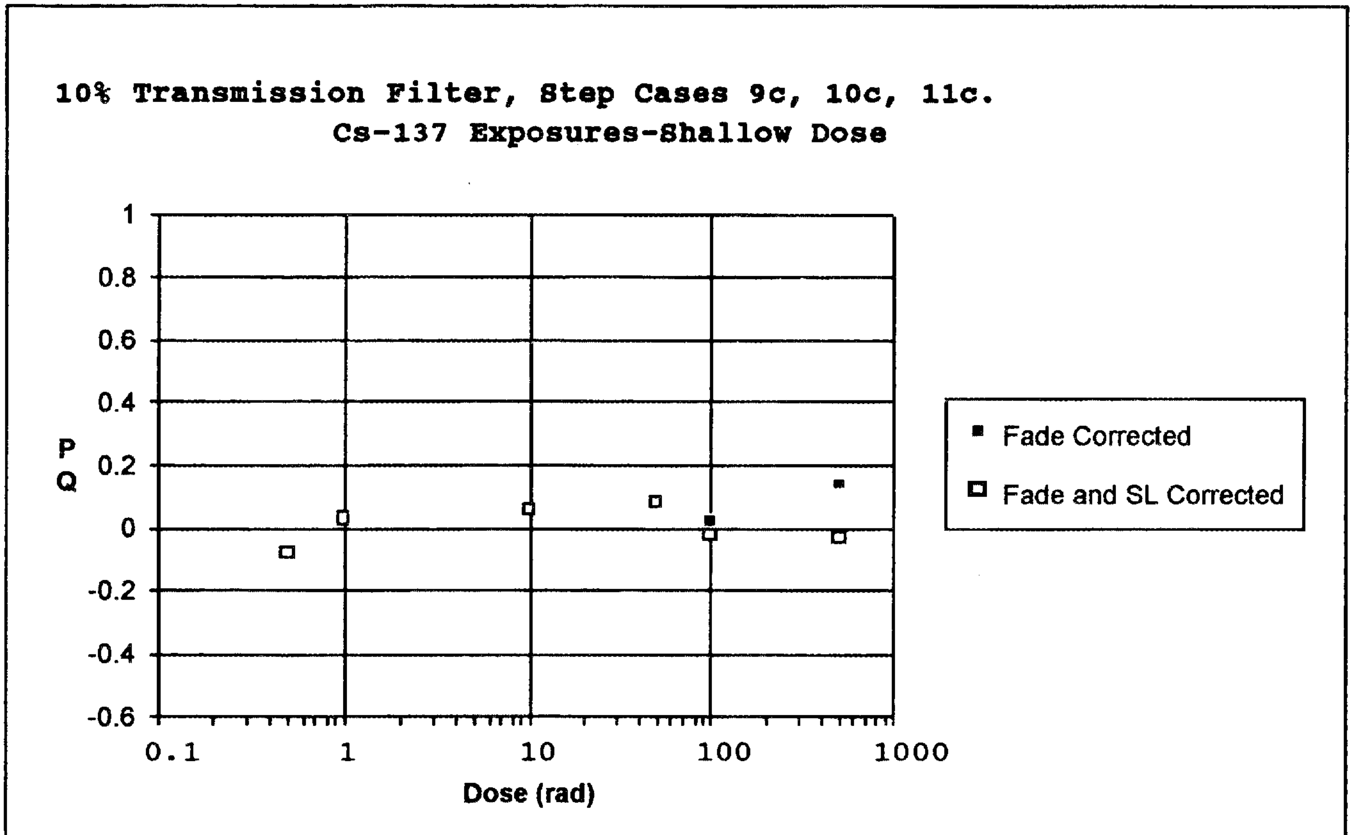


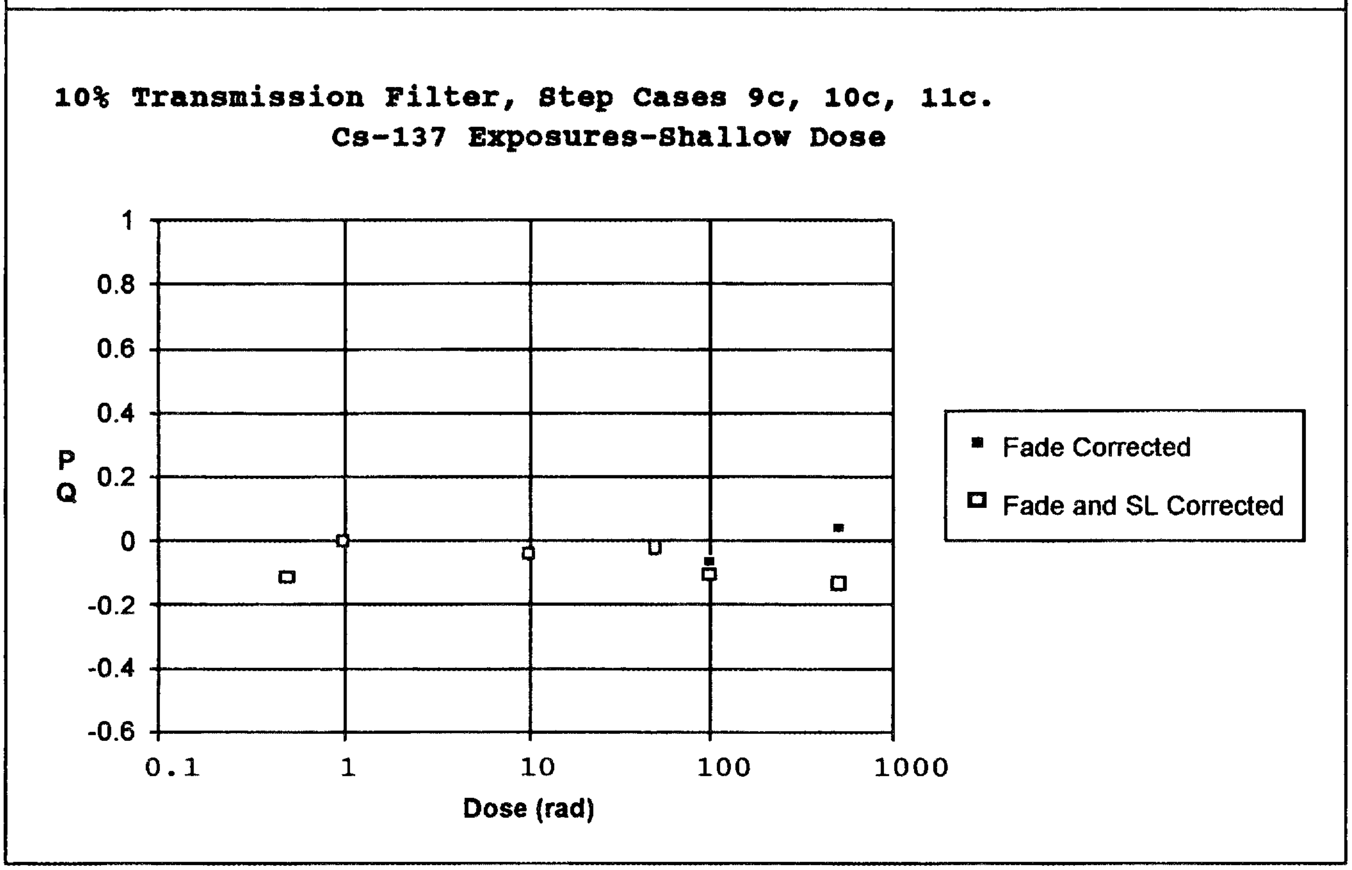
10% Transmission Filter. Step Cases 9a, 10b, 11b.
Cs-137 Exposures-Deep Dose



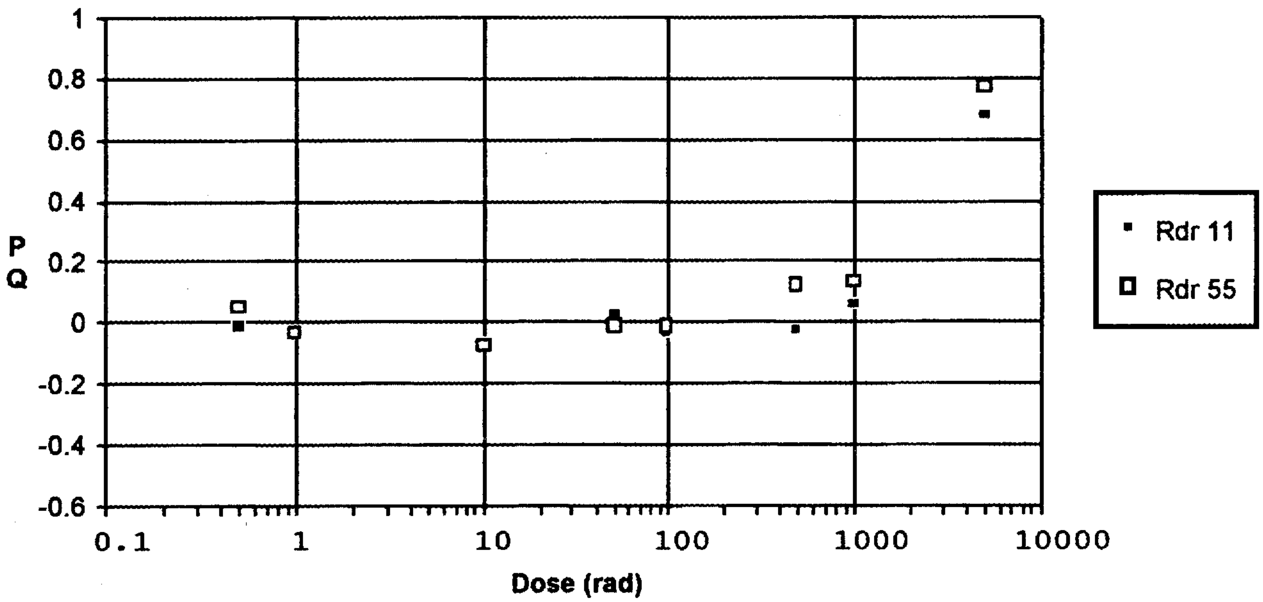
10% Transmission Filter, Step Cases 9c, 10c, 11c.
Cs-137 Exposures-Deep Dose



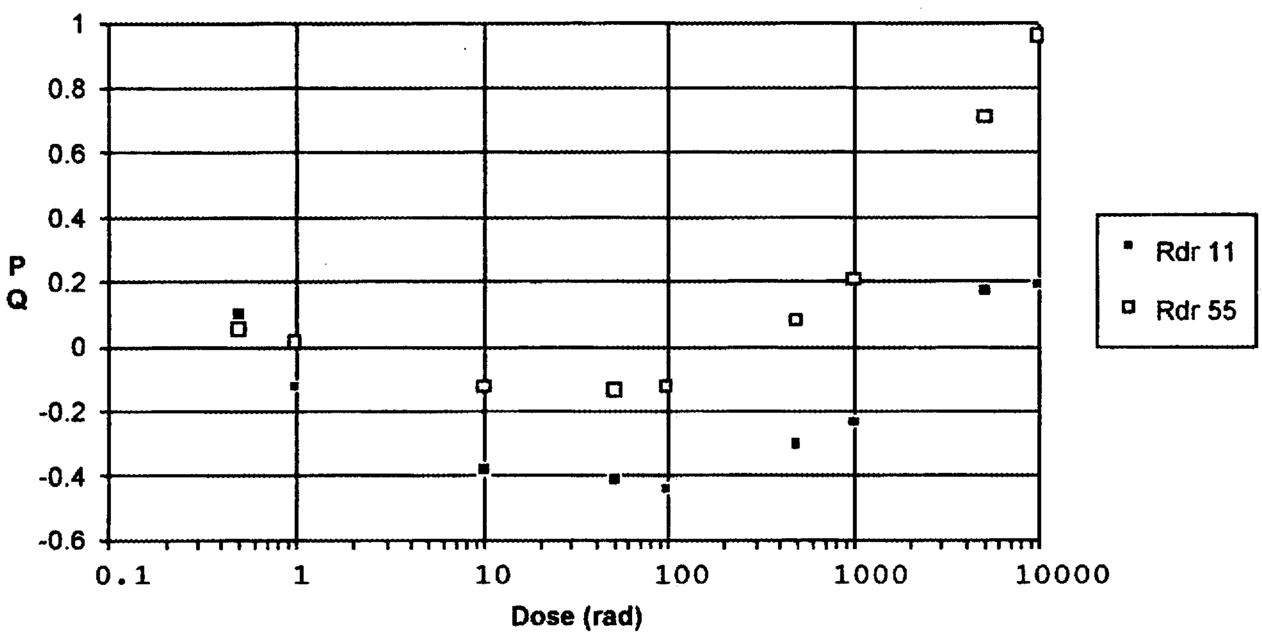

10% Transmission Filter, Step Cases 9c, 10c, 11c.
Cs-137 Exposures-Shallow Dose
P
Q
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.1
1
10
100
1000
Dose (rad)
Fade Corrected
Fade and SL Corrected


10% Transmission Filter, Step Cases 9c, 10c, 11c.
Cs-137 Exposures-Shallow Dose
P
Q
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.1
1
10
100
1000
Dose (rad)
Fade Corrected
Fade and SL Corrected

Non Corrected Element 1 Performance with Each Reader Using 1% Transmission Filter



Non Corrected Element 3 Performance with Each Reader Using 1% Transmission Filter



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