

Pacific Northwest National Laboratory

Operated by Battelle for the
U.S. Department of Energy

February 2, 1999

Armin Vogt
B & W Hanford Company
P.O. Box 1000
Richland, WA 99352

324 BUILDING DOSIMETRY SUPPORT (CONTRACT 619, RELEASE 9)

References: 1. E. Piesch in "Applied Thermoluminescence Dosimetry" edited by M. Oberhofer and A. Scharmann, published by Adam Hilger Ltd, 1981.

2. J. Douglas in "Applied Thermoluminescence Dosimetry" edited by M. Oberhofer and A. Scharmann, published by Adam Hilger Ltd, 1981.

Dear Mr. Vogt:

Please find attached the results for the TLD strings used to measure radiation exposure rates in the 324 Facility waste tanks. The results are provided in **Attachments A - I**. In general, there seemed to be good agreement between chip results at the same location on the TLD string. There also seemed to be the expected trend from one location to the next on the string. Considering all sources of error, the reported net exposure and net exposure rate for each packet (i.e. string location) are believed to be within $\pm 30\%$ of their "true" values. A description of the dosimeter design, readout methods and data analysis is presented below. If you have any questions, please don't hesitate to call.

METHOD:

Each dosimeter consisted of two TLD 700 LiF:Ti,Mg chips (240 mg/cm^2 thick) placed side by side and heat-sealed in a black heat shrink tubing. The ends of each section containing two chips were hot crimped using a heat-sealing tool to form a packet. Because excessive heat would change the fade and sensitivity characteristics of the enclosed chips, the tubing was not subjected to heat from a hot air gun as would normally be done to shrink this type of material. Approximately 275 packets were prepared and labeled accordingly with packet IDs between 1 and 275. The results in **Attachments A - I** were reported against this packet ID. The dosimeter packets were taped by your staff on to an electrician's $\frac{1}{4}$ inch fish tape at approximately 6 inch intervals and one foot intervals representing the depths (from bottom of tank) shown on **Attachments A - H**. The tapes were fed into the thermocouple risers of eight waste tanks in the 324 Facility vaults and left for approximately 30 minutes to obtain a profile of dose rates in the tanks. Those packet IDs which are shaded indicate a disagreement between the packet ID for a given depth as provided in your

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template spreadsheet vs. the actual packet ID on the packet taped to the paper sheets on which they were returned. These paper sheets indicated that the packets were taped on the sheets in the order in which they were removed from the electrician's fish tape (i.e. locations ascending from bottom to top of tank). One paper sheet was used per tank. The locations in **Attachments A - I** were inferred from the paper sheets on which the packets were returned.

The TLD chips used in the packets on the TLD string were oven-annealed on May 28, 1998 for 2 hours at 400°C followed by 16 hours at 80°C. The packets were exposed in the thermocouple risers during the first week of November, 1998. The chips were read on January 13 and 14, 1999 using an Atlas 2000D hot gas TLD reader programmed for a readout time of 20 seconds at a constant temperature of 300°C.

Just prior to processing the packet chips, the reader was calibrated using a set of chips annealed on January 4, 1999. Half were exposed in air to 100 mR of ^{137}Cs radiation on January 5, 1995 to be used as reader checks and half were left unexposed to be used as reader blanks. Ten checks and ten blanks were used to calibrate the reader. The mean blank reading was subtracted from the mean check reading to obtain a net reading in nC which was divided by the given exposure (100 mR) to obtain a reader calibration factor of 7.667 mR/nC. This calibration factor was applied to packet chips subsequently processed from the TLD string. The readings used to determine the reader calibration factor are shown in **Attachment J**.

Reader QC was accomplished by taking a light source reading, a photomultiplier tube dark current reading, a check reading and, a blank chip reading at the beginning and end of each chip wheel. Each chip wheel holds 50 loose chips including the two checks and two blanks. Data was captured using a Turbo BASIC program called HOTGAS running on a DOS PC in conjunction with a logging printer.

DATA ANALYSIS:

The mean of the blank chip readings (0.5981 nC) obtained during reader calibration, was used as a system background value to subtract from each packet TLD chip reading. The resulting net reading in nC was then converted to exposure units of mR by multiplying by the reader calibration factor 7.667 mR/nC. A natural environmental background component based on historical Hanford environmental exposure rates measured with the same type of chip, was subtracted from this net chip reading. In this case, an environmental background of 37.9 mR was calculated based on 230 days between chip anneal and readout. The resulting net readings in mR for individual chips are shown in the columns for chip A and B on **Attachments A - I**. Those chips that received only natural environmental background radiation therefore have net readings near zero in these two columns. The background corrections may be summarized as follows:

$$\text{CHIP mR} = ((\text{RAW} - \text{RDRBKG}) * \text{RCF}) - \text{ENVBKG}$$

Where: RAW = raw chip reading in nanocoulombs (nC)
RDRBKG = mean blank chip reading obtained during reader calibration (nC)
RCF = reader calibration factor (nC/mR)
ENVBKG = estimated environmental background component on chip

$$\text{ENVBKG} = 0.18 (1 - e^{-\lambda t}) / \lambda$$

Where: 0.18 = historical Hanford environmental background (mR/d)
t = time between chip anneal and readout (days)
 λ = exponential fade constant (0.00078/d)

The mean and % difference of the two chip readings from each packet are given in the columns labeled "Average" and "Diff" respectively. To correct for possible unintended exposure of the packet TLDs during preparation and handling, the unused packets were considered to be controls. Their average value as shown on Attachment I (already corrected for natural background using the equation above) was subtracted from each string packet result to obtain the net (i.e. man made) exposure. The results are shown in the column labeled "net exposure". Finally, the net exposure rate in mR/h was calculated by dividing the net exposure by the exposure time provided for each string. The result is shown in the last column labeled "net exposure rate".

DISCUSSION:

The expected trend in results from bottom to top of each riser was seen. The exposure rates generally are largest at the bottom of each tank, gradually decreasing toward the top. The sharp decrease in dose rates presumably occurs at the point where the riser transitions from liquid to air, or where it passes through shielding.

The agreement between the pair of chips from each packet was evaluated. The % difference between the two chips from each packet was generally less than 30% as expected. It should be noted that the TLD chips used for this study came from a population of chips originally screened to have sensitivities within $\pm 15\%$ of the population mean. Because these loose chips are not individually identified, individual chip sensitivity correction factors cannot be applied. This fact alone would account for differences of up to 30%. These chips used for this study were used for many years in the Hanford Two Chip Ring Dosimeter until mid 1996 when a new Extremity Dosimetry System was implemented at Hanford. Over the course of time, the sensitivities of the chips may have drifted slightly from their originally screened values. This fact combined with geometry and shielding effects could account for slightly larger observed differences between neighboring chips in the same pouch on the TLD string. Considering the expected range of sensitivity of individual chips used in the string packets and the sensitivity of chips used to calibrate the reader, (even though they are from the same population) the uncertainty in reported net exposures and net exposure rates is estimated to be less than $\pm 30\%$. Therefore, only the first two figures are really significant in the calculated results reported in Attachments A - J.

Due to TLD equipment malfunction while reading out the first wheel of chips, the readings from 46 chips were considered suspect and not reported (indicated by n/a on Attachments A and B). The exposure results for the effected packets were based on the remaining good chip reading from each packet.

The largest TLD readings seen from the TLD strings was about 7000 R. The TLD readings using TLD 700 with the Atlas system have been shown to be linear up to 100 R above which the reported dose becomes supralinear. Based on studies done by E. Peisch and other investigators (Reference 1), supralinearity increases up to about 50,000 R then decreases. Above 10^6 R the material begins to under respond. The maximum reported over response is by a factor of 3.83 at an exposure of 50,000 R. *Adjustments for supralinearity were not made to the data in Attachments A-I.* If greater accuracy is needed for the TLD string data, then Attachment K (from Reference 2) can be used to estimate the corrections needed. The bottom axis (^{137}Cs Gamma Exposure) should be used in conjunction with the data points labeled with triangles (gamma response of TLD 700).

Because of the large readings seen on the TLD strings, the TLD reader's electrometer was tested using a calibrated current source and shown to be linear in its charge integration function with currents up to 10^{-4} amps. For the 20-second charge integration period used to read TLD chips, this corresponds to a charge of 2×10^{-3} coulombs which corresponds to a dose of approximately 160000 R. The linearity of the photomultiplier tube's current out put as a function of light input was not tested. The maximum current that the tube can generate has not been determined.

The TLD 700 material has an energy dependent response when used to measure exposure. Relative to its response to 662 keV photons, it over responds to photons with energies less than 150 keV. A maximum over response by a factor of about 1.5 is observed at about 40 keV. If the string TLD measurements were made in tanks with typical mixed fission product inventories dominated by photons from ^{137}Cs , then corrections for energy dependence should not be needed.

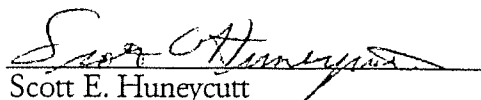
Fading corrections were not applied to any of the TLD readings. With the standard anneal treatment used for this study, fading of signal in TLD 700 would be about 5% for the 2 months between exposure and readout for the string TLDs in this study.

Very truly yours,



Bruce A. Rathbone
Sr. Research Scientist
Radiation Health and Technology

Peer Reviewed by:



Scott E. Huneycutt

Date: 2/2/99

Attachment A

Tank No.	101
String No.	1
Exposure Time (min)	31
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	n/a	187 missing	n/a	n/a	n/a	n/a	n/a	n/a
0.5'	TP101	00257	5736	n/a	5736	n/a	5732	11094
1.0'	TP102	00264	5254	n/a	5254	n/a	5250	10161
1.5'	TP103	00242	2763	n/a	2763	n/a	2759	5339
2.0'	TP104	00062	3214	n/a	3214	n/a	3210	6212
2.5'	TP105	00059	3138	n/a	3138	n/a	3134	6065
3.0'	TP106	00197	2471	n/a	2471	n/a	2467	4774
3.5'	TP107	00181	1641	n/a	1641	n/a	1637	3168
4.0'	TP108	00133	2228	n/a	2228	n/a	2224	4305
4.5'	TP109	00084	1873	n/a	1873	n/a	1869	3617
5.0'	TP110	00139	1741	n/a	1741	n/a	1737	3361
5.5'	TP111	00222	1922	n/a	1922	n/a	1918	3713
6.0'	TP112	00031	1824	n/a	1824	n/a	1820	3522
6.5'	TP113	00271	1891	n/a	1891	n/a	1887	3652
7.0'	TP114	00085	1752	n/a	1752	n/a	1748	3384
7.5'	TP115	00249	1758	n/a	1758	n/a	1754	3394
8.0'	TP116	00057	1873	n/a	1873	n/a	1869	3618
9.0'	TP117	00202	2034	n/a	2034	n/a	2030	3928
10.0'	TP118	00248	1764	n/a	1764	n/a	1760	3407
11.0'	TP119	00060	1298	n/a	1298	n/a	1294	2504
12.0'	TP120	00135	2117	n/a	2117	n/a	2113	4090
13.0'	TP121	00261	1357	n/a	1357	n/a	1353	2618
14.0'	TP122	00244	576	n/a	576	n/a	572	1107
15.0'	TP123	00093	1303	n/a	1303	n/a	1299	2514
16.0'	TP124	00252	1791	n/a	1791	n/a	1787	3459
17.0'	TP125	00076	53	n/a	53	n/a	49	95
18.0'	TP126	00104	34	n/a	34	n/a	30	58
19.0'	TP127	00269	26	n/a	26	n/a	22	43
20.0'	TP128	00041	26	n/a	26	n/a	22	42
21.0'	TP129	00228	29	n/a	29	n/a	25	48
22.0'	TP130	00199	12	n/a	12	n/a	8	15
23.0'	TP131	00119	35	n/a	35	n/a	31	60
24.0'	TP132	00208	23	n/a	23	n/a	19	36

Attachment B

Tank No.	107
String No.	2
Exposure Time (min)	30
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP201	00231	588476	n/a	588476	n/a	588472	1176945
0.5'	TP202	00010	418422	n/a	418422	n/a	418418	836836
1.0'	TP203	00068	220460	n/a	220460	n/a	220456	440913
1.5'	TP204	00158	105839	n/a	105839	n/a	105835	211669
2.0'	TP205	00040	94568	n/a	94568	n/a	94564	189128
2.5'	TP206	00055	82531	n/a	82531	n/a	82527	165054
3.0'	TP207	00067	88435	n/a	88435	n/a	88431	176861
3.5'	TP208	00213	49026	n/a	49026	n/a	49022	98044
4.0'	TP209	00225	59147	n/a	59147	n/a	59143	118285
4.5'	TP210	00195	51326	n/a	51326	n/a	51322	102645
5.0'	TP211	00128	34919	n/a	34919	n/a	34915	69830
5.5'	TP212	00260	32465	n/a	32465	n/a	32461	64923
6.0'	TP213	00061	10614	n/a	10614	n/a	10610	21221
6.5'	TP214	00198	13451	n/a	13451	n/a	13447	26895
7.0'	TP215	00025	12915	12608	12761	2	12757	25515
7.5'	TP216	00177	7402	5628	6515	27	6511	13022
8.0'	TP217	00027	7390	6953	7171	6	7167	14335
9.0'	TP218	00012	7854	6934	7394	12	7390	14781
10.0'	TP219	00069	383	443	413	15	409	818
11.0'	TP220	00013	26	25	25	2	21	43
12.0'	TP221	00074	22	26	24	16	20	41
13.0'	TP222	00201	5	23	14	128	10	21
14.0'	TP223	00171	26	34	30	28	26	52
15.0'	TP224	00212	3	21	12	155	8	16
16.0'	TP225	00206	22	15	19	40	15	29
17.0'	TP226	00056	30	34	32	11	28	56
18.0'	TP227	00168	21	20	20	2	16	33
19.0'	TP228	00186	6	30	18	135	14	28
20.0'	TP229	00192	24	13	19	60	15	29
21.0'	TP230	00023	19	36	28	63	24	47
22.0'	TP231	00243	31	27	29	15	25	50
23.0'	TP232	00250	26	27	27	5	23	45
24.0'	TP233	00048	34	39	37	15	33	65

Attachment C

Tank No. 103
 String No. 3
 Exposure Time (min) 31
 Average Control Result (mR) 4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP301	00112	1485	1680	1582	12	1578	3055
0.5'	TP302	00154	1008	788	898	25	894	1730
1.0'	TP303	00001	1003	1009	1006	1	1002	1940
1.5'	TP304	00007	772	759	765	2	761	1474
2.0'	TP305	00047	923	847	885	9	881	1705
2.5'	TP306	00042	807	872	839	8	835	1617
3.0'	TP307	00019	959	871	915	10	911	1762
3.5'	TP308	00161	614	772	693	23	689	1334
4.0'	TP309	00262	683	999	841	38	837	1620
4.5'	TP310	00063	819	915	867	11	863	1670
5.0'	TP311	00237	898	1009	953	12	949	1837
5.5'	TP312	00127	1022	1138	1080	11	1076	2082
6.0'	TP313	00043	1062	1352	1207	24	1203	2329
6.5'	TP314	00053	1337	1271	1304	5	1300	2516
7.0'	TP315	00229	1418	1690	1554	18	1550	3000
7.5'	TP316	00125	1389	1448	1418	4	1414	2737
8.0'	TP317	00148	2013	1658	1835	19	1831	3545
9.0'	TP318	00033	2277	1901	2089	18	2085	4036
10.0'	TP319	00178	2307	2499	2403	8	2399	4643
11.0'	TP320	00259	2931	2392	2662	20	2658	5144
12.0'	TP321	00120	2018	2720	2369	30	2365	4577
13.0'	TP322	00254	2232	2315	2274	4	2270	4393
14.0'	TP323	00070	2185	1975	2080	10	2076	4018
15.0'	TP324	00217	3772	2977	3375	24	3371	6524
16.0'	TP325	00200	2417	3656	3036	41	3032	5869
17.0'	TP326	00089	2020	2266	2143	11	2139	4140
18.0'	TP327	00107	1337	1804	1570	30	1566	3031
19.0'	TP328	00081	247	266	257	7	253	489
20.0'	TP329	00236	69	46	58	40	54	104
21.0'	TP330	00232	17	26	22	41	18	34
22.0'	TP331	00273	26	31	29	17	25	48
23.0'	TP332	00103	37	28	33	28	29	55
24.0'	TP333	00173	8	16	12	74	8	15

Attachment D

Tank No.	104
String No.	4
Exposure Time (min)	30
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP401	00018	850994	827993	839494	3	839490	1678980
0.5'	TP402	00114	453997	441347	447672	3	447668	895336
1.0'	TP403	00130	250592	291840	271216	15	271212	542424
1.5'	TP404	00188	190866	205280	198073	7	198069	396137
2.0'	TP405	00132	126386	128303	127345	2	127341	254681
2.5'	TP406	00137	142180	149004	145592	5	145588	291176
3.0'	TP407	00274	73944	110822	92383	40	92379	184758
3.5'	TP408	00151	73791	73331	73561	1	73557	147113
4.0'	TP409	00179	70417	99552	84984	34	84980	169961
4.5'	TP410	00138	101085	110899	105992	9	105988	211976
5.0'	TP411	00183	59530	69650	64590	16	64586	129172
5.5'	TP412	00115	49870	64514	57192	26	57188	114375
6.0'	TP413	00194	29092	37832	33462	26	33458	66916
6.5'	TP414	00121	28785	27865	28325	3	28321	56643
7.0'	TP415	00175	28939	35839	32389	21	32385	64770
7.5'	TP416	00180	32695	34766	33731	6	33727	67453
8.0'	TP417	00020	22345	32619	27482	37	27478	54956
9.0'	TP418	00258	19278	25258	22268	27	22264	44529
10.0'	TP419	00073	12225	12761	12493	4	12489	24978
11.0'	TP420	00147	11151	10768	10960	3	10956	21911
12.0'	TP421	00255	10231	7438	8835	32	8831	17661
13.0'	TP422	00126	6896	8468	7682	20	7678	15356
14.0'	TP423	00072	8468	8314	8391	2	8387	16774
15.0'	TP424	00185	22	17	20	29	16	31
16.0'	TP425	00226	32	11	22	96	18	36
17.0'	TP426	00066	24	5	15	124	11	21
18.0'	TP427	00204	8	28	18	109	14	28
19.0'	TP428	00044	16	20	18	20	14	28
20.0'	TP429	00035	15	30	22	68	18	37
21.0'	TP430	00167	29	36	33	22	29	57
22.0'	TP431	00123	17	24	20	33	16	33
23.0'	TP432	00109	17	8	12	70	8	17
24.0'	TP433	00026	33	36	35	10	31	61

Attachment E

Tank No.	105
String No.	5
Exposure Time (min)	30
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP501	00124	6624245	7383278	7003762	11	7003758	14007516
0.5'	TP502	00029	3427106	3649449	3538278	6	3538274	7076548
1.0'	TP503	00071	1962709	2054713	2008711	5	2008707	4017415
1.5'	TP504	00220	958332	1142340	1050336	18	1050332	2100665
2.0'	TP505	00111	596220	774324	685272	26	685268	1370536
2.5'	TP506	00196	499232	570152	534692	13	534688	1069377
3.0'	TP507	00146	526604	480908	503756	9	503752	1007504
3.5'	TP508	00141	342136	381697	361916	11	361912	723825
4.0'	TP509	00129	319825	245838	282831	26	282827	565655
4.5'	TP510	00190	296824	209343	253083	35	253079	506159
5.0'	TP511	00159	218160	172465	195313	23	195309	390617
5.5'	TP512	00166	212257	189716	200986	11	200982	401964
6.0'	TP513	00116	152531	207426	179979	31	179975	359949
6.5'	TP514	00233	157821	181129	169475	14	169471	338941
7.0'	TP515	00046	106529	116189	111359	9	111355	222710
7.5'	TP516	00235	121249	116802	119026	4	119022	238044
8.0'	TP517	00009	117569	114886	116227	2	116223	232447
9.0'	TP518	00028	74634	85521	80078	14	80074	160147
10.0'	TP519	00117	22882	21962	22422	4	22418	44835
11.0'	TP520	00227	25028	30472	27750	20	27746	55492
12.0'	TP521	00052	29552	29169	29360	1	29356	58713
13.0'	TP522	00105	21578	27405	24492	24	24488	48976
14.0'	TP523	00003	25948	28325	27137	9	27133	54266
15.0'	TP524	00218	9924	9158	9541	8	9537	19074
16.0'	TP525	00245	61	95	78	43	74	147
17.0'	TP526	00169	27	28	28	4	24	47
18.0'	TP527	00210	19	21	20	9	16	32
19.0'	TP528	00049	9	16	13	56	9	18
20.0'	TP529	00253	19	20	20	6	16	31
21.0'	TP530	00090	27	36	31	27	27	55
22.0'	TP531	00101	29	14	21	71	17	35
23.0'	TP532	00216	32	27	30	17	26	52
24.0'	TP533	00024	33	29	31	14	27	54

Attachment F

Tank No.	106
String No.	6
Exposure Time (min)	32
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP601	00082	broken	97865	97865	n/a	97861	183489
0.5'	TP602	00098	67734	60680	64207	11	64203	120380
1.0'	TP603	00011	54546	68577	61562	23	61558	115421
1.5'	TP604	00094	50330	38522	44426	27	44422	83291
2.0'	TP605	00077	46113	47799	46956	4	46952	88035
2.5'	TP606	00037	26485	35686	31085	30	31081	58278
3.0'	TP607	00215	36989	36376	36682	2	36678	68772
3.5'	TP608	00095	25565	22038	23802	15	23798	44621
4.0'	TP609	00268	19815	27099	23457	31	23453	43974
4.5'	TP610	00097	16518	15981	16250	3	16246	30461
5.0'	TP611	00153	13988	19815	16901	34	16897	31683
5.5'	TP612	00032	22652	24415	23533	7	23529	44118
6.0'	TP613	00083	chip missing	chip missing	n/a	n/a	n/a	n/a
6.5'	TP614	00004	19508	31162	25335	46	25331	47496
7.0'	TP615	00110	20275	23878	22077	16	22073	41386
7.5'	TP616	00174	15751	23188	19470	38	19466	36499
8.0'	TP617	00002	19048	18588	18818	2	18814	35277
9.0'	TP618	00100	17285	15215	16250	13	16246	30461
10.0'	TP619	00164	1763	1344	1553	27	1549	2905
11.0'	TP620	00172	24	16	20	43	16	30
12.0'	TP621	00038	23	15	19	38	15	28
13.0'	TP622	00050	3	15	9	135	5	9
14.0'	TP623	00189	15	12	14	26	10	18
15.0'	TP624	00270	28	7	17	121	13	25
16.0'	TP625	00008	24	20	22	15	18	34
17.0'	TP626	00144	28	24	26	15	22	41
18.0'	TP627	00165	23	7	15	105	11	21
19.0'	TP628	00234	32	30	31	5	27	50
20.0'	TP629	00017	26	22	24	14	20	37
21.0'	TP630	00265	29	33	31	13	27	51
22.0'	TP631	00209	24	33	29	31	25	47
23.0'	TP632	00263	9	35	22	119	18	33
24.0'	TP633	00193	33	33	33	0	29	55

Attachment G

Tank No. 102
 String No. 7
 Exposure Time (min) 31
 Average Control Result (mR) 4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	n/a	162 missing	n/a	n/a	n/a	n/a	n/a	n/a
0.5'	TP701	00058	594	675	635	13	631	1221
1.0'	TP702	00207	499	557	528	11	524	1015
1.5'	TP703	00036	483	410	447	16	443	856
2.0'	TP704	00106	535	493	514	8	510	986
2.5'	TP705	00156	539	527	533	2	529	1024
3.0'	TP706	00078	551	490	521	12	517	1000
3.5'	TP707	00075	505	566	535	11	531	1029
4.0'	TP708	00080	482	585	533	19	529	1024
4.5'	TP709	00091	616	587	601	5	597	1156
5.0'	TP710	00152	655	534	594	20	590	1143
5.5'	TP711	00230	574	699	636	20	632	1224
6.0'	TP712	00272	775	581	678	29	674	1305
6.5'	TP713	00079	669	663	666	1	662	1282
7.0'	TP714	00022	596	694	645	15	641	1241
7.5'	TP715	00150	862	907	885	5	881	1705
8.0'	TP716	00034	860	1027	943	18	939	1818
9.0'	TP717	00118	854	1134	994	28	990	1916
10.0'	TP718	00246	831	898	864	8	860	1665
11.0'	TP719	00191	1190	1214	1202	2	1198	2319
12.0'	TP720	00221	1198	921	1060	26	1056	2043
13.0'	TP721	00205	1045	1115	1080	7	1076	2082
14.0'	TP722	00142	2636	3411	3023	26	3019	5844
15.0'	TP723	00016	2847	3168	3008	11	3004	5814
16.0'	TP724	00211	3030	3031	3030	0	3026	5857
17.0'	TP725	00065	2300	2529	2414	9	2410	4665
18.0'	TP726	00096	2389	2374	2381	1	2377	4601
19.0'	TP727	00224	1268	959	1114	28	1110	2148
20.0'	TP728	00005	27	46	36	51	32	62
21.0'	TP729	00030	23	30	27	26	23	44
22.0'	TP730	00238	13	32	22	88	18	36
23.0'	TP731	00163	26	39	32	38	28	55
24.0'	TP732	00054	25	34	29	32	25	49

Attachment H

Tank No.	108
String No.	8
Exposure Time (min)	30
Average Control Result (mR)	4

Data Identifiers			Exposure Results					
Location	Payroll ID	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)	Diff (%)	Net Exposure (mR)	Net Exposure Rate (mR/h)
0'	TP801	00241	10461	10921	10691	4	10687	21374
0.5'	TP802	00149	9694	9848	9771	2	9767	19534
1.0'	TP803	00140	5409	4459	4934	19	4930	9860
1.5'	TP804	00143	3532	4527	4030	25	4026	8051
2.0'	TP805	00214	2629	2748	2689	4	2685	5369
2.5'	TP806	00088	2969	3670	3320	21	3316	6631
3.0'	TP807	00155	1844	2047	1946	10	1942	3884
3.5'	TP808	00092	2283	2102	2192	8	2188	4377
4.0'	TP809	00145	1398	1518	1458	8	1454	2908
4.5'	TP810	00134	1873	2015	1944	7	1940	3880
5.0'	TP811	00064	1767	1851	1809	5	1805	3610
5.5'	TP812	00015	1075	1202	1138	11	1134	2269
6.0'	TP813	00136	1375	1578	1477	14	1473	2945
6.5'	TP814	00122	1542	1060	1301	37	1297	2594
7.0'	TP815	00051	1078	1215	1146	12	1142	2284
7.5'	TP816	00087	1337	1025	1181	26	1177	2353
8.0'	TP817	00086	1233	1478	1356	18	1352	2704
9.0'	TP818	00160	1389	1430	1409	3	1405	2811
10.0'	TP819	00006	1126	1608	1367	35	1363	2726
11.0'	TP820	00267	1101	1599	1350	37	1346	2692
12.0'	TP821	00223	1534	1654	1594	8	1590	3181
13.0'	TP822	00014	1397	1555	1476	11	1472	2944
14.0'	TP823	00251	1327	1396	1361	5	1357	2714
15.0'	TP824	00157	3968	4190	4079	5	4075	8150
16.0'	TP825	00039	1965	2517	2241	25	2237	4474
17.0'	TP826	00184	3729	5247	4488	34	4484	8968
18.0'	TP827	00021	6823	8161	7492	18	7488	14976
19.0'	TP828	00247	7492	8161	7826	9	7822	15645
20.0'	TP829	00203	4751	5257	5004	10	5000	10000
21.0'	TP830	00108	200	187	193	7	189	378
22.0'	TP831	00102	35	41	38	16	34	68
23.0'	TP832	00045	12	22	17	60	13	26
24.0'	TP833	00182	14	24	19	51	15	31

Attachment I

CONTROLS (unused packets)

Payroll	Packet ID	Chip A (mR)	Chip B (mR)	Average (mR)
TP901	00176	3	8	5
TP902	00266	11	2	6
TP903	00275	-4	-1	-3
TP904	00256	4	15	9
TP905	00113	11	9	10
TP906	00170	-1	3	1
TP907	00219	5	11	8
TP908	00239	-6	-2	-4
TP909	00131	-1	-1	-1
TP910	00240	11	9	10
TP911	00099	-4	11	3
	Avg	3	6	4.1

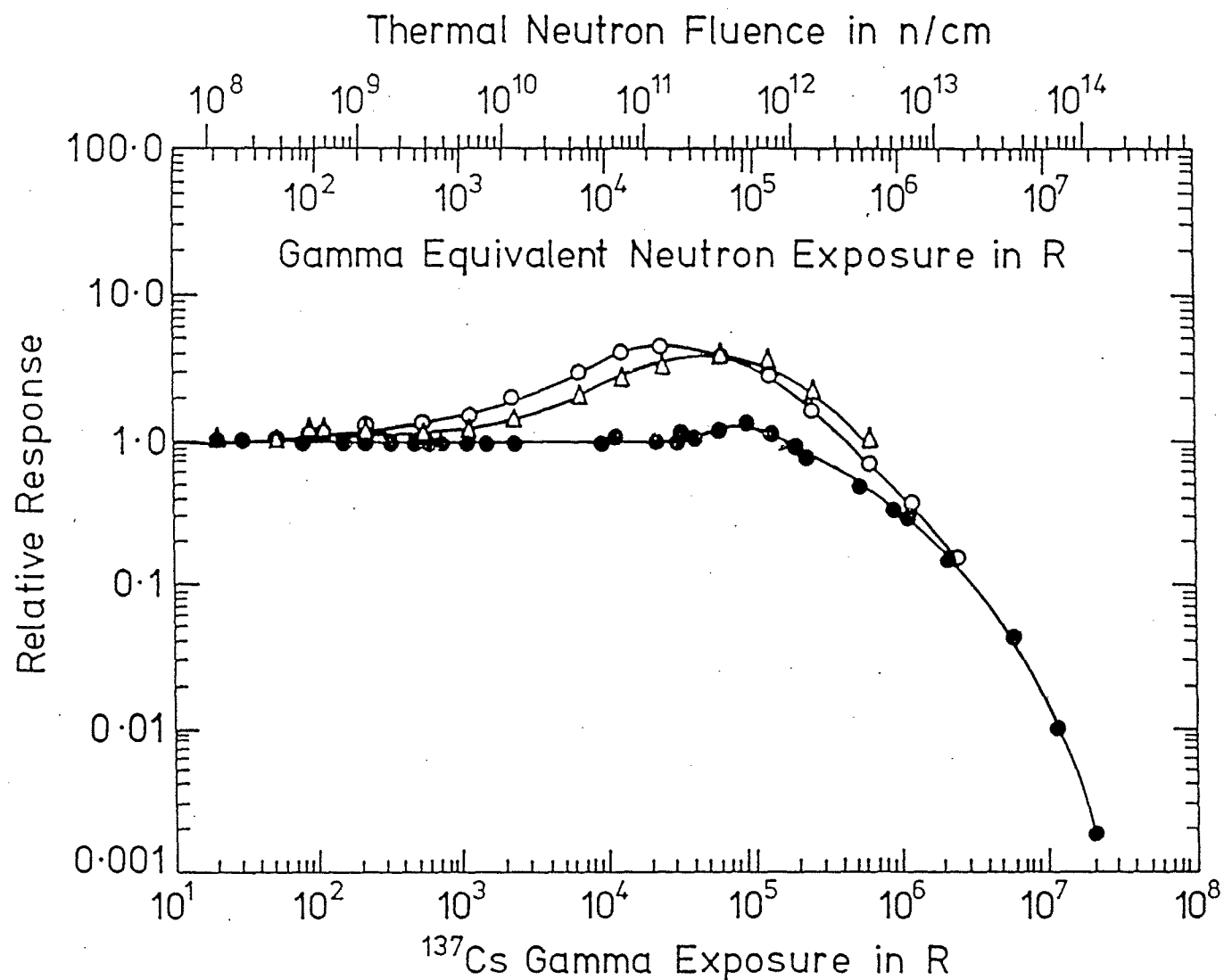
Attachment J

READER CALIBRATION FOR 324 VAULT TLD STRINGS

CHECKS (100 mR)			BLANKS (0 mR)		
Seq. No.	Payroll	nC	Seq. No.	Payroll	nC
80854084	CK084	14.500	80854097	BL097	0.695
80854086	CL086	14.400	80854103	BK103	0.648
80854092	CL092	14.400	80854087	BL087	0.625
80854096	CL096	13.900	80854089	BL089	0.610
80854088	CL088	13.801	80854099	BL099	0.604
80854100	CL100	13.601	80854085	BK085	0.603
80854105	CK105	13.601	80854095	BL095	0.594
80854098	CL098	13.400	80854091	BL091	0.573
80854094	CL094	12.900	80854093	BL093	0.542
80854090	CL090	11.900	80854101	BL101	0.487
	avg	13.640		avg	0.598
	%std	5.795		%std	9.481
	n	10		n	10

net response (nC/mR) = 0.1304

calibration factor (mR/nC) = 7.667



Attachment K

Figure 12.5. The variation with exposure of the relative responses of TLD 600 and TLD 700 to neutron and gamma irradiations. ●, neutron response TLD 600; ○, gamma response TLD 600; △, gamma response TLD 700 (after [70]).