ALARA Dosimetry Study for Non Productive Radiation Exposures in Pacific Northwest Laboratory Facilities

D. E. Hadlock

April 1981

**Prepared for
Richland Operations Office
Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The views, opinions and conclusions contained in this report are those of the contractor and do not necessarily represent those of the United States Government or the United States Department of Energy.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
Under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy \$_____*; Microfiche \$3.00

*Pages	NTIS
	Selling Price
001-025	\$4.00
026-050	\$4.50
051-075	\$5.25
076-100	\$6.00
101-125	\$6.50
126-150	\$7.25
151-175	\$8.00
176-200	\$9.00
201-225	\$9.25
226-250	\$9.50
251-275	\$10.75
276-300	\$11.00

ALARA DOSIMETRY STUDY
FOR NON PRODUCTIVE RADIATION
EXPOSURES IN PACIFIC NORTHWEST
LABORATORY FACILITIES

D. E. Hadlock

April 1981

Prepared for
Richland Operations Office
Department of Energy
under Contract DE-ACC6-76RLO-1830

Pacific Northwest Laboratory
Richland, Washington 99352

INTRODUCTION

A special ALARA study was conducted during 1980 in selected Pacific Northwest Laboratory facilities. The study utilized thermoluminescent dosimeters (TLDs) which were designed to detect gamma, beta, and neutron exposures;⁽¹⁾ however, only gamma exposures are evaluated in this report. The processing of ALARA (As Low As Reasonably Achievable) dosimeters was performed by the Dosimetry Technology Section of the Radiological Sciences Department. Evaluation of dosimetry data and locations was performed in conjunction with the Radiation Monitoring Section and the Radiological Safety and Engineering Section of the Occupational and Environmental Protection Department.

This study was prompted by a DOE-RL directive to reduce radiation exposure to As Low As Reasonably Achievable (ALARA) with a goal of no personnel whole-body penetrating exposures exceeding 3 rem for calendar year 1980. In the past, methods have been devised to reduce the occupational exposure to the worker but little has been done to reduce the non productive exposure. The purpose of this study was to characterize the background radiation environment at selected locations within PNL facilities. Attention was focused on non productive radiation exposure received from the work environment.

DOSIMETER

The ALARA dosimeter utilized during the study consisted of a hard plastic cylindrical holder containing 5 TLDs. The cylinder was 4 inches long with a diameter of 5/8-inch and a 1/16-inch wall thickness. An inner cylindrical vial was utilized to hold the TLDs and also to provide a barrier against contamination. A tantalum foil, 11/1000-inch thick, was incorporated inside the holder to provide filtering for 3 of the TLDs. The holders were color coded for ease of identification at the time of dosimeter exchange.

(1) All exposures in this report are in terms of mR.

Five TLDs were placed end to end along the axis of the cylindrical holder so that they were all in the same plane. Three types of TLDs were utilized, one TLD-400, two TLD-600s, and two TLD-700s. The TLD-400 was a $\text{CaF}_2\text{-Mn}$ phosphor and the TLD-600s and TLD-700s were LiF phosphors with a composition as summarized below:

<u>Isotope</u>	<u>TLD-600</u>	<u>TLD-700</u>
^6Li	95.6%	0.01%
^7Li	4.4%	99.99%

A combination of TLD-400s, TLD-600s, and TLD-700s were utilized to measure a mixed field of penetrating, non penetrating, and neutron fluxes. Data was collected for the three types of exposures but only the penetrating contribution was studied in depth. The non penetrating and neutron contributions were found to be negligible compared to the penetrating contribution. The tantalum filter was incorporated over one TLD-400, one TLD-600, and one TLD-700 giving these TLDs a lower photon energy sensitivity of 60 keV. The unfiltered TLD-600 and TLD-700 had a lower photon energy sensitivity of 30 keV. From the calibration constants and the fluxes for each position, the values of penetrating (beta-gamma), non penetrating, thermal neutron, and fast neutron exposures were determined.

PROGRAM

A program to characterize the non productive background radiation environment in selected PNL facilities was implemented on December 29, 1979 and completed on January 15, 1981. The program entailed placing TLDs at various locations within these facilities to measure background radiation. Fifty-two locations were utilized as shown in Appendix A. The processed TLD data was then analyzed from an ALARA viewpoint to see if further investigation was necessary.

A cylindrical TLD holder, as described earlier, was suspended at each of the 52 locations. The holders were positioned 6-1/2 to 7 feet above the floor so as not to interfere with normal worker traffic. In addition, the holders were placed as far away from walls and other surfaces as possible to minimize scattering contributions. Two additional locations were supplied with TLD units as a control mechanism. The first was located in the second floor office spaces of the 318 building

(300 area). The other was located in a lead brick shielded safe for the Dosimetry Technology Section of the Radiological Sciences Department at the 3717 building (300 area).

The TLDs were exchanged every other month within the first three working days. The Radiation Monitoring Section of the Occupational and Environmental Protection Department had the responsibility for exchanging dosimeters and ensuring that they were free of contamination and properly located. The bimonthly dosimeters were then processed by the Dosimetry Technology Section with the data tabulated in Appendix B as total milliroentgens (mR) for the period of exposure. The six bimonthly mR values were then totaled for the year. An average mR/hr value was determined for each location based on a 384-day period (9216 hours).⁽²⁾

The purpose of the ALARA study was to determine if non productive radiation exposure was contributing unnecessarily to the doses received by PNL staff members. It was determined that exposures in excess of 5% of the 5 rem per year occupational exposure limit would be investigated. A one-to-one correlation between rem and roentgen (R) was utilized assuming the energy spectra of the radiation measured allowed this. Thus, a value greater than 250 mR for the calendar year was to be designated for further investigation. A 50-week working year with 40 working hours per week was used giving a total of 2000 working hours per calendar year for a typical worker. An average exposure rate of 0.125 mR/hr was thus determined based on the above data. The value of 0.125 mR/hr was compared against the dosimeter data collected and tabulated in Appendices B and C. Two locations with an average exposure rate in excess of 0.125 mR/hr were identified. The locations were the first floor men's change room in the 331 building (300 area) and the hallway outside labs 410 and 411 in the 325 building (300 area).

The average exposure rate of 0.225 mR/hr in the 331 building men's room (location No. 19) has been identified in the past as a source of non productive exposure.⁽³⁾ However, due to the length of the time since

(2) A 326-day period (7824 hours) was used for locations 27-30. This was based on the fact that the dosimeter package for the last bimonthly period was incomplete and data could not be obtained for these locations.

(3) A continuing study has been underway for the last two years by D. W. Murphy of the Dosimetry Technology Section.

the problem was discovered, with no apparent solutions at hand, further study and corrective measures are suggested.

The 410 lab area of the 325 building has also been recognized as an exposure problem area for some time. Not only does it contribute occupational exposure to personnel working in the area but it also contributes non productive exposure to other areas such as the adjacent hallway. The average exposure rate of 0.372 mR/hr in the hallway (location No. 33) suggests this conclusion. The hallway adjacent to lab 410 is heavily traveled and it is not uncommon for staff members to congregate there. Thus, the possibility of receiving significant non productive exposures at this location is probable and further investigation is warranted.

CONCLUSIONS

The areas evaluated by this study, other than the two locations identified previously, were found to be below the 0.125 mR/hr investigation level derived within this document. However, location No. 30 in the corridor outside lab 604 of the 325 building may warrant some additional investigation. The average exposure rate at this location was 0.113 mR/hr. It was noted that 83% of the locations had average exposure rates below 0.05 mR/hr. In the view of this investigator, these levels are well within the scope of a good ALARA program.

It is recommended that non productive exposure rates present in the 331 building men's change room and the hallway adjacent to lab 410 in the 325 building be further investigated. In addition, if these exposure rates (0.225 mR/hr and 0.372 mR/hr) are substantiated, it is recommended that corrective actions be taken to reduce them to ALARA.

APPENDIX A
ALARA Dosimeter Locations

TABLE A-1. ALARA Dosimeter Locations

<u>LOCATION NUMBER</u>	<u>BUILDING</u>	<u>LOCATION DESCRIPTION</u>
1	3720	room # 131
2	3720	room # 156
3	314	room # 100
4	314	room # 21
5	314	room # 20
6	314	shop
7	331	room # 329
8	331	room # 376
9	331	in hall outside room # 317
10	331	room # 304
11	331	room # 173
12	331	room # 305
13	331	room # 309-A
14	331	room # 356
15	331	room # 361-A
16	331	room # 355
17	331	room # 177
18	331	room # 179
19	331	first floor mens change room
20	331	room # 120
21	331	room # 121
22	331	room # 168
23	331	in hall outside room # 110
24	331	room # 102-A
25	331	room # 169
26	329	in hall outside room # 7-A
27	329	in hall outside room # 5-A
28	329	in hall outside room # 1-B
29	325	in hall outside room #'s 516,517
30	325	in hall outside room #'s 516,604
31	325	in hall outside room #'s 500,501
32	325	in hall outside room # 118
33	325	in hall outside room #'s 410,411
34	324	control room (west)
35	324	control room (east)
36	324	in hall outside room # 211
37	324	canyon;tank pit # 5
38	324	canyon;tank pit # 1
39	324	in hall outside room # 115
40	320	in hall outside room # B-3
41	320	room # B-16
42	320	in hall outside room # 107
43	320	room # 112
44	209-E	control room
45	231-Z	in corridor "D" outside room # 34
46	324	in room # 244 next to "D" cell
47	EDL	in bay area outside room # 107
48	PSL	room # 241
49	PSL	room # 1622
50	LSL-II	room # 1412
51	231-Z	room # 7
52	331	in hall outside room # 103

3720 BUILDING

314 BUILDING

FIRST FLOOR

MEZZANINE

331 BUILDING
THIRD FLOOR

329 BUILDING
FIRST FLOOR

331 BUILDING

FIRST FLOOR

FIRST FLOOR

324 BUILDING

FIRST FLOOR

SECOND FLOOR

THIRD FLOOR

320 BUILDING

FIRST FLOOR

BASEMENT

ENERGY DEVELOPMENT LAB (EDL)
FIRST FLOOR

209-E BUILDING

231-Z BUILDING

PHYSICAL SCIENCES BUILDING (PSL)

BASEMENT

PHYSICAL SCIENCES BUILDING (PSL)

FIRST FLOOR

FIRST FLOOR

APPENDIX B
ALARA Dosimeter Data

TABLE B-1. ALARA Dosimeter Data

LOC.	JAN. FEB.	MARCH APRIL	MAY JUNE	JULY AUGUST	SEPT. OCT.	NOV. DEC.	TOTAL mR	AVG. mR/hr
01	12.2	40.2	27.8	29.5	23.9	25.0	158.6	0.017
02	33.6	15.4	15.0	14.9	15.0	15.6	109.5	0.012
03	16.0	15.2	23.3	15.0	14.3	16.0	99.8	0.011
04	14.4	15.5	14.8	15.5	15.5	16.6	92.3	0.010
05	14.1	14.5	14.6	14.5	14.5	16.1	88.3	0.009
06	15.8	16.7	17.7	17.1	15.4	17.5	100.2	0.011
07	14.1	22.2	24.7	23.6	22.9	25.7	133.2	0.014
08	70.8	17.6	19.4	19.0	19.6	20.9	167.3	0.018
09	178.7	16.6	17.8	17.5	17.1	17.8	265.5	0.029
10	14.5	14.7	15.7	15.2	15.6	16.5	92.2	0.010
11	15.2	77.7	84.6	66.8	61.7	64.7	370.7	0.040
12	22.0	13.6	15.3	14.3	15.7	16.3	97.2	0.010
13	15.1	13.4	14.7	13.7	14.7	14.8	86.4	0.009
14	18.2	14.6	15.6	15.1	14.8	16.5	94.8	0.010
15	187.9	14.5	15.0	16.1	15.1	17.2	265.8	0.029
16	20.8	26.8	26.3	26.3	25.0	26.0	151.2	0.016
17	30.8	78.7	84.8	71.3	59.4	59.5	384.5	0.041
18	28.6	34.6	37.3	37.2	27.7	29.8	195.2	0.021
19	144.4	582.6	445.6	361.7	274.2	283.2	2091.7	0.225
20	49.8	16.3	19.7	17.2	19.2	20.2	142.4	0.015
21	79.7	14.8	16.4	16.3	15.7	17.1	160.0	0.017
22	601.7	17.0	18.7	19.1	19.5	18.6	694.6	0.075
23	59.3	58.4	21.5	22.0	19.1	24.5	204.8	0.022
24	16.4	18.2	15.6	15.5	15.8	16.1	97.6	0.010
25	15.1	16.3	19.9	19.6	16.3	17.3	104.5	0.011
26	19.0	17.8	22.1	24.3	27.7	28.0	138.9	0.015
27	14.8	16.2	15.7	20.7	23.8	----	91.2	0.012
28	76.3	17.6	16.9	17.5	23.2	----	151.5	0.019
29	77.7	82.1	95.9	134.3	160.2	----	550.2	0.071
30	579.4	65.3	67.4	78.1	94.8	----	885.0	0.113
31	28.4	60.8	53.3	45.4	45.8	53.6	287.3	0.031
32	15.8	147.4	143.4	193.7	135.4	145.1	780.8	0.084
33	13.4	631.0	635.7	690.1	700.1	795.3	3465.6	0.372
34	14.9	25.8	24.0	17.2	26.9	19.9	128.7	0.014
35	77.9	23.0	23.2	16.4	22.6	19.7	182.8	0.020
36	17.7	20.2	23.6	17.8	16.2	17.7	113.2	0.012
37	20.3	14.1	16.2	13.4	14.2	14.6	92.8	0.010
38	29.9	23.7	26.7	14.5	12.2	13.2	120.2	0.013
39	14.3	18.4	22.3	18.2	16.9	17.7	107.8	0.012
40	13.7	14.1	14.9	15.8	16.0	16.9	91.4	0.010
41	17.9	16.3	17.3	17.2	18.5	19.1	106.3	0.011
42	20.4	149.0	78.9	92.9	189.7	43.3	574.2	0.062
43	15.5	203.6	98.9	45.6	80.8	40.2	484.6	0.052
44	14.2	12.5	14.4	14.0	13.1	13.9	82.1	0.009
45	12.6	17.2	18.9	18.0	19.0	19.0	104.7	0.011
46	13.2	138.8	150.8	170.3	119.8	119.0	711.3	0.076
47	19.6	14.0	16.2	15.3	16.5	15.7	97.3	0.010
48	39.3	35.6	39.8	38.6	39.0	39.6	231.9	0.025
49	16.0	17.2	17.1	15.5	17.1	18.6	101.5	0.011
50	31.0	37.8	50.1	38.3	40.5	37.3	235.0	0.025
51	14.6	27.7	29.7	28.2	30.0	27.5	157.7	0.017
52	41.5	17.8	19.1	20.9	19.6	20.3	139.2	0.015

APPENDIX C

ALARA Dosimeter Location vs. Average mR/hr

FIGURE C-1. ALARA Dosimeter Location vs. Average mR/hr

DISTRIBUTION

No. of
Copies

OFFSITE

A.A. Churm
DOE Chicago Patent Division
9800 South Cass Avenue
Argonne, IL 60439

- 27 DOE Technical Information
Center
Oak Ridge, TN

ONSITE

- 3 DOE-Richland Operations Office

GR Yesberger
JL Rhoades
HE Ransom

- 28 Pacific Northwest Laboratory

GE Backman
JR Berry
LC Carrick
FN Eichner
GWR Endres
LG Faust
WA Glass
DE Hadlock
DP Higby
JD Hudspeth
JJ Jech
RL Kathren
HV Larsen
MW Leale
JB Martin (5)
ED McFall
AP Mileham
DW Murphy
NP Nisick
EE Oscarson
CD Pringle
CR Richey
RC Schrotke
RP Shaw
VW Thomas
Technical Information (5)
Publishing Coordination (2)