PNL-8308
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PNL--8308
DE93 003114

CHARACTERIZATION OF RADIATION
ENVIRONMENTS AT SELECTED PACIFIC
NORTHWEST LABORATORY FACILITIES

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October 1992

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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MASTER

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SUMMARY

Pacific Northwest Laboratory (PNL) conducted a study from December 15, 1990, to December 15, 1991, to characterize the radiation environments at selected locations within PNL facilities. Thermoluminescent dosimeters were placed at 72 locations to measure non-productive radiation exposure to identify areas in which continuous occupation by a staff member would expose the staff member to radiation exceeding the 100 mrem/yr limit. The areas measured were found to be below the 0.05 mR/hr limit with the exception of three locations. At these three locations above the limit, radiation exposure was reduced by changing office locations and by additional shielding around radiation sources. Evaluations are recommended to determine the causes of elevated exposure rate readings.

CONTENTS

SUMMARY	iii
INTRODUCTION	1
METHOD	1
SHIELDED ANALYTICAL LABORATORY	3
327 BUILDING	3
329 BUILDING	3
CONCLUSIONS	4
REFERENCES	4
APPENDIX A - DOSIMETER PLACEMENT	A.1
APPENDIX B - DOSIMETER LOCATIONS	B.1
APPENDIX C - DOSIMETER LOCATIONS BY BUILDING	C.1
APPENDIX D - DOSIMETER RESULTS	D.1

INTRODUCTION

A special ALARA study was conducted from December 15, 1990, to December 15, 1991, in selected Pacific Northwest Laboratory (PNL)^(a) facilities. This study was prompted by Department of Energy (DOE) "good-practices" manual PNL-6577, *Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)*. The objectives of this study were to characterize the radiation environments at selected locations within PNL facilities and to locate areas in which continuous occupation by a staff member would expose the staff member to radiation exceeding 100 mrem/yr.

Staff members at PNL facilities should not be needlessly exposed to radiation. DOE 5480.11, Section 8.k. defines a dose limit of 100 mrem/yr for non-radiation workers. Staff members should not be exposed above this limit when not actively working with radioactivity. For the purpose of this study, any exposure which meets this criterion is defined as non-productive radiation exposure.

A previous non-productive radiation study was conducted in 1980 by PNL (Hadlock 1981). The criterion used for that study was 250 mR/yr based on 5% of the 5 rem annual dose limit. The areas investigated in that study were different from the ones investigated in this study due to differences in operations over the last 10 years.

METHOD

The study used thermoluminescent dosimeters (TLDs) that were designed to detect gamma exposure. The processing of these dosimeters was performed by the Instrumentation and External Dosimetry Section of the Health Physics Department. Evaluation of dosimetry data was performed by the Radiation Protection Section of the Laboratory Safety Department.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

The TLDs were placed at selected locations within PNL facilities to measure non-productive radiation exposure. Sixty nine locations were selected because of proximity to radiation sources. These locations were areas where work with radioactive materials was not part of the work done in those locations. Three additional locations were added midway through the study to obtain additional radiation exposure characterization data. The 72 locations are shown in Appendix A. Appendix B is a list of these locations. Appendix C arranges the locations by building.

Two different types of TLDs (TLD-200 and TLD-700) were used to measure the exposure at each location. The TLD-200 is a $\text{CaF}_2:\text{Dy}$ phosphor sensitive to beta/gamma radiation. The TLD-700 is a ^7LiF phosphor sensitive to gamma radiation. The TLD-200 is more sensitive over a wider range of energies than is the TLD-700. The beta component of the radiation fields to which the dosimeter was exposed was shielded out by wrapping the dosimeter in aluminum foil.

The TLDs were put into soft plastic holders and placed on office walls facing radiation sources. The dosimeters were changed each quarter.

Background dose (as determined from Hanford environmental TLDs) from natural sources was subtracted from each result because exposure from materials in the workplace was the primary concern. The calendar quarterly and annual average exposure rates, in units of mR/hr, were based on a 365 day period. This data is shown in Appendix D.

The main purpose of this 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 which could lead to exceeding the 100 mrem/yr limit would be investigated. This limits exposure rates to 0.05 mR/hr in the areas studied. This number was derived from the DOE limit of 100 mrem/yr divided by 2000 work hours per year. Based on first and second quarter results, three locations with an average exposure rate greater than 0.05 mR/hr were identified. These locations were the Shielded Analytical Laboratory (SAL) gallery area in the 325 Building (this area was used as an

office and as a hot cell gallery), Room 18A in the 327 Building [the Radiation Protection Technician (RPT) office], and Room 2 in the 329 facility (this was an office next door to a radioactive materials storage facility).

SHIELDED ANALYTICAL LABORATORY

The exposure rate in the SAL averaged 0.215 mR/hr. The source of the radiation is "shine" from the materials contained in the hot cells. This rate could expose an individual who continuously occupied the area to a dose of 430 mrem/yr. Based on this information from the study, the SAL office was changed from the gallery area to Room 104.

327 BUILDING

The exposure rate in Room 18A in the 327 Building averaged 0.315 mR/hr. The source of this exposure is "shine" from materials in the hot cells located near Room 18A. This rate could expose an individual who continuously occupied the area to a dose of 630 mrem/yr. The RPT office was relocated to Room 10, and dosimeters were placed in Room 10 and on the chair used in Room 18A. These additional locations were studied for two quarters. The measured exposure rate at the chair in Room 18A agreed with that measured along the wall facing the cell area. The exposure rate in Room 10 averaged 0.016 mR/hr, 95% lower than that measured in Room 18A.

329 BUILDING

The exposure rate in Room 2 of the 329 facility averaged 0.058 mR/hr. This rate could expose any individual continuously occupying the area to a dose of 116 mrem/yr. An investigation of the cause of the elevated radiation readings concluded that the source was a gamma radiation source stored in Room 1. The source was covered with additional shielding, which reduced the

exposure rate in Room 2 from 0.064 mR/hr in the first two quarters of the study to 0.052 mR/hr in the final two quarters of the study. A dosimeter was placed in Room 2A of the 329 Building upon request of the occupant of that lab. The average exposure rate recorded by this dosimeter was 0.047 mR/hr. Additional investigation should be done to determine the cause of the elevated exposure rates, and measures should be taken to reduce it to less than 0.05 mR/hr in Room 2.

CONCLUSIONS

The areas evaluated by this study, with the exception of the three previously described locations, were found to be below the 0.05 mR/hr limit defined in this document. Ninety-five percent of all locations were well below the 0.05 mR/hr limit. Fifty percent of the locations studied had exposure rates of 0.01 mR/hr or less (this equals a dose of 20 mrem/yr). These levels are well within the scope of a good ALARA program.

Further study is recommended for non-productive exposure rates present in Room 2 of the 329 Building. Other areas which showed elevated exposure rate readings were Rooms 600 and 712 in the 325 Building and Room 2A in the 329 Building. Investigations should be done to determine the causes of these elevated exposure rates and, if practical, measures should be taken to reduce them.

REFERENCES

Hadlock, D. E. 1988. "ALARA Dosimetry Study for Non Productive Radiation Exposures in Pacific Northwest Laboratory Facilities." PNL-3834, Pacific Northwest Laboratory, Richland, Washington.

Munson, L. H., S. E. Merwin, G. A. Stoetzel, and W. N. Herrington. 1988. "Health Physics Manual of Good Practices for Reducing Radiation Exposure to Levels that are As Low As Reasonably Achievable (ALARA)." PNL-6577, Pacific Northwest Laboratory, Richland, Washington.

U.S. Department of Energy (DOE). 1988. "Radiation Protection for Occupational Workers." DOE 5480.11, Washington, D.C.

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APPENDIX A

DOSIMETER PLACEMENT

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FIRST FLOOR PLAN

305-B BLDG

SECOND FLOOR PLAN

FIRST FLOOR PLAN

306-W BLDG

FIRST FLOOR

314 BLDG

FIRST FLOOR PLAN

318 BLDG

02

SECOND FLOOR PLAN

318 BLDG

9

70

FIRST FLOOR PLAN
320 BLDG

10

11

323 BLDG

ND

SECOND FLOOR PLAN

324 BLDG

THIRD FLOOR PLAN

FIRST FLOOR PLAN

325 BLDG

FIRST FLOOR PLAN
326 BLDG

SECOND FLOOR PLAN

326 BLDG

31

07

32

BASMENT FLOOR PLAN

326 BLDG

THIRD FLOOR PLAN
331 BLDG

FIRST FLOOR PLAN
331 BLDG

THIRD FLOOR PLAN

337 BLDG

43

3708 BLDG

3730 BLDG

FIRST FLOOR PLAN

3745 BLDG

3746 BLDG

17

622-R BLDG

01

6652-H BLDG

20

747-A BLDG

17

6TH ST WAREHOUSE & GAS STATION

BASEMENT

PSL

APPENDIX B

DOSIMETER LOCATIONS

APPENDIX B

DOSIMETER LOCATIONS

<u>Location Number</u>	<u>Building</u>	<u>Location Description</u>
1	305B	Room 2
2	306W	Room 120
3	306W	Room 229
4	314	Room 5
5	314	Room 25
6	318	Room 126
7	318	Room 129
8	318	Room 122
9	318	Room 202
10	320	Room 108
11	323	Room 2
12	324	Room 310 - Control Room - west side
13	324	Room 310 - Control Room - east side
14	324	Room 232
15	324	Room 301
16	324	Room 125
17	324	Room 235
18	324	Room 120
19	324	Room 112
20	324	Room 129
21	325	Room 600
22	325	Room 25
23	325	Shielded Analytical Laboratory
24	325	Room 105
25	325	Room 711
26	325	Room 116
27	325	Room 19
28	326	Room 14B

<u>Location Number</u>	<u>Building</u>	<u>Location Description</u>
29	326	Room 16B
30	326	Room 38B
31	326	Room 38C
32	326	Room 3A
33	327	Room 18A
34	327	Room 1
35	327	Room 8
36	329	Room 2
37	329	Room 14
38	329	Room 17C
39	331	Room 365A
40	331	Room 113
41	331	Room 310A
42	331	Room 11B
43	337	Room 3112
44	3708	Room 111
45	3720	Room 331
46	3720	Room 225
47	3720	Room 10
48	3730	Room 1
49	3745	Room 7
50	3745B	Room 1
51	3746	Room 3
52	622R	Room 110
53	6652H	Room 304
54	747A	Room 8
55	6th St. Warehouse	Room 2
56	ESB	Room 2
57	ESB	Room 25
58	LSL II	Room 1207
59	LSL II	Room 1101
60	LSL II	Room 1328
61	LSL II	Room 1519

<u>Location Number</u>	<u>Building</u>	<u>Location Description</u>
62	PSL	Room 604
63	PSL	Room 511
64	PSL	Room 420
65	PSL	Room 1315
66	PSL	Room 1626
67	RTL	Room 233
68	RTL	Room 135
69	RTL	Room 433
70	327	Room 18A - chair
71	327	Room 10
72	329	Room 2A

APPENDIX C

DOSIMETER LOCATIONS BY BUILDING

APPENDIX C

DOSIMETER LOCATIONS BY BUILDING

<u>Building</u>	<u>Location Number</u>	<u>Location Description</u>
305B	1	Room 2
306W	2	Room 120
306W	3	Room 229
314	4	Room 5
314	5	Room 25
318	8	Room 122
318	6	Room 126
318	7	Room 129
318	9	Room 202
320	10	Room 108
323	11	Room 2
324	19	Room 112
324	18	Room 120
324	16	Room 125
324	20	Room 129
324	14	Room 232
324	17	Room 235
324	15	Room 301
324	13	Room 310 - Control Room - east side
324	12	Room 310 - Control Room - west side
325	27	Room 19
325	22	Room 25
325	24	Room 105
325	26	Room 116
325	25	Room 711
325	21	Room 600
325	23	Shielded Analytical Laboratory
326	32	Room 3A

<u>Building</u>	<u>Location Number</u>	<u>Location Description</u>
326	28	Room 14B
326	29	Room 16B
326	30	Room 38B
326	31	Room 38C
327	34	Room 1
327	35	Room 8
327	71	Room 10
327	33	Room 18A
329	72	Room 2A
329	38	Room 17C
331	42	Room 11B
337	43	Room 3112
622R	52	Room 110
747A	54	Room 8
3708	44	Room 111
3720	47	Room 10
3720	46	Room 225
3720	45	Room 331
3730	48	Room 1
3745	49	Room 7
3745B	50	Room 1
3746A	51	Room 3
6652H	53	Room 304
6th St. Warehouse	55	Room 2
ESB	56	Room 2
ESB	57	Room 25
LSL II	59	Room 1101
LSL II	58	Room 1207
LSL II	60	Room 1328
LSL II	61	Room 1519
PSL	64	Room 420
PSL	63	Room 511
PSL	62	Room 604

<u>Building</u>	<u>Location Number</u>	<u>Location Description</u>
PSL	65	Room 1315
PSL	66	Room 1626
RTL	68	Room 135
RTL	67	Room 233
RTL	69	Room 433

APPENDIX D

DOSIMETER RESULTS

APPENDIX D

DOSIMETER RESULTS

<u>Location Number</u>	<u>First Quarter Results (mR/hr)</u>	<u>Second Quarter Results (mR/hr)</u>	<u>Third Quarter Results (mR/hr)</u>	<u>Fourth Quarter Results (mR/hr)</u>	<u>Average for Year (mR/hr)</u>
1	0.013	0.018	0.013	0.013	0.014
2	0.017	0.018	0.017	0.018	0.018
3	0.025	0.030	0.023	0.028	0.027
4	0.009	0.010	0.010	0.011	0.010
5	0.011	0.011	0.011	0.012	0.011
6	0.010	0.008	0.009	0.009	0.009
7	0.008	0.008	0.009	0.009	0.009
8	0.009	0.009	0.020	0.012	0.013
9	0.010	0.010	0.011	0.010	0.010
10	0.010	0.009	0.009	0.011	0.010
11	0.008	0.014	0.009	0.011	0.011
12	0.012	0.008	0.012	0.012	0.011
13	0.011	0.011	0.014	0.016	0.013
14	0.010	0.009	0.010	0.010	0.010
15	0.009	0.0009	0.010	0.012	0.010
16	0.009	0.008	0.010	0.012	0.010
17	0.011	0.012	0.012	0.011	0.012
18	0.011	0.010	0.011	0.010	0.011
19	0.015	0.013	0.013	0.015	0.014
20	0.012	0.030	0.025	0.038	0.033
21	0.029	0.034	0.030	0.038	0.033
22	0.010	0.010	0.010	0.010	0.010
23	0.105	0.268	0.198	0.288	0.215
24	0.013	0.015	0.015	0.015	0.015
25	0.018	0.026	0.027	0.058	0.032
26	0.013	0.014	0.014	0.018	0.015

<u>Location Number</u>	<u>First Quarter Results (mR/hr)</u>	<u>Second Quarter Results (mR/hr)</u>	<u>Third Quarter Results (mR/hr)</u>	<u>Fourth Quarter Results (mR/hr)</u>	<u>Average for Year (mR/hr)</u>
27	0.013	0.010	0.015	0.015	0.013
28	0.018	0.018	0.022	0.028	0.022
29	0.008	0.008	0.009	0.023	0.022
30	0.021	0.023	0.019	0.012	0.011
31	0.009	0.010	0.011	0.012	0.011
32	0.008	0.010	0.009	0.009	0.009
33	0.267	0.368	0.263	0.362	0.315
34	0.013	0.014	0.016	0.012	0.014
35	0.029	0.023	0.025	0.022	0.025
36	0.067	0.061	0.045	0.059	0.058
37	0.008	0.008	0.008	0.008	0.008
38	0.009	0.008	0.009	0.009	0.009
39	0.009	0.009	0.010	0.010	0.010
40	0.008	0.009	0.010	0.010	0.009
41	0.008	0.008	0.009	0.009	0.009
42	0.008	0.008	0.009	0.009	0.009
43	0.010	0.009	0.009	0.012	0.010
44	0.009	0.009	0.009	0.009	0.009
45	0.008	0.008	0.010	0.009	0.009
46	0.009	0.008	0.009	0.008	0.009
47	0.010	0.010	0.011	0.010	0.010
48	0.013	0.013	0.012	0.012	0.013
49	0.008	0.008	0.009	0.011	0.009
50	0.010	0.010	0.009	0.010	0.010
51	0.008	0.009	0.008	0.010	0.009
52	0.014	0.012	0.012	0.015	0.013
53	0.009	0.009	0.009	0.010	0.009
54	0.008	0.008	0.008	0.009	0.008
55	0.011	0.010	0.010	0.011	0.011
56	0.008	0.009	0.009	0.009	0.009
57	0.010	0.011	0.011	0.011	0.011

<u>Location Number</u>	<u>First Quarter Results (mR/hr)</u>	<u>Second Quarter Results (mR/hr)</u>	<u>Third Quarter Results (mR/hr)</u>	<u>Fourth Quarter Results (mR/hr)</u>	<u>Average for Year (mR/hr)</u>
58	0.010	0.010	0.010	0.011	0.010
59	0.009	0.009	0.009	0.010	0.009
60	0.009	0.009	0.010	0.011	0.010
61	0.018	0.018	0.019	0.020	0.019
62	0.009	0.009	0.010	0.010	0.010
63	0.010	0.009	0.010	0.010	0.010
64	0.009	0.009	0.010	0.010	0.010
65	0.009	0.010	0.010	0.010	0.010
66	0.010	0.010	0.010	0.011	0.010
67	0.009	0.009	0.010	0.010	0.010
68	0.011	0.010	0.010	0.011	0.011
69	0.010	0.009	0.010	0.010	0.010
70	NA	NA	0.158	0.247	0.203
71	NA	NA	0.014	0.017	0.016
72	NA	NA	0.050	0.044	0.047

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