U.S. NUCLEAR REGULATORY COMMISSION
REGION I
INSPECTION REPORT

Report No. 030-19963/92-001

Docket No. 030-19963

License No. 37-05680-04 Priority 3 Category E

Licensee: The Budd Company
2450 Hunting Park Avenue
Philadelphia, Pennsylvania 19132

Facility Name: Budd Company

Inspection At: Hot Cell Facility
X-ray Building
2950 Roberts Avenue
Philadelphia, Pennsylvania

Inspection Conducted: May 26 and 27, 1992

Review of Final Survey Report Completed: October 30, 1992

Inspectors: Mark C. Roberts 11/23/92
Mark C. Roberts date
Senior Health Physicist

James M. Bondick 11/23/92
James M. Bondick date
Health Physicist

Approved by: John D. Kinneman 12-22-92
John D. Kinneman, Chief date
Research, Development and Decommissioning Section

Inspection Summary: Closeout inspection conducted May 26-27, 1992 (Inspection No. 030-19963/92-001).

Areas Inspected: Announced, closeout inspection limited to a survey of the facility for residual contamination prior to release for unrestricted use and termination of the license. Eighteen wipes were taken and assayed for removable gross beta activity. The facility was surveyed to identify fixed radioactive contamination, quantify exposure rates and determine if any licensed material remained. Two soil samples from beneath the concrete floor of the hot cell, one soil

sample from the exterior yard and four samples from the concrete block walls were analyzed for gamma emitting radioisotopes. The inspection also included a review of the draft survey data prepared by the contractor. The final survey, received on September 26, 1992, was evaluated to determine if it accurately represents the current condition of the facility.

Results: No violations were identified. No radioactive contamination was found on any of the surfaces and no remaining licensed materials were found. Elevated gamma exposure rates measured in one location were attributed to naturally occurring radioactive material in building material. The licensee's survey enclosed with their letter dated September 24, 1992, accurately reflects the condition of the facility.

DETAILS

1. Persons Contacted

*John Andrews, Radiation Safety Officer, SEG Corporation
*Philip Mann, Radiological Engineer, SEG Corporation
Henry Benavides, Radiological Engineer, SEG Corporation
Michael Muncer, Environmental Protection Manager, The Budd Company
Richard Lemke, Counsel, The Budd Company (via telephone)

*Denotes those present at exit interview.

2. Background

The Budd Company (Budd) operated a hot cell facility at 2950 Roberts Avenue, Philadelphia, Pennsylvania from 1956 through 1967. Budd was licensed to manufacture sealed iridium-192 (Ir-192), thulium-170 (Tm-170) and cobalt-60 (Co-60) sources for use in industrial radiography. A small amount of cesium-137 (Cs-137) was also used for a brief duration.

The hot cell is an "L-shaped" structure of about 200 square feet attached to an outside corner of a larger building (See figure in Appendix A). This building (the X-ray building) is located in the center of a large storage yard (the Die Yard). The walls and roof of the hot cell are of reinforced concrete from three to four feet thick. Penetrations included an access door, ventilation and exhaust ports, cable ports, a shielded window for observation, and ports for the manipulators used to remotely perform operations inside the hot cell. Licensed material was primarily stored at the bottom of two four-foot deep storage wells in the floor of the hot cell opposite the window. A thirty-inch deep stainless steel lined pit (the "cesium pit"), located between the two storage wells, was used to store other objects.

In 1967, Budd terminated source manufacturing operations and began decontamination of the facility. At that time, large amounts of equipment and licensed material were removed from the facility and properly disposed or transferred. The interior of the hot cell was cleaned, but not completely decontaminated. After operations were terminated, and since the hot cell had not undergone complete decontamination, the window and door openings to the cell were sealed with 16-inch thick concrete block and structural steel. All other openings to the hot cell were also sealed to maintain the integrity of the cell. At the time of facility shutdown, the quantity of cobalt 60 in the hot cell was estimated to be approximately 5 curies. All Ir-192 and Tm-170 remaining have decayed to insignificant levels due to the long entombment period and the relatively short half-lives of Ir-192 (74 days) and Tm-170 (129 days). The interior of the enclosed hot cell was maintained as a restricted area until remediation began in July 1990. Budd performed periodic surveillance of the cell to ensure the integrity of the cell was maintained.

In May 1990, the licensee was informed that submission and implementation of a characterization and decommissioning plan for the hot cell would be required. A formal decommissioning plan was submitted by the licensee in November 1990. NRC Region

I staff approved the initial characterization activities described in the plan. The licensee's contractor, Westinghouse's Scientific Ecology Group, Inc. (SEG), performed the characterization measurements in December 1990. The characterization of the hot cell was accomplished by drilling four two-inch holes through the exterior cell walls. Measurements performed with a radiation survey meter with a telescoping probe inserted through the holes indicated exposure rates of 5 milliroentgens/hour. Smears taken on the walls and floor of the cell did not indicate significant removable contamination. Based on these characterization results, a final decontamination plan was submitted and approved in April 1991.

SEG was also contracted to perform the tasks described in the decommissioning plan. These decontamination efforts were conducted from July 1991 through May 1992. The major decommissioning tasks included: entry into the hot cell; removal of a small overhead crane, the crane rail, ventilation ducts, the two four-foot deep source wells, the thirty-inch deep stainless steel storage pit and other contaminated debris from inside the hot cell; removal (scabbling) of contaminated concrete surfaces; excavation of a small amount of contaminated soil beneath the cesium pit; transportation and disposal of waste; and performing and documenting the closeout survey. Exposure rate measurements performed above one of the source wells indicated that the well contained up to 800 millicuries of Co-60. This well was removed from the site in a special transportation cask.

Contaminated objects and rubble were placed in large boxes (B-25 containers) or standard drums. Superficial layers of the concrete floor, ceiling and walls of the hot cell were removed with a variety of scabbling devices. Concrete and soil were removed from the area beneath and surrounding the two source wells and the storage pit. Small areas of fixed contamination were also identified in the concrete on the floor and walls outside the hot cell. The contractor scabbled these areas to remove the contamination. The radioactive wastes generated by the decommissioning efforts were removed from the facility by SEG and sent to their Oak Ridge, Tennessee facility for volume reduction and disposal. The contractor performed a final radiological survey of the facility in May 1992. SEG and Budd representatives discussed the survey results with Region I staff and requested that any NRC confirmatory measurements be performed while their contractor was still on site. Region I agreed to make confirmatory measurements and to review the draft data prior to the receipt of the final, completed survey document. Some printed data was available, with the remainder available in computer data files.

3. Instruments Used in Surveys

Radiation measurements were conducted with two Ludlum Model 19 Micro R meters (NRC Nos. 33511 and 33513), an Eberline E-120 count rate meter (NRC No. 870) with an HP-260 "pancake" GM detector and a Ludlum Model 239-1F Floor Monitor (NRC No. 23411) with a Model 43-37 proportional counter detector (NRC No. 23410). The active area of this probe is 425 cm^2. The background exposure rate measured with the

Micro R meter ranged from 8 to 10 μR/hour outside and from 10 to 12 μR/hour inside the X-ray Building. Background count rates measured with the ratemeter instrument were approximately 100 counts per minute (cpm). The background count rate of the floor monitor ranged from 1200 to 1400 cpm. The detector efficiency for the floor monitor probe was approximately 17% for the licensee's 10 x 10 centimeter NIST traceable Cs-137 source. The inspectors made comparison readings to the contractor's pressurized ion chamber (PIC), a Reuter-Stokes RSS-112. The two Micro R meters read approximately 17% higher than the PIC for a single comparison. The inspectors concluded that this comparison showed very good agreement between these two instruments since the Micro R meter should exhibit a moderate over-response under the conditions of the measurement.

Wipe samples for removable contamination and soil and concrete block samples were collected at various locations and returned to the NRC Region I laboratory for analysis. Wipe samples were counted in a Tennelec Model LB 5100 Gas-Flow Proportional Counter. The soil and concrete block samples were counted and analyzed using a PGT intrinsic germanium detector and Nuclear Data gamma spectrometry system.

4. Results of Confirmatory Surveys

The inspectors made confirmatory measurements inside the hot cell, in the areas and small rooms adjacent to the hot cell, in other areas of the X-ray Building away from the hot cell, on the roof of the X-ray building, on the roof of the hot cell and around the perimeters of the X-ray Building and Die Yard. Measurements were made in all areas where licensed material was reported to have been used as well as in areas with no history of radioactive material use. Wipe samples were performed with filter paper disks in the locations identified in Appendix B of this report. Each wipe was made over an area of approximately 100 cm^2. No removable contamination exceeding decommissioning guidelines (1,000 dpm/100 cm^2 for gross beta) was identified.

The floor monitor was used to survey remediated and non-remediated areas in the area outside the hot cell. This instrument could not be used inside the hot cell since portions of the floor had been removed during decontamination. Count rates were generally in the range of background. Two isolated areas reading 700 net cpm and a single area reading 2,200 net cpm were identified on the floor in the high bay area of the X-ray Building (Area III in the Budd survey documentation). These values translate to 4,200 dpm/probe area and 14,000 dpm/probe area respectively. Direct measurements in these areas with the ratemeter and pancake GM probe did not identify any hot spots. The inspectors concluded that these areas were not contaminated in excess of the maximum release criteria (15,000 dpm/100 cm^2).

The results of the analysis of the soil samples collected from the hot cell and the Die Yard appear in Appendix C. The sample collected from the Die Yard was obtained to evaluate any potential release of Co-60 outside the X-ray Building. This sample did not

show any detectable Co-60 activity. The two soil samples from the floor of the hot cell showed Co-60 activities of 0.4 and 11.8 pCi/gram. One sample also showed 0.17 pCi/gram of Cs-137. The contractor also collected and analyzed soil samples from the cesium pit area of the hot cell. Cobalt-60 activity measured in these five samples ranged from less than 0.2 to 4.7 pCi/gram with an average of 2.0 pCi/gram. Exposure rate measurements in the excavated areas of the hot cell were similar to the remainder of the cell and did not indicate any localized contamination.

The licensee had not proposed criteria for residual contamination in soil in the original decommissioning plan, however, on a case-by-case basis, the NRC Staff has developed or provided such criteria for release of property whose soil shows evidence of radioactive contamination. The residual contamination values for Co-60 and Cs-137 are 8 pCi/gram and 15 pCi/gram, respectively. Where more than one radionuclide is present, the sum of the ratios of the individual radionuclide concentrations to their respective concentration limits shall not exceed unity. This criteria has been previously presented in the "Order Establishing Criteria and Schedule for Decommissioning the Bloomsburg Site" (57 FR 6136-6141) and in a May 6, 1987 memorandum from J. Hickey, NMSS to W. Cline, RII, providing an evaluation of acceptability of proposed decommissioning activities for a hot cell facility at Fort McClellan, Alabama. This latter memorandum indicates that the primary pathway for exposure to individuals for these nuclides is by direct radiation and the gamma exposure rate shall not exceed 10 microentgen/hour above background for an area of greater than 30 ft x 30 ft and shall not exceed 20 microentger/hour above background for discrete areas.

After review of the data in the close out survey and the data from the samples obtained and analyzed by Region I, the inspectors concluded that the facility meets the guidelines for residual Co-60 and Cs-137 contamination since the average concentration of the NRC samples and the average concentration of the samples reported in the closeout survey were below 8 pCi/gram and 15 pCi/gram respectively and the exposure rate guidance was met.

Exposure rates measured around the perimeter of the Die Yard and around the perimeter of the X-ray Building ranged from 6 to 12 μR/hour at one meter above the ground. Measurements inside the hot cell ranged from 11 to 17 μR/hour. The inspectors measured exposure rates at numerous other areas inside the X-ray Building. Included in these measurements were areas where radioactive materials had been used and where remediation had been performed and other areas of the building that had no history of radioactive material use. In areas with no history of radioactive material use, exposure rate measurements ranged from 6 to 21 μR/hour. The readings of 21 μR/hour were found in two areas; along a tiled wall in a rest room and adjacent to a wall in an unused storage area. In both cases, the elevated readings appeared to be from naturally occurring radioactive materials in the building materials. In the rest room, only the tiled areas exhibited the elevated exposure rates. In the storage room, the elevated measurement was only along one inside wall and not evident anywhere else in the room.

Measurements in the areas adjacent to the hot cell where remediation had been performed ranged from 9 to 13 μR/hour; however, readings in areas adjacent to the walls in Room 1 ranged from 19.5 to 37 μR/hour. Since the contractor had performed surface contamination measurements with a proportional counter detector on most of these walls, the inspectors examined this data. The data indicated that nearly all of the survey locations were less than 5,000 dpm/100 cm^2 and no values exceeded 15,000 dpm/100 cm^2. Since the surface contamination rates were low, the inspectors concluded that the elevated exposure rates were due to materials in the walls and not to surface contamination. An analysis of the data for the area where the highest exposure rate was measured is shown in Section 5 of this report below.

5. Elevated Exposure Rates Measured in Room 1

The inspectors measured elevated external gamma exposure rates in the inside portion of Room 1, a small walled area outside the hot cell. Exposure rate measurements in this area ranged from 32 to 37 μR/hour. This room had apparently been used only for inspection of encapsulated sources. The walls and a portion of the floor had been scabbled to remove superficial contamination. Since the inspectors had measured elevated exposure rates adjacent to walls of similar construction, and the dimensions of the room are small (approximately 4.5' by 6'), the inspectors considered the possibility that the elevated exposure rates were due to the presence of radioactive materials in the building materials. In a small area such as this, exposure rates from radioactive materials in each of the four walls would contribute to the total measured exposure rate. This contribution would be in addition to the measured background exposure rate inside the building. In order to examine this possibility, the inspectors requested Budd's contractor to provide samples of the concrete block walls. The inspectors submitted these samples to the Region I laboratory for analysis. The results of the analyses appear in Appendix C.

The results of the analysis of the concrete block samples indicate only a trace of Co-60 on the outer wall surface and no measurable Co-60 contamination within the wall. The subsurface concrete block samples shows measurable concentrations of U-238 (averaging 4.0 pCi/gram) and Th-232 (averaging 2.0 pCi/gram). The U-238 and Th-232 concentrations were not directly measured, but were determined by inference from the presence of their radioactive decay products, Ra-226 and Ac-228, respectively.

A commercial computer program for calculating the exposure rates from various configurations of sources and shields (Microshield) was used to calculate the expected exposure rate using the specific dimensions of the walls and the measured concentrations. The results of these calculations appear in Appendix D. Assuming all daughters are present and in secular equilibrium, the computed exposure rate at the center of the room from the long wall is 7.5 μR/hour. The computed exposure rate at the center of the room from the short wall is 6.5 μR/hour. The total exposure rate at the center of the room would be the sum of the measured background inside the building and the

calculated contribution from each of the four walls. The total exposure rate would thus be:

10.0 μR/hour	Measured contribution from natural background in building
7.5 μR/hour	Calculated contribution from one long wall
19.5 μR/hour	Calculated contribution from three short walls (the length of one long wall is shorter due to an opening)
37 μR/hour	

A similar calculation using Microshield was done to evaluate the exposure rate for a surface uniformly contaminated with 5,000 dpm/100 cm^2 of Co-60. For similar geometries, the calculated exposure rate ranged from 0.8 to 1.2 μR/hour. These calculations also appear in Appendix D. Based on these measurements and calculations, the inspectors concluded that the elevated exposure rates in this room were due to the presence of naturally occurring radioactive materials in the concrete block and not due to the presence of any residual licensed materials. The inspectors also concluded that the slightly elevated exposure rates (approximately 5 to 10 μR/hour above background) measured adjacent to other walls in the building were also due to naturally occurring radioactive material, since these walls appeared to be similar in construction.

6. Waste Disposal

All radioactive waste was shipped to the SEG facility in Oak Ridge Tennessee for processing and disposal at a licensed burial facility. Most of the wastes were shipped as Low Specific Activity in B-25 boxes (approximately 90 ft^3). The source storage well that contained approximately 800 millicuries of Co-60 was shipped in a custom fabricated liner and Type A cask. The final quantity of waste removed from the site was shipped in standard 7.5 ft^3 steel drums on May 27, 1992. Contaminated lead removed from the facility was also sent to SEG for decontamination.

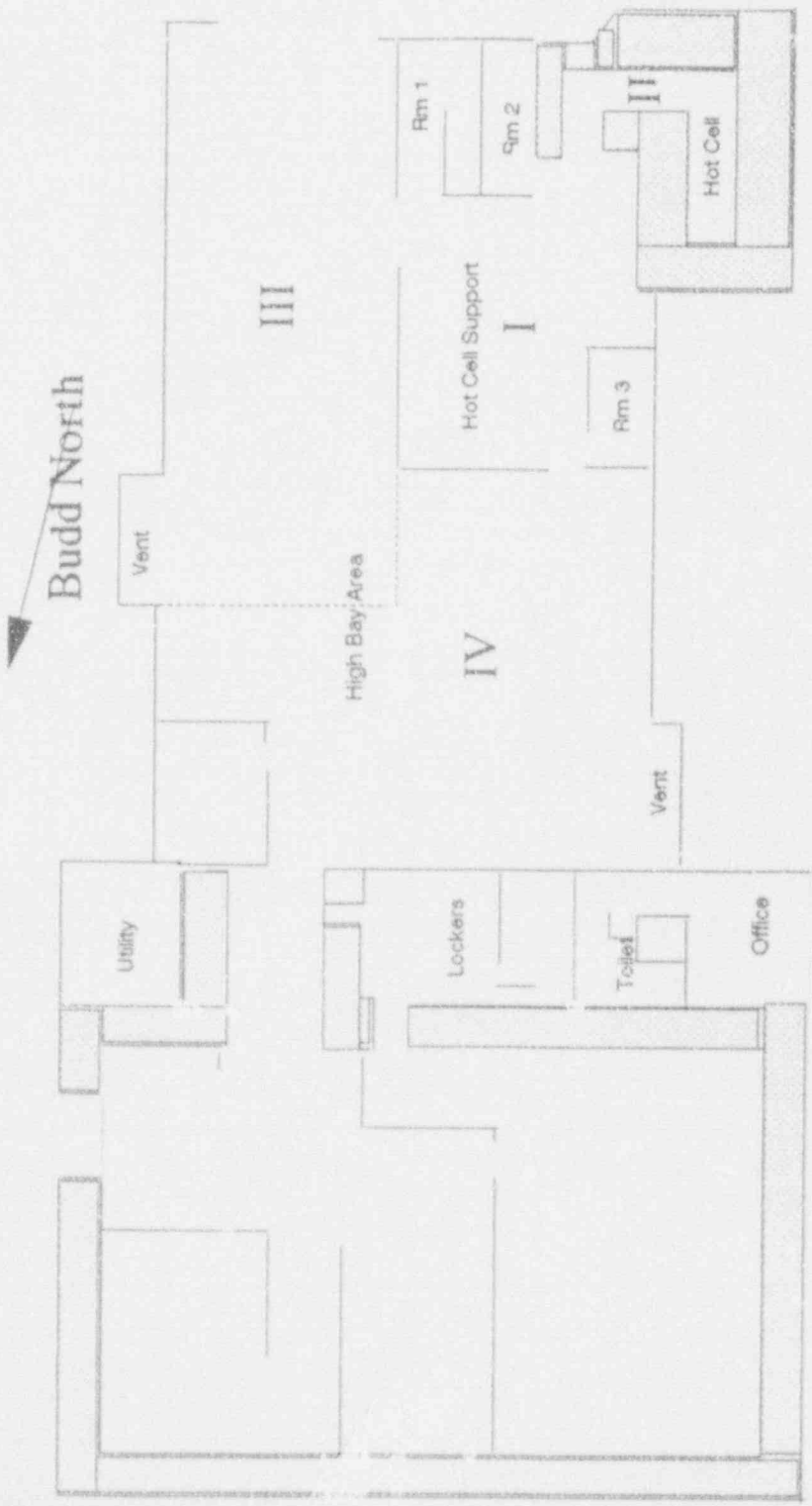
7. Exit Interview

The results of the inspection were discussed with the licensee's contractor representatives identified in Section 1 of this report. The inspector also discussed the inspection results with a Budd representative via telephone. The inspector discussed the elevated exposure levels measured in Room 1 and indicated that an evaluation of the concrete wall samples was needed to make a final conclusion. The soil, concrete block and wipe samples taken by the inspectors were to be counted in the NRC Regional Office laboratory.

APPENDIX A

PLAN VIEW OF X-RAY BUILDING AND HOT CELL FACILITY

THE BUDD COMPANY, PHILADELPHIA, PENNSYLVANIA



X-RAY BUILDING AND HOT CELL FACILITY

Docket No. 030-19963 License No. 37-05680-04

APPENDIX B

RESULTS OF WIPE SAMPLES TAKEN AT

THE BUDD COMPANY - MAY 26-27, 1992

Location

1. Hot Cell - Floor, northern corner of "L"
2. Hot Cell - Floor, near viewing port
3. Hot Cell - Wall, above wipe #1
4. Hot Cell - Wall, above wipe #2
5. Area III - Floor, Section A2, center
6. Area III - Floor, Section B2, center
7. Area III - Floor, Section A2, near wall
8. Area III - Floor, Section A2, near wall
9. Area I - Diagonal metal strut on wall outside Hot Cell
10. Hot Cell - Frame of viewing port
11. Hot Cell - Door Frame
12. Room 2 - Diagonal metal strut on wall
13. Room 1 - Floor, outer metal bar along wall
14. Room 1 - Floor, inner metal bar along wall
15. Hot Cell - Inside Wall, southern corner of "L"
16. Area I - Surface of pipes sticking through floor, right of hot cell
17. Area I - Trough in floor, bottom
18. Area I - Trough in floor, metal edge on top
19. Area I - Metal edges of filled concrete area, right of hot cell
20. Area I - Top of electrical conduit
21. Area III - Horizontal metal strut along east wall
22. Area III - Floor next to heater on east wall
23. Area IV - Horizontal ledge on north wall
24. Area IV - Floor, Section D

Results are reported in units of net dpm per 100 cm^2. All results are less than the LLD for Gross Beta (20 dpm/100 cm^2).

APPENDIX C

RESULTS OF SOIL AND CONCRETE SAMPLES TAKEN AT

THE BUDD COMPANY - MAY 26-27, 1992

SAMPLE LOCATION	SAMPLE TYPE	RADIONUCLIDE	RESULT (pCi/gram)
Room 1-South Wall Surface (0"-1/2")	Concrete Block	Co-60	0.62 ± 0.04
Room 1-South Wall Subsurface (1/2"-1")	Concrete Block	Bi-214	1.63 ± 0.07
		Pb-214	1.80 ±0.08
		Ra-226	4.2 ±0.5
		Bi-212	1.5 ±0.2
		Pb-212	2.22 ±0.05
		Ac-228	2.10 ±0.12
Room 1-East Wall Surface (0"-1/2")	Concrete Block	Co-60	0.34 ±0.03
Room 1-East Wall Subsurface (1/2"-1")	Concrete Block	Bi-214	1.50 ±0.07
		Pb-214	1.60 ±0.06
		Ra-226	3.7 ±0.4
		Bi-212	1.3 ±0.2
		Pb-212	2.03 ±0.05
		Ac-228	1.87 ±0.11

APPENDIX C (CONTINUED)

RESULTS OF SOIL AND CONCRETE SAMPLES TAKEN AT

THE BUDD COMPANY - MAY 26-27, 1992

SAMPLE LOCATION	SAMPLE TYPE	RADIONUCLIDE	RESULT (pCi/gram)
Hot Cell Floor Next to Storage Well	Soil	Co-60	0.42 ±0.04
		Cs-137	0.17 ±0.03
		Bi-214	1.00 ±0.06
		Pb-214	1.13 ±0.07
		Ra-226	2.4 ±0.4
		Pb-212	1.30 ±0.05
		Ac-228	1.22 ±0.11
Hot Cell Floor Cesium Pit	Soil	Co-60	11.8 ±0.2
		Bi-214	0.83 ±0.08
		Pb-214	0.76 ±0.06
		Ra-226	2.2 ±0.5
		Pb-212	1.06 ±0.04
Exterior Yard Low area, 50 Yards from Hot Cell	Soil	Cs-137	0.1 ±0.02
		Bi-214	0.81 ±0.05
		Pb-214	1.02 ±0.05
		Ra-226	3.0 ±0.5
		Pb-212	1.12 ±0.04
		Ac-228	1.21 ±0.09

APPENDIX D

COMPUTER EXPOSURE RATE CALCULATIONS

FOR CERTAIN WALLS AT THE BUDD COMPANY

PHILADELPHIA, PENNSYLVANIA

Microshield 3.13
(U.S. NRC - #210)

Page : 1
File : BUDD_WL1.MSH
Run date: October 26, 1992
Run time: 9:36 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: Budd Company - short wall, Ra-226, Th-232 & daughters incl.

GEOMETRY 11: Rectangular solid source - slab shields

Distance to detector.....	X	135.	cm.
Source width.....	W	135.	"
Source length.....	L	245.	"
Rectangular solid, thickness toward dose pt..	T1	45.	"
Thickness of second shield.....	T2	90.	"

Source Volume: 1488375 cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2
Air		.001220
Aluminum		
Carbon		
Concrete	2.350	
Hydrogen		
Iron		
Lead		
Lithium		
Nickel		
Tin		
Titanium		
Tungsten		
Urania		
Uranium		
Water		
Zirconium		

CASE: Budd Company - short wall, Ra-226, Th-232 & daughters incl.

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies	Nuclide	Curies
Ac-228	6.9954e-06	Bi-212	6.9954e-06	Bi-214	1.3991e-05
Pa-234	1.3991e-05	Pb-212	6.9954e-06	Pb-214	1.3991e-05
Ra-224	6.9954e-06	Ra-226	1.3991e-05	Th-228	6.9954e-06

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	2.1092	6.483e+04	2.431e-01	3.884e-04
2	1.5927	2.758e+05	7.358e-01	1.276e-03
3	1.0488	4.276e+05	6.993e-01	1.336e-03
4	.8386	7.720e+05	9.713e-01	1.937e-03
5	.5964	4.461e+05	4.213e-01	8.712e-04
6	.4268	7.999e+04	5.148e-02	1.054e-04
7	.3246	3.978e+05	1.739e-01	3.538e-04
8	.2343	2.803e+05	7.693e-02	1.480e-04
9	.1616	7.663e+04	1.240e-02	2.176e-05
10	.1269	1.927e+05	2.110e-02	3.425e-05
11				
12				
13				
14				
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16				
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18				
19				
20				
TOTALS:		3.014e+06	3.407e+00	6.472e-03

Microshield 3.13
(U.S. NRC - #210)

Page : 1
File : BUDD_WL2.MSH
Run date: October 26, 1992
Run time: 9:39 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: Budd Company - long wall, Ra-226, Th-232 & daughters incl.

GEOMETRY 11: Rectangular solid source - slab shields

Distance to detector.....	X	115.	cm.
Source width.....	W	175.	"
Source length.....	L	245.	"
Rectangular solid, thickness toward dose pt..	T1	45.	"
Thickness of second shield.....	T2	70.	"

Source Volume: 1929375 cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2
Air		.001220
Aluminum		
Carbon		
Concrete	2.350	
Hydrogen		
Iron		
Lead		
Lithium		
Nickel		
Tin		
Titanium		
Tungsten		
Urania		
Uranium		
Water		
Zirconium		

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies	Nuclide	Curies
Ac-228	6.9954e-06	Bi-212	6.9954e-06	Bi-214	1.3991e-05
Pa-234	1.3991e-05	Pb-212	6.9954e-06	Pb-214	1.3991e-05
Ra-224	6.9954e-06	Ra-226	1.3991e-05	Th-228	6.9954e-06

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	2.1092	6.483e+04	2.842e-01	4.539e-04
2	1.5927	2.758e+05	8.574e-01	1.487e-03
3	1.0488	4.276e+05	8.116e-01	1.551e-03
4	.8386	7.720e+05	1.125e+00	2.244e-03
5	.5964	4.461e+05	4.864e-01	1.006e-03
6	.4268	7.999e+04	5.916e-02	1.211e-04
7	.3246	3.978e+05	1.991e-01	4.^50e-04
8	.2343	2.803e+05	8.764e-02	1.686e-04
9	.1616	7.663e+04	1.404e-02	2.464e-05
10	.1269	1.927e+05	2.377e-02	3.857e-05
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.014e+06	3.948e+00	7.499e-03

Microshield 3.13
(U.S. NRC - #210)

Page : 1
File : BUDD_WL4.MSH
Run date: October 26, 1992
Run time: 9:42 a.m.

File Ref: _____
Date: ___/___/___
By: _____
Checked: _____

CASE: Budd Company - short wall, Co-60 surface contamination

GEOMETRY 11: Rectangular solid source - slab shields

Distance to detector.....	X	90.1	cm.
Source width.....	W	135.	"
Source length.....	L	245.	"
Rectangular solid, thickness toward dose pt..	T1	0.1	"
Thickness of second shield.....	T2	90.	"

Source Volume: 3307.5 cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2
Air		.001220
Aluminum		
Carbon		
Concrete	2.350	
Hydrogen		
Iron		
Lead		
Lithium		
Nickel		
Tin		
Titanium		
Tungsten		
Urania		
Uranium		
Water		
Zirconium		

CASE: Budd Company - short wall, Co-60 surface contamination

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Co-60: 7.4463e-07 curies

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	1.3359	2.755e+04	2.212e-01	3.991e-04
2	1.1797	2.755e+04	1.956e-01	3.634e-04
3	.6953	4.494e+00	1.898e-05	3.908e-08
4				
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16				
17				
18				
19				
20				
TOTALS:		5.511e+04	4.168e-01	7.625e-04

Microshield 3.13

(U.S. NRC - #210)

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By: _____
Checked: _____

CASE: Budd Company - long wall, Co-60 surface contamination

GEOMETRY 11: Rectangular solid source - slab shields

Distance to detector.....	X	70.1	cm.
Source width.....	W	175.	"
Source length.....	L	245.	"
Rectangular solid, thickness toward dose pt..	T1	0.1	"
Thickness of second shield.....	T2	70.	"

Source Volume: 4287.5 cubic centimeters

MATERIAL DENSITIES (g/cc):

Material	Source	Shield 2
Air		.001220
Aluminum		
Carbon		
Concrete	2.350	
Hydrogen		
Iron		
Lead		
Lithium		
Nickel		
Tin		
Titanium		
Tungsten		
Urania		
Uranium		
Water		
Zirconium		

CASE: Budd Company - long wall, Co-60 surface contamination

BUILDUP FACTOR: based on TAYLOR method.
Using the characteristics of the materials in shield 1.

INTEGRATION PARAMETERS:

Number of lateral angle segments (Ntheta).....	11
Number of azimuthal angle segments (Npsi).....	11
Number of radial segments (Nradius).....	11

SOURCE NUCLIDES:

Co-60: 9.6527e-07 curies

RESULTS:

Group #	Energy (MeV)	Activity (photons/sec)	Dose point flux MeV/(sq cm)/sec	Dose rate (mr/hr)
1	1.3359	3.571e+04	3.623e-01	6.538e-04
2	1.1797	3.571e+04	3.204e-01	5.953e-04
3	.6953	5.826e+00	3.109e-05	6.402e-08
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		7.144e+04	6.827e-01	1.249e-03