

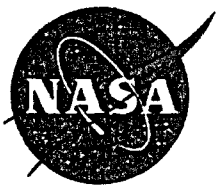
SAFETY AND MISSION ASSURANCE DIRECTORATE

Plum Brook Reactor Facility

Final Status Survey Plan
for the
Plum Brook Reactor Facility
(Rev 0)
May 2006

BOOK 2

Form
AD-01/ 7
Rev 2



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BOOK 2

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Final Status Survey Plan
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Plum Brook Reactor Facility

Attachment A

Radionuclide Distribution Basis for DCGL Determination & Final Status Survey of the Plum Brook Reactor Facility (PBRF)

1.0 Purpose

This attachment provides evaluations of the Plum Brook Reactor Facility (PBRF) radionuclide distribution used to determine the site structure and soil DCGL values. Radionuclides determined to be insignificant contributors per the guidance described in NUREG-1757 (Reference 2.6) were eliminated from further consideration. Embedded piping radionuclide distribution data is provided in Attachment C of this FSSP.

2.0 References

2.1 Plum Brook Reactor Facility Decommissioning Plan

2.2 NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)

2.3 NUREG/CR-3474, "Long-Lived Activation Products in Reactor Materials"

2.4 NUREG/CR-0130, "Technology, Safety and Cost of Decommissioning"

2.5 NUREG/CR-4289, "Residual Radionuclide Contamination Within and Around Commercial Nuclear Power Plants"

2.6 NUREG-1757, Vol. 2, "Characterization, Survey, and Determination of Radiological Criteria"

2.7 "An Evaluation of the Plum Brook Reactor Facility and Documentation of Existing Conditions," Teledyne Isotopes, December, 1987

3.0 Assumptions and General Information

3.1 Nuclides positively identified in a single sample were assumed to be present at their stated MDA values in all other samples in their applicable populations where the nuclides were not detected.

3.2 RESRAD and RESRAD-BUILD input values used to evaluate dose contributions from specific radionuclides employ the building reuse, subsurface structure and surface soil parameters and scenarios used for site-specific DCGL development are provided in PBRF Technical Basis Documents and are available for review, as needed.

4.0 Discussion

The evaluation provided in this attachment was performed to identify the suite of radionuclides that could potentially be present in site structures and soils following completion of decommissioning activities and structure demolition. 10 CFR Part 61 waste stream characterization analyses as well as the results of the isotopic analysis of concrete core samples collected as part of the characterization survey were used to estimate radionuclide distributions.

A variety of concrete structures containing residual contamination may remain after decommissioning including the walls and floors of the basements of major buildings as well as concrete demolition debris that may be used as clean fill. At PBRF, the two major sources for the radioactive contamination of the concrete were the reactor coolant water, which contained both fission and activation products, and the irradiation of experiments. The presence of low levels of fission products in some of the sample results suggests that a small clad failure or a recycling of treated water from the Hot Laboratory may have occurred.

In order to assess the possibility that more than one radionuclide distribution could apply to the concrete structures and post demolition concrete debris that will undergo FSS, both the operational history and uses of the different structures were evaluated.

5.0 Historical Overview

The PBRF was used to perform nuclear irradiation testing of fueled and unfueled experiments for space program applications. Construction of the PBRF began in 1956. Preoperational testing of the reactor was performed during 1961 and 1962 and full power operations began in April 1963. The 60 MW reactor was operated by NASA on an essentially uninterrupted basis for almost 10 years until January 1973 when it was shut down after accumulating 98,000 Mega Watt Days (MWD) of operation.

The reactor was defueled from January to July 1973. During that time, the reactor fuel element assemblies (all special nuclear material, source material, and radioactive waste generated at that time) were removed from the PBRF and preliminary decontamination was performed. The fuel assemblies were transferred and reprocessed offsite and the radioactive wastes were disposed of offsite at licensed commercial facilities. The PBRF systems and support facilities not required for safe storage were maintained (mothballed) for possible future operations. During 1997 and 1998, NASA management decided to decontaminate and decommission the PBRF to allow termination of the NRC licenses and release the PBRF for unrestricted use.

The PBRF consists of six major buildings, several subsurface "tunnels", three water holding basins and an effluent release "ditch". The major structures include the Containment Building, the Reactor Building, the Hot Laboratory, the Reactor Office and Laboratory Building, the Waste Handling Building, the Primary Pump House and the Fan House. Subsurface structures include the Hot Pipe Tunnel and the Cold Pipe Tunnel. The holding basins include the Hot Retention Basin, the Cold Retention Basin and the Emergency Retention Basin.

Reactor fuel was constructed of uranium/aluminum alloy fuel elements clad with aluminum alloy. The reactor fuel material was uranium enriched to about 93% in the U-235 isotope in an aluminum alloy of not more than 25% uranium by weight. The maximum core loading did not exceed 6 kg of U-235. Beryllium reflector pieces surrounded the fuel along with cadmium/beryllium regulating and shim rods. The core was moderated and cooled by de-ionized water which was pressurized by the elevation of water in the head tank and the head of the primary system pumps.

Most primary system piping and components are located in the Containment Building, the Reactor Building, the Primary Pump House and the Fan House. Primary systems were also present in portions of the Hot Pipe Tunnel. The primary cooling water system was subdivided into four groups, the main loop, the by-pass clean-up loop, the instrument and test hole cooling loop and the shutdown loop. The main loop was a closed loop, 26,000 gallon system that was routed from the reactor through 24 in. supply and return lines to the Primary Pump House where coolant water was passed through two primary heat exchangers, three primary pumps, a strainer and a flow meter and returned to the inlet supply line.

During reactor operation, the reactor tank was essentially a closed system. Experiments were inserted by means of two horizontal through tubes, six horizontal beam tubes, and two vertical experiment tubes, all of which are of aluminum alloy construction. However, direct interface with the canal system did occur, most notably in the hydraulic "rabbit" tubes, which transferred experiment materials in and out of the reactor tank using the difference in hydraulic pressure between the reactor coolant and the canals. During shutdown, materials and fuel elements were routinely transferred between the reactor tank and the canals.

The reactor tank and concrete biological shield are surrounded by four quadrants, three (A, C, and D) of which could be flooded with water for additional biological shielding. Quadrant B was a dry area. A system of canals was used to transfer materials or fuel assemblies to and from the reactor tank, the fuel storage area, and the adjacent Hot Laboratory. Quadrant D contained the underwater beam room. In the Hot Laboratory, materials were remotely transferred from the canals to either the hot cells or the Hot Dry Storage Area. It was here that irradiated materials were handled and tested.

The hot drain system consists of the drain collection systems for all wastewater drainage that originated directly or indirectly from a radioactively contaminated area. The system is made up of 12 collection sumps (located in the Fan House, Waste Handling Building, Reactor Office and Laboratory Building, Primary Pump House, Hot Laboratory, Reactor Building, and inside the containment vessel) along with associated pumps and valves. Pumps were used to move liquids that had collected in the sumps to the Hot Retention Area.

The Mock-Up Reactor (MUR) was a 100KW swimming pool type reactor located in Canal H and setup to simulate the main Plum Brook Reactor. The MUR used the same uranium enriched aluminum alloy fuel assemblies, with the exception of uranium loadings, as the larger reactor core. As such, the nuclide distribution resultant from the operation of the MUR should be essentially the same as the distribution resultant from the operation of the larger reactor.

The secondary coolant system consisted of a single loop system that took waste heat from a pair of primary to secondary heat exchangers, carried it to a cooling tower for disposal, and then returned the water to the heat exchangers located within the Primary Pump House. The secondary system piping leaves the Reactor Building (RB) and proceeds

down the length of the Cold Pipe Tunnel that connects the RB to the Service Equipment Building (SEB) and to the cooling tower.

The Hot Retention Area, located south of the Fan House, contains eight 60,000 gal and four 7500 gal steel underground storage tanks. The larger tanks, located in an underground concrete room, received all of the radioactively contaminated water from the hot drain system. The four smaller tanks were used as holding tanks. The contaminated water was treated and the water in the holding tanks was monitored and then discharged to the Cold Retention Basins, the quadrant and canal recirculating system, or to the Water Effluent Monitoring Station.

The Cold Retention Basins are two 500,000 gal below grade storage basins in the shape of inverted pyramids. The basins were used to store low-level radioactive water primarily from the quadrants and canals in the Reactor Building. During facility operations the basins were known to leak, so a plastic liner was installed. At the time of shutdown, the Cold Retention Basins were opened to permit groundwater to enter the structures to equalize the water levels in the groundwater and basins and prevent the basins from floating in the event of a high groundwater table. Silt and sludge accumulated on the side walls and bottoms of the basins.

5.1 Assessment of Historical and Operational Factors

The following conclusions were reached following an assessment of the lay-out, structures, systems and processes that were used during the operation of the PBRF. Reactor coolant systems containing reactor originated fission and corrosion products are prevalent in the Containment, the Reactor Building, the Hot Laboratory, the Primary Pump House, the Waste Handling Building, the Fan House and the Hot Pipe Tunnel. Other environmental areas were also directly impacted by exposure to either treated and/or untreated primary coolant, including the Hot Retention Area, the Cold Retention Basins, the Emergency Retention Basin, the Water Effluent Monitoring Station, the Pentolite Ditch and Drainage System. Subsequently, it was anticipated that all the areas listed above should exhibit approximately the same radionuclide mixture.

One building, the Reactor Office and Laboratory Building (ROLB) did not contain any major systems that carried primary coolant. It is believed that the source of contamination discovered in the ROLB was from the importation and analysis of reactor coolant and reactor material samples. Radiological operational surveys taken in the fuel vault and in several laboratories located in the ROLB showed significant alpha contamination that was later identified as U-234 and U-235. Subsequent radiological characterization surveys did not identify U-234 and U-235 in any other of the impacted structures at the concentrations observed in the ROLB. As such, the ROLB was evaluated as an area that could exhibit a unique mixture.

In the Hot Laboratory, a wide variety of irradiated materials were unpackaged, directly handled and tested in this area. Subsequently, it is anticipated that the

radionuclide distribution in the Hot Laboratory could also be significantly different from the balance of plant mixture.

6.0 Sample Collection and Analysis

6.1 Smear Samples of Structural Surfaces

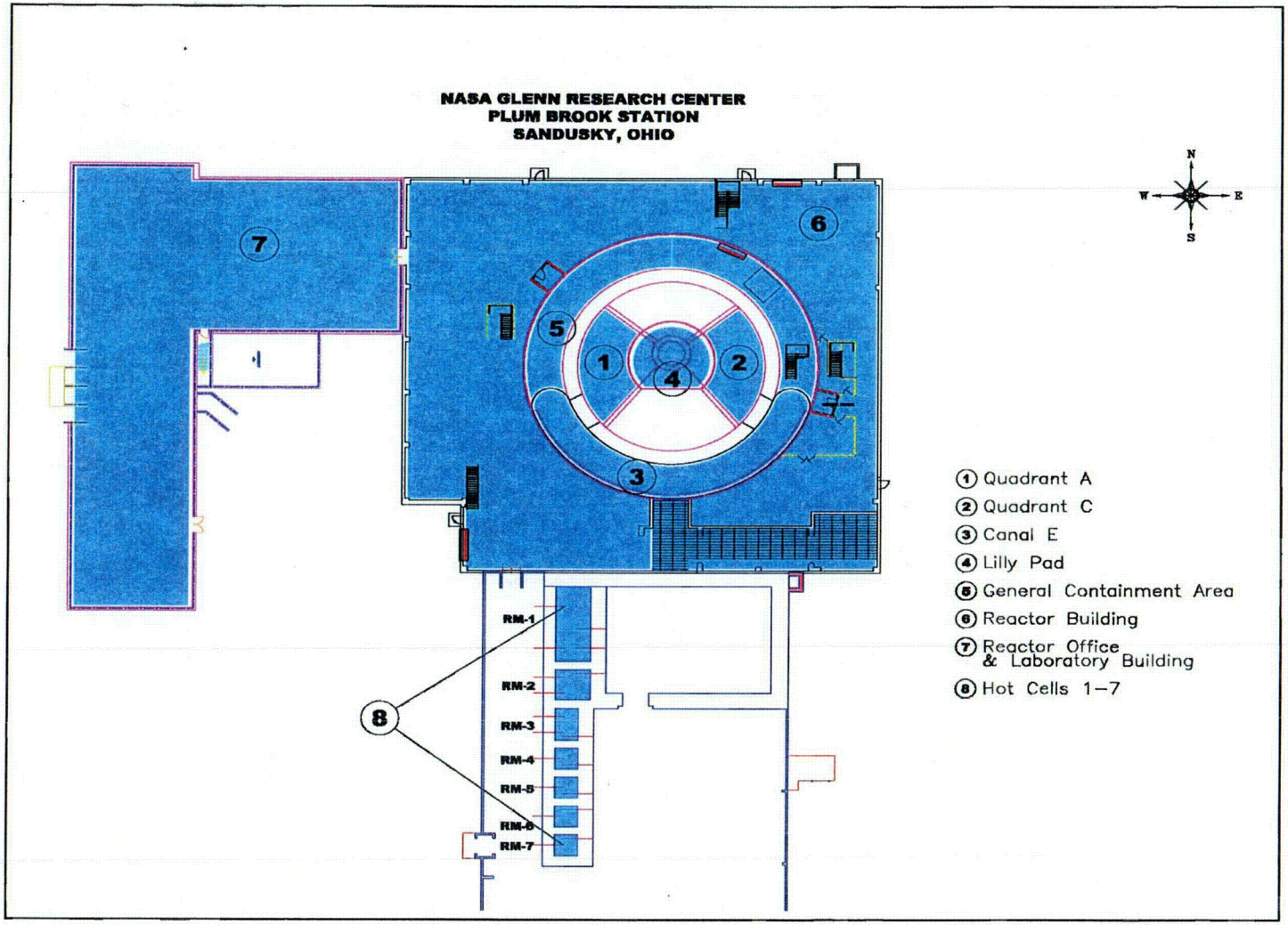
As part of a previous investigation performed to substantiate the nuclide distribution that would be applicable to waste disposition, twenty-two (22) smear samples were acquired and subjected to 10 CFR Part 61 analyses. The samples were as follows;

- 7 smears taken on loose equipment and materials in Hot Cells numbers 1 through 7,
- 7 smears taken on structural surfaces in Hot Cells numbers 1 through 7,
- 5 smears taken from within the Containment structure, including Quads A, Quad C, Canal E, the Lilly Pad and general area,
- 2 smears taken from the Reactor Office and Laboratory Building, and
- 1 smear taken from the Reactor Building.

In addition, alpha contamination was positively identified by direct measurement and on smear samples collected in the ROLB fuel vault and in several of the laboratories during the radiological evaluation of loose equipment in these areas for disposition and disposal. Additional smear samples were collected specifically at locations in the ROLB where positive alpha measurements were obtained. These smears were combined into composite samples and analyzed for isotopic content. To support the assessment of the nuclide mixture in the ROLB, the results from these samples were added to the Part 61 smear sample population described above. The results of the analyses of these smear samples are presented in Addendum 1 of this attachment.

Figure A-1

Part 61 Smear Populations Sample Locations



C01

6.2 Concrete Core Sampling

In addition to the smears, concrete core bore samples were collected at various locations throughout the PBRF structures. A plan for concrete sample collection was prepared to ensure that core bore samples were collected at representative locations from each of the primary structures designated to remain and be subjected to FSS. Core samples were collected at biased locations in the areas known to be the most exposed to radioactive contamination during plant operation. Areas in lower levels of buildings, areas housing waste processing equipment, and areas near sumps and floor trenches were chosen.

The biased location of each core bore was selected by performing a beta scan of the floor area of the targeted structure. The location with the highest total surface contamination reading was identified and assessed for the presence of loose surface contamination. If loose surface contamination was detected, the location was decontaminated. If there was appreciable fixed contamination left following the decontamination, the location was selected for obtaining a core bore sample.

By obtaining the highest activity samples from each key structure, the likelihood of detecting nuclides with low activity levels was improved and the relative fractions of the MDA values were minimized. In total, sixteen core bore samples were obtained. One core sample broke during extraction and was unusable leaving 15 samples for analysis. Of the 15 samples, thirteen were used as sent for isotopic analysis. The other two core samples were saved for possible site-specific K_D analysis.

Under Characterization Survey Package Number C9000 101I1, core bore samples were acquired at the following locations:

- In the Reactor Building on the 0' elevation, southern floor, a core bore sample was acquired on the floor adjacent to a removable steel hatch cover. This sample broke during extraction and was subsequently unusable for further analysis.

- In the Reactor Building on the -25' elevation in the southwest quadrant, a core bore sample was acquired on the floor adjacent to the sump in the Area #22 Pump Room.

- In the Reactor Building on the -15' elevation in the east floor area, one core bore sample was acquired on the floor adjacent to the concrete shielding for the primary water piping systems.

- In the Primary Containment on the -25' elevation at the bottom of Canal "E", a core bore sample was acquired on the floor along the southern wall adjacent to the south canal entrance.

- In the Primary Containment on the -25' elevation in the west area, a core bore sample was acquired on the floor adjacent to the inner wall across from the west stairwell.

- In the Waste Handling Building on the -13' elevation, a core bore sample was acquired on the floor adjacent to the north building sump.

- In the Hot Laboratory on the 0' elevation, four core bore samples were acquired, one on the floor in front of Room #2, one on the floor in front of Room #6, one in the middle of the floor adjacent to Room #5 and one at the entrance to Room #16.

- In the Hot Pipe Tunnel on the -12' elevation, two core bore samples were acquired, one in the middle of the tunnel section to the east of the corner and one on the side by the corner. Two additional core samples were acquired and placed in storage.

- In the Fan House on the -12' foot elevation, one core bore sample was acquired on the floor adjacent to the air plenum and venture located against the north wall.

- In the Primary Pump House on the 0' elevation, three core bore samples were acquired, one on the floors of Room numbers 1, 2 and 4 respectively. These samples were not included as part of the sample population due to QA concerns that could not be resolved.

- In the Reactor Office and Laboratory Building (ROLB), one core sample was acquired on the floor of the New Fuel Vault.

Structures that could potentially contain activated concrete such as the bio-shield were not sampled at the time of this study because current decommissioning plans call for the removal of activated portions of the concrete bioshield and disposition of the activated concrete as radioactive waste.

Each of the core samples was sliced and surveyed. Two ½ inch thick "pucks" were sliced from the top of each core. Direct alpha and beta measurements were obtained on both the tops and bottoms of each puck. A preliminary radionuclide analysis was performed on each puck using the PBRF on-site gamma spectroscopy system. This analysis was performed not to specifically assess the nuclide distribution, but rather to qualitatively evaluate the depth of contaminant migration into the concrete at each of these locations. Each ½ puck was analyzed twice, exposing the detector to both sides of each puck. The results of these analyses are presented in Addendum 2 of this attachment.

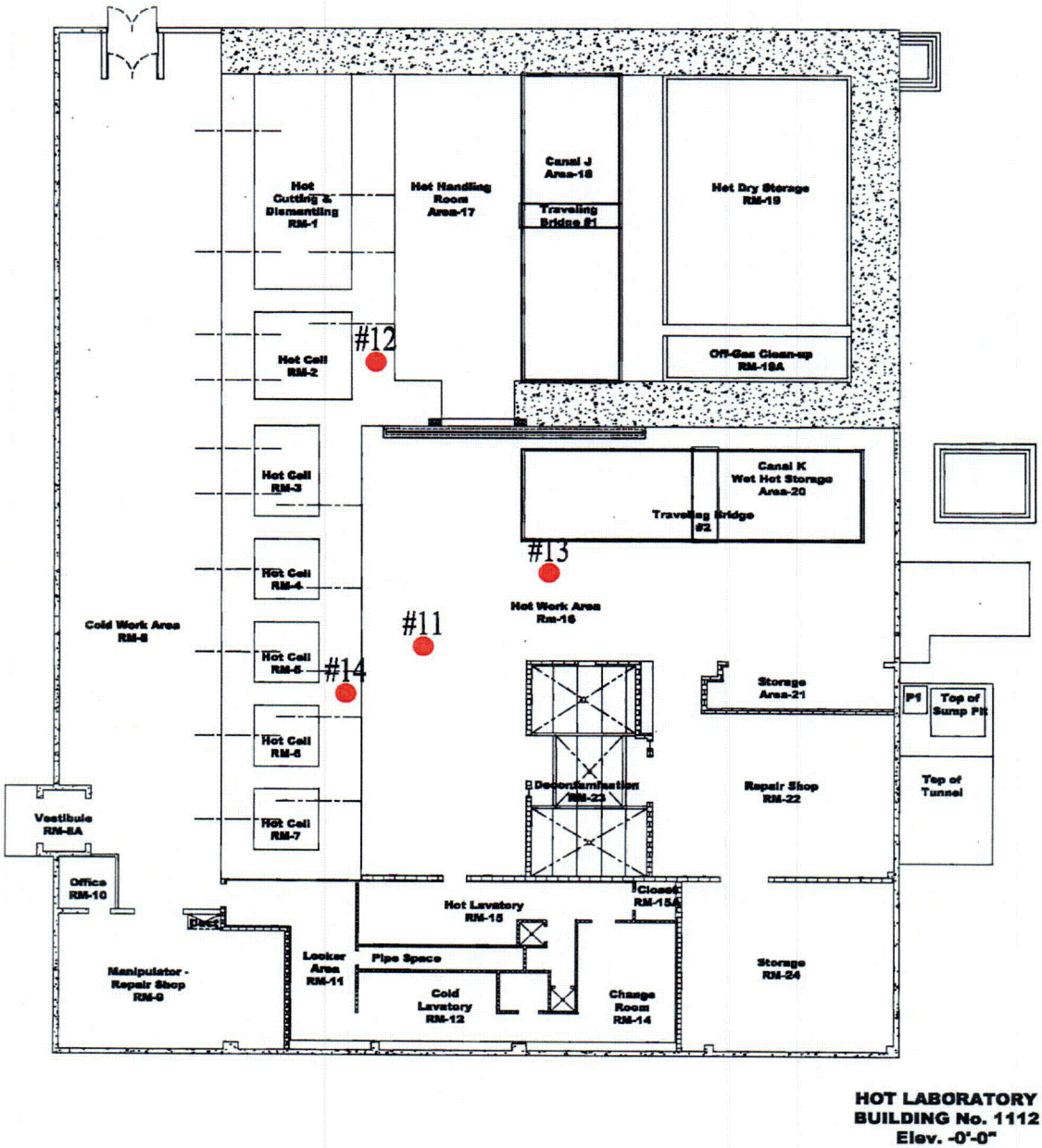
The data presented suggests that with the exception of the Hot Laboratory, the majority of the reactor produced radionuclides were confined to the 1st ½ inch of

concrete surface. In the Hot Lab, the contaminant migration observed went deeper, at some locations to a depth of one inch.

After the preliminary radionuclide analysis was complete, the samples were sent to an off-site laboratory for a full isotopic analysis. The top 1 inch concrete core was pulverized and analyzed for full isotopic content. Samples were prepared by transfer of the sample to a standard geometry or by removing a representative aliquot from the sample and processing the sample in accordance with the analytical technology selected. Gamma emitting isotopes were analyzed using a high purity Germanium (HPGe) gamma detector. Analysis for low energy gamma emitters used a planar, high purity germanium, low energy response gamma ray detector. Analysis for beta emitting isotopes employed beta liquid scintillation and alpha emitting isotopes were analyzed using alpha spectroscopy. These results are presented in Addendum 4 of this attachment.

Figure A-2

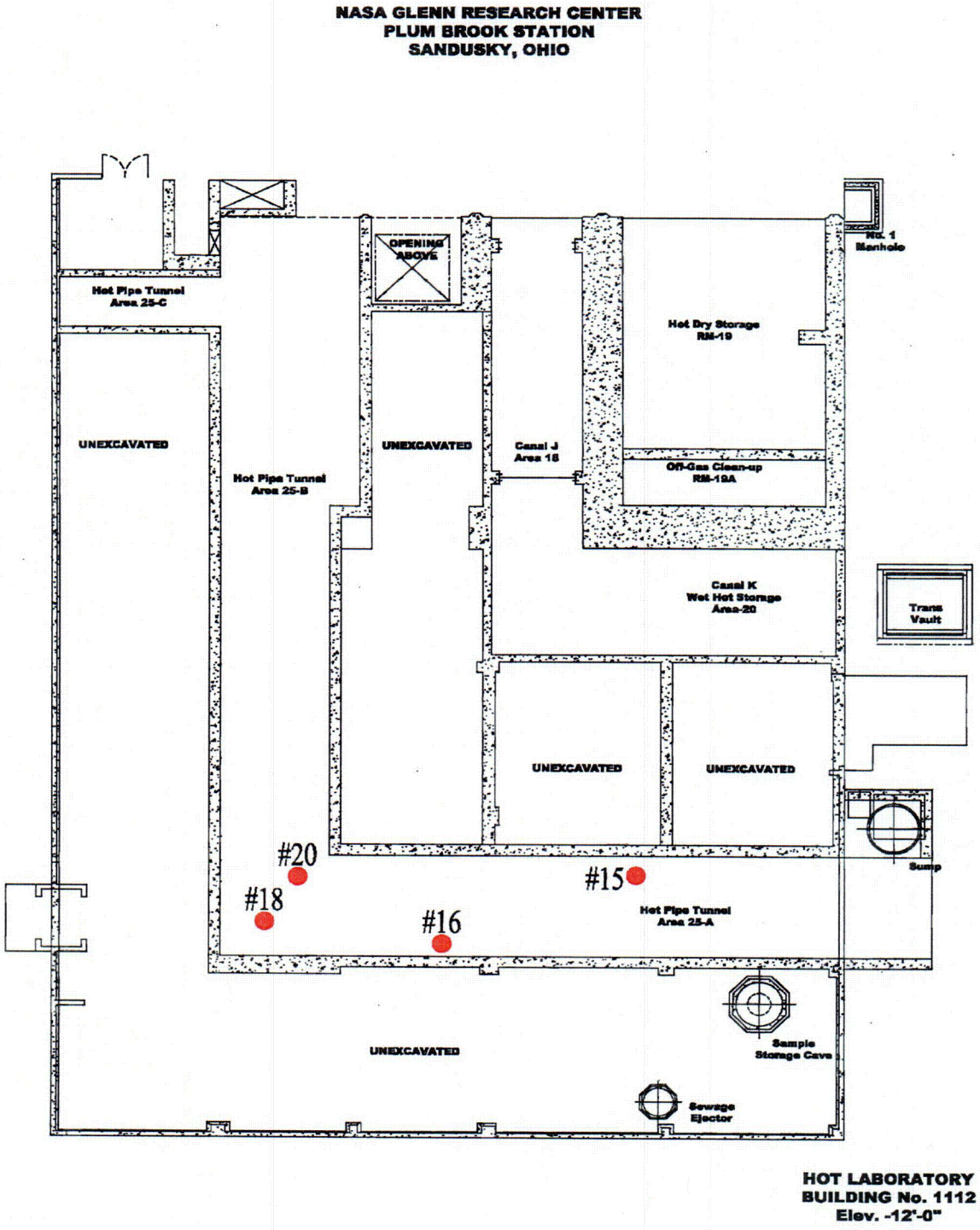
Concrete Core Population Sample Locations – Hot Laboratory



C02

Figure A-3

Concrete Core Population Sample Locations – Hot Pipe Tunnel



C03

C04

Figure A-4

Concrete Core Population Sample Locations – Reactor Building

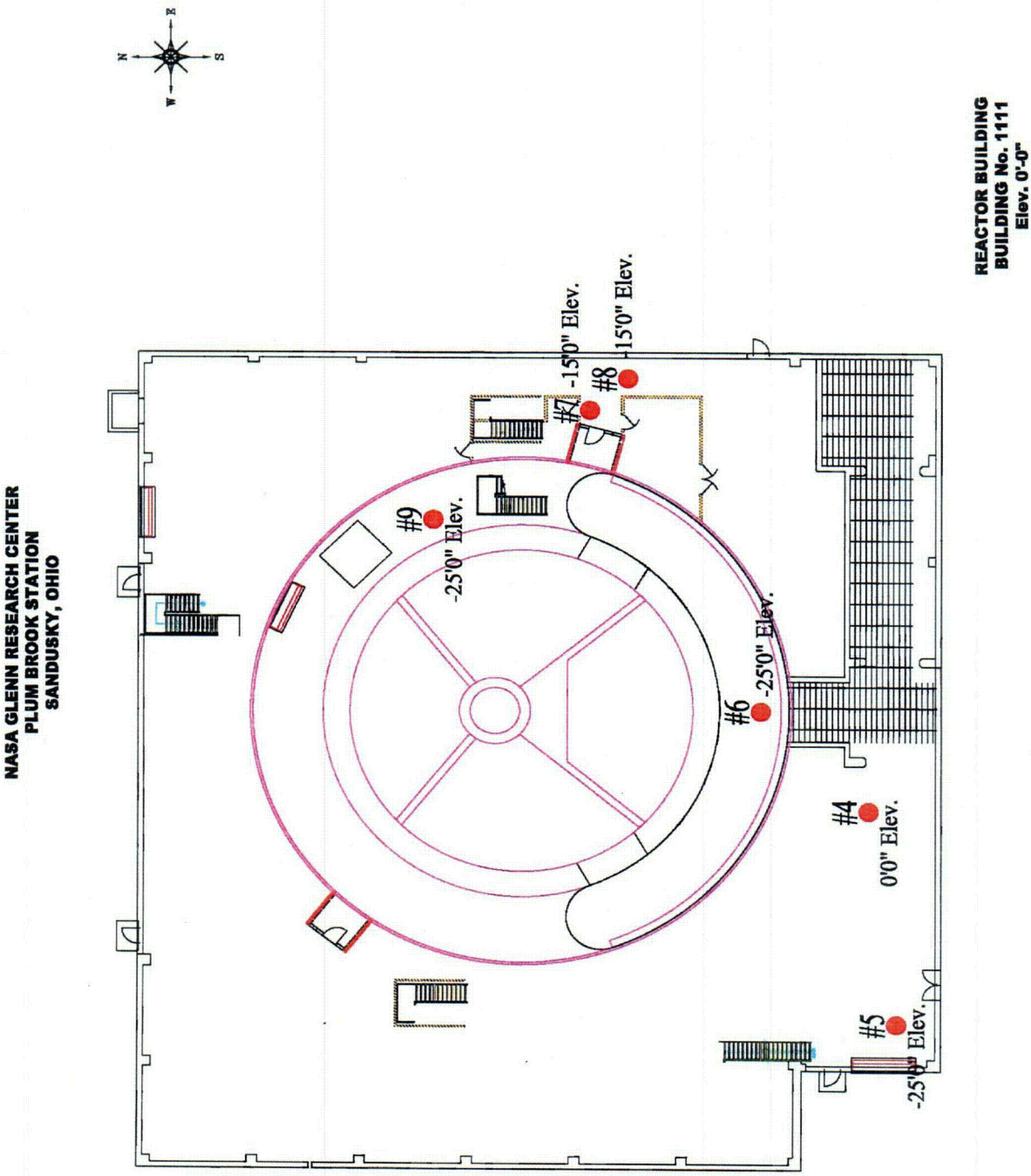
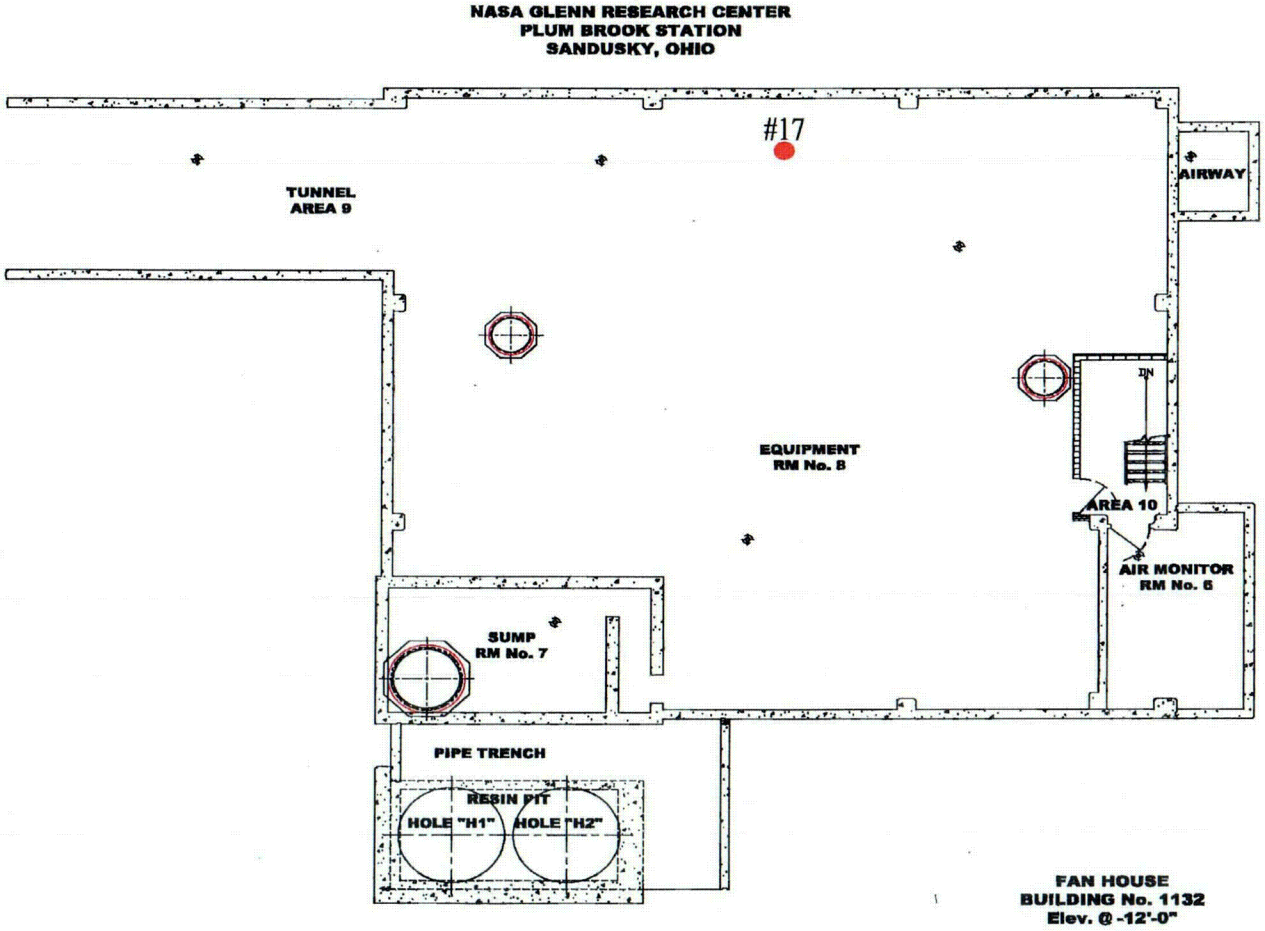


Figure A-5

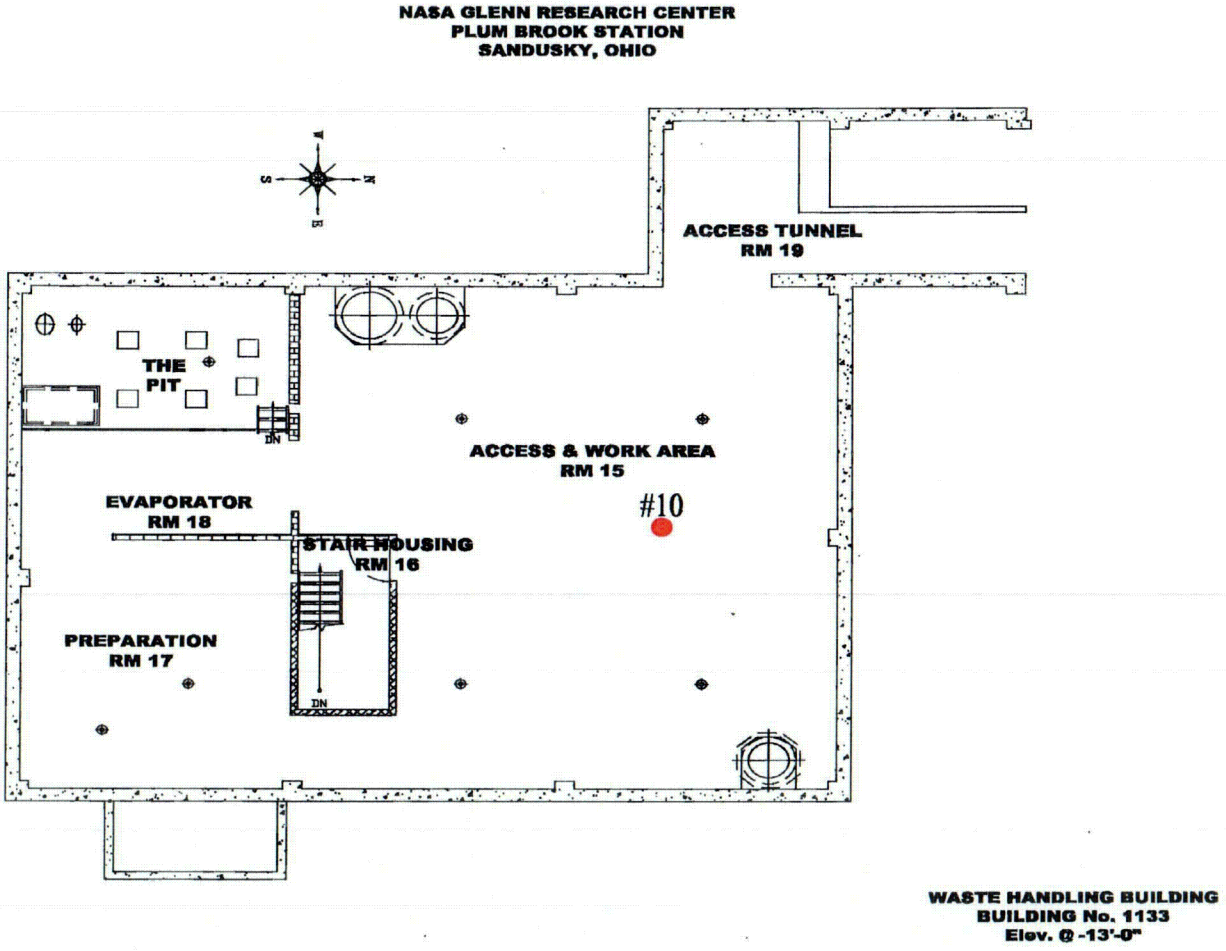
Concrete Core Population Sample Locations – Fan House



C05

Figure A-6

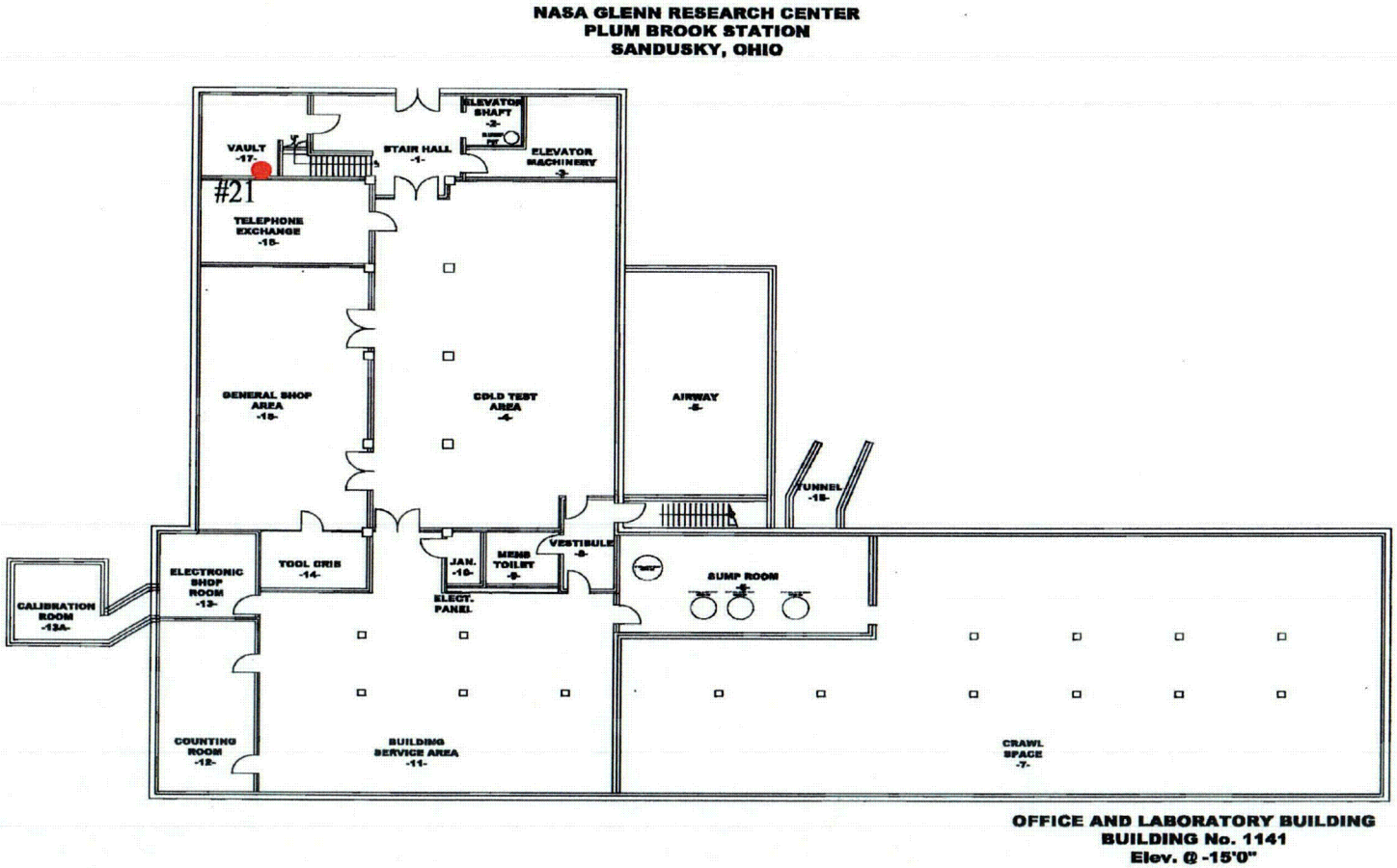
Concrete Core Population Sample Locations – Waste Handling Building



C16

Figure A-7

Concrete Core Population Sample Locations – ROLB



C07

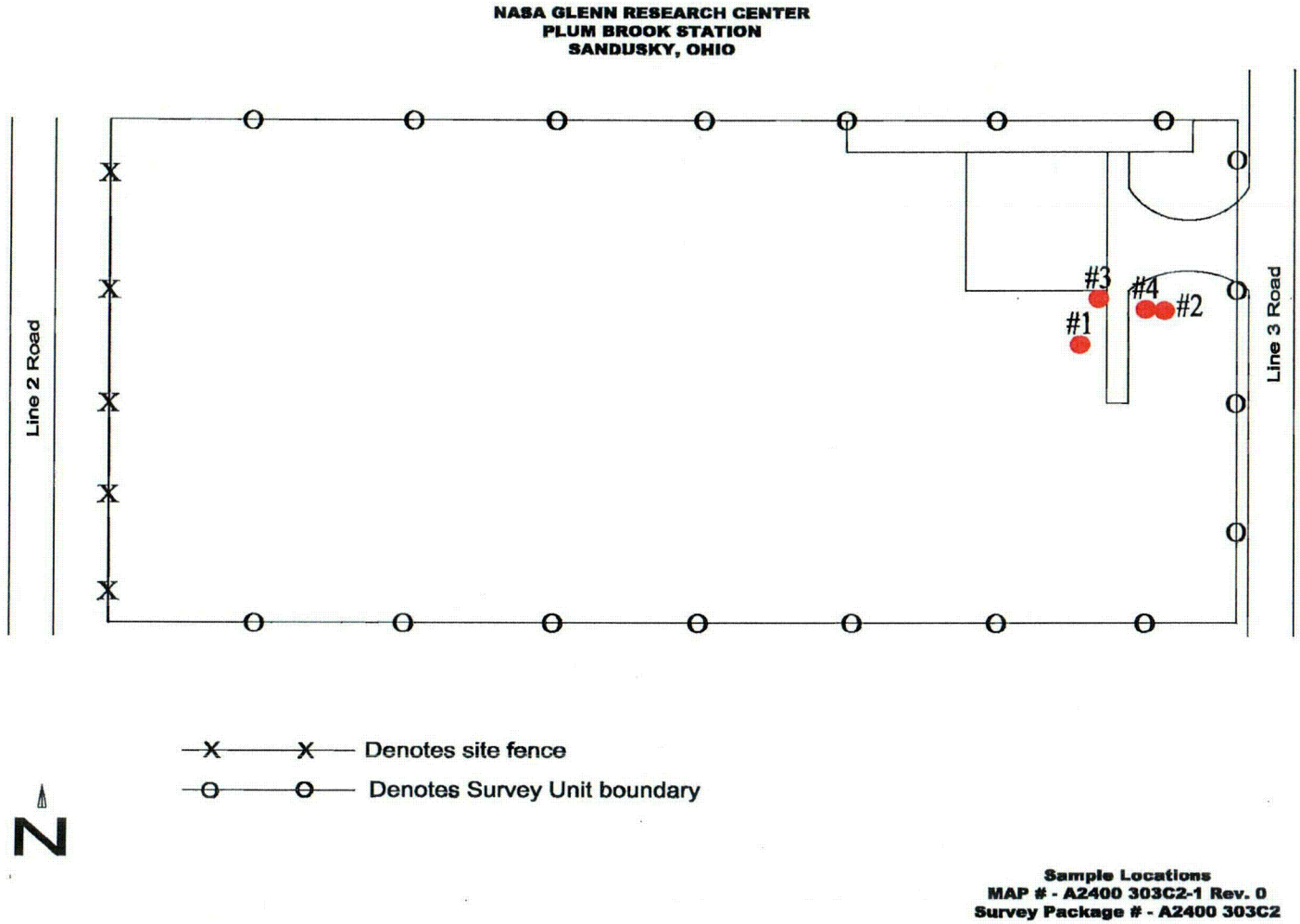
6.3 Soil Sampling

Surface soil samples were obtained to assess the radionuclide distribution in soils surrounding the facility. A sampling plan was developed and documented in characterization survey packages A2400 303C2 and A2100 101C2. Gamma scan surveys were performed using sodium iodide (NaI) detectors to ascertain the highest activity locations at the PBRF. Survey areas exhibiting scan results greater than twice the observed background were selected. At the area of highest observed scan activity, a one-liter soil sample was collected. Soil samples were sent to an off-site laboratory for processing and full isotopic analysis. Samples were analyzed for gamma emitting isotopes using a high purity germanium (HPGe) gamma detector. Analysis for low energy gamma emitters used a planar, high purity germanium, low energy response gamma ray detector. Analysis for beta emitting isotopes employed beta liquid scintillation and alpha emitting isotopes were analyzed using alpha spectroscopy.

In total, eight soil samples were obtained: four from the Emergency Retention Basin and four from a suspected spill area south of the Waste Handling Building. Other open land areas on site also indicated elevated scan activity; however the eight locations selected were biased in order to acquire samples with relatively high isotopic concentrations in order to minimize the contribution of MDA values to the resultant nuclide distribution. Analytical results for the surface soil samples are presented in Addendum 3 of this attachment.

Figure A-8

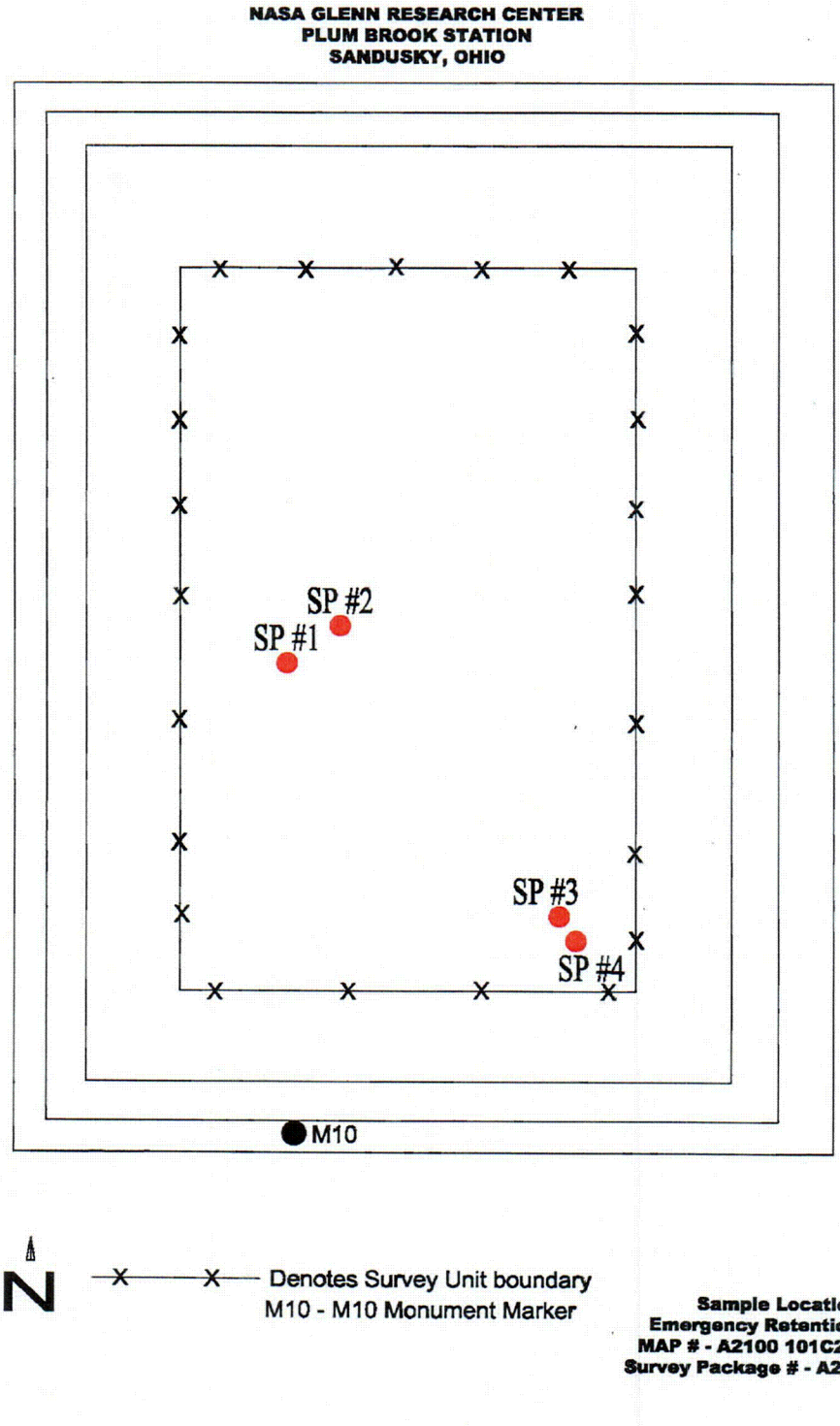
Surface Soil Population Sample Locations – WHB Spill Location



C08

Figure A-9

Surface Soil Population Sample Locations – ERB



C09

7.0 Evaluation of Sample Results and Elimination of Insignificant Radionuclides

7.1 Minimum Detectable Activity (MDA)

In all three sample types (smear samples, core samples and soil samples), before the nuclide distribution could be evaluated, the analysis results reported as less than MDA were considered. It was expected that several of the nuclides would be reported as less than MDA since these nuclides have a low probability of being present. Two approaches were considered for evaluating MDA results: 1) include the MDA values as representing actual concentrations, and 2) remove the less than MDA nuclides from the mixture. Removing the nuclides was considered more appropriate and representative of actual site conditions because the non-detected nuclides are believed either to not be present or to be present at negligible concentrations well below the MDA value. A nuclide was included in the "discarded" category if it was not detected at concentrations above MDA in any individual sample in the respective smear, core and/or soil sample population.

If a nuclide was detected above MDA in one or more samples in a given population, then the nuclide was retained and included in the mixture. For those radionuclides that were reported as positive in only a portion of the sample population, the MDA values were combined with the positive results to determine the mixture fraction. The MDA values were used in this case because it was conservatively assumed that if a radionuclide was positive in an individual sample then it could also be present in the remaining samples of the population. Using the MDA also has the effect of reducing the probability that a single positive radionuclide result in a given sample population will skew the overall percentage relationship between the isotopes when those percentages are normalized.

The remaining nuclides were then evaluated for the presence of naturally occurring isotopes. Naturally occurring isotopes were ignored in subsequent calculations.

7.2 Mean Distribution Evaluation

Following the analysis of all nuclides identified at activities greater than their respective MDAs, an assessment was performed to ascertain the activity of radionuclides that could be attributed to background. K-40, Pb-212, Pb-214, Bi-214, Th-228, Th-230, Th-232, and Ra-226 were detected at concentrations commensurate with levels normally found in background. Subsequently, these isotopes were removed from consideration in all the sample populations.

The radionuclide distribution percentage for each remaining nuclide was then calculated by dividing the concentration for each nuclide by the sum of all remaining radionuclide concentrations in the sample population expressing the abundance of the specific nuclide compared against the total sample activity. The mean nuclide distribution was then calculated by taking the average of the individual core nuclide fractions in each sample population.

The smear sample mean nuclide distribution in Table A-1 below contains all remaining radionuclides that were above MDA in one or more smear samples.

Table A-1

Smear Radionuclide Distribution

Radionuclide	Hot Laboratory	Balance of Plant	ROLB
Ag-108m	ND	0.06%	ND
Am-241	0.19%	0.13%	0.02%
C-14	0.20%	0.58%	0.26%
Co-57	0.03%	ND	ND
Co-60	2.38%	5.22%	0.98%
Cm-242	ND	ND	0.01%
Cm243/244	0.13%	0.02%	0.01%
Cm-245/246	ND	ND	ND
Cs-134	0.03%	ND	ND
Cs-137	43.69%	7.46%	16.62%
Eu-152	ND	0.13%	ND
Eu-154	0.08%	0.15%	ND
Eu-155	ND	ND	0.12%
Fe-55	2.75%	1.98%	ND
H-3	8.29%	66.53%	38.87%
I-129	0.02%	0.06%	2.66%
Na-22	0.03%	ND	ND
Nb-94	0.12%	0.03%	0.05%
Ni-59	0.33%	0.45%	1.68%
Ni-63	13.39%	13.66%	0.23%
Np-237	ND	ND	0.05%
Pu-238	0.11%	0.04%	ND
Pu-239/240	0.13%	0.02%	0.02%
Pu-241	1.19%	0.32%	0.45%
Pu-242	0.06%	ND	ND
Sb-125	ND	ND	0.23%
Sr-89	0.81%	0.03%	ND
Sr-90	25.43%	3.01%	4.03%
Tc-99	0.58%	0.12%	0.30%
U-233/234	0.03%	0.01%	31.87%
U-235/236	ND	ND	1.12%
U-238	ND	ND	0.42%

ND - Radionuclide Not Detected

The nuclide distribution for the Balance of Plant (BOP) smear population indicates a nuclide distribution for H-3 of 66.53%. It is unlikely that the actual contribution of tritium to the nuclide distribution is of this magnitude. The H-3 contribution is skewed by the inherent inaccuracy of the smear sample approach for material sampling as a means to quantify H-3 activity. The core sample data analysis provides a more realistic indication of H-3 concentrations as the core bore material sampling approach results in a volumetric sample medium more appropriate for the quantification of H-3. However, as the presence of H-3 has very little effect on the calculation of the adjusted gross DCGL, the distribution of H-3 in the smear populations was not adjusted.

The concrete core samples are believed to be more representative of the mixture that will remain after license termination than the smear samples because the majority of loose contamination will be removed during remediation. The majority of the potentially contaminated surfaces that will remain following structural remediation will be concrete.

As previously stated, radionuclides that were not present in concentrations greater than their respective MDA values in any of the concrete core samples were removed from the mixture. These isotopes included Sb-125, Eu-152, Eu-154, Eu-155, Nb-95, I-129, Np-237, Ni-59, Tc-99 and Cm-243/244. The core sample taken in the ROLB indicated no activity greater than background. Subsequently, a nuclide distribution based upon core sample analysis results can not be presented for the ROLB at this time. The concrete core sample mean nuclide distribution in Table A-2 below contains all remaining radionuclides that were above MDA in one or more core samples.

Table A-2

Concrete Core Radionuclide Distribution

Radionuclide	Hot Laboratory	Balance of Plant	ROLB
Am-241	0.41%	0.29%	ND
C-14	1.97%	ND	ND
Co-60	0.65%	1.23%	ND
Cm-245/246	0.07%	0.19%	ND
Cs-137	78.04%	34.79%	ND
Fe-55	ND	18.93%	ND
H-3	0.83%	8.46%	ND
Ni-63	3.09%	19.71%	ND
Pu-238	0.06%	0.07%	ND
Pu-239/240	0.59%	0.06%	ND
Pu-241	0.81%	2.49%	ND
Sr-90	13.23%	11.74%	ND
U-233/234	0.14%	0.98%	ND
U-235/236	0.01%	0.09%	ND
U-238	0.11%	0.97%	ND

ND - Radionuclide Not Detected

In the surface soil samples, Th-228, Th-230, Th-232, Th-227, Ra-226, U-234, U-235 and U-238 were detected at concentrations commensurate with levels normally found in background (U-234 concentrations ranged from 0.793 pC/g to 1.876 pC/g, U-235 concentrations ranged from 0.051 pC/g to 0.197 pC/g and U-238 concentrations ranged from 0.850 pC/g to 1.861 pC/g). Subsequently, these isotopes were removed from consideration in the soil radionuclide distribution mixture. The soil nuclide distribution in Table A-3 contains all remaining radionuclides that were above MDA in one or more surface soil samples.

Table A-3

Surface Soil Radionuclide Distribution

Radionuclide	Open Land Areas
Am-241	0.15%
Am-243	0.16%
C-14	2.11%
Cm-245	0.22%
Co-60	1.68%
Cs-137	58.50%
Eu-155	0.76%
H-3	22.68%
I-129	0.53%
Nb-94	0.30%
Ni-63	6.96%
Pu-238	0.17%
Pu-239	0.16%
Sr-90	5.49%
U-236	0.12%

7.3 Application of the 10% Rule

Based on data reviewed to date and considering the PBRF operational history, there appear to be three radionuclide mixtures for site structures and one distribution for soils. For site structures, the first applies to the Hot Laboratory, the second to the ROLB and the third to the remaining structures designated as Balance of Plant (BOP).

The final step in determining the radionuclide distribution for each of the mixtures involved the elimination of radionuclides that have insignificant dose consequences. NUREG-1757, Vol. 2, Section 3.3, states that nuclides with a combined dose of less than 10% of the 25 mrem/yr unrestricted use criteria can be eliminated from further consideration. To determine which nuclides can be eliminated by the "10%" rule, a RESRAD or RESRAD-Build run was performed using the mean nuclide distribution derived for each sample population. The concentration entered for each radionuclide was the fraction listed in Tables A-1, A-2 and A-3, respectively. The RESRAD/RESRAD-Build runs used to perform the "10%" rule calculations are provided in site Technical Basis Documents and are available for review, as needed.

For the mean distribution derived from the smear samples, RESRAD-Build and RESRAD evaluations were performed for the Building Reuse and Subsurface Structure scenarios, respectively. Concrete K_d data were not available in the

literature for three radionuclides with very low nuclide fractions; i.e. Na-22, Np-237, and Sb-125 at 0.03%, 0.00%, and 0.23%, respectively.

The RESRAD default K_d was used in the Subsurface Structure analysis for these radionuclides. Two radionuclides, Sr-89 and Cm-242, were reported as above MDA in one or more smear samples with mean fractions of 0.81% and 0.00%, respectively. RESRAD and RESRAD-Build do not list these radionuclides. Because of their very low fractions these nuclides were disregarded. In addition, Sr-89 is suspected to be a false positive because the half life is very short relative to the time since plant shutdown.

The radionuclides that, in aggregate, were less than 10% of the total dose for both of the scenarios were eliminated. The mixtures were readjusted to 100% based on the relative fractions of the radionuclides remaining after the insignificant radionuclides were removed.

The results of all RESRAD-Build and RESRAD runs, i.e. BOP, ROLB and Hot Lab mixtures in the Subsurface Structure and Building Reuse scenarios indicate that for the smear sample population, the aggregate dose from six radionuclides, i.e., Cs-137, Sr-90, Co-60, H-3, Eu-154 and I-129 resulted in 94% or more of the 25 mrem/yr limit in all BOP cases, the aggregate dose from five radionuclides, i.e., Cs-137, Sr-90, Co-60, H-3, and Eu-154 resulted in 93% or more of the 25 mrem/yr limit in all Hot Lab cases and the aggregate dose from seven radionuclides, i.e., Cs-137, Sr-90, Co-60, H-3, I-129, U-234 and U-235 resulted in 93% or more of the 25 mrem/yr limit in all ROLB cases.

For the core sample population, the aggregate dose from four radionuclides, i.e., Cs-137, Sr-90, Co-60 and H-3, resulted in 90% or more of the 25 mrem/yr limit in all BOP cases and the aggregate dose from three radionuclides, i.e., Cs-137, Sr-90 and Co-60 resulted in 92% or more of the 25 mrem/yr limit in all Hot Lab cases. As previously stated, a nuclide distribution based upon core sample analysis results can not be presented for the ROLB at this time due to the fact that the only available core sample indicated only background activity.

The lowest total aggregate dose from the remaining radionuclides was 90% of the 25 mrem/yr criterion, which means that radionuclides potentially representing a dose of 2.5 mrem/yr were eliminated. To ensure the 25 mrem/yr criterion is met, any structural survey unit where the mean of FSS results indicates that the dose may be greater than 22.5 mrem/yr dose (including dose from embedded pipe in the given survey unit, if applicable) shall be reviewed for compliance with the unrestricted use limit. The final normalized radionuclide distributions for structural surfaces are provided in Tables A-4 and A-5 below.

Additionally, the current decommissioning strategy for PBRF calls for the removal of activated portions of the concrete bioshield and disposition of the activated concrete as radioactive waste. Therefore, the activated concrete was not evaluated.

Table A-4

Final Smear Radionuclide Distribution

Radionuclide	Hot Laboratory	Balance of Plant	ROLB
Co-60	3.41%	6.72%	1.01%
Cs-137	53.11%	7.74%	17.29%
Eu-154	0.12%	0.17%	ND
H-3	10.84%	82.15%	39.71%
I-129	ND	0.08%	2.82%
Sr-90	32.52%	3.13%	4.17%
U-233/234	ND	ND	33.82%
U-235/236	ND	ND	1.19%

ND - Radionuclide Not Detected

Table A-5

Final Concrete Core Radionuclide Distribution

Radionuclide	Hot Laboratory	Balance of Plant
Co-60	0.79%	7.84%
Cs-137	83.45%	41.45%
H-3	ND	35.35%
Sr-90	15.77%	15.36%

ND - Radionuclide Not Detected

For surface soil samples, the doses from all radionuclides other than Cs-137, Co-60, and Sr-90 totaled 0.5 mrem/yr. Because this dose is 2% of the 25 mrem/yr limit, all radionuclides other than Cs-137, Co-60, and Sr-90 were eliminated from further consideration. To ensure the 25 mrem/yr criterion is met, any open land survey unit where the mean of FSS results indicates that the dose may be greater than 24.5 mrem/yr shall be reviewed for compliance with the unrestricted use limit. The final normalized radionuclide distributions for soils are provided in Table A-6 below.

Table A-6

Final Soil Radionuclide Distribution

Radionuclide	Open Land Areas
Co-60	2.56 %
Cs-137	89.08 %
Sr-90	8.36 %

8.0 Conclusion

Per NUREG-1757 (Reference 2.6), the Nuclear Regulatory Commission (NRC) staff considers radionuclides and exposure pathways that contribute no greater than 10% of the 25 mrem/yr dose criteria to be insignificant contributors. This 10% limit for insignificant contributors is an aggregate limitation only. That is, the sum of the dose contributions from all radionuclides and pathways considered insignificant will be no greater than 10% of the dose criteria of 25 mrem/yr per 10 CFR Part 20, Subpart E.

The dose from the insignificant radionuclides will be accounted for in demonstrating compliance, but may be eliminated from further detailed evaluations. The lowest total aggregate dose from the remaining radionuclides was evaluated at 90% of the 25 mrem/yr criterion, which means that radionuclides potentially representing a dose of 2.5 mrem/yr were eliminated. To ensure the 25 mrem/yr criterion is met, any structural survey unit where the mean of FSS results indicates that the dose may be greater than 22.5 mrem/yr dose (including dose from embedded pipe in the given survey unit, if applicable) shall be reviewed for compliance with the unrestricted use limit.

For surface soil samples, the doses from all radionuclides other than Cs-137, Co-60, and Sr-90 totaled 0.5 mrem/yr. Because this dose is 2% of the 25 mrem/yr limit, all radionuclides other than Cs-137, Co-60, and Sr-90 were eliminated from further consideration. To ensure the 25 mrem/yr criterion is met, any open land survey unit where the mean of FSS results indicates that the dose may be greater than 24.5 mrem/yr will be reviewed for compliance with the unrestricted use limit.

Based on the evaluation of insignificant radionuclides as described in this attachment, soil and structural surfaces at the PBRF may contain one or more of the radionuclides listed in Table A-7. These radionuclides will be considered during the FSS design and sample analysis process.

Table A-7

PBRF Radionuclides of Concern

Co-60
Cs-137
Eu-154
H-3
I-129
Sr-90
U-233/234
U-235/236

The BOP core population does not include samples from a number of BOP locations such as the primary pump house and quads. However, the cores collected are considered representative of all BOP areas because the predominant source of contamination in all areas is reactor coolant. Additional confirmatory samples and/or measurements will be

performed in appropriate BOP areas to confirm the assumption that the cores collected are representative of all BOP areas. The final radionuclide distribution, gross activity DCGL values, and surrogate DCGL values will be determined and documented in each survey unit FSS design package.

9.0 Addendums

Addendum 1 - Results of Isotopic Analysis of Smear Samples

Addendum 2 - Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

Addendum 3 - Results of Isotopic Analysis of Concrete Core Samples by the Offsite Laboratory

Addendum 4 - Results of Isotopic Analysis of Surface Soil Samples

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment A

Radionuclide Distribution Basis for DCGL Determination & Final Status Survey of the Plum Brook Reactor Facility (PBRF)

Addendum 1
Results of Isotopic Analysis of Smear Samples

Attachment A
Addendum 1
Results of Isotopic Analysis of Smear Samples

HOT LABORATORY

	Hot Cell Equipment #1 Smear (pCi/filter)				Hot Cell Equipment #2 Smear (pCi/filter)				Hot Cell Equipment #3 Smear (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Am-241	7.27E+03	6.85E+00	7.27E+03	0.15%	3.00E+02	5.05E-01	3.00E+02	0.07%	1.35E+02	8.83E-01	1.35E+02	0.11%
C-14	9.25E+02	1.37E+03	1.37E+03	0.03%	1.24E+02	6.12E+01	1.24E+02	0.03%	2.40E+02	6.21E+01	2.40E+02	0.20%
Co-57	0.00E+00	1.20E+02	1.20E+02	0.00%	0.00E+00	6.26E+01	6.26E+01	0.01%	0.00E+00	2.94E+01	2.94E+01	0.02%
Co-60	2.74E+05	1.24E+02	2.74E+05	5.73%	8.64E+03	2.25E+01	8.64E+03	1.94%	2.67E+03	1.27E+01	2.67E+03	2.26%
Cm-242	2.61E+00	7.82E+00	7.82E+00	0.00%	3.77E-01	7.22E-01	7.22E-01	0.00%	1.65E-01	2.47E-01	2.47E-01	0.00%
Cm-243/244	2.24E+02	2.25E+01	2.24E+02	0.00%	7.55E+00	7.32E-01	7.55E+00	0.00%	2.88E+00	5.50E-01	2.88E+00	0.00%
Cs-134	4.14E+02	1.71E+02	4.14E+02	0.01%	4.01E+01	6.92E+01	6.92E+01	0.02%	8.03E+00	3.01E+01	3.01E+01	0.03%
Cs-137	8.07E+05	2.06E+02	8.07E+05	18.89%	2.71E+05	6.98E+01	2.71E+05	60.88%	4.51E+04	3.22E+01	4.51E+04	38.23%
Eu-154	1.79E+03	3.69E+02	1.79E+03	0.04%	0.00E+00	8.27E+01	8.27E+01	0.02%	1.94E+02	7.49E+01	1.94E+02	0.16%
Fe-55	1.69E+05	7.58E+01	1.69E+05	3.54%	3.44E+03	3.85E+03	3.85E+03	0.86%	1.00E+03	4.09E+03	4.09E+03	3.47%
H-3	6.26E+05	3.49E+02	6.26E+05	13.10%	4.69E+03	2.53E+02	4.69E+03	1.05%	1.73E+03	4.51E+02	1.73E+03	1.47%
I-129	-2.31E+00	2.32E+01	2.32E+01	0.00%	2.03E+00	2.14E+01	2.14E+01	0.00%	1.25E-01	8.51E+00	8.51E+00	0.01%
Na-22	0.00E+00	1.18E+02	1.18E+02	0.00%	4.81E+01	1.59E+02	1.59E+02	0.04%	0.00E+00	1.42E+01	1.42E+01	0.01%
Nb-94	4.99E+04	1.52E+02	4.99E+04	1.04%	1.50E+01	2.92E+01	2.92E+01	0.01%	1.18E+02	1.57E+01	1.18E+02	0.10%
Ni-59	6.28E+03	2.90E+02	6.28E+03	0.13%	1.86E+02	1.98E+02	1.98E+02	0.04%	2.11E+02	2.70E+02	2.70E+02	0.23%
Ni-63	9.42E+05	1.80E+06	1.80E+06	37.67%	3.76E+04	1.80E+03	3.76E+04	8.45%	1.56E+04	8.28E+02	1.56E+04	13.22%
Np-237	2.03E+00	2.65E-01	2.03E+00	0.00%	2.60E-01	2.60E-01	2.60E-01	0.00%	2.58E-01	2.58E-01	2.58E-01	0.00%
Pu-238	3.56E+03	2.04E+01	3.56E+03	0.07%	2.17E+02	6.34E+00	2.17E+02	0.05%	7.52E+01	5.55E+00	7.52E+01	0.06%
Pu-239/240	3.65E+03	2.04E+01	3.65E+03	0.08%	3.11E+02	2.51E+00	3.11E+02	0.07%	1.79E+02	2.91E+00	1.79E+02	0.15%
Pu-241	3.16E+04	2.37E+02	3.16E+04	0.66%	2.39E+03	1.65E+02	2.39E+03	0.54%	8.07E+02	1.83E+02	8.07E+02	0.68%
Pu-242	2.56E+01	3.59E+01	3.59E+01	0.00%	5.07E+00	3.46E+00	5.07E+00	0.00%	4.24E+00	1.16E+00	4.24E+00	0.00%
Sr-89	-9.60E+04	2.20E+02	2.20E+02	0.00%	-2.16E+04	2.42E+02	2.42E+02	0.05%	-6.00E+03	2.70E+02	2.70E+02	0.23%
Sr-90	8.27E+05	3.49E+02	8.27E+05	17.31%	1.15E+05	3.50E+02	1.15E+05	25.84%	4.63E+04	3.65E+02	4.63E+04	39.25%
Tc-99	1.68E+05	4.19E+02	1.68E+05	3.52%	-3.26E+00	6.12E+01	6.12E+01	0.01%	6.71E+01	4.55E+01	6.71E+01	0.06%
U-233/234	6.69E+02	7.48E-01	6.69E+02	0.01%	4.23E+01	7.00E-01	4.23E+01	0.01%	2.48E+01	3.01E-01	2.48E+01	0.02%
U-235/236	4.34E+01	7.50E-01	4.34E+01	0.00%	2.84E+00	2.75E-01	2.84E+00	0.00%	1.11E+00	3.02E-01	1.11E+00	0.00%
U-238	9.58E+00	9.36E-01	9.58E+00	0.00%	4.57E+00	2.74E-01	4.57E+00	0.00%	8.02E-01	7.67E-01	8.02E-01	0.00%
			4.78E+06	100.00%			4.45E+05	100.00%			1.18E+05	100.00%

	Hot Cell Equipment #4 Smear (pCi/filter)				Hot Cell Equipment #5 Smear (pCi/filter)				Hot Cell Equipment #6 Smear (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Am-241	2.78E+01	2.45E-01	2.78E+01	0.09%	1.03E+02	7.73E-01	1.03E+02	0.03%	1.05E+02	2.01E-01	1.05E+02	0.37%
C-14	2.80E+01	3.37E+02	3.37E+02	1.11%	3.56E+00	3.59E+01	3.59E+01	0.01%	3.67E+01	3.89E+01	3.89E+01	0.14%
Co-57	5.23E+00	1.13E+01	1.13E+01	0.04%	6.33E+00	6.15E+01	6.15E+01	0.02%	0.00E+00	1.40E+01	1.40E+01	0.05%
Co-60	1.58E+03	1.23E+01	1.58E+03	5.20%	3.23E+02	7.06E+00	3.23E+02	0.10%	4.91E+02	7.50E+00	4.91E+02	1.74%
Cm-242	9.67E-02	7.40E-01	7.40E-01	0.00%	1.91E-01	2.86E-01	2.86E-01	0.00%	3.96E-01	2.38E-01	3.96E-01	0.00%
Cm-243/244	2.21E+00	7.83E-01	2.21E+00	0.01%	1.46E+00	9.96E-01	1.46E+00	0.00%	2.42E+00	2.02E-01	2.42E+00	0.01%
Cs-134	3.77E+00	1.47E+01	1.47E+01	0.05%	1.82E+01	6.52E+01	6.52E+01	0.02%	4.45E+00	1.54E+01	1.54E+01	0.05%
Cs-137	3.99E+03	1.61E+01	3.99E+03	13.13%	2.65E+05	6.04E+01	2.65E+05	86.87%	1.16E+04	1.47E+01	1.16E+04	41.10%
Eu-154	2.64E+01	3.99E+01	3.99E+01	0.13%	0.00E+00	3.04E+01	3.04E+01	0.01%	0.00E+00	3.11E+01	3.11E+01	0.11%
Fe-55	7.50E+02	2.90E+01	7.50E+02	2.47%	5.17E+02	8.52E+02	8.52E+02	0.26%	5.54E+02	7.98E+02	7.98E+02	2.83%
H-3	1.51E+04	3.94E+02	1.51E+04	49.70%	7.61E+01	2.70E+02	2.70E+02	0.08%	1.95E+02	2.63E+02	2.63E+02	0.93%
I-129	1.64E+00	1.83E+01	1.83E+01	0.06%	-4.97E+00	2.33E+01	2.33E+01	0.01%	-5.22E-01	6.17E+00	6.17E+00	0.02%
Na-22	9.55E+00	1.44E+01	1.44E+01	0.05%	1.33E+01	6.15E+00	1.33E+01	0.00%	1.53E+01	8.23E+00	1.53E+01	0.05%
Nb-94	-1.25E+00	1.27E+01	1.27E+01	0.04%	2.91E+00	9.20E+00	9.20E+00	0.00%	3.64E+00	8.03E+01	8.03E+01	0.28%
Ni-59	-4.30E+01	2.42E+02	2.42E+02	0.80%	1.62E+02	2.41E+02	2.41E+02	0.07%	1.17E+02	2.21E+02	2.21E+02	0.78%
Ni-63	4.50E+03	8.73E+02	4.50E+03	14.81%	1.42E+03	3.67E+02	1.42E+03	0.43%	3.75E+03	4.69E+02	3.75E+03	13.29%
Np-237	-1.57E-01	9.33E-01	9.33E-01	0.00%	4.30E-03	8.13E-01	8.13E-01	0.00%	3.62E-03	6.83E-01	6.83E-01	0.00%
Pu-238	1.86E+01	3.07E+00	1.86E+01	0.06%	5.51E+01	2.16E+00	5.51E+01	0.02%	5.64E+01	2.98E+00	5.64E+01	0.20%
Pu-239/240	1.55E+01	2.55E+00	1.55E+01	0.05%	1.04E+02	1.97E+00	1.04E+02	0.03%	4.55E+01	1.29E+00	4.55E+01	0.16%
Pu-241	1.92E+02	1.87E+02	1.92E+02	0.63%	7.39E+02	2.09E+02	7.39E+02	0.23%	7.10E+02	2.00E+02	7.10E+02	2.52%
Pu-242	4.77E-01	2.55E+00	2.55E+00	0.01%	2.49E+00	1.97E+00	2.49E+00	0.00%	3.26E-01	2.26E+00	2.26E+00	0.01%
Sr-89	-2.52E+02	2.85E+02	2.85E+02	0.94%	-6.86E+03	2.53E+02	2.53E+02	0.08%	-3.70E+03	2.47E+02	2.47E+02	0.88%
Sr-90	3.18E+03	3.94E+02	3.18E+03	10.47%	3.84E+04	2.87E+02	3.84E+04	11.71%	9.70E+03	3.54E+02	9.70E+03	34.37%
Tc-99	-1.45E+01	4.05E+01	4.05E+01	0.13%	4.67E+01	1.00E+01	4.67E+01	0.01%	2.44E+01	2.44E+01	2.44E+01	0.09%
U-233/234	3.88E+00	8.24E-01	3.88E+00	0.01%	8.16E+00	1.42E+00	8.16E+00	0.00%	2.15E+00	8.95E-01	2.15E+00	0.01%
U-235/236	3.24E-01	8.26E-01	8.26E-01	0.00%	5.32E-01	3.19E-01	5.32E-01	0.00%	1.87E-01	2.81E-01	2.81E-01	0.00%
U-238	8.62E-01	1.03E+00	1.03E+00	0.00%	2.12E-01	8.11E-01	8.11E-01	0.00%	2.80E-01	2.80E-01	2.80E-01	0.00%
			3.04E+04	100.00%			3.28E+05	100.00%			2.82E+04	100.00%

	Hot Cell Equipment #7 Smear (pCi/filter)				Hot Cell #1 Surface Smear (pCi/filter)				Hot Cell #2 Surface Smear (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Am-241	2.94E+02	2.63E-01	2.94E+02	0.07%	1.10E+03	1.89E-01	1.10E+03	0.05%	3.25E+03	6.96E+00	3.25E+03	0.86%
C-14	8.60E+02	1.42E+02	8.60E+02	0.19%	3.94E+02	8.37E+01	3.94E+02	0.02%	1.39E+02	6.93E+01	1.39E+02	0.04%
Co-57	0.00E+00	4.41E+01	4.41E+01	0.01%	0.00E+00	1.14E+02	1.14E+02	0.00%	1.38E+01	4.27E+01	4.27E+01	0.01%
Co-60	6.08E+03	2.03E+01	6.08E+03	1.35%	5.16E+04	5.16E+01	5.16E+04	2.19%	2.01E+04	3.13E+01	2.01E+04	5.31%
Cm-242	4.12E-01	3.09E-01	4.12E-01	0.00%	5.64E-01	2.11E-01	5.64E-01	0.00%	1.51E+00	2.32E+01	2.32E+01	0.01%
Cm-243/244	1.93E+02	8.41E-01	1.93E+02	0.04%	5.07E+01	8.46E-01	5.07E+01	0.00%	3.05E+01	2.53E+01	3.05E+01	0.01%
Cs-134	-3.15E+00	4.72E+01	4.72E+01	0.01%	9.78E+00	1.17E+02	1.17E+02	0.00%	1.41E+01	5.03E+01	5.03E+01	0.01%
Cs-137	1.09E+05	5.49E+01	1.09E+05	24.21%	8.03E+05	1.25E+02	8.03E+05	34.12%	1.09E+05	6.47E+01	1.09E+05	28.81%
Eu-154	0.00E+00	7.95E+01	7.95E+01	0.02%	1.18E+03	1.44E+02	1.18E+03	0.05%	4.07E+02	7.91E+01	4.07E+02	0.11%
Fe-55	2.36E+03	3.70E+03	3.70E+03	0.82%	1.05E+04	4.28E+03	1.05E+04	0.45%	2.62E+03	9.04E+02	2.62E+03	0.69%
H-3	1.63E+05	6.91E+02	1.63E+05	36.20%	5.43E+04	4.01E+02	5.43E+04	2.31%	1.09E+04	5.33E+02	1.09E+04	2.88%
I-129	-3.79E-01	2.14E+01	2.14E+01	0.00%	0.00E+00	3.33E+01	3.33E+01	0.00%	0.00E+00	3.82E+01	3.82E+01	0.01%
Na-22	7.14E+01	1.78E+01	7.14E+01	0.02%	0.00E+00	7.17E+01	7.17E+01	0.00%	0.00E+00	4.01E+01	4.01E+01	0.01%
Nb-94	8.38E+01	2.30E+01	8.38E+01	0.02%	6.66E+01	7.06E+01	7.06E+01	0.00%	2.79E+01	3.64E+01	3.64E+01	0.01%
Ni-59	0.00E+00	2.66E+02	2.66E+02	0.06%	2.21E+03	2.67E+02	2.21E+03	0.09%	5.53E+02	2.10E+02	5.53E+02	0.15%
Ni-63	4.05E+04	1.94E+03	4.05E+04	9.00%	1.66E+05	7.78E+03	1.66E+05	7.05%	8.34E+04	3.93E+03	8.34E+04	22.05%
Np-237	6.26E-01	5.89E-01	6.26E-01	0.00%	1.01E+00	5.95E-01	1.01E+00	0.00%	8.98E-02	7.85E-01	7.85E-01	0.00%
Pu-238	1.63E+02	3.70E+00	1.63E+02	0.04%	9.49E+02	4.78E+00	9.49E+02	0.04%	8.75E+02	4.18E+01	8.75E+02	0.23%
Pu-239/240	3.91E+02	1.37E+00	3.91E+02	0.09%	3.01E+03	1.99E+00	3.01E+03	0.13%	2.01E+03	2.37E+01	2.01E+03	0.53%
Pu-241	1.82E+03	2.05E+02	1.82E+03	0.40%	7.17E+03	1.11E+02	7.17E+03	0.30%	1.64E+04	1.89E+02	1.64E+04	4.34%
Pu-242	1.79E+01	3.17E+00	1.79E+01	0.00%	3.40E+01	1.99E+00	3.40E+01	0.00%	2.97E+01	4.17E+01	4.17E+01	0.01%
Sr-89	6.70E+02	2.36E+02	6.70E+02	0.15%	-1.96E+05	2.04E+02	2.04E+02	0.01%	-1.97E+04	2.78E+02	2.78E+02	0.07%
Sr-90	1.22E+05	3.47E+02	1.22E+05	27.10%	1.25E+06	2.72E+02	1.25E+06	53.12%	1.15E+05	3.29E+02	1.15E+05	30.40%
Tc-99	7.54E+01	1.08E+02	1.08E+02	0.02%	-4.11E+00	6.17E+01	6.17E+01	0.00%	1.30E+04	1.04E+02	1.30E+04	3.44%
U-233/234	7.82E+02	1.02E+00	7.82E+02	0.17%	1.05E+03	6.27E-01	1.05E+03	0.04%	5.43E+01	8.26E-01	5.43E+01	0.01%
U-235/236	4.09E+01	1.42E+00	4.09E+01	0.01%	5.52E+01	6.29E-01	5.52E+01	0.00%	3.03E+00	6.62E-01	3.03E+00	0.00%
U-238	1.33E+01	1.14E+00	1.33E+01	0.00%	3.11E+01	2.46E-01	3.11E+01	0.00%	2.50E+00	9.53E-01	2.50E+00	0.00%
			4.50E+05	100.00%			2.35E+06	100.00%			3.78E+05	100.00%

Attachment A
Addendum 1
Results of Isotopic Analysis of Smear Samples

	Hot Cell #3 Surface Smear (pCi/filter)				Hot Cell #4 Surface Smear (pCi/filter)				Hot Cell #5 Surface Smear (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Am-241	5.26E+01	8.73E-01	5.26E+01	0.45%	3.31E+01	2.42E-01	3.31E+01	0.19%	2.99E+01	2.48E-01	2.99E+01	0.11%
C-14	9.95E+00	3.55E+01	3.55E+01	0.31%	-1.08E+01	5.84E+01	5.84E+01	0.33%	-8.55E+00	5.48E+01	5.48E+01	0.21%
Co-57	8.00E+00	7.42E+00	7.42E+00	0.06%	9.09E-01	9.59E+00	9.59E+00	0.05%	1.27E+01	1.50E+01	1.50E+01	0.06%
Co-60	3.87E+02	8.70E+00	3.87E+02	3.33%	2.70E+02	5.70E+00	2.70E+02	1.54%	1.53E+02	9.69E+00	1.53E+02	0.58%
Cm-242	0.00E+00	3.92E-01	3.92E-01	0.00%	9.57E-02	2.87E-01	2.87E-01	0.00%	-1.16E-08	7.47E-01	7.47E-01	0.00%
Cm-243/244	2.06E+02	3.43E-01	2.06E+02	1.78%	1.46E+00	2.43E-01	1.46E+00	0.01%	9.96E-01	7.95E-01	9.96E-01	0.00%
Cs-134	3.86E-02	1.00E+01	1.00E+01	0.09%	-3.80E+00	9.62E+00	9.62E+00	0.05%	3.63E+00	1.82E+01	1.82E+01	0.07%
Cs-137	3.57E+03	9.55E+00	3.57E+03	30.76%	5.87E+03	1.17E+01	5.87E+03	33.53%	1.75E+04	1.70E+01	1.75E+04	66.42%
Eu-154	5.35E+00	2.59E+01	2.59E+01	0.22%	1.76E+00	1.89E+01	1.89E+01	0.10%	2.62E+00	2.75E+01	2.75E+01	0.10%
Fe-55	4.50E+02	9.34E+02	9.34E+02	8.05%	6.54E+02	7.55E+02	7.55E+02	4.31%	6.06E+02	7.52E+02	7.52E+02	2.85%
H-3	1.71E+01	2.26E+02	2.26E+02	1.95%	6.17E+02	4.37E+02	6.17E+02	3.52%	3.32E+01	3.17E+02	3.17E+02	1.20%
I-129	N/A	N/A	0	0.00%	-1.39E+00	1.53E+01	1.53E+01	0.09%	2.12E+00	7.17E-01	2.12E+00	0.01%
Na-22	1.89E+00	9.30E+00	9.30E+00	0.08%	6.47E-01	6.11E+00	6.11E+00	0.03%	9.62E-01	9.96E+00	9.96E+00	0.04%
Nb-94	5.04E+00	9.15E+00	9.15E+00	0.08%	-3.24E+00	5.23E+00	5.23E+00	0.03%	-1.25E+00	7.94E+00	7.94E+00	0.03%
Ni-59	N/A	N/A	0	0.00%	7.29E+01	2.03E+02	2.03E+02	1.16%	1.02E+02	5.47E+00	1.02E+02	0.39%
Ni-63	2.78E+03	4.33E+02	2.78E+03	23.95%	4.32E+03	4.54E+02	4.32E+03	24.67%	9.00E+02	2.53E+02	9.00E+02	3.42%
Np-237	5.08E-02	7.78E-01	7.78E-01	0.01%	-1.41E-01	8.17E-01	8.17E-01	0.00%	-1.46E-01	2.41E+00	2.41E+00	0.01%
Pu-238	1.29E+01	2.48E+00	1.29E+01	0.11%	7.28E+01	5.17E+00	7.28E+01	0.42%	3.39E+01	1.16E+00	3.39E+01	0.13%
Pu-239/240	2.58E+01	2.10E+00	2.58E+01	0.22%	2.28E+01	3.04E+00	2.28E+01	0.13%	2.08E+01	9.60E+00	2.08E+01	0.08%
Pu-241	3.35E+02	2.01E+02	3.35E+02	2.89%	2.68E+02	1.55E+02	2.68E+02	1.53%	2.53E+02	1.87E+02	2.53E+02	0.96%
Pu-242	2.20E+00	2.48E+00	2.48E+00	0.02%	5.08E-01	3.69E+00	3.69E+00	0.02%	2.33E+00	1.90E+02	1.90E+02	0.72%
Sr-89	6.91E+02	3.21E+02	6.91E+02	5.95%	-9.25E+02	2.13E+02	2.13E+02	1.22%	-3.70E+02	2.44E+02	2.44E+02	0.93%
Sr-90	2.24E+03	3.67E+02	2.24E+03	19.30%	4.70E+03	3.00E+02	4.70E+03	26.84%	5.66E+03	3.56E+02	5.66E+03	21.48%
Tc-99	1.88E+01	3.80E+01	3.80E+01	0.33%	1.18E+01	3.36E+01	3.36E+01	0.19%	-1.15E+01	4.90E+01	4.90E+01	0.19%
U-233/234	3.85E+00	1.61E+00	3.85E+00	0.03%	1.74E+00	8.34E-01	1.74E+00	0.01%	3.03E+00	2.84E-01	3.03E+00	0.01%
U-235/236	2.41E-01	9.23E-01	9.23E-01	0.01%	5.21E-08	8.37E-01	8.37E-01	0.00%	9.51E-02	7.27E-01	7.27E-01	0.00%
U-238	1.20E-01	1.15E+00	1.15E+00	0.01%	1.74E-01	2.61E-01	2.61E-01	0.00%	3.79E-01	2.84E-01	3.79E-01	0.00%
			1.16E+04	100.00%			1.75E+04	100.00%			2.63E+04	100.00%

	Hot Cell #6 Surface Smear (pCi/filter)				Hot Cell #7 Surface Smear (pCi/filter)					MEAN (pCi/gm)	MEAN (%)	STD DEV
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution				
Am-241	5.63E+01	8.58E-01	5.63E+01	0.04%	4.52E+01	2.70E-01	4.52E+01	0.09%	Am-241	9.82E+02	0.19%	0.23%
C-14	1.72E+02	5.77E+01	1.72E+02	0.13%	-3.30E+01	4.91E+01	4.91E+01	0.10%	C-14	2.96E+02	0.20%	0.28%
Co-57	3.36E+01	2.74E+01	3.36E+01	0.02%	-6.57E+00	2.23E+01	2.23E+01	0.04%	Co-57	4.40E+01	0.03%	0.02%
Co-60	1.44E+03	9.69E+00	1.44E+03	1.05%	5.30E+02	9.30E+00	5.30E+02	1.03%	Co-60	2.83E+04	2.38%	1.82%
Cm-242	-1.58E-08	1.10E+00	1.10E+00	0.00%	2.12E-01	8.11E-01	8.11E-01	0.00%	Cm-242	2.84E+00	0.00%	0.00%
Cm-243/244	1.01E+00	1.08E+00	1.08E+00	0.00%	1.08E+00	1.21E+00	1.21E+00	0.00%	Cm-243/244	5.57E+01	0.13%	0.47%
Cs-134	-1.16E+01	3.06E+01	3.06E+01	0.02%	9.06E+00	2.73E+01	2.73E+01	0.05%	Cs-134	6.93E+01	0.03%	0.03%
Cs-137	8.19E+04	2.75E+01	8.19E+04	59.82%	3.95E+04	2.40E+01	3.95E+04	76.81%	Cs-137	1.98E+05	43.69%	22.68%
Eu-154	0.00E+00	4.01E+01	4.01E+01	0.03%	1.31E+01	3.46E+01	3.46E+01	0.07%	Eu-154	3.04E+02	0.08%	0.06%
Fe-55	3.48E+03	8.54E+03	8.54E+03	6.24%	4.03E+02	8.20E+02	8.20E+02	1.59%	Fe-55	1.59E+04	2.75%	2.29%
H-3	4.47E+02	2.44E+02	4.47E+02	0.33%	6.81E+02	2.44E+02	6.81E+02	1.32%	H-3	6.76E+04	8.29%	15.26%
I-129	-3.23E+00	2.07E+01	2.07E+01	0.02%	5.41E-02	1.11E+01	1.11E+01	0.02%	I-129	1.85E+01	0.02%	0.03%
Na-22	1.69E+01	9.79E+00	1.69E+01	0.01%	4.74E+00	1.22E+01	1.22E+01	0.02%	Na-22	4.32E+01	0.03%	0.02%
Nb-94	2.13E+01	1.25E+01	2.13E+01	0.02%	4.42E-01	1.04E+01	1.04E+01	0.02%	Nb-94	3.88E+03	0.12%	0.28%
Ni-59	1.35E+02	2.61E+02	2.61E+02	0.19%	1.67E+02	2.36E+02	2.36E+02	0.46%	Ni-59	8.60E+02	0.33%	0.35%
Ni-63	5.44E+03	5.49E+02	5.44E+03	3.97%	2.80E+03	4.18E+02	2.80E+03	5.44%	Ni-63	1.67E+05	13.39%	10.41%
Np-237	2.56E-01	8.31E-01	8.31E-01	0.00%	1.53E-01	8.28E-01	8.28E-01	0.00%	Np-237	7.89E-01	0.00%	0.00%
Pu-238	4.53E+01	7.75E+00	4.53E+01	0.03%	1.23E+01	2.05E+00	1.23E+01	0.02%	Pu-238	4.70E+02	0.11%	0.11%
Pu-239/240	1.32E+02	1.35E+00	1.32E+02	0.10%	3.07E+01	1.17E+00	3.07E+01	0.06%	Pu-239/240	7.64E+02	0.13%	0.13%
Pu-241	4.47E+02	2.02E+02	4.47E+02	0.33%	3.32E+02	2.76E+02	3.32E+02	0.65%	Pu-241	4.85E+03	1.19%	1.22%
Pu-242	8.98E+00	1.35E+00	8.98E+00	0.01%	2.80E-01	2.70E+00	2.70E+00	0.01%	Pu-242	1.26E+01	0.06%	0.19%
Sr-89	-5.97E+03	2.64E+02	2.64E+02	0.19%	-6.23E+02	3.01E+02	3.01E+02	0.59%	Sr-89	3.18E+02	0.81%	1.54%
Sr-90	3.75E+04	2.89E+02	3.75E+04	27.39%	5.91E+03	2.95E+02	5.91E+03	11.49%	Sr-90	1.98E+05	25.43%	11.76%
Tc-99	3.44E+01	4.27E+01	4.27E+01	0.03%	1.81E+01	4.58E+01	4.58E+01	0.09%	Tc-99	1.40E+04	0.58%	1.23%
U-233/234	3.91E+01	8.38E-01	3.91E+01	0.03%	7.59E+00	1.26E+00	7.59E+00	0.01%	U-233/234	2.07E+02	0.03%	0.04%
U-235/236	2.97E+00	8.41E-01	2.97E+00	0.00%	4.11E-01	7.87E-01	7.87E-01	0.00%	U-235/236	1.18E+01	0.00%	0.00%
U-238	1.42E+00	1.05E+00	1.42E+00	0.00%	1.03E-01	9.82E-01	9.82E-01	0.00%	U-238	5.21E+00	0.00%	0.00%
			1.37E+05	100.00%			5.14E+04	100.00%			100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

BALANCE OF PLANT

Quad A Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	5.63E+01	7.24E+00	5.63E+01	0.06%
Am-241	1.43E+00	1.02E+00	1.43E+00	0.00%
C-14	1.08E+03	4.47E+01	1.08E+03	1.08%
Co-60	3.78E+03	7.07E+00	3.78E+03	3.78%
Cm-243/244	1.70E+01	1.28E+00	1.70E+01	0.02%
Cm-245/246	9.73E-01	7.22E-01	9.73E-01	0.00%
Cs-137	1.22E+02	9.49E+00	1.22E+02	0.12%
Eu-152	4.37E+01	2.01E+01	4.37E+01	0.04%
Eu-154	0.00E+00	2.31E+01	2.31E+01	0.02%
Fe-55	8.58E+02	3.79E+01	8.58E+02	0.86%
H-3	8.07E+04	5.22E+02	8.07E+04	80.79%
I-129	5.06E+00	1.57E+01	1.57E+01	0.02%
Nb-94	2.29E+00	8.66E+00	8.66E+00	0.01%
Ni-59	2.20E+02	4.46E+01	2.20E+02	0.22%
Ni-63	1.28E+04	8.64E+01	1.28E+04	12.81%
Pu-238	2.92E+00	6.23E-01	2.92E+00	0.00%
Pu-239/240	1.28E+00	9.49E-01	1.28E+00	0.00%
Pu-241	1.02E+01	2.64E+01	2.64E+01	0.03%
Sr-89	1.39E+01	8.86E+00	1.39E+01	0.01%
Sr-90	7.93E+01	8.56E+00	7.93E+01	0.08%
Tc-99	3.20E+01	3.04E+01	3.20E+01	0.03%
U-233/234	1.94E-01	9.43E-01	9.43E-01	0.00%
			9.99E+04	100.00%

Quad C Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	4.44E+01	7.67E+00	4.44E+01	0.07%
Am-241	1.62E+00	8.09E-01	1.62E+00	0.00%
C-14	7.60E+02	4.89E+01	7.60E+02	1.20%
Co-60	4.50E+03	7.40E+00	4.50E+03	7.10%
Cm-243/244	2.18E+01	2.80E-01	2.18E+01	0.03%
Cm-245/246	1.40E+00	3.23E-01	1.40E+00	0.00%
Cs-137	7.44E+01	1.02E+01	7.44E+01	0.12%
Eu-152	5.17E+01	2.11E+01	5.17E+01	0.08%
Eu-154	0.00E+00	2.63E+01	2.63E+01	0.04%
Fe-55	9.00E+02	3.80E+01	9.00E+02	1.42%
H-3	3.90E+04	3.57E+02	3.90E+04	61.57%
I-129	3.62E+00	1.35E+01	1.35E+01	0.02%
Nb-94	-6.07E-01	9.26E+00	9.26E+00	0.01%
Ni-59	2.19E+02	6.56E+01	2.19E+02	0.35%
Ni-63	1.76E+04	9.97E+01	1.76E+04	27.79%
Pu-238	1.74E+00	1.16E+00	1.74E+00	0.00%
Pu-239/240	7.24E-01	7.03E-01	7.24E-01	0.00%
Pu-241	5.87E+00	2.50E+01	2.50E+01	0.04%
Sr-89	7.22E+00	1.46E+01	1.46E+01	0.02%
Sr-90	4.27E+01	9.20E+00	4.27E+01	0.07%
Tc-99	3.16E+01	3.02E+01	3.16E+01	0.05%
U-233/234	7.96E-01	7.62E-01	7.96E-01	0.00%
			6.33E+04	100.00%

Canal E Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	1.98E+02	9.21E+00	1.98E+02	0.22%
Am-241	3.48E+00	3.60E-01	3.48E+00	0.00%
C-14	7.92E+02	4.42E+01	7.92E+02	0.87%
Co-60	7.61E+03	9.32E+00	7.61E+03	8.36%
Cm-243/244	1.79E+01	3.62E-01	1.79E+01	0.02%
Cm-245/246	2.23E+00	4.18E-01	2.23E+00	0.00%
Cs-137	1.44E+02	1.23E+01	1.44E+02	0.16%
Eu-152	6.52E+01	2.58E+01	6.52E+01	0.07%
Eu-154	0.00E+00	2.77E+01	2.77E+01	0.03%
Fe-55	8.08E+02	3.79E+01	8.08E+02	0.89%
H-3	4.81E+04	4.14E+02	4.81E+04	52.82%
I-129	3.74E+00	1.88E+01	1.88E+01	0.02%
Nb-94	1.14E+00	1.11E+01	1.11E+01	0.01%
Ni-59	2.58E+02	7.98E+01	2.58E+02	0.28%
Ni-63	3.28E+04	1.30E+02	3.28E+04	36.02%
Pu-238	3.68E+00	1.64E+00	3.68E+00	0.00%
Pu-239/240	1.84E+00	7.07E-01	1.84E+00	0.00%
Pu-241	2.13E+01	2.82E+01	2.82E+01	0.03%
Sr-89	-1.38E+01	1.18E+01	1.18E+01	0.01%
Sr-90	1.02E+02	8.25E+00	1.02E+02	0.11%
Tc-99	5.91E+01	4.30E+01	5.91E+01	0.06%
U-233/234	4.65E-01	8.95E-01	8.95E-01	0.00%
			9.11E+04	100.00%

Lilly Pad Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	4.70E+00	3.63E+00	4.70E+00	0.05%
Am-241	6.25E-01	7.17E-01	7.17E-01	0.01%
C-14	5.30E+01	2.38E+01	5.30E+01	0.59%
Co-60	2.53E+02	4.03E+00	2.53E+02	2.81%
Cm-243/244	2.05E+00	8.75E-01	2.05E+00	0.02%
Cm-245/246	6.60E-01	3.96E-01	6.60E-01	0.01%
Cs-137	1.39E+01	4.05E+00	1.39E+01	0.15%
Eu-152	2.56E+00	1.07E+01	1.07E+01	0.12%
Eu-154	1.43E+00	1.04E+01	1.04E+01	0.12%
Fe-55	7.91E+02	3.82E+01	7.91E+02	8.80%
H-3	6.42E+03	3.09E+02	6.42E+03	71.40%
I-129	1.54E+01	2.21E+01	2.21E+01	0.25%
Nb-94	8.85E-01	3.91E+00	3.91E+00	0.04%
Ni-59	0.00E+00	7.98E+01	7.98E+01	0.89%
Ni-63	1.24E+03	2.68E+01	1.24E+03	13.79%
Pu-238	2.24E-01	7.25E-01	7.25E-01	0.01%
Pu-239/240	4.33E-01	4.14E-01	4.33E-01	0.00%
Pu-241	2.56E+00	3.08E+01	3.08E+01	0.34%
Sr-89	-8.02E-01	8.76E+00	8.76E+00	0.10%
Sr-90	9.77E+00	8.11E+00	9.77E+00	0.11%
Tc-99	1.02E+01	3.39E+01	3.39E+01	0.38%
U-233/234	3.14E-01	1.01E+00	1.01E+00	0.01%
			8.99E+03	100.00%

CTMT General Area Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	8.69E+01	7.47E+00	8.69E+01	0.03%
Am-241	3.61E+00	7.24E-01	3.61E+00	0.00%
C-14	2.90E+02	4.53E+01	2.90E+02	0.11%
Co-60	3.57E+03	6.77E+00	3.57E+03	1.36%
Cm-243/244	4.71E+01	8.62E-01	4.71E+01	0.02%
Cm-245/246	9.33E-01	4.00E-01	9.33E-01	0.00%
Cs-137	3.64E+02	9.38E+00	3.64E+02	0.14%
Eu-152	1.40E+01	2.06E+01	2.06E+01	0.01%
Eu-154	0.00E+00	2.08E+01	2.08E+01	0.01%
Fe-55	4.43E+03	4.02E+01	4.43E+03	1.68%
H-3	2.42E+05	9.07E+02	2.42E+05	91.95%
I-129	-5.02E+00	1.00E+01	1.00E+01	0.00%
Nb-94	1.73E+01	8.28E+00	1.73E+01	0.01%
Ni-59	9.04E+01	7.67E+01	9.04E+01	0.03%
Ni-63	1.19E+04	8.27E+01	1.19E+04	4.52%
Pu-238	6.51E-01	9.05E-01	9.05E-01	0.00%
Pu-239/240	2.16E+00	1.04E+00	2.16E+00	0.00%
Pu-241	2.71E+01	2.37E+01	2.71E+01	0.01%
Sr-89	2.99E+01	7.18E+00	2.99E+01	0.01%
Sr-90	2.42E+02	8.64E+00	2.42E+02	0.09%
Tc-99	9.06E+00	3.36E+01	3.36E+01	0.01%
U-233/234	3.73E-01	9.00E-01	9.00E-01	0.00%
			2.63E+05	100.00%

Rx Building Smear (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	N/A	N/A	0	0.00%
Am-241	7.84E+01	1.47E+01	7.84E+01	0.42%
C-14	2.09E+01	1.37E+01	2.09E+01	0.11%
Co-60	2.38E+02	8.51E+00	2.38E+02	1.29%
Cm-243/244	2.39E+00	4.02E-01	2.39E+00	0.01%
Cm-245/246	N/A	N/A	0	0.00%
Cs-137	4.64E+03	1.02E+01	4.64E+03	25.15%
Eu-152	6.50E+01	3.70E+01	6.50E+01	0.35%
Eu-154	7.18E+01	1.75E+01	7.18E+01	0.39%
Fe-55	-1.59E+01	1.79E+01	1.79E+01	0.10%
H-3	1.07E+04	2.89E+01	1.07E+04	58.00%
I-129	1.02E+01	8.17E+00	1.02E+01	0.06%
Nb-94	-3.66E-01	9.12E+00	9.12E+00	0.05%
Ni-59	2.36E+02	2.31E+01	2.36E+02	1.28%
Ni-63	3.27E+01	6.59E+01	6.59E+01	0.36%
Pu-238	2.86E+01	3.50E+00	2.86E+01	0.16%
Pu-239/240	1.48E+01	2.71E+00	1.48E+01	0.08%
Pu-241	1.78E+02	1.43E+02	1.78E+02	0.96%
Sr-89	N/A	N/A	0	0.00%
Sr-90	2.04E+03	1.44E+01	2.04E+03	11.06%
Tc-99	0.00E+00	2.81E+01	2.81E+01	0.15%
U-233/234	4.38E+00	4.43E+00	4.43E+00	0.02%
			1.84E+04	100.00%

Rx Building Smear Duplicate (pCi/filter)

	Results	MDA	Used	Distribution
Ag-108m	N/A	N/A	0	0.00%
Am-241	1.01E+02	1.55E+01	1.01E+02	0.47%
C-14	2.09E+01	1.37E+01	2.09E+01	0.10%
Co-60	2.53E+03	7.07E+00	2.53E+03	11.85%
Cm-243/244	2.31E+00	7.91E-01	2.31E+00	0.01%
Cm-245/246	N/A	N/A	0	0.00%
Cs-137	5.63E+03	1.01E+01	5.63E+03	26.36%
Eu-152	3.29E+01	4.62E+01	4.62E+01	0.22%
Eu-154	9.62E+01	1.59E+01	9.62E+01	0.45%
Fe-55	-9.63E+00	2.00E+01	2.00E+01	0.09%
H-3	1.05E+04	2.84E+01	1.05E+04	49.16%
I-129	1.94E+01	1.00E+01	1.94E+01	0.09%
Nb-94	-1.29E+00	8.60E+00	8.60E+00	0.04%
Ni-59	-1.65E+01	2.03E+01	2.03E+01	0.10%
Ni-63	6.79E+01	6.83E+01	6.83E+01	0.32%
Pu-238	2.86E+01	3.50E+00	2.86E+01	0.13%
Pu-239/240	1.48E+01	2.71E+00	1.48E+01	0.07%
Pu-241	1.78E+02	1.43E+02	1.78E+02	0.83%
Sr-89	N/A	N/A	0	0.00%
Sr-90	2.04E+03	1.44E+01	2.04E+03	9.55%
Tc-99	-1.21E+01	2.81E+01	2.81E+01	0.13%
U-233/234	4.38E+00	4.43E+00	4.43E+00	0.02%
			2.14E+04	100.00%

	MEAN (pCi/gm)	MEAN (%)	STD DEV
Ag-108m	5.58E+01	0.06%	0.07%
Am-241	2.72E+01	0.13%	0.22%
C-14	4.31E+02	0.58%	0.48%
Co-60	3.21E+03	5.22%	3.99%
Cm-243/244	1.58E+01	0.02%	0.01%
Cm-245/246	8.85E-01	0.00%	0.00%
Cs-137	1.57E+03	7.46%	12.50%
Eu-152	4.33E+01	0.13%	0.12%
Eu-154	3.95E+01	0.15%	0.19%
Fe-55	1.12E+03	1.98%	3.07%
H-3	6.25E+04	66.53%	15.60%
I-129	1.57E+01	0.06%	0.09%
Nb-94	9.71E+00	0.03%	0.02%
Ni-59	1.61E+02	0.45%	0.46%
Ni-63	1.09E+04	13.66%	13.78%
Pu-238	9.60E+00	0.04%	0.07%
Pu-239/240	5.15E+00	0.02%	0.04%
Pu-241	7.05E+01	0.32%	0.41%
Sr-89	1.13E+01	0.03%	0.03%
Sr-90	6.51E+02	3.01%	3.80%
Tc-99	3.52E+01	0.12%	0.13%
U-233/234	1.91E+00	0.01%	0.01%
		100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

Attachment A
Addendum 1
Results of Isotopic Analysis of Smear Samples

Reactor Operations & Laboratory Building

	ROLB Smear (pCi/filter)				ROLB Smear Duplicate (pCi/filter)				ROLB Smear 2 (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Am-241	1.82E+00	1.64E+00	1.82E+00	0.01%	1.82E+00	1.64E+00	1.82E+00	0.01%	6.07E+00	1.70E+00	6.07E+00	0.03%
C-14	1.55E+01	1.53E+01	1.55E+01	0.06%	1.05E+01	1.03E+01	1.05E+01	0.04%	-4.65E+01	8.61E+01	8.61E+01	0.47%
Co-60	4.09E+02	1.16E+01	4.09E+02	1.45%	4.09E+02	1.16E+01	4.09E+02	1.45%	8.90E+01	8.81E+00	8.90E+01	0.48%
Cm-242	-2.54E-01	3.27E+00	3.27E+00	0.01%	-2.54E-01	3.27E+00	3.27E+00	0.01%	8.22E-01	1.53E+00	1.53E+00	0.01%
Cm-243/244	3.04E+00	1.64E+00	3.04E+00	0.01%	3.04E+00	1.64E+00	3.04E+00	0.01%	5.60E-01	2.09E+00	2.09E+00	0.01%
Cs-137	4.77E+03	1.37E+01	4.77E+03	16.96%	4.77E+03	1.37E+01	4.77E+03	16.96%	2.97E+03	1.14E+01	2.97E+03	16.18%
Eu-155	1.26E+01	1.86E+01	1.86E+01	0.07%	1.26E+01	1.86E+01	1.86E+01	0.07%	1.46E+02	3.23E+01	3.23E+01	0.18%
H-3	2.08E+04	5.30E+01	2.08E+04	73.93%	2.08E+04	5.30E+01	2.08E+04	73.96%	-4.98E+02	6.84E+02	6.84E+02	3.73%
I-129	1.67E+01	1.20E+01	1.67E+01	0.06%	1.67E+01	1.20E+01	1.67E+01	0.06%	9.63E+02	1.04E+01	9.63E+02	5.24%
Nb-94	6.74E+00	1.41E+01	1.41E+01	0.05%	6.74E+00	1.41E+01	1.41E+01	0.05%	1.91E+02	8.11E+00	8.11E+00	0.04%
Ni-59	5.16E+01	1.95E+02	1.95E+02	0.69%	5.16E+01	1.95E+02	1.95E+02	0.69%	-4.30E+02	4.71E+02	4.71E+02	2.56%
Ni-63	3.13E+01	6.30E+01	6.30E+01	0.22%	3.13E+01	6.30E+01	6.30E+01	0.22%	1.70E+02	4.47E+01	4.47E+01	0.24%
Np-237	4.93E+00	1.00E+01	1.00E+01	0.04%	7.94E-01	4.43E+00	4.43E+00	0.02%	3.85E+00	1.74E+01	1.74E+01	0.09%
Pu-239/240	5.64E+00	1.95E+00	5.64E+00	0.02%	1.08E+01	3.19E+00	1.08E+01	0.04%	1.88E+00	1.53E+00	1.88E+00	0.01%
Pu-241	5.88E+01	9.47E+01	9.47E+01	0.34%	9.32E+01	1.50E+02	1.50E+02	0.53%	8.80E+01	7.57E+01	7.57E+01	0.41%
Sb-125	-1.24E+00	5.26E+01	5.26E+01	0.19%	-1.24E+00	5.26E+01	5.26E+01	0.19%	5.92E+00	4.63E+01	4.63E+01	0.26%
Sr-90	1.53E+03	1.48E+01	1.53E+03	5.44%	1.48E+03	1.39E+01	1.48E+03	5.26%	4.81E+02	1.23E+01	4.81E+02	2.62%
Tc-99	5.96E-01	2.80E+01	2.80E+01	0.10%	5.96E-01	2.80E+01	2.80E+01	0.10%	9.04E+01	8.89E+01	8.89E+01	0.48%
U-233/234	9.15E+01	3.97E+00	9.15E+01	0.33%	8.52E+01	1.81E+00	8.52E+01	0.30%	1.18E+04	4.93E+00	1.18E+04	64.02%
U-235/236	5.82E+00	2.84E+00	5.82E+00	0.02%	4.42E+00	2.24E+00	4.42E+00	0.02%	3.94E+02	3.35E+00	3.94E+02	2.14%
U-238	4.81E+00	2.85E+00	4.81E+00	0.02%	4.46E+00	2.18E+00	4.46E+00	0.02%	1.42E+02	2.71E+00	1.42E+02	0.77%
			2.81E+04	100.00%			2.81E+04	100.00%			1.84E+04	100%

	ROLB Smear 2 Duplicate (pCi/filter)					MEAN (pCi/gm)	MEAN (%)	STD DEV
	Results	MDA	Used	Distribution				
Am-241	2.35E+00	2.90E+00	2.90E+00	0.02%	Am-241	3.15E+00	0.02%	0.01%
C-14	-2.04E+01	8.51E+01	8.51E+01	0.48%	C-14	4.93E+01	0.26%	0.25%
Co-60	9.58E+01	7.77E+00	9.58E+01	0.54%	Co-60	2.51E+02	0.98%	0.54%
Cm-242	-6.70E-03	2.23E+00	2.23E+00	0.01%	Cm-242	2.58E+00	0.01%	0.00%
Cm-243/244	6.50E-01	2.11E+00	2.11E+00	0.01%	Cm-243/244	2.57E+00	0.01%	0.00%
Cs-137	2.90E+03	1.17E+01	2.90E+03	16.40%	Cs-137	3.85E+03	16.82%	0.40%
Eu-155	2.77E+01	3.18E+01	3.18E+01	0.18%	Eu-155	2.53E+01	0.12%	0.06%
H-3	-4.15E+02	6.85E+02	6.85E+02	3.87%	H-3	1.07E+04	38.87%	40.50%
I-129	9.32E+02	1.05E+01	9.32E+02	5.27%	I-129	4.82E+02	2.66%	3.00%
Nb-94	1.94E+02	7.77E+00	7.77E+00	0.04%	Nb-94	1.10E+01	0.05%	0.00%
Ni-59	4.21E+01	4.93E+02	4.93E+02	2.79%	Ni-59	3.38E+02	1.68%	1.15%
Ni-63	1.68E+02	4.36E+01	4.36E+01	0.25%	Ni-63	5.36E+01	0.23%	0.01%
Np-237	-1.58E+00	8.72E+00	8.72E+00	0.05%	Np-237	1.01E+01	0.05%	0.03%
Pu-239/240	2.00E+00	9.05E-01	2.00E+00	0.01%	Pu-239/240	5.08E+00	0.02%	0.01%
Pu-241	5.34E+01	9.19E+01	9.19E+01	0.52%	Pu-241	1.03E+02	0.45%	0.09%
Sb-125	-5.72E+00	4.69E+01	4.69E+01	0.27%	Sb-125	5.01E+01	0.23%	0.04%
Sr-90	4.97E+02	1.26E+01	4.97E+02	2.81%	Sr-90	9.97E+02	4.03%	1.53%
Tc-99	4.51E+01	8.87E+01	8.87E+01	0.50%	Tc-99	5.84E+01	0.30%	0.23%
U-233/234	1.11E+04	5.04E+00	1.11E+04	62.82%	U-233/234	5.76E+03	31.87%	36.44%
U-235/236	4.08E+02	3.28E+00	4.08E+02	2.30%	U-235/236	2.03E+02	1.12%	1.27%
U-238	1.52E+02	4.58E+00	1.52E+02	0.86%	U-238	7.58E+01	0.42%	0.46%
			1.77E+04	100%			100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

Attachment A
Addendum 1
Results of Isotopic Analysis of Smear Samples (10% Rule Normalized)

HOT LABORATORY

Hot Cell Equipment #1 Smear (pCi/filter)

	Results	MDA	Used	Distribution
Co-60	2.74E+05	1.24E+02	2.74E+05	10.81%
Cs-137	8.07E+05	2.06E+02	8.07E+05	31.82%
Eu-154	1.79E+03	3.69E+02	1.79E+03	0.07%
H-3	6.26E+05	3.49E+02	6.26E+05	24.69%
Sr-90	8.27E+05	3.49E+02	8.27E+05	32.61%
			2.54E+06	100.00%

Hot Cell Equipment #2 Smear (pCi/filter)

	Results	MDA	Used	Distribution
	8.64E+03	2.25E+01	8.64E+03	2.16%
	2.71E+05	6.98E+01	2.71E+05	67.85%
	0.00E+00	8.27E+01	8.27E+01	0.02%
	4.69E+03	2.53E+02	4.69E+03	1.17%
	1.15E+05	3.50E+02	1.15E+05	28.79%
			3.99E+05	100.00%

Hot Cell Equipment #3 Smear (pCi/filter)

	Results	MDA	Used	Distribution
	2.67E+03	1.27E+01	2.67E+03	2.78%
	4.51E+04	3.22E+01	4.51E+04	46.98%
	1.94E+02	7.49E+01	1.94E+02	0.20%
	1.73E+03	4.51E+02	1.73E+03	1.80%
	4.63E+04	3.65E+02	4.63E+04	48.23%
			9.60E+04	100.00%

Hot Cell Equipment #4 Smear (pCi/filter)

	Results	MDA	Used	Distribution
Co-60	1.58E+03	1.23E+01	1.58E+03	6.61%
Cs-137	3.99E+03	1.61E+01	3.99E+03	16.70%
Eu-154	2.64E+01	3.99E+01	3.99E+01	0.17%
H-3	1.51E+04	3.94E+02	1.51E+04	63.21%
Sr-90	3.18E+03	3.94E+02	3.18E+03	13.31%
			2.39E+04	100.00%

Hot Cell Equipment #5 Smear (pCi/filter)

	Results	MDA	Used	Distribution
	3.23E+02	7.08E+00	3.23E+02	0.10%
	2.85E+05	6.04E+01	2.85E+05	87.96%
	0.00E+00	3.04E+01	3.04E+01	0.01%
	7.61E+01	2.70E+02	2.70E+02	0.08%
	3.84E+04	2.87E+02	3.84E+04	11.85%
			3.24E+05	100.00%

Hot Cell Equipment #6 Smear (pCi/filter)

	Results	MDA	Used	Distribution
	4.91E+02	7.50E+00	4.91E+02	2.22%
	1.16E+04	1.47E+01	1.16E+04	52.52%
	0.00E+00	3.11E+01	3.11E+01	0.14%
	1.95E+02	2.63E+02	2.63E+02	1.19%
	9.70E+03	3.54E+02	9.70E+03	43.92%
			2.21E+04	100.00%

Hot Cell Equipment #7 Smear (pCi/filter)

	Results	MDA	Used	Distribution
Co-60	6.08E+03	2.03E+01	6.08E+03	1.52%
Cs-137	1.09E+05	5.49E+01	1.09E+05	27.24%
Eu-154	0.00E+00	7.95E+01	7.95E+01	0.02%
H-3	1.63E+05	6.91E+02	1.63E+05	40.73%
Sr-90	1.22E+05	3.47E+02	1.22E+05	30.49%
			4.00E+05	100.00%

Hot Cell #1 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
	5.16E+04	5.16E+01	5.16E+04	2.39%
	8.03E+05	1.25E+02	8.03E+05	37.17%
	1.18E+03	1.44E+02	1.18E+03	0.05%
	5.43E+04	4.01E+02	5.43E+04	2.51%
	1.25E+06	2.72E+02	1.25E+06	57.87%
			2.16E+06	100.00%

Hot Cell #2 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
	2.01E+04	3.13E+01	2.01E+04	7.87%
	1.09E+05	6.47E+01	1.09E+05	42.68%
	4.07E+02	7.91E+01	4.07E+02	0.16%
	1.09E+04	5.33E+02	1.09E+04	4.27%
	1.15E+05	3.29E+02	1.15E+05	45.03%
			2.55E+05	100.00%

Hot Cell #3 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
Co-60	3.87E+02	8.70E+00	3.87E+02	6.00%
Cs-137	3.57E+03	9.55E+00	3.57E+03	55.36%
Eu-154	5.35E+00	2.59E+01	2.59E+01	0.40%
H-3	1.71E+01	2.26E+02	2.26E+02	3.50%
Sr-90	2.24E+03	3.67E+02	2.24E+03	34.73%
			6.45E+03	100.00%

Hot Cell #4 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
	2.70E+02	5.70E+00	2.70E+02	2.35%
	5.87E+03	1.17E+01	5.87E+03	51.16%
	1.76E+00	1.69E+01	1.69E+01	0.15%
	6.17E+02	4.37E+02	6.17E+02	5.38%
	4.70E+03	3.00E+02	4.70E+03	40.96%
			1.15E+04	100.00%

Hot Cell #5 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
	1.53E+02	9.69E+00	1.53E+02	0.65%
	1.75E+04	1.70E+01	1.75E+04	73.97%
	2.62E+00	2.75E+01	2.75E+01	0.12%
	3.32E+01	3.17E+02	3.17E+02	1.34%
	5.66E+03	3.56E+02	5.66E+03	23.92%
			2.37E+04	100.00%

Hot Cell #6 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
Co-60	1.44E+03	9.69E+00	1.44E+03	1.19%
Cs-137	8.19E+04	2.75E+01	8.19E+04	67.50%
Eu-154	0.00E+00	4.01E+01	4.01E+01	0.03%
H-3	4.47E+02	2.44E+02	4.47E+02	0.37%
Sr-90	3.75E+04	2.89E+02	3.75E+04	30.91%
			1.21E+05	100.00%

Hot Cell #7 Surface Smear (pCi/filter)

	Results	MDA	Used	Distribution
	5.30E+02	9.30E+00	5.30E+02	1.14%
	3.95E+04	2.40E+01	3.95E+04	84.66%
	1.31E+01	3.46E+01	3.46E+01	0.07%
	6.81E+02	2.44E+02	6.81E+02	1.46%
	5.91E+03	2.95E+02	5.91E+03	12.67%
			4.67E+04	100.00%

	MEAN (pCi/gm)	MEAN (%)	STD DEV
Co-60	2.83E+04	3.41%	3.15%
Cs-137	1.98E+05	53.11%	21.35%
Eu-154	3.04E+02	0.12%	0.10%
H-3	6.76E+04	10.84%	19.01%
Sr-90	1.98E+05	32.52%	13.97%
		100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

Results of Isotopic Analysis of Smear Samples (10% Rule Normalized)

BALANCE OF PLANT

	Quad A Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	3.78E+03	7.07E+00	3.78E+03	4.46%
Cs-137	1.22E+02	9.49E+00	1.22E+02	0.14%
Eu-154	0.00E+00	2.31E+01	2.31E+01	0.03%
H-3	8.07E+04	5.22E+02	8.07E+04	95.25%
I-129	5.06E+00	1.57E+01	1.57E+01	0.02%
Sr-90	7.93E+01	8.56E+00	7.93E+01	0.09%
			8.47E+04	100.00%

	Quad C Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	4.50E+03	7.40E+00	4.50E+03	10.31%
Cs-137	7.44E+01	1.02E+01	7.44E+01	0.17%
Eu-154	0.00E+00	2.63E+01	2.63E+01	0.06%
H-3	3.90E+04	3.57E+02	3.90E+04	89.33%
I-129	3.62E+00	1.35E+01	1.35E+01	0.03%
Sr-90	4.27E+01	9.20E+00	4.27E+01	0.10%
			4.37E+04	100.00%

	Canal E Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	7.61E+03	9.32E+00	7.61E+03	13.59%
Cs-137	1.44E+02	1.23E+01	1.44E+02	0.26%
Eu-154	0.00E+00	2.77E+01	2.77E+01	0.05%
H-3	4.81E+04	4.14E+02	4.81E+04	85.89%
I-129	3.74E+00	1.88E+01	1.88E+01	0.03%
Sr-90	1.02E+02	8.25E+00	1.02E+02	0.18%
			5.60E+04	100.00%

	Lilly Pad Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	2.53E+02	4.03E+00	2.53E+02	3.76%
Cs-137	1.39E+01	4.05E+00	1.39E+01	0.21%
Eu-154	1.43E+00	1.04E+01	1.04E+01	0.15%
H-3	6.42E+03	3.09E+02	6.42E+03	95.41%
I-129	1.54E+01	2.21E+01	2.21E+01	0.33%
Sr-90	9.77E+00	8.11E+00	9.77E+00	0.15%
			6.73E+03	100.00%

	CTMT General Area Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	3.57E+03	6.77E+00	3.57E+03	1.45%
Cs-137	3.64E+02	9.38E+00	3.64E+02	0.15%
Eu-154	0.00E+00	2.08E+01	2.08E+01	0.01%
H-3	2.42E+05	9.07E+02	2.42E+05	98.29%
I-129	-5.02E+00	1.00E+01	1.00E+01	0.00%
Sr-90	2.42E+02	8.64E+00	2.42E+02	0.10%
			2.46E+05	100.00%

	Rx Building Smear (pCi/filter) Results	MDA	Used	Distribution
Co-60	2.38E+02	8.51E+00	2.38E+02	1.34%
Cs-137	4.64E+03	1.02E+01	4.64E+03	26.21%
Eu-154	7.18E+01	1.75E+01	7.18E+01	0.41%
H-3	1.07E+04	2.89E+01	1.07E+04	60.45%
I-129	1.02E+01	8.17E+00	1.02E+01	0.06%
Sr-90	2.04E+03	1.44E+01	2.04E+03	11.53%
			1.77E+04	100.00%

	Rx Building Smear Duplicate (pCi/filter) Results	MDA	Used	Distribution
Co-60	2.53E+03	7.07E+00	2.53E+03	12.15%
Cs-137	5.63E+03	1.01E+01	5.63E+03	27.05%
Eu-154	9.62E+01	1.59E+01	9.62E+01	0.46%
H-3	1.05E+04	2.84E+01	1.05E+04	50.44%
I-129	1.94E+01	1.00E+01	1.94E+01	0.09%
Sr-90	2.04E+03	1.44E+01	2.04E+03	9.80%
			2.08E+04	100.00%

	MEAN (pCi/gm)	MEAN (%)	STD DEV
Co-60	3.21E+03	6.72%	5.17%
Cs-137	1.57E+03	7.74%	12.91%
Eu-154	3.95E+01	0.17%	0.19%
H-3	6.25E+04	82.15%	18.93%
I-129	1.57E+01	0.08%	0.11%
Sr-90	6.51E+02	3.13%	3.88%
		100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

Attachment A
Addendum 1
Results of Isotopic Analysis of Smear Samples (10% Rule Normalized)

Reactor Operations & Laboratory Building

	ROLB Smear (pCi/filter)				ROLB Smear Duplicate (pCi/filter)				ROLB Smear 2 (pCi/filter)			
	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution	Results	MDA	Used	Distribution
Co-60	4.09E+02	1.16E+01	4.09E+02	1.48%	4.09E+02	1.16E+01	4.09E+02	1.48%	8.90E+01	8.81E+00	8.90E+01	0.51%
Cs-137	4.77E+03	1.37E+01	4.77E+03	17.27%	4.77E+03	1.37E+01	4.77E+03	17.30%	2.97E+03	1.14E+01	2.97E+03	17.14%
H-3	2.08E+04	5.30E+01	2.08E+04	75.30%	2.08E+04	5.30E+01	2.08E+04	75.46%	-4.98E+02	6.84E+02	6.84E+02	3.95%
I-129	1.67E+01	1.20E+01	1.67E+01	0.06%	1.67E+01	1.20E+01	1.67E+01	0.06%	9.63E+02	1.04E+01	9.63E+02	5.55%
Sr-90	1.53E+03	1.48E+01	1.53E+03	5.54%	1.48E+03	1.39E+01	1.48E+03	5.37%	4.81E+02	1.23E+01	4.81E+02	2.77%
U-233/234	9.15E+01	3.97E+00	9.15E+01	0.33%	8.52E+01	1.81E+00	8.52E+01	0.31%	1.18E+04	4.93E+00	1.18E+04	67.81%
U-235/236	5.82E+00	2.84E+00	5.82E+00	0.02%	4.42E+00	2.24E+00	4.42E+00	0.02%	3.94E+02	3.35E+00	3.94E+02	2.27%
			2.76E+04	100.00%			2.76E+04	100.00%			1.73E+04	100%

	ROLB Smear 2 Duplicate (pCi/filter)					MEAN (pCi/gm)	MEAN (%)	STD DEV
	Results	MDA	Used	Distribution				
Co-60	9.58E+01	7.77E+00	9.58E+01	0.58%	Co-60	2.51E+02	1.01%	0.54%
Cs-137	2.90E+03	1.17E+01	2.90E+03	17.44%	Cs-137	3.85E+03	17.29%	0.13%
H-3	-4.15E+02	6.85E+02	6.85E+02	4.12%	H-3	1.07E+04	39.71%	41.19%
I-129	9.32E+02	1.05E+01	9.32E+02	5.60%	I-129	4.82E+02	2.82%	3.19%
Sr-90	4.97E+02	1.26E+01	4.97E+02	2.99%	Sr-90	9.97E+02	4.17%	1.49%
U-233/234	1.11E+04	5.04E+00	1.11E+04	66.82%	U-233/234	5.76E+03	33.82%	38.68%
U-235/236	4.08E+02	3.28E+00	4.08E+02	2.45%	U-235/236	2.03E+02	1.19%	1.35%
			1.66E+04	100%			100.00%	

Units for sample concentrations are presented in pCi/filter. Filter in this context is defined as a standard smear sample take over a 100cm2 area.

Final Status Survey Plan
for the
Plum Brook Reactor Facility

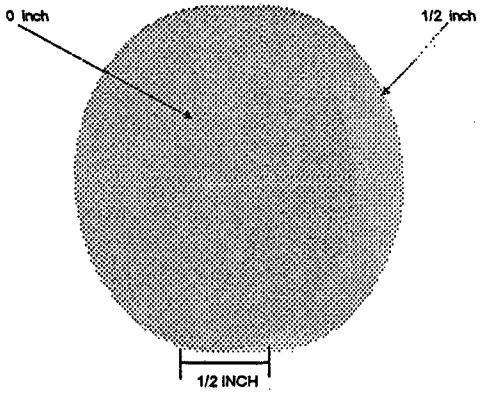
Attachment A
Radionuclide Distribution Basis for DCGL Determination & Final Status Survey of the Plum Brook Reactor Facility (PBRF)

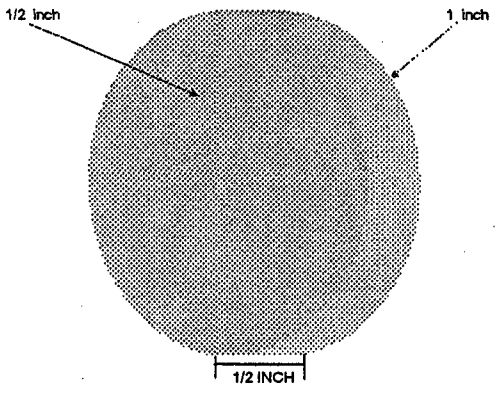
Addendum 2
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

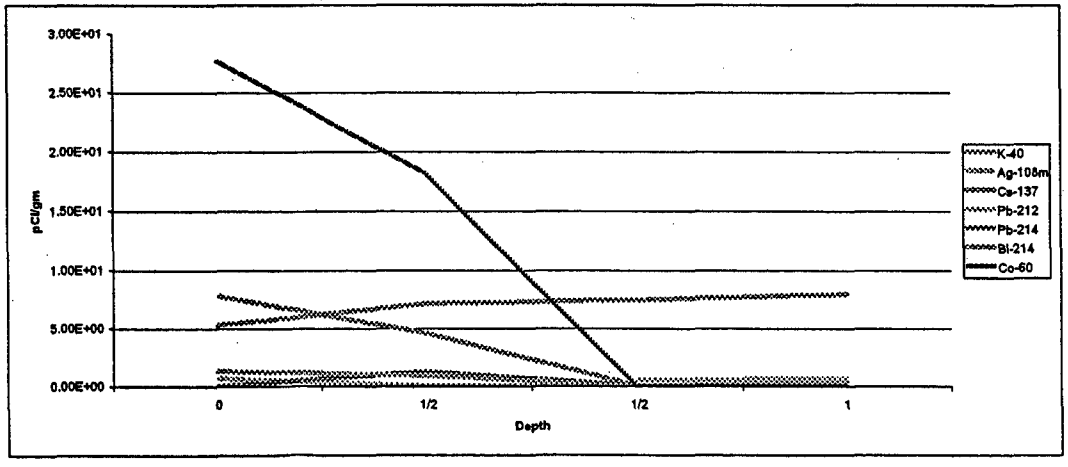
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #5, Reactor Building -25 ft., Area 22

	C9000101HFL1C1L0505-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0505-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0505-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0505-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	5.26E+00	1.94E+00	5.26E+00	12.35%	7.10E+00	1.94E+00	7.10E+00	22.27%	7.41E+00	2.02E+00	7.41E+00	93.01%	7.95E+00	2.02E+00	7.95E+00	88.66%
Co-60	2.77E+01	1.97E-01	2.77E+01	64.98%	1.81E+01	1.97E-01	1.81E+01	56.81%	ND		0		ND		0	
Nb-94	ND				ND				ND		0		ND		0	
Ag-108m	6.61E-01	3.21E-01	6.61E-01	1.55%	ND		0		ND		0		3.93E-01	2.04E-01	3.93E-01	4.39%
Cs-137	7.74E+00	3.34E-01	7.74E+00	18.17%	4.56E+00	3.71E-01	4.56E+00	14.31%	ND		0		ND			
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				6.24E-01	3.91E-01	6.24E-01	6.95%
Pb-212	ND				ND				5.57E-01	3.76E-01	5.57E-01	6.99%	ND		0	
Pb-214	ND		0		1.21E+00	7.07E-01	1.21E+00	3.79%	ND		0		ND		0	
Bi-212	ND				ND				ND				ND			
Bi-214	1.26E+00	5.26E-01	1.26E+00	2.95%	9.00E-01	5.24E-01	9.00E-01	2.82%	ND		0		ND		0	
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			4.26E+01	100.00%			3.19E+01	100.00%			7.96E+00	100.00%			8.97E+00	100.00%



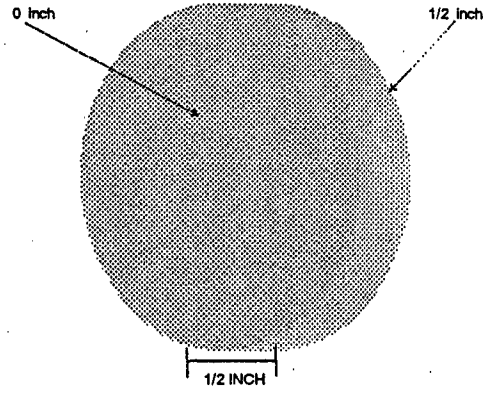


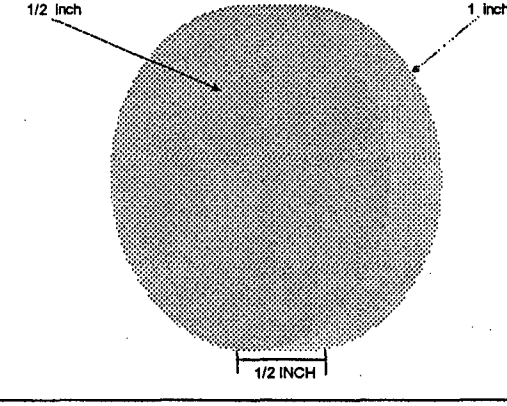


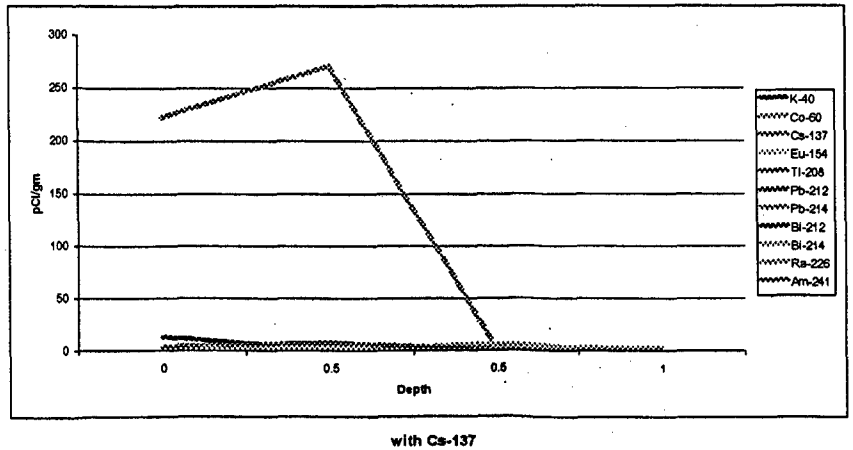
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #6, Containment -25 ft, Canal E

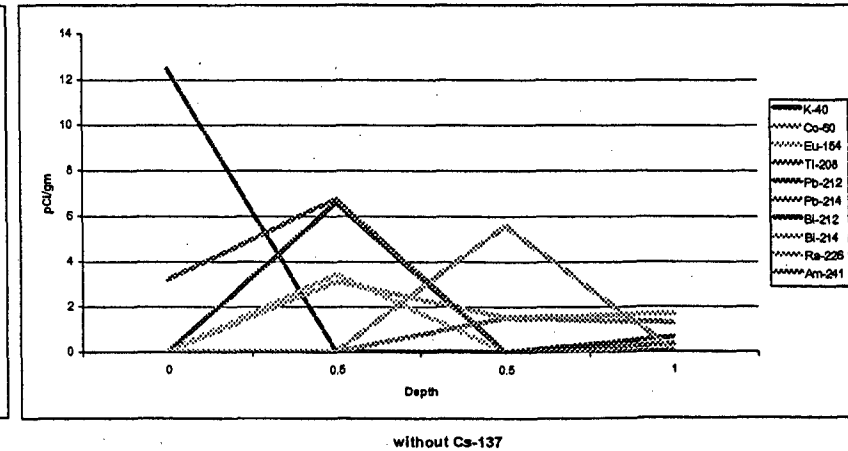
	C9000101HFL1C3L0506-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C3L0506-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C3L0506-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0506-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.24E+01	2.96E+00	1.24E+01	5.23%	ND		0		ND		0		ND		0	
Co-60	ND		0		6.61E+00	3.00E-01	6.61E+00	2.23%	ND		0		ND		0	
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	2.22E+02	9.47E-01	2.22E+02	93.43%	2.70E+02	8.92E-01	2.70E+02	91.10%	ND		0		2.58E-01	1.36E-01	2.58E-01	6.23%
Eu-152	ND				ND				ND				ND			
Eu-154	ND		0		3.42E+00	1.62E+00	3.42E+00	1.15%	ND		0		ND		0	
Tl-208	ND		0		ND		0		ND		0		3.29E-01	1.64E-01	3.29E-01	7.96%
Pb-212	ND		0		ND		0		ND		0		6.33E-01	4.58E-01	6.33E-01	15.31%
Pb-214	ND		0		ND		0		1.48E+00	4.98E-01	1.48E+00	17.26%	1.26E+00	4.76E-01	1.26E+00	30.55%
Bi-212	ND		0		6.54E+00	7.08E+00	6.54E+00	2.21%	ND		0		ND		0	
Bi-214	ND		0		3.10E+00	1.67E+00	3.10E+00	1.04%	1.52E+00	2.34E-01	1.52E+00	17.77%	1.65E+00	4.49E-01	1.65E+00	39.96%
Ra-226	ND		0		ND		0		5.57E+00	3.89E+00	5.57E+00	64.97%	ND		0	
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	3.17E+00	1.95E+00	3.17E+00	1.33%	6.75E+00	2.23E+00	6.75E+00	2.27%	ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			2.38E+02	100.00%			2.97E+02	100.00%			8.58E+00	100.00%			4.13E+00	100.00%







with Cs-137

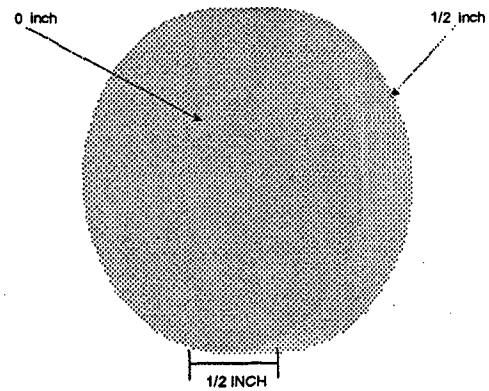


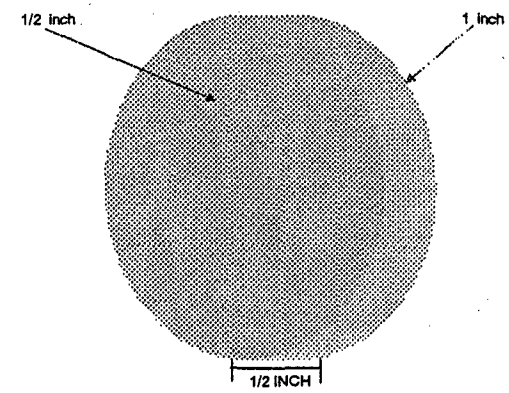
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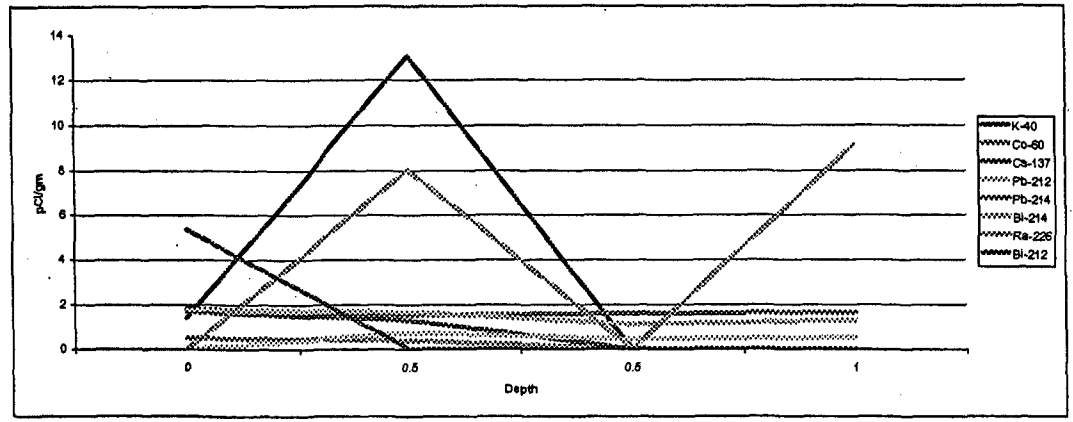
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #7, Reactor Building -15 ft, SE Area

	C9000101HFL1C1L0507-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0507-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0507-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0507-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.38E+00	3.25E+00	1.38E+00	11.09%	1.30E+01	2.13E+00	1.30E+01	49.03%	ND		0		ND		0	
Co-60	5.02E-01	2.17E-01	5.02E-01	4.04%	3.83E-01	2.17E-01	3.83E-01	1.44%	ND		0		ND		0	
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	1.69E+00	2.58E-01	1.69E+00	13.57%	1.28E+00	2.06E-01	1.28E+00	4.83%	ND		0		ND		0	
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	ND		0		7.15E-01	4.35E-01	7.15E-01	2.69%	4.37E-01	4.09E-01	4.37E-01	13.84%	5.28E-01	4.38E-01	5.28E-01	4.19%
Pb-214	1.79E+00	4.03E-01	1.79E+00	14.39%	1.50E+00	4.96E-01	1.50E+00	5.64%	1.60E+00	4.90E-01	1.60E+00	50.72%	1.62E+00	4.79E-01	1.62E+00	12.88%
Bi-212	5.35E+00	1.97E+00	5.35E+00	43.02%	ND		0		ND		0		ND		0	
Bi-214	1.73E+00	4.87E-01	1.73E+00	13.90%	1.67E+00	5.16E-01	1.67E+00	6.27%	1.12E+00	3.47E-01	1.12E+00	35.44%	1.28E+00	3.81E-01	1.28E+00	10.20%
Ra-226	ND		0		8.00E+00	5.84E+00	8.00E+00	30.10%	6.03E+00		0		9.16E+00	4.41E+00	9.16E+00	72.72%
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			1.24E+01	100.00%			2.66E+01	100.00%			3.16E+00	100.00%			1.26E+01	100.00%



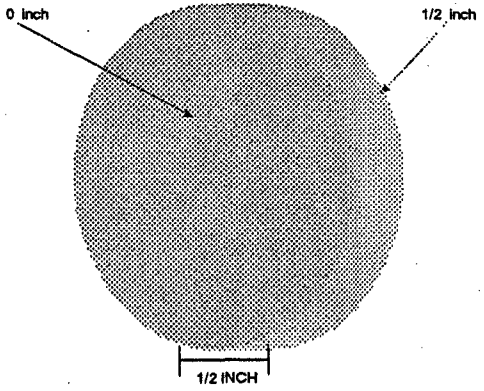


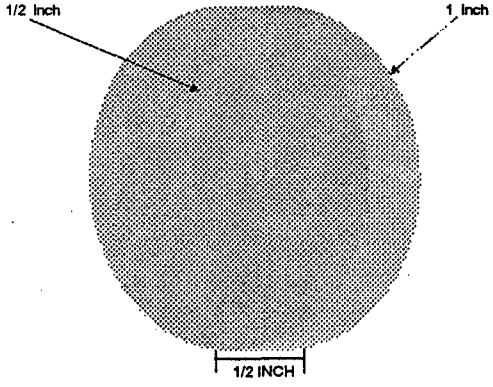


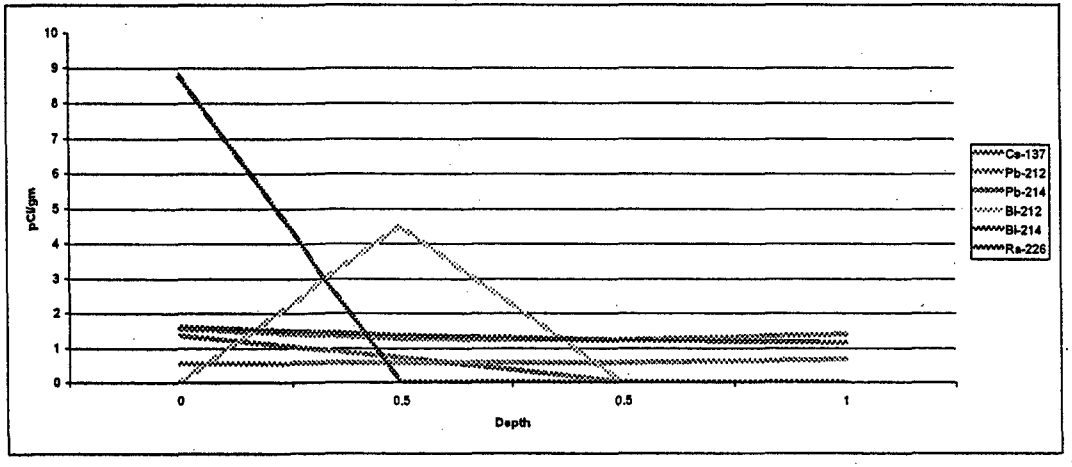
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE#9, Containment -25 ft, Area 18

	C9000101H1FL1C3L0509-01 1ST PUCK 0-INCH DEPTH				C9000101H1FL1C1L0509-01A 1ST PUCK 1/2-INCH DEPTH				C9000101H1FL1C1L0509-02 2CND PUCK 1/2-INCH DEPTH				C9000101H1FL1C1L0509-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	ND				ND				ND				ND			
Co-60	ND				ND				ND				ND			
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	1.35E+00	2.34E-01	1.35E+00	9.81%	7.11E-01	2.34E-01	7.11E-01	8.52%	1.40E-01		0		ND		0	
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	5.40E-01	4.27E-01	5.40E-01	3.91%	5.62E-01	4.40E-01	5.62E-01	6.74%	5.58E-01	4.55E-01	5.58E-01	18.70%	6.56E-01	3.42E-01	6.56E-01	20.58%
Pb-214	1.53E+00	4.04E-01	1.53E+00	11.07%	1.25E+00	5.50E-01	1.25E+00	14.95%	1.22E+00	3.51E-01	1.22E+00	40.80%	1.39E+00	4.03E-01	1.39E+00	43.57%
Bi-212	ND		0		4.48E+00	1.94E+00	4.48E+00	53.72%	ND		0		ND		0	
Bi-214	1.59E+00	3.98E-01	1.59E+00	11.53%	1.34E+00	3.44E-01	1.34E+00	16.07%	1.21E+00	4.01E-01	1.21E+00	40.50%	1.14E+00	3.22E-01	1.14E+00	35.85%
Ra-226	8.78E+00	6.08E+00	8.78E+00	63.68%	ND		0		ND		0		ND		0	
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			1.38E+01	100.00%			8.34E+00	100.00%			2.98E+00	100.00%			3.19E+00	100.00%



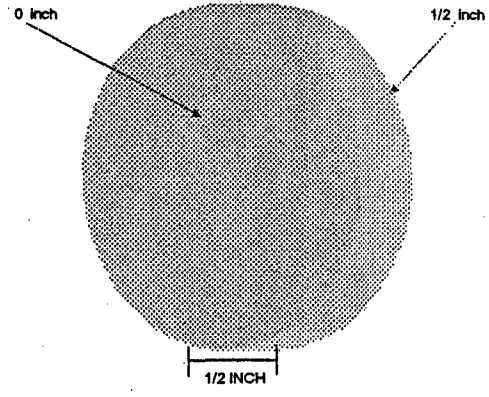


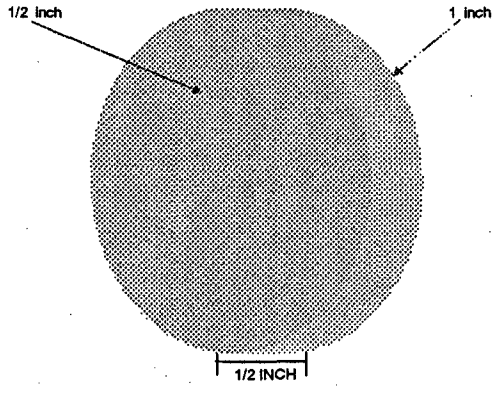


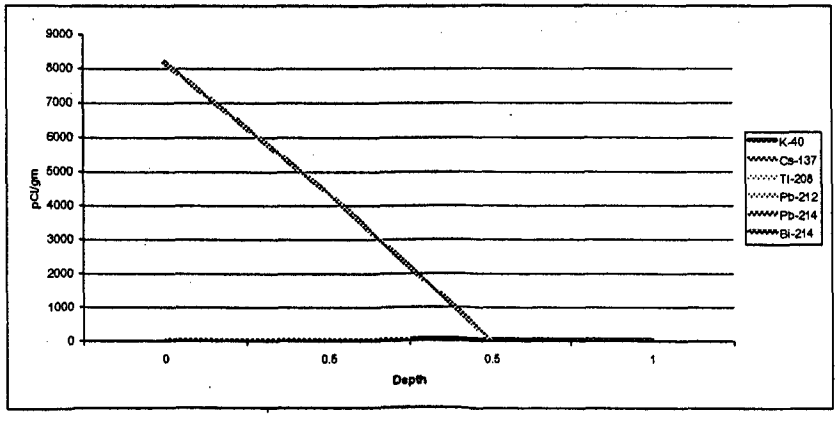
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #10, Waste Handling Building -15ft

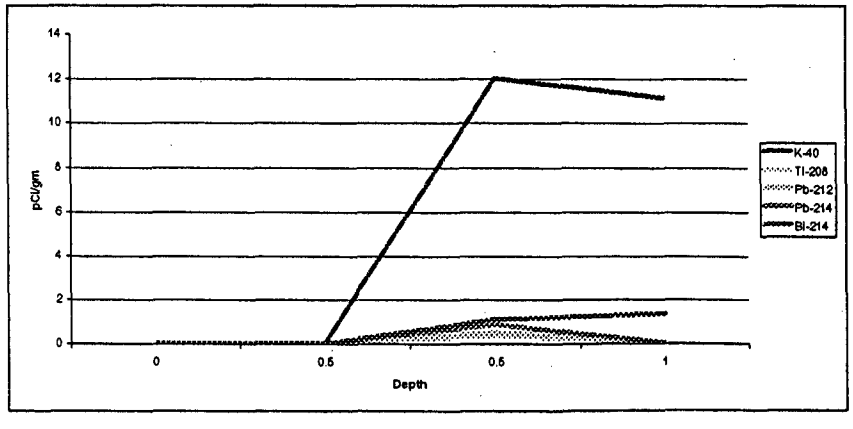
	C9000101HFL1C3L0510-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C3L0510-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0510-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0510-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	ND		0		ND		0		1.20E+01	2.10E+00	1.20E+01	78.10%	1.11E+01	2.10E+00	1.11E+01	87.04%
Co-60	ND				ND				ND				ND			
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	8.17E+03	3.85E+00	8.17E+03	100.00%	4.37E+03	3.40E+00	4.37E+03	100.00%	5.09E-01	2.48E-01	5.09E-01	3.32%	3.21E-01	1.39E-01	3.21E-01	2.51%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND		0		ND		0		3.77E-01	1.26E-01	3.77E-01	2.46%	ND		0	
Pb-212	ND		0		ND		0		5.12E-01	4.16E-01	5.12E-01	3.34%	ND		0	
Pb-214	ND		0		ND		0		8.54E-01	5.05E-01	8.54E-01	5.57%	ND		0	
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		ND		0		1.11E+00	2.40E-01	1.11E+00	7.22%	1.34E+00	2.40E-01	1.34E+00	10.45%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			8.17E+03	100.00%			4.37E+03	100.00%			1.53E+01	100.00%			1.28E+01	100.00%







with Cs-137

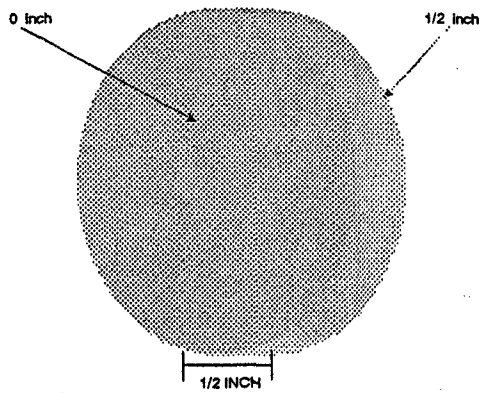


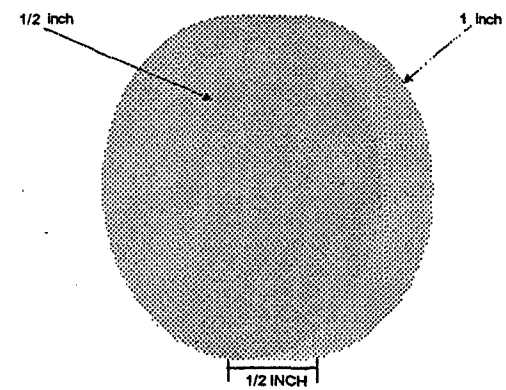
without Cs-137

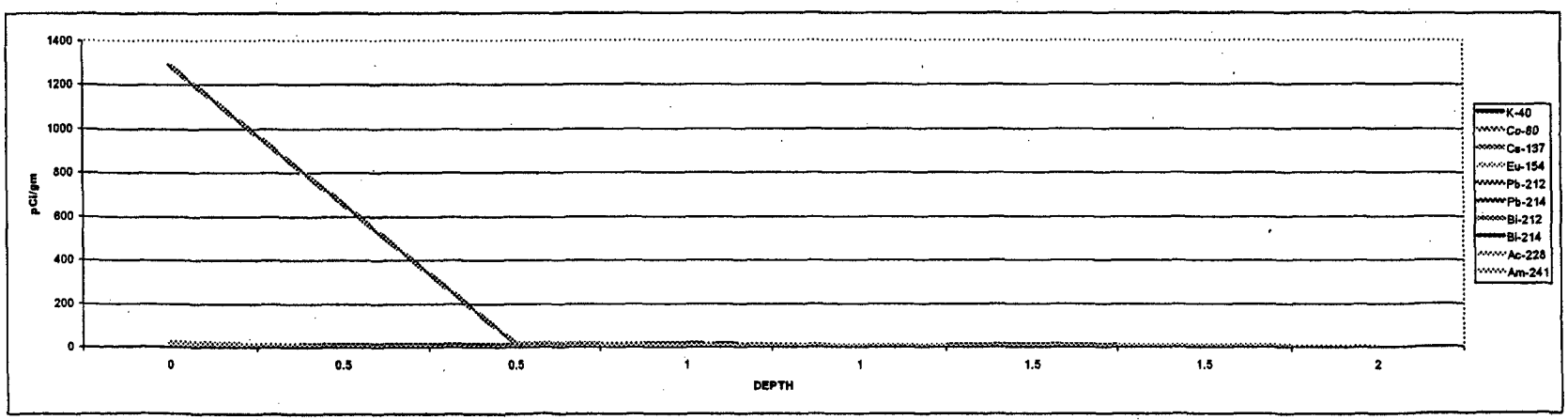
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #11, Hot Laboratory 0 ft (0 inch to 1 inch)

	C9000101HFL1C1L0511-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0511-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0511-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0511-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	6.34E+00	1.87E+00	6.34E+00	0.48%	7.61E+00	1.87E+00	7.61E+00	1.13%	9.76E+00	2.25E+00	9.76E+00	37.03%	1.34E+01	2.25E+00	1.34E+01	49.33%
Co-60	2.83E+00	1.90E-01	2.83E+00	0.21%	1.36E+00	1.90E-01	1.36E+00	0.20%	ND		0		ND		0	
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	1.29E+03	1.46E+00	1.29E+03	97.36%	6.59E+02	1.22E+00	6.59E+02	98.18%	1.39E+01	2.72E-01	1.39E+01	52.67%	1.18E+01	3.31E-01	1.18E+01	43.44%
Eu-152	ND				ND				ND				ND			
Eu-154	4.71E+00	3.67E+00	4.71E+00	0.36%	ND		0		ND		0		ND		0	
Tl-208	ND				ND				ND				ND			
Pb-212	2.79E+00		0		ND		0		ND		0		9.33E-01	5.29E-01	9.33E-01	3.43%
Pb-214	3.69E+00		0		ND		0		1.45E+00	5.13E-01	1.45E+00	5.52%	1.03E+00	7.41E-01	1.03E+00	3.80%
Bi-212	ND		0		ND		0		ND		0		ND		0	
Bi-214	2.10E+00		0		ND		0		1.26E+00	4.12E-01	1.26E+00	4.78%	ND		0	
Ra-226	ND				ND				ND				ND			
Ac-228	ND		0		ND		0		ND		0		ND		0	
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	2.08E+01	3.25E+00	2.08E+01	1.58%	3.26E+00	2.04E+00	3.26E+00	0.49%	ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			1.32E+03	100.00%			6.71E+02	100.00%			2.64E+01	100.00%			2.72E+01	100.00%





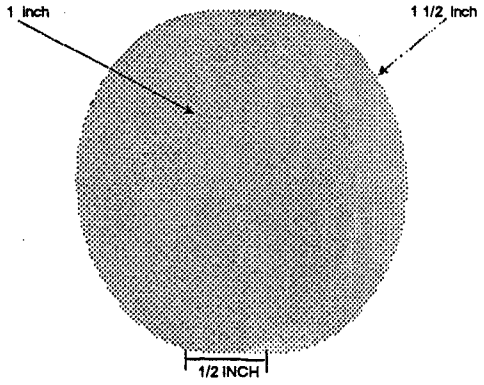


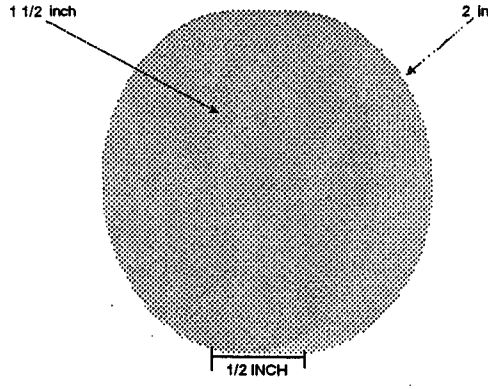
with Cs-137

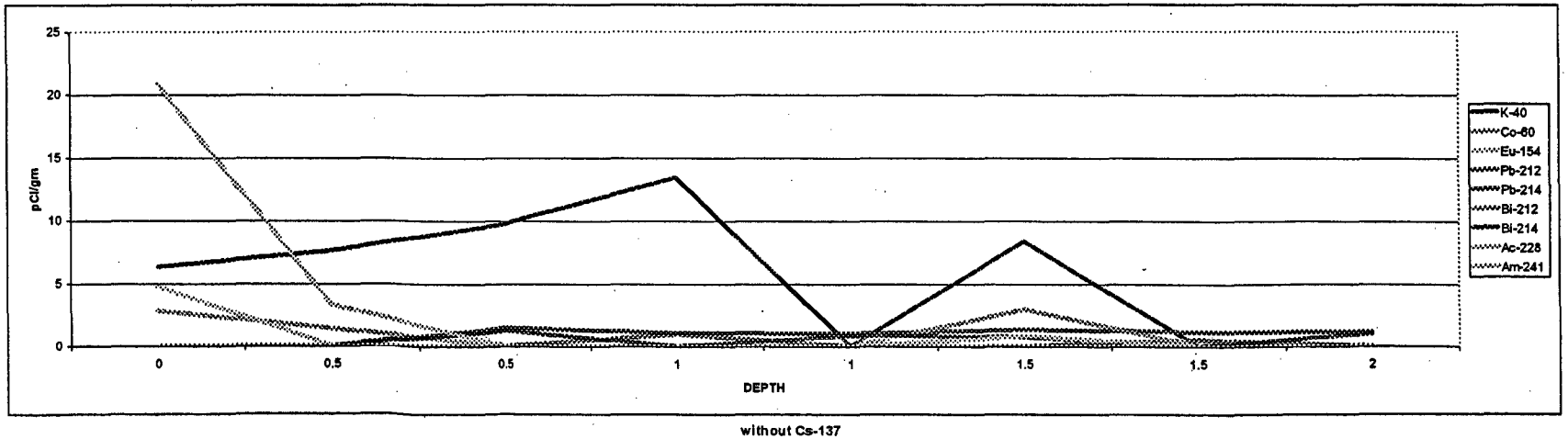
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #11, Hot Laboratory 0 ft (1 inch to 2 inch)

	C9000101HFL1C1L0511-03 3RD PUCK 1-INCH DEPTH				C9000101HFL1C1L0511-03A 3RD PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0511-04 4TH PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0511-04A 4TH PUCK 2-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40			0		8.38E+00	2.13E+00	8.38E+00	47.91%			0				0	
Co-60			0				0				0				0	
Nb-94																
Ag-108m																
Cs-137	3.22E+00	2.02E-01	3.22E+00	63.95%	3.29E+00	1.41E-01	3.29E+00	18.82%	1.52E+00	2.06E-01	1.52E+00	47.92%	1.27E+00	2.46E-01	1.27E+00	37.25%
Eu-152																
Eu-154			0				0				0				0	
Tl-208																
Pb-212			0				0		5.03E-01	3.84E-01	5.03E-01	15.87%			0	
Pb-214	1.02E+00	5.60E-01	1.02E+00	20.32%	1.31E+00	4.58E-01	1.31E+00	7.51%	1.15E+00	4.16E-01	1.15E+00	36.21%	1.15E+00	5.19E-01	1.15E+00	33.59%
Bi-212			0		2.94E+00	1.97E+00	2.94E+00	16.80%			0				0	
Bi-214	7.92E-01	2.43E-01	7.92E-01	15.73%	7.48E-01	4.09E-01	7.48E-01	4.27%			0		9.96E-01	3.17E-01	9.96E-01	29.17%
Ra-226																
Ac-228			0		8.22E-01	6.06E-01	8.22E-01	4.70%			0				0	
Th-234																
U-235																
Am-241			0				0				0				0	
Cm-243																
Cm-245																
			5.03E+00	100.00%			1.75E+01	100.00%			3.17E+00	100.00%			3.41E+00	100.00%





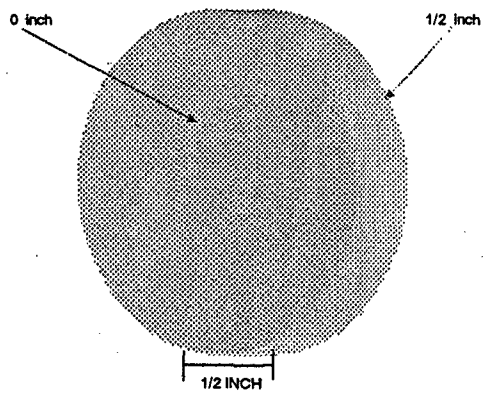


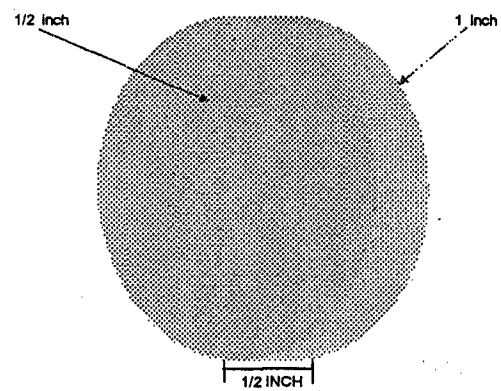
without Cs-137

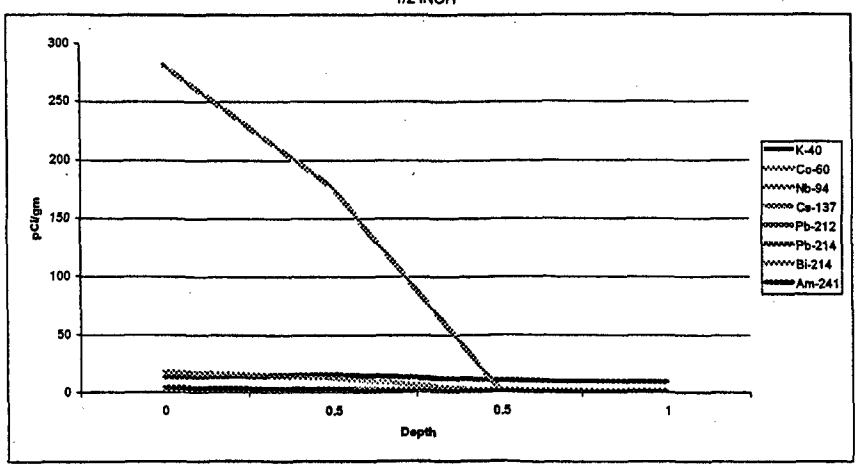
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #12, Hot Laboratory 0 ft

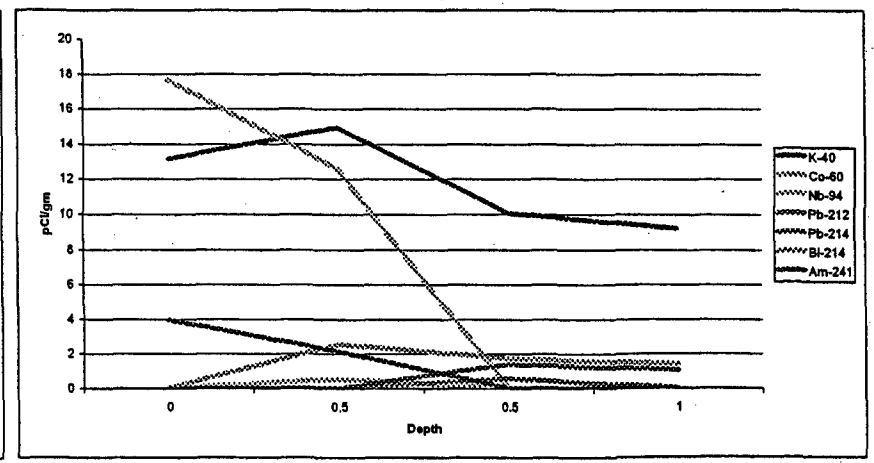
	C9000101HFL1C3L0512-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0512-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0512-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0512-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.31E+01	2.62E+00	1.31E+01	4.16%	1.49E+01	3.83E+00	1.49E+01	7.13%	1.00E+01	2.11E+00	1.00E+01	71.84%	9.16E+00	2.11E+00	9.16E+00	79.06%
Co-60	1.76E+01	2.66E-01	1.76E+01	5.57%	1.26E+01	2.66E-01	1.26E+01	6.02%	2.15E-01		0		ND		0	
Nb-94	ND		0		5.38E-01	1.85E-01	5.38E-01	0.26%	1.49E-01		0		ND		0	
Ag-108m	ND				ND				ND				ND			
Cs-137	2.81E+02	9.32E-01	2.81E+02	89.02%	1.76E+02	9.92E-01	1.76E+02	84.37%	2.84E-01	1.40E-01	2.84E-01	2.04%	ND		0	
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	ND		0		ND		0		5.61E-01	3.46E-01	5.61E-01	4.02%	ND		0	
Pb-214	ND		0		2.67E+00	2.26E+00	0		1.38E+00	5.84E-01	1.38E+00	9.88%	1.06E+00	4.13E-01	1.06E+00	9.13%
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		2.54E+00	1.24E+00	2.54E+00	1.21%	1.71E+00	4.24E-01	1.71E+00	12.22%	1.37E+00	4.06E-01	1.37E+00	11.81%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	3.92E+00	1.73E+00	3.92E+00	1.24%	2.11E+00	1.53E+00	2.11E+00	1.01%	ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			3.16E+02	100.00%			2.09E+02	100.00%			1.40E+01	100.00%			1.16E+01	100.00%







with Cs-137

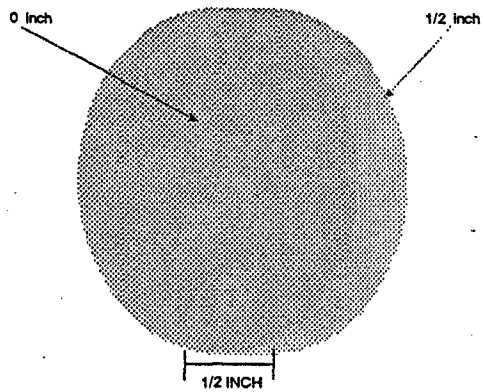


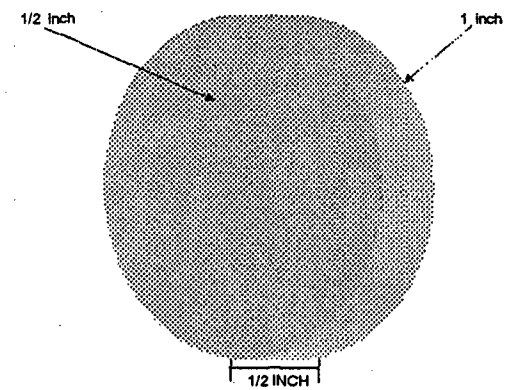
without Cs-137

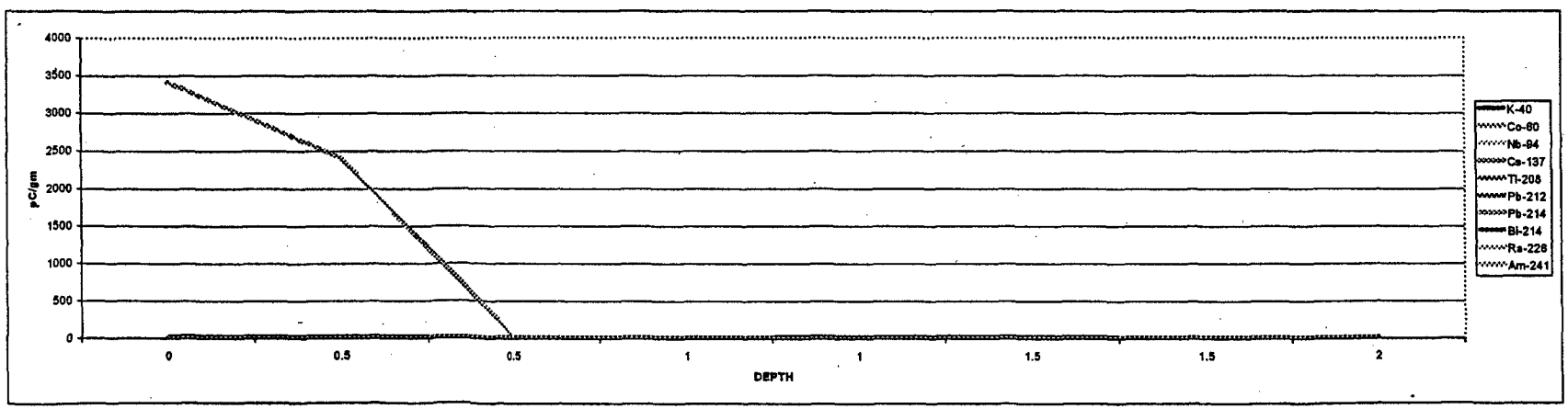
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #13, Hot Laboratory 0 ft (0 inch to 1 inch)

	C9000101HFL1C3L0513-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0513-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0513-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0513-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.67E+01	2.70E+00	1.67E+01	0.54%	1.28E+01	2.70E+00	1.28E+01	0.53%	9.42E+00	2.24E+00	9.42E+00	63.89%	7.90E+00	2.24E+00	7.90E+00	63.50%
Co-60	1.28E+00	2.75E-01	1.28E+00	0.04%	8.12E-01	2.75E-01	8.12E-01	0.03%	ND		0		ND		0	
Nb-94	ND		0		ND		0		2.37E-01	1.58E-01	2.37E-01	1.61%	ND		0	
Ag-108m	ND				ND				ND				ND			
Cs-137	3.41E+03	2.92E+00	3.41E+03	99.17%	2.40E+03	2.77E+00	2.40E+03	99.44%	1.75E+00	1.48E-01	1.75E+00	11.87%	1.09E+00	1.48E-01	1.09E+00	8.73%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND		0		ND		0		ND		0		ND		0	
Pb-212	ND		0		ND		0		ND		0		7.00E-01	4.55E-01	7.00E-01	5.63%
Pb-214	ND		0		ND		0		1.56E+00	6.00E-01	1.56E+00	10.55%	1.16E+00	6.05E-01	1.16E+00	9.31%
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		ND		0		1.78E+00	4.04E-01	1.78E+00	12.08%	1.60E+00	2.56E-01	1.60E+00	12.83%
Ra-226	ND		0		ND		0		ND		0		ND		0	
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	8.58E+00	4.49E+00	8.58E+00	0.25%	ND		0		ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			3.44E+03	100.00%			2.42E+03	100.00%			1.48E+01	100.00%			1.24E+01	100.00%





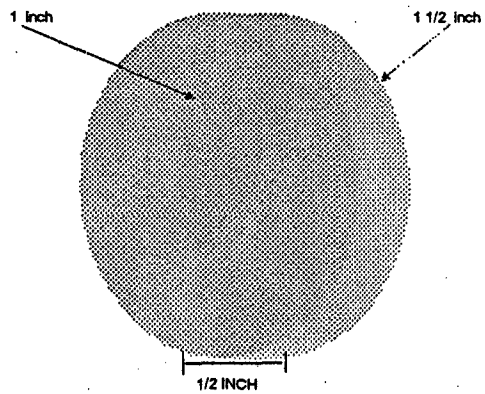


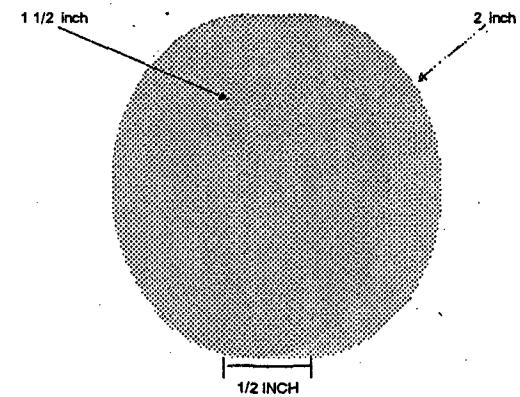
with Cs-137

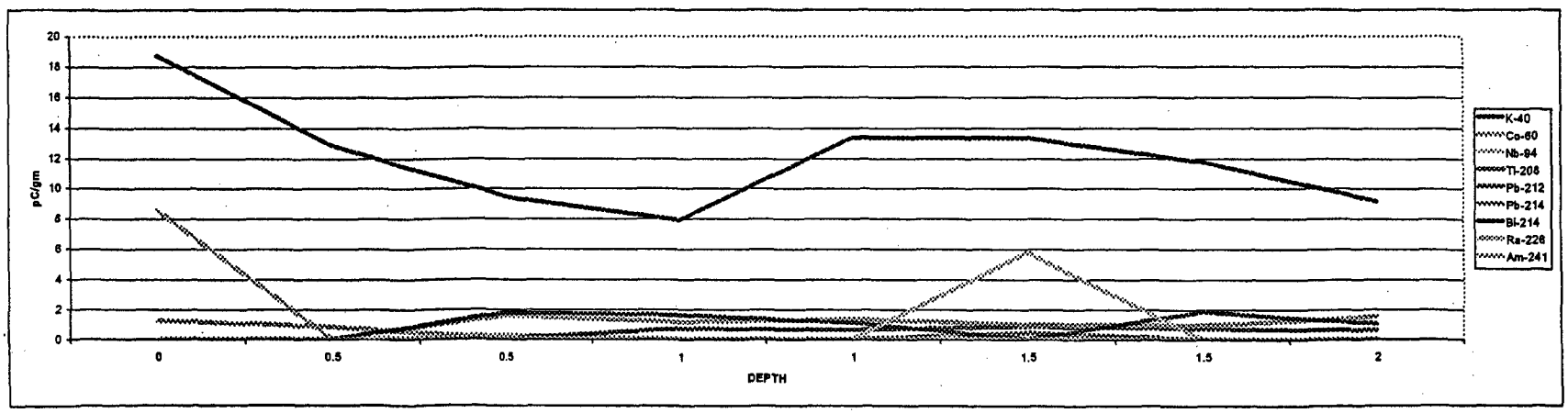
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #13, Hot Laboratory 0 ft (1 inch to 2 inch)

	C9000101HFL1C3L0513-03 3RD PUCK 1-INCH DEPTH				C9000101HFL1C1L0513-03A 3RD PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0513-04 4TH PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0513-04A 4TH PUCK 2-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.33E+01	2.18E+00	1.33E+01	78.43%	1.33E+01	2.18E+00	1.33E+01	60.81%	1.17E+01	2.11E+00	1.17E+01	73.60%	9.16E+00	2.11E+00	9.16E+00	74.59%
Co-60			0				0				0				0	
Nb-94			0				0				0				0	
Ag-108m																
Cs-137	6.01E-01	2.20E-01	6.01E-01	3.54%	5.39E-01	1.97E-01	5.39E-01	2.46%	7.21E-01	1.40E-01	7.21E-01	4.52%			0	
Eu-152																
Eu-154																
Tl-208			0		4.18E-01	1.79E-01	4.18E-01	1.91%			0				0	
Pb-212	6.15E-01	4.66E-01	6.15E-01	3.62%	8.76E-01	3.98E-01	8.76E-01	4.00%	6.91E-01	4.76E-01	6.91E-01	4.33%	5.92E-01	3.27E-01	5.92E-01	4.82%
Pb-214	1.34E+00	4.85E-01	1.34E+00	7.91%	9.67E-01	4.27E-01	9.67E-01	4.42%	9.57E-01	5.26E-01	9.57E-01	6.00%	1.49E+00	4.44E-01	1.49E+00	12.17%
Bi-212																
Bi-214	1.10E+00	4.55E-01	1.10E+00	6.50%			0		1.84E+00	0.4177	1.84E+00	11.55%	1.04E+00	3.21E-01	1.04E+00	8.43%
Ra-226			0		5.78E+00	4.30E+00	5.78E+00	26.40%			0				0	
Ac-228																
Th-234																
U-235																
Am-241			0				0				0				0	
Cm-243																
Cm-245																
			1.70E+01	100.00%			2.19E+01	100.00%			1.60E+01	100.00%			1.23E+01	100.00%





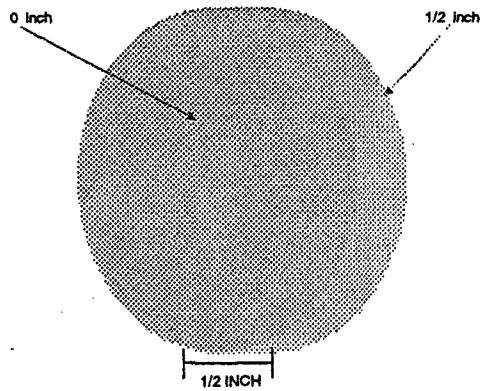


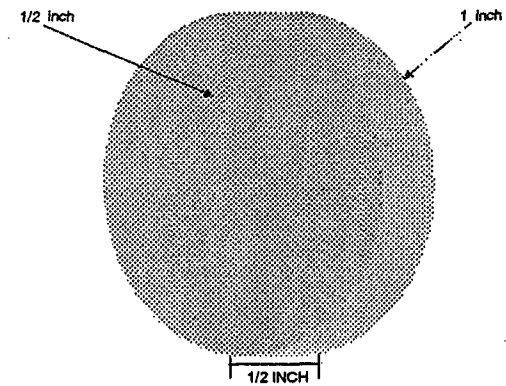
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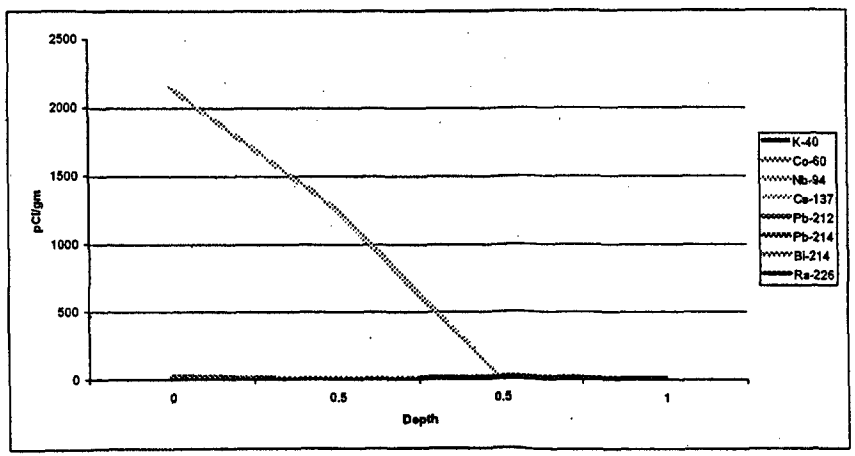
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #14, Hot Laboratory 0 ft

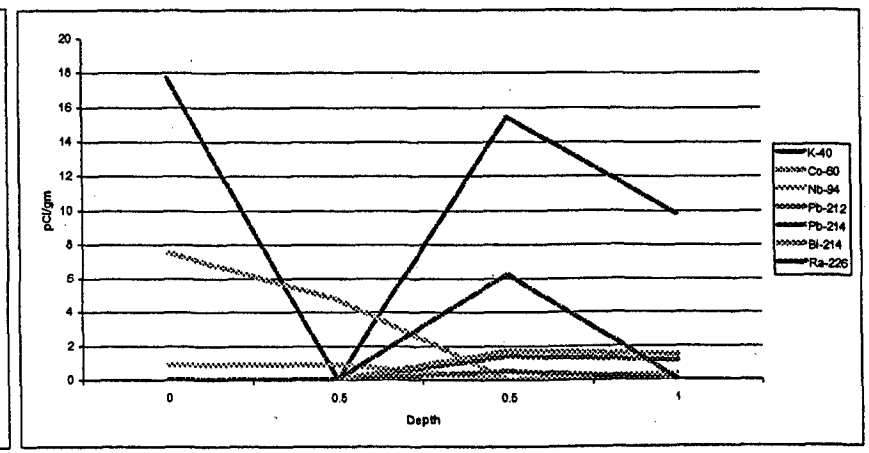
	C9000101HFL1C3L0514-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0514-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0514-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0514-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.77E+01	2.29E+00	1.77E+01	0.82%	7.58E+00		0		1.54E+01	2.18E+00	1.54E+01	61.13%	9.77E+00	2.18E+00	9.77E+00	77.26%
Co-60	7.49E+00	2.32E-01	7.49E+00	0.35%	4.73E+00	2.32E-01	4.73E+00	0.37%	2.23E-01		0		2.98E-01	2.22E-01	2.98E-01	2.36%
Nb-94	8.98E-01	5.26E-01	8.98E-01	0.04%	6.63E-01	3.77E-01	8.63E-01	0.07%	1.89E-01		0		1.54E-01		0	
Ag-108m	ND				ND				ND				ND			
Cs-137	2.14E+03	2.01E+00	2.14E+03	98.80%	1.26E+03	1.94E+00	1.26E+03	99.56%	1.82E-01		0		1.44E-01		0	
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	ND		0		ND		0		4.99E-01	3.44E-01	4.99E-01	1.98%	3.72E-01		0	
Pb-214	ND		0		ND		0		1.39E+00	3.34E-01	1.39E+00	5.51%	1.11E+00	6.14E-01	1.11E+00	8.78%
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		ND		0		1.68E+00	3.49E-01	1.68E+00	6.66%	1.47E+00	6.14E-01	1.47E+00	11.60%
Ra-226	ND		0		ND		0		6.22E+00	4.76E+00	6.22E+00	24.71%	6.19E+00		0	
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			2.17E+03	100.00%			1.26E+03	100.00%			2.52E+01	100.00%			1.26E+01	100.00%







with Cs-137

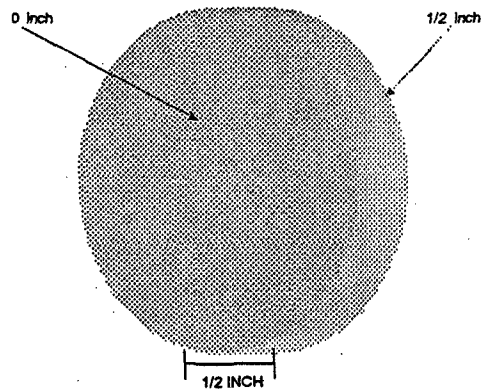


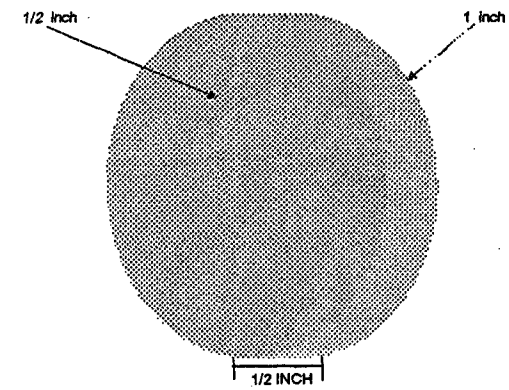
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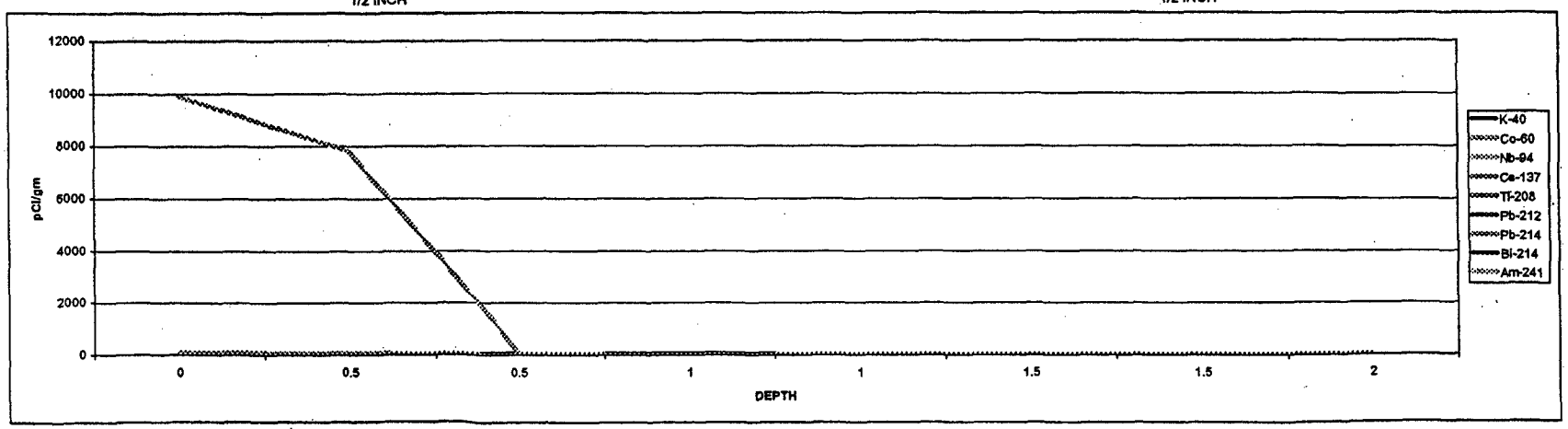
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #15, Hot Laboratory 0 ft (0 inch to 1 inch)

	C9000101HFL1C1L0515-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0515-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0515-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0515-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.29E+01	2.50E+00	1.29E+01	0.13%	1.76E+01	2.49E+00	1.76E+01	0.22%	1.40E+01	2.10E+00	1.40E+01	46.13%	1.33E+01	2.10E+00	1.33E+01	53.76%
Co-60	7.20E+01	5.02E-01	7.20E+01	0.72%	5.36E+01	2.53E-01	5.36E+01	0.68%	8.69E-01	2.13E-01	8.69E-01	2.87%	8.84E-01	2.13E-01	8.84E-01	3.57%
Nb-94	ND		0		1.10E+00	8.53E-01	1.10E+00	0.01%	ND		0		ND		0	
Ag-108m	ND				ND				ND				ND			
Cs-137	9.87E+03	5.11E+00	9.87E+03	99.05%	7.79E+03	4.90E+00	7.79E+03	98.99%	1.40E+01	4.53E-01	1.40E+01	46.41%	8.28E+00	2.94E-01	8.28E+00	33.40%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND		0		ND		0		ND		0		ND		0	
Pb-212	ND		0		ND		0		ND		0		ND		0	
Pb-214	ND		0		ND		0		1.39E+00	6.27E-01	1.39E+00	4.59%	1.24E+00	7.66E-01	1.24E+00	4.99%
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		ND		0		ND		0		1.06E+00	6.65E-01	1.06E+00	4.26%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	9.63E+00	6.17E+00	9.63E+00	0.10%	7.10E+00	6.51E+00	7.10E+00	0.09%	ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			9.96E+03	100.00%			7.87E+03	100.00%			3.03E+01	100.00%			2.48E+01	100.00%





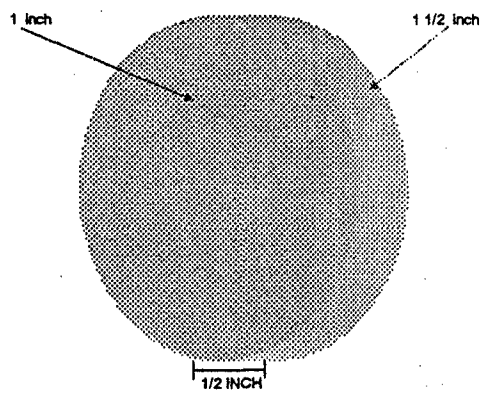


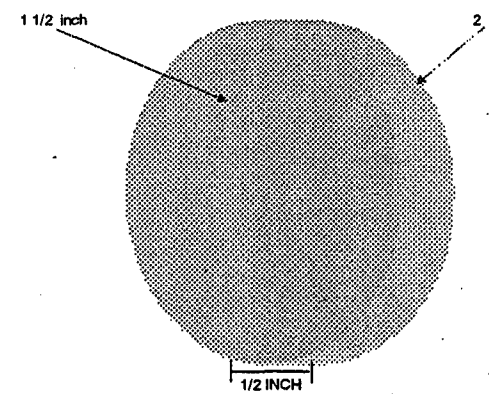
with Cs-137

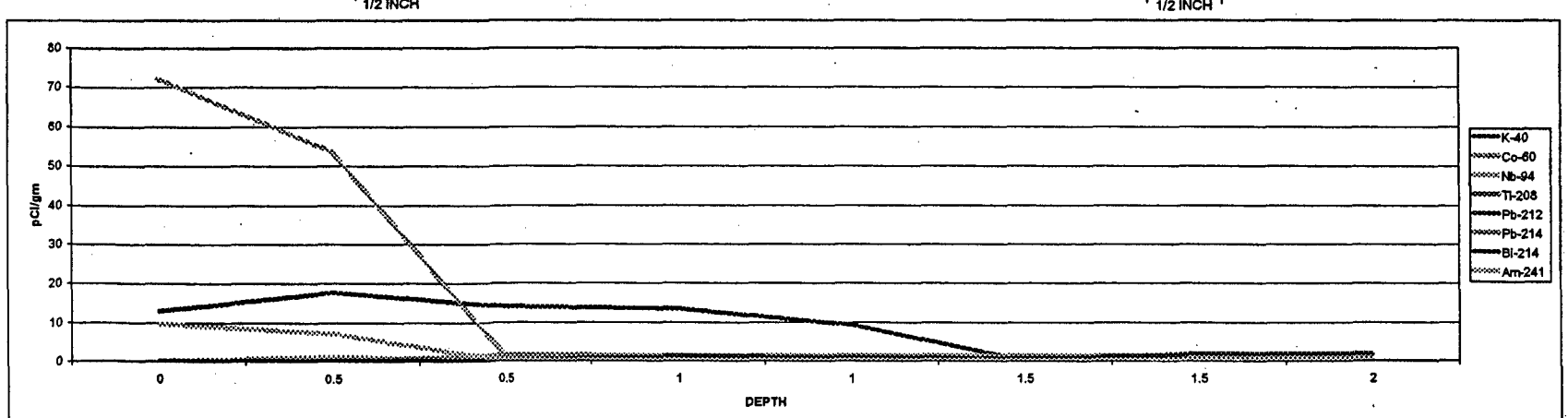
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #15, Hot Laboratory 0 ft (1 inch to 2 inch)

	C9000101HFL1C1L0515-03 3RD PUCK 1-INCH DEPTH				C9000101HFL1C1L0515-03A 3RD PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0515-04 4TH PUCK 1 1/2-INCH DEPTH				C9000101HFL1C1L0515-04A 4TH PUCK 2-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	9.23E+00	1.79E+00	9.23E+00	79.00%	ND		0		1.15E+00	2.36E+00	1.15E+00	21.46%	1.15E+00	2.36E+00	1.15E+00	21.46%
Co-60	ND		0		ND		0		ND		0		ND		0	
Nb-94	ND		0		ND		0		ND		0		ND		0	
Ag-108m	ND				ND				ND				ND			
Cs-137	3.22E-01	1.18E-01	3.22E-01	2.75%	5.31E-01	1.18E-01	5.31E-01	21.71%	5.95E-01	1.56E-01	5.95E-01	11.05%	5.95E-01	1.56E-01	5.95E-01	11.05%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND		0		2.53E-01	1.70E-01	2.53E-01	10.35%	ND		0		ND		0	
Pb-212	ND		0		ND		0		7.17E-01	5.33E-01	7.17E-01	13.32%	7.17E-01	5.33E-01	7.17E-01	13.32%
Pb-214	1.24E+00	4.83E-01	1.24E+00	10.61%	1.25E+00	3.18E-01	1.25E+00	51.11%	1.19E+00	6.04E-01	1.19E+00	22.18%	1.19E+00	6.04E-01	1.19E+00	22.18%
Bi-212	ND				ND				ND				ND			
Bi-214	8.92E-01	2.93E-01	8.92E-01	7.63%	4.11E-01	2.04E-01	4.11E-01	16.83%	1.72E+00	2.70E-01	1.72E+00	31.98%	1.72E+00	2.70E-01	1.72E+00	31.98%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND		0		ND		0		ND		0		ND		0	
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			1.17E+01	100.00%			2.44E+00	100.00%			5.38E+00	100.00%			5.38E+00	100.00%





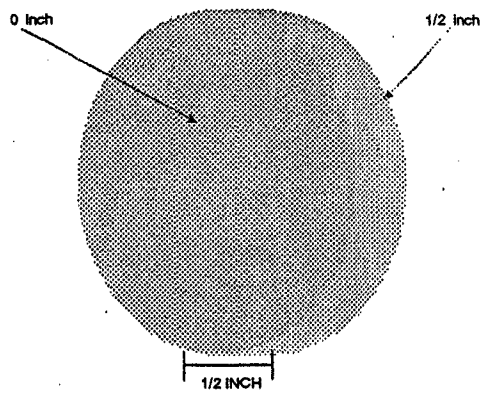


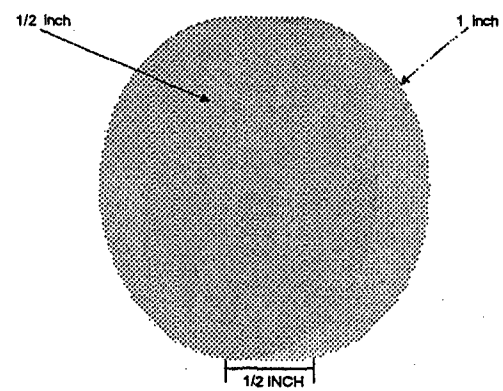
without Cs-137

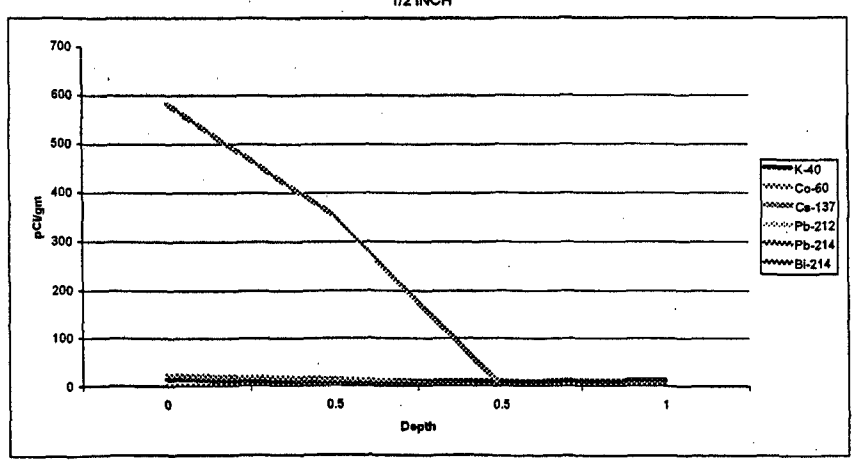
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #16, Hot Pipe Tunnel, -12 ft

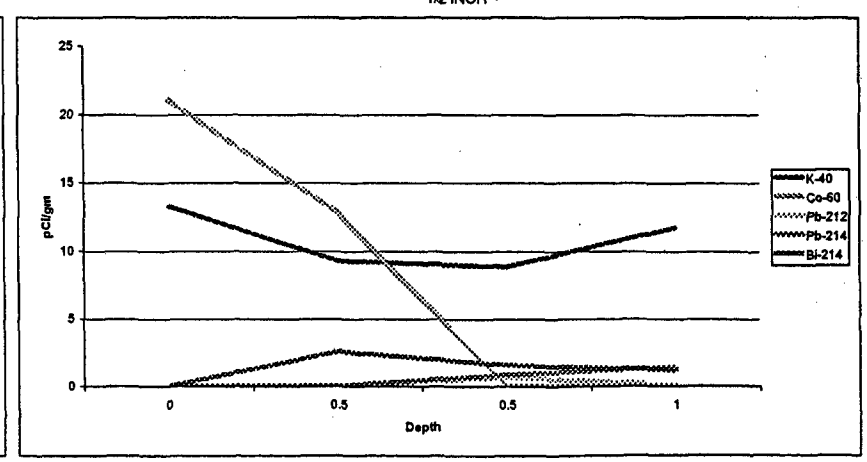
	C9000101HFL1C1L0516-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0516-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0516-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0516-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.32E+01	1.95E+00	1.32E+01	2.15%	9.26E+00	1.95E+00	9.26E+00	2.46%	8.84E+00	2.10E+00	8.84E+00	70.20%	1.17E+01	2.10E+00	1.17E+01	77.73%
Co-60	2.10E+01	1.98E-01	2.10E+01	3.41%	1.28E+01	1.98E-01	1.28E+01	3.39%	2.14E-01		0		2.14E-01		0	
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	5.82E+02	1.39E+00	5.82E+02	94.45%	3.53E+02	8.79E-01	3.53E+02	93.47%	6.17E-01	2.54E-01	6.17E-01	4.89%	8.12E-01	2.27E-01	8.12E-01	5.39%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	ND		0		ND		0		6.82E-01	4.07E-01	6.82E-01	5.42%	5.55E-01		0	
Pb-214	ND		0		ND		0		8.59E-01	5.50E-01	8.59E-01	6.82%	1.37E+00	5.43E-01	1.37E+00	9.12%
Bi-212	ND				ND				ND				ND			
Bi-214	ND		0		2.57E+00	1.35E+00	2.57E+00	0.68%	1.60E+00	2.40E-01	1.60E+00	12.67%	1.17E+00	3.58E-01	1.17E+00	7.76%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			6.16E+02	100.00%			3.77E+02	100.00%			1.26E+01	100.00%			1.50E+01	100.00%







with Cs-137

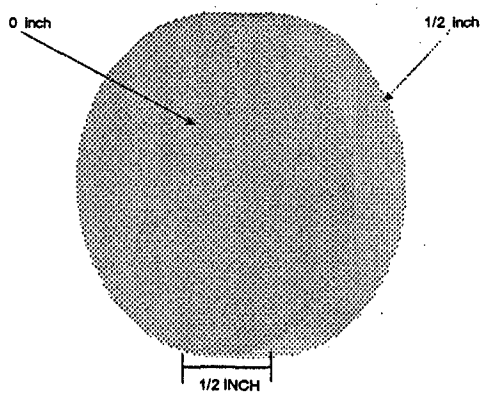


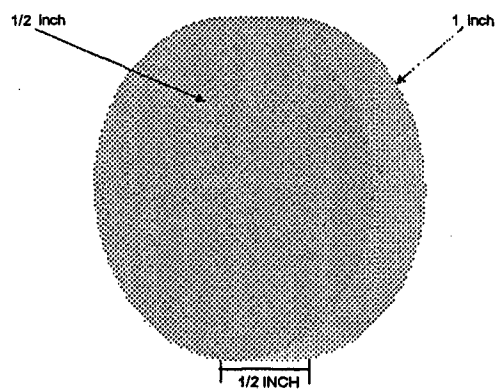
without Cs-137

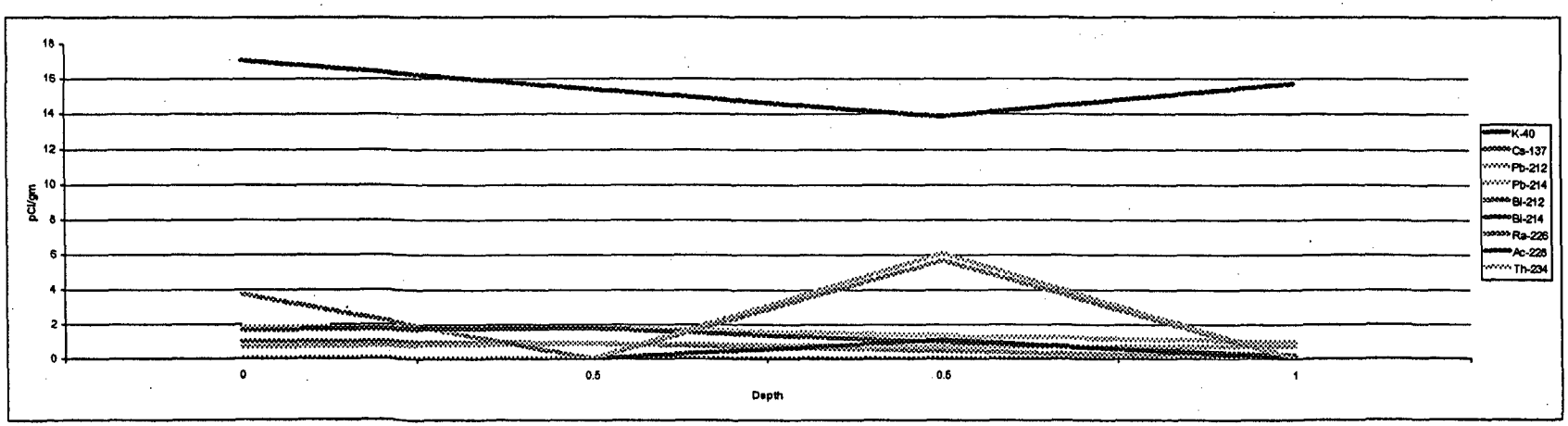
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #17, Fan House, -12 ft

	C9000101HFL1C1L0517-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0517-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0517-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0516-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.70E+01	2.46E+00	1.70E+01	65.69%	1.54E+01	2.46E+00	1.54E+01	74.32%	1.39E+01	2.27E+00	1.39E+01	46.03%	1.57E+01	2.27E+00	1.57E+01	89.44%
Co-60	ND				ND				ND				ND			
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				1.90E-01				ND			
Cs-137	9.95E-01	1.63E-01	9.95E-01	3.83%	8.85E-01	1.63E-01	8.85E-01	4.28%	4.48E-01	1.50E-01	4.48E-01	1.49%	3.68E-01		0	
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND				ND				ND				ND			
Pb-212	6.68E-01	5.55E-01	6.68E-01	2.58%	8.81E-01	4.85E-01	8.81E-01	4.26%	6.52E-01	5.11E-01	6.52E-01	2.17%	7.25E-01	5.56E-01	7.25E-01	4.13%
Pb-214	1.87E+00	7.01E-01	1.87E+00	7.21%	1.79E+00	6.30E-01	1.79E+00	8.65%	1.34E+00	5.27E-01	1.34E+00	4.46%	9.64E-01	4.77E-01	9.64E-01	5.49%
Bi-212	3.71E+00	2.28E+00	3.71E+00	14.29%	ND		0		ND		0		ND		0	
Bi-214	1.66E+00	6.27E-01	1.66E+00	6.40%	1.76E+00	2.81E-01	1.76E+00	8.49%	9.61E-01	4.09E-01	9.61E-01	3.19%	1.65E-01	2.59E-01	1.65E-01	0.94%
Ra-226	ND		0		ND		0		5.65E+00	5.38E+00	5.65E+00	18.77%	ND		0	
Ac-228	ND		0		ND		0		1.12E+00	6.45E-01	1.12E+00	3.70%	ND		0	
Th-234	ND		0		ND		0		6.08E+00	6.00E+00	6.08E+00	20.20%	ND		0	
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			2.60E+01	100.00%			2.07E+01	100.00%			3.01E+01	100.00%			1.76E+01	100.00%



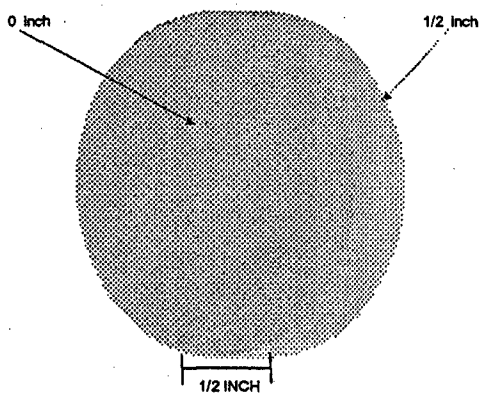


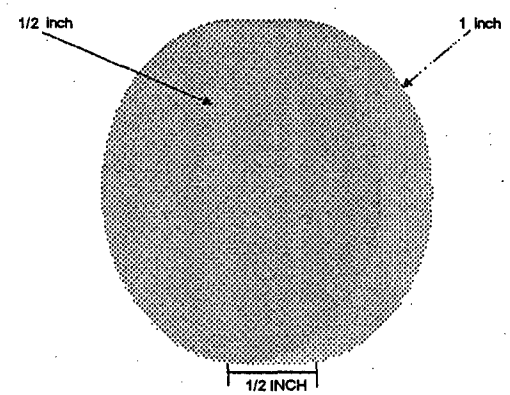


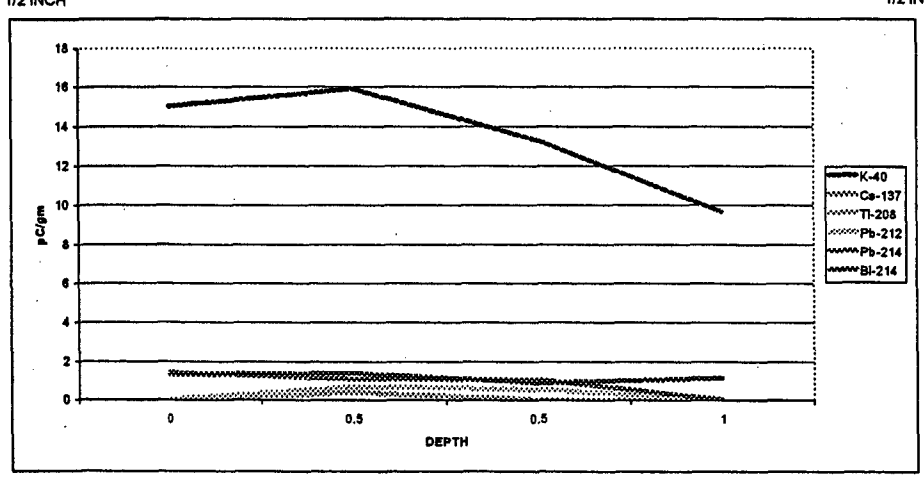
Preliminary Analysis of Concrete Core "Puck" Samples by the On-Site Laboratory

CORE BORE #21, ROLB Fuel Vault

	C9000101HFL1C1L0521-01 1ST PUCK 0-INCH DEPTH				C9000101HFL1C1L0521-01A 1ST PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0521-02 2CND PUCK 1/2-INCH DEPTH				C9000101HFL1C1L0521-02A 2CND PUCK 1-INCH DEPTH			
	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%	Results	MDA	Used	%
K-40	1.50E+01	2.21E+00	1.50E+01	84.76%	1.59E+01	2.21E+00	1.59E+01	81.31%	1.33E+01	2.08E+00	1.33E+01	84.59%	9.65E+00	2.98E+00	9.65E+00	87.04%
Co-60	ND				ND				ND				ND			
Nb-94	ND				ND				ND				ND			
Ag-108m	ND				ND				ND				ND			
Cs-137	ND		0		2.38E-01	1.46E-01	2.38E-01	1.22%	ND		0		3.05E-01	1.93E-01	3.05E-01	2.75%
Eu-152	ND				ND				ND				ND			
Eu-154	ND				ND				ND				ND			
Tl-208	ND		0		3.49E-01	2.66E-01	3.49E-01	1.78%	ND		0		ND		0	
Pb-212	ND		0		6.53E-01	5.68E-01	6.53E-01	3.34%	5.26E-01	4.71E-01	5.26E-01	3.35%	ND		0	
Pb-214	1.39E+00	6.69E-01	1.39E+00	7.85%	1.06E+00	4.75E-01	1.06E+00	5.43%	1.02E+00	5.06E-01	1.02E+00	6.51%	ND		0	
Bi-212	ND				ND				ND				ND			
Bi-214	1.31E+00	4.05E-01	1.31E+00	7.39%	1.35E+00	5.85E-01	1.35E+00	6.92%	8.70E-01	4.55E-01	8.70E-01	5.55%	1.13E+00	3.62E-01	1.13E+00	10.21%
Ra-226	ND				ND				ND				ND			
Ac-228	ND				ND				ND				ND			
Th-234	ND				ND				ND				ND			
U-235	ND				ND				ND				ND			
Am-241	ND				ND				ND				ND			
Cm-243	ND				ND				ND				ND			
Cm-245	ND				ND				ND				ND			
			1.77E+01	100.00%			1.95E+01	100.00%			1.57E+01	100.00%			1.11E+01	100.00%







Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment A
Radionuclide Distribution Basis for DCGL Determination & Final Status Survey of the Plum Brook Reactor Facility (PBRF)

Addendum 3
Results of Isotopic Analysis of Concrete Core Samples

Attachment A,
Addendum 3
Results of Isotopic Analysis of Concrete Core Samples

	Rx Bldg -25ft, Area 22 Core Location #5 C9000101IFL1C1L0505-01				CTMT -25 ft, Canal E Core Location #6 C9000101IFL1C3L0506-01				Rx Bldg -15 ft, SE Area Core Location #7 C9000101IFL1C1L0507-01			
	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
H-3	4.90E+00	5.20E+00	5.20E+00	2.60%	6.40E+00	5.10E+00	6.40E+00	4.07%	3.00E+00	5.20E+00	5.20E+00	15.33%
Cs-137	2.86E+00	1.70E-01	2.86E+00	1.43%	1.17E+02	2.00E-01	1.17E+02	74.32%	7.20E-01	1.10E-01	7.20E-01	2.12%
Co-60	1.13E+01	1.00E-01	1.13E+01	5.65%	2.21E+00	1.20E-01	2.21E+00	1.40%	1.40E-01	2.40E-01	2.40E-01	0.71%
Fe-55	1.70E+01	6.70E+01	6.70E+01	33.48%	1.80E+00	1.20E+01	1.20E+01	7.62%	4.40E-01	1.30E+01	1.30E+01	38.33%
Ni-63	1.07E+02	2.70E+01	1.07E+02	53.47%	1.19E+01	1.30E+01	1.30E+01	8.26%	8.30E+00	9.80E+00	9.80E+00	28.89%
Sr-90	2.07E+00	6.40E-01	2.07E+00	1.03%	4.60E-01	4.40E-01	4.60E-01	0.29%	4.00E-02	5.70E-01	5.70E-01	1.68%
Pu-238	4.10E-02	6.90E-02	6.90E-02	0.03%	8.50E-02	2.90E-02	8.50E-02	0.05%	6.00E-03	5.30E-02	5.30E-02	0.16%
Pu-239/240	2.70E-02	5.40E-02	5.40E-02	0.03%	1.90E-02	4.70E-02	4.70E-02	0.03%	1.00E-02	2.80E-02	2.80E-02	0.08%
Pu-241	6.00E-01	2.60E+00	2.60E+00	1.30%	1.20E+00	2.80E+00	2.80E+00	1.78%	-2.00E-01	2.50E+00	2.50E+00	7.37%
Am-241	6.00E-02	2.10E-01	2.10E-01	0.10%	1.67E+00	3.00E-01	1.67E+00	1.06%	0.00E+00	1.00E-01	1.00E-01	0.29%
Cm-245/246	5.00E-02	3.90E-01	3.90E-01	0.19%	1.60E-02	8.70E-02	8.70E-02	0.06%	1.00E-01	1.30E-01	1.30E-01	0.38%
U-234	6.40E-01	9.00E-02	6.40E-01	0.32%	7.50E-01	3.00E-02	7.50E-01	0.48%	7.20E-01	4.00E-02	7.20E-01	2.12%
U-235	1.10E-01	7.70E-02	1.10E-01	0.05%	1.30E-02	3.40E-02	3.40E-02	0.02%	2.90E-02	7.70E-02	7.70E-02	0.23%
U-238	6.20E-01	4.00E-02	6.20E-01	0.31%	8.80E-01	3.00E-02	8.80E-01	0.56%	7.80E-01	6.00E-02	7.80E-01	2.30%
			2.00E+02	100%			1.57E+02	100%			3.39E+01	100%

	CTMT -25 ft, Area 18 Core Location #9 C9000101IFL1C3L0509-01				Waste Handling Bldg -15 ft Core Location #10 C9000101IFL1C3L0507-01				Hot Pipe Tunnel, -12 ft Core Location #15 C9000101IFL1C1L0515-01			
	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
H-3	1.11E+01	5.10E+00	1.11E+01	28.99%	2.70E+00	5.30E+00	5.30E+00	0.17%	1.60E+00	5.30E+00	5.30E+00	0.09%
Cs-137	6.10E-01	8.00E-02	6.10E-01	1.59%	3.15E+03	8.00E-01	3.15E+03	98.90%	4.43E+03	1.00E+00	4.43E+03	76.87%
Co-60	2.32E-01	2.10E-01	2.32E-01	0.61%	-3.30E-02	1.10E-01	1.10E-01	0.00%	2.69E+01	3.00E-01	2.69E+01	0.47%
Fe-55	3.10E+00	1.30E+01	1.30E+01	33.96%	3.30E+00	1.40E+01	1.40E+01	0.44%	1.90E+01	1.70E+01	1.90E+01	0.33%
Ni-63	-4.10E+00	1.10E+01	1.10E+01	28.73%	-1.00E+00	1.00E+01	1.00E+01	0.31%	1.61E+02	2.00E+01	1.61E+02	2.79%
Sr-90	-3.00E-01	4.50E-01	4.50E-01	1.18%	1.20E+00	4.80E-02	1.20E+00	0.04%	1.01E+03	1.00E+00	1.01E+03	17.52%
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00%	1.90E-02	4.80E-02	4.80E-02	0.00%	6.59E+00	5.00E-02	6.59E+00	0.11%
Pu-239/240	0.00E+00	6.00E-02	6.00E-02	0.16%	1.10E-02	3.00E-02	3.00E-02	0.00%	7.58E+00	3.00E-02	7.58E+00	0.13%
Pu-241	-2.00E-02	3.00E-02	3.00E-02	0.08%	-5.00E-01	2.90E+00	2.90E+00	0.09%	7.47E+01	2.70E+00	7.47E+01	1.30%
Am-241	0.00E+00	2.00E-01	2.00E-01	0.52%	6.00E-03	1.00E-01	1.00E-01	0.00%	1.30E+01	3.00E-01	1.30E+01	0.23%
Cm-245/246	1.55E-01	9.40E-02	1.55E-01	0.40%	4.40E-02	8.70E-02	8.70E-02	0.00%	6.95E+00	1.60E-01	6.95E+00	0.12%
U-234	7.00E-01	4.00E-02	7.00E-01	1.83%	5.50E-01	8.00E-02	5.50E-01	0.02%	1.28E+00	7.00E-02	1.28E+00	0.02%
U-235	1.70E-02	4.70E-02	4.70E-02	0.12%	5.30E-02	4.80E-02	5.30E-02	0.00%	9.00E-02	9.10E-02	9.10E-02	0.00%
U-238	7.00E-01	4.00E-02	7.00E-01	1.83%	5.00E-01	4.00E-02	5.00E-01	0.02%	9.10E-01	7.00E-02	9.10E-01	0.02%
			3.83E+01	100%			3.18E+03	100%			5.76E+03	100%

	Hot Pipe Tunnel, -12 ft Core Location #16 C9000101IFL1C1L0516-01				Fan House -12 ft Core Location #17 C9000101IFL1C1L0517-01			
	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
H-3	2.10E+00	5.20E+00	5.20E+00	0.44%	6.20E+00	5.30E+00	6.20E+00	15.99%
Cs-137	2.60E+02	4.00E-01	2.60E+02	22.04%	4.10E-01	9.00E-02	4.10E-01	1.06%
Co-60	8.97E+00	2.40E-01	8.97E+00	0.76%	-2.70E-02	1.10E-01	1.10E-01	0.28%
Fe-55	8.20E+00	1.40E+01	1.40E+01	1.19%	-2.40E+00	1.40E+01	1.40E+01	36.11%
Ni-63	5.00E+01	2.50E+01	5.00E+01	4.24%	-3.00E+00	1.20E+01	1.20E+01	30.95%
Sr-90	8.36E+02	2.00E+00	8.36E+02	70.87%	0.00E+00	5.00E-01	5.00E-01	1.29%
Pu-238	1.70E-02	5.60E-01	5.60E-01	0.05%	6.00E-03	5.90E-02	5.90E-02	0.15%
Pu-239/240	7.30E-02	5.80E-02	7.30E-02	0.01%	1.10E-02	3.10E-02	3.10E-02	0.08%
Pu-241	1.90E+00	2.70E+00	2.70E+00	0.23%	9.00E-01	3.00E+00	3.00E+00	7.74%
Am-241	4.60E-02	6.70E-02	6.70E-02	0.01%	9.00E-03	5.30E-02	5.30E-02	0.14%
Cm-245/246	0.00E+00	1.00E-01	1.00E-01	0.01%	1.20E-01	1.40E-01	1.40E-01	0.36%
U-234	9.10E-01	6.00E-02	9.10E-01	0.08%	1.14E+00	4.00E-02	1.14E+00	2.94%
U-235	6.50E-02	9.30E-02	9.30E-02	0.01%	5.80E-02	1.10E-01	1.10E-01	0.28%
U-238	9.10E-01	6.00E-02	9.10E-01	0.08%	1.02E+00	4.00E-02	1.02E+00	2.63%
			1.18E+03	100%			3.88E+01	100%

BALANCE OF PLANT CORE RESULTS

	MEAN (pCi/gm)	MEAN (%)	STD DEV
H-3	6.24E+00	8.46%	10.57%
Cs-137	9.95E+02	34.79%	41.45%
Co-60	6.26E+00	1.23%	1.83%
Fe-55	2.08E+01	18.93%	17.89%
Ni-63	4.67E+01	19.71%	18.76%
Sr-90	2.31E+02	11.74%	24.60%
Pu-238	9.33E-01	0.07%	0.06%
Pu-239/240	9.88E-01	0.06%	0.06%
Pu-241	1.14E+01	2.49%	3.19%
Am-241	1.93E+00	0.29%	0.35%
Cm-245/246	1.00E+00	0.19%	0.17%
U-234	8.36E-01	0.98%	1.15%
U-235	7.69E-02	0.09%	0.11%
U-238	7.90E-01	0.97%	1.10%
		100.00%	

Results of Isotopic Analysis of Concrete Core Samples

	Hot Laboratory 0 ft Core Location #11 C9000101IFL1C1L0511-01 Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Hot Laboratory 0 ft Core Location #12 C9000101IFL1C1L0512-01 Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %	Hot Laboratory 0 ft Core Location #13 C9000101IFL1C3L0513-01 Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
H-3	-9.00E-02	5.20E+00	5.20E+00	0.50%	6.00E-01	5.20E+00	5.20E+00	1.82%	7.20E+00	5.40E+00	7.20E+00	0.37%
C-14	-5.30E-01	8.80E-01	8.80E-01	0.09%	2.16E+01	1.30E+00	2.16E+01	7.57%	4.10E-01	1.20E+00	1.20E+00	0.06%
Cs-137	9.45E+02	5.00E-01	9.45E+02	91.64%	1.13E+02	3.00E-01	1.13E+02	39.60%	1.71E+03	6.00E-01	1.71E+03	88.43%
Co-60	1.82E+00	1.70E-01	1.82E+00	0.18%	5.79E+00	1.30E-01	5.79E+00	2.03%	2.70E-01	1.70E-01	2.70E-01	0.01%
Ni-63	2.50E+01	5.20E+01	5.20E+01	5.04%	1.42E+01	1.20E+01	1.42E+01	4.98%	-3.00E+00	1.10E+01	1.10E+01	0.57%
Sr-90	1.18E+01	5.00E-01	1.18E+01	1.14%	1.08E+02	5.00E-01	1.08E+02	37.84%	1.93E+02	6.00E-01	1.93E+02	9.98%
Pu-238	3.90E-01	5.00E-02	3.90E-01	0.04%	4.80E-01	3.00E-02	4.80E-01	0.17%	6.50E-01	9.00E-02	6.50E-01	0.03%
Pu-239/240	2.05E-01	2.90E-02	2.05E-01	0.02%	6.39E+00	6.00E-02	6.39E+00	2.24%	5.00E-01	4.00E-02	5.00E-01	0.03%
Pu-241	2.20E+00	2.90E+00	2.90E+00	0.28%	6.80E+00	3.10E+00	6.80E+00	2.38%	4.70E+00	3.70E+00	4.70E+00	0.24%
Am-241	9.90E+00	9.00E-01	9.90E+00	0.96%	1.40E+00	1.90E-01	1.40E+00	0.49%	2.90E+00	1.00E+00	2.90E+00	0.15%
Cm-245/246	1.90E-01	8.00E-02	1.90E-01	0.02%	6.00E-01	1.20E-01	6.00E-01	0.21%	3.80E-01	1.20E-01	3.80E-01	0.02%
U-234	3.60E-01	6.00E-02	3.60E-01	0.03%	1.04E+00	3.00E-02	1.04E+00	0.36%	9.60E-01	4.00E-02	9.60E-01	0.05%
U-235	9.00E-03	8.90E-02	8.90E-02	0.01%	2.80E-02	3.80E-02	3.80E-02	0.01%	5.10E-02	4.60E-02	5.10E-02	0.00%
U-238	4.40E-01	6.00E-02	4.40E-01	0.04%	8.50E-01	5.00E-02	8.50E-01	0.30%	8.20E-01	4.00E-02	8.20E-01	0.04%
			1.03E+03	100%			2.85E+02	100%			1.93E+03	100%

	Hot Laboratory 0 ft Core Location #14 C9000101IFL1C3L0514-01 Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
H-3	1.70E+00	5.20E+00	5.20E+00	0.62%
C-14	-6.00E-01	1.30E+00	1.30E+00	0.16%
Cs-137	7.75E+02	5.00E-01	7.75E+02	92.48%
Co-60	3.12E+00	1.20E-01	3.12E+00	0.37%
Ni-63	1.10E+00	1.50E+01	1.50E+01	1.79%
Sr-90	3.30E+01	4.00E-01	3.30E+01	3.94%
Pu-238	9.70E-02	4.90E-02	9.70E-02	0.01%
Pu-239/240	5.90E-01	3.00E-02	5.90E-01	0.07%
Pu-241	7.00E-01	2.80E+00	2.80E+00	0.33%
Am-241	3.20E-01	3.00E-02	3.20E-01	0.04%
Cm-245/246	1.07E-01	8.90E-02	1.07E-01	0.01%
U-234	8.10E-01	7.00E-02	8.10E-01	0.10%
U-235	5.90E-02	7.40E-02	7.40E-02	0.01%
U-238	6.40E-01	6.00E-02	6.40E-01	0.08%
			8.38E+02	100%

HOT LAB CORE RESULTS

	MEAN (pCi/gm)	MEAN (%)	STD DEV
H-3	5.70E+00	0.83%	0.67%
C-14	6.25E+00	1.97%	3.73%
Cs-137	8.86E+02	78.04%	25.69%
Co-60	2.75E+00	0.65%	0.93%
Ni-63	2.31E+01	3.09%	2.27%
Sr-90	8.65E+01	13.23%	16.82%
Pu-238	4.04E-01	0.06%	0.07%
Pu-239/240	1.92E+00	0.59%	1.10%
Pu-241	4.30E+00	0.81%	1.05%
Am-241	3.63E+00	0.41%	0.41%
Cm-245/246	3.19E-01	0.07%	0.10%
U-234	7.93E-01	0.14%	0.15%
U-235	6.30E-02	0.01%	0.00%
U-238	6.88E-01	0.11%	0.12%
		100.00%	

Attachment A,
Addendum 3
Results of Isotopic Analysis of Concrete Core Samples

ROLB Fuel Vault
Core Location #21
C9000101IFL1C1L0521-01

	Result pCi/gm	MDC pCi/gm	Used pCi/gm	Disribution %
Cs-137	1.30E-02	1.00E-01	1.00E-01	6.67%
Co-60	4.70E-02	1.30E-01	1.30E-01	8.67%
U-234	6.00E-01	6.00E-02	6.00E-01	40.00%
U-238	6.70E-01	3.00E-02	6.70E-01	44.67%
			1.50E+00	100%

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment A
Radionuclide Distribution Basis for DCGL Determination & Final Status Survey of the Plum Brook Reactor Facility (PBRF)

Addendum 4
Results of Isotopic Analysis of Surface Soil Samples

Attachment A,
Addendum 4
Results of Isotopic Analysis of Surface Soil Samples

Sample CS013004-004
Spill Area 2400303C1
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	1.822E-02	4.936E-02	4.94E-02	0.02%
AM243	1.347E-01	1.567E-01	1.57E-01	0.06%
C-14	1.377E+00	1.401E+00	1.40E+00	0.58%
CM-245	1.659E-01	1.590E-01	1.66E-01	0.07%
CO-60	9.387E-02	2.641E-01	2.641E-01	0.11%
CS-137	2.075E+02	4.241E-01	2.08E+02	85.26%
EU-155	1.052E-01	9.603E-01	9.603E-01	0.39%
H-3	7.497E+00	1.012E+01	1.012E+01	4.16%
I-129	8.993E-01	6.558E-01	8.99E-01	0.37%
NB-94	3.835E-02	1.926E-01	1.926E-01	0.08%
NI-63	5.589E-01	1.563E+00	1.563E+00	0.64%
PU-238	4.512E-02	1.092E-01	1.092E-01	0.04%
PU-239	1.811E-02	4.909E-02	4.909E-02	0.02%
SR-90	1.990E+01	5.885E-01	1.99E+01	8.17%
U-236	1.795E-02	4.866E-02	4.866E-02	0.02%
			2.43E+02	100.00%

Sample CS013004-005
Spill Area 2400303C1
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	1.648E-02	1.354E-01	1.35E-01	0.20%
AM243	9.944E-02	8.982E-02	9.94E-02	0.14%
C-14	1.435E+00	1.051E+00	1.44E+00	2.07%
CM-245	9.517E-02	1.556E-01	1.556E-01	0.22%
CO-60	2.277E-01	2.486E-01	2.486E-01	0.36%
CS-137	5.081E+01	2.355E-01	5.08E+01	73.42%
EU-155	6.000E-01	5.594E-01	6.00E-01	0.87%
H-3	1.043E+00	9.755E+00	9.755E+00	14.10%
I-129	3.374E-01	3.883E-01	3.883E-01	0.56%
NB-94	-3.178E-02	1.259E-01	1.259E-01	0.18%
NI-63	1.970E+00	1.836E+00	1.97E+00	2.85%
PU-238	1.932E-02	5.234E-02	5.234E-02	0.08%
PU-239	9.464E-03	1.165E-01	1.165E-01	0.17%
SR-90	3.200E+00	6.905E-01	3.20E+00	4.62%
U-236	1.482E-02	1.121E-01	1.121E-01	0.16%
			6.92E+01	100.00%

Sample CS013004-006
Spill Area 2400303C1
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	4.326E-02	3.908E-02	4.33E-02	0.02%
AM243	6.588E-02	8.926E-02	8.93E-02	0.04%
C-14	6.130E-01	1.378E+00	1.38E+00	0.67%
CM-245	7.752E-02	2.188E-01	2.188E-01	0.11%
CO-60	3.030E-02	2.529E-01	2.529E-01	0.12%
CS-137	1.744E+02	4.606E-01	1.74E+02	84.55%
EU-155	4.207E-01	9.052E-01	9.052E-01	0.44%
H-3	-1.411E-01	9.899E+00	9.899E+00	4.80%
I-129	1.256E+00	6.032E-01	1.26E+00	0.61%
NB-94	-1.763E-02	1.544E-01	1.544E-01	0.07%
NI-63	1.173E+00	1.641E+00	1.641E+00	0.80%
PU-238	8.891E-02	1.074E-01	1.074E-01	0.05%
PU-239	1.856E-01	6.289E-02	1.86E-01	0.09%
SR-90	1.566E+01	6.545E-01	1.57E+01	7.59%
U-236	2.698E-02	6.822E-02	6.822E-02	0.03%
			2.06E+02	100.00%

Sample CS013004-007
Spill Area 2400303C1
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	0.000E+00	6.228E-02	6.23E-02	0.24%
AM243	3.134E-02	7.924E-02	7.92E-02	0.31%
C-14	1.277E+00	1.379E+00	1.38E+00	5.34%
CM-245	2.589E-02	1.048E-01	1.05E-01	0.41%
CO-60	3.570E-02	1.939E-01	1.939E-01	0.75%
CS-137	9.349E+00	1.823E-01	9.35E+00	36.21%
EU-155	1.401E-01	3.895E-01	3.895E-01	1.51%
H-3	8.951E+00	1.029E+01	1.029E+01	39.87%
I-129	-9.881E-03	3.125E-01	3.125E-01	1.21%
NB-94	-8.472E-03	1.630E-01	1.630E-01	0.63%
NI-63	2.145E+00	1.499E+00	2.14E+00	8.31%
PU-238	-1.245E-02	1.471E-01	1.471E-01	0.57%
PU-239	2.025E-02	1.129E-01	1.129E-01	0.44%
SR-90	1.041E+00	6.891E-01	1.04E+00	4.03%
U-236	3.381E-02	4.581E-02	4.581E-02	0.18%
			2.58E+01	100.00%

Sample CS013004-008
Emergency Retention Basin
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	1.708E-02	1.403E-01	1.40E-01	0.20%
AM243	5.986E-03	1.224E-01	1.22E-01	0.17%
C-14	1.121E+00	1.445E+00	1.44E+00	2.02%
CM-245	-3.809E-04	1.406E-01	1.41E-01	0.20%
CO-60	7.355E-01	2.409E-01	7.36E-01	1.03%
CS-137	2.129E+01	2.536E-01	2.13E+01	29.76%
EU-155	1.728E-01	4.628E-01	4.628E-01	0.65%
H-3	4.298E+01	9.814E+00	4.30E+01	60.08%
I-129	1.526E-02	2.837E-01	2.837E-01	0.40%
NB-94	7.072E-02	2.582E-01	2.582E-01	0.36%
NI-63	2.700E+00	1.510E+00	2.70E+00	3.77%
PU-238	1.485E-02	1.220E-01	1.220E-01	0.17%
PU-239	2.250E-02	6.098E-02	6.098E-02	0.09%
SR-90	7.010E-01	6.790E-01	7.01E-01	0.98%
U-236	4.074E-02	9.868E-02	9.868E-02	0.14%
			7.15E+01	100.00%

Sample CS013004-009
Emergency Retention Basin
Surface Soils (1st 6")
(pCi/gm)

	Result	MDA	Used	%
AM-241	6.563E-02	9.722E-02	9.72E-02	0.19%
AM243	1.550E-01	5.999E-02	1.55E-01	0.30%
C-14	7.087E-01	1.331E+00	1.33E+00	2.59%
CM-245	1.759E-01	1.039E-01	1.76E-01	0.34%
CO-60	8.647E-01	2.417E-01	8.65E-01	1.68%
CS-137	3.240E+01	2.798E-01	3.24E+01	63.03%
EU-155	3.470E-01	5.541E-01	5.541E-01	1.08%
H-3	3.006E+00	1.054E+01	1.054E+01	20.51%
I-129	-1.874E-02	2.716E-01	2.716E-01	0.53%
NB-94	5.722E-02	2.256E-01	2.256E-01	0.44%
NI-63	3.210E+00	1.496E+00	3.21E+00	6.24%
PU-238	4.426E-02	1.445E-01	1.445E-01	0.28%
PU-239	-4.532E-03	1.233E-01	1.233E-01	0.24%
SR-90	1.161E+00	6.452E-01	1.16E+00	2.26%
U-236	1.475E-01	4.995E-02	1.48E-01	0.29%
			5.14E+01	100.00%

Attachment A,
Addendum 4

Results of Isotopic Analysis of Surface Soil Samples

	Sample CS013004-010 Emergency Retention Basin Surface Soils (1st 6") (pCi/gm)				Sample CS013004-011 Emergency Retention Basin Surface Soils (1st 6") (pCi/gm)			
	Result	MDA	Used	%	Result	MDA	Used	%
AM-241	6.704E-03	1.371E-01	1.37E-01	0.12%	1.765E-01	1.437E-01	1.77E-01	0.24%
AM243	5.310E-02	1.343E-01	1.34E-01	0.12%	1.039E-01	9.952E-02	1.04E-01	0.14%
C-14	1.210E+00	1.427E+00	1.43E+00	1.24%	1.734E+00	1.524E+00	1.73E+00	2.34%
CM-245	3.384E-02	2.060E-01	2.06E-01	0.18%	1.124E-01	1.527E-01	1.53E-01	0.21%
CO-60	5.665E+00	2.814E-01	5.67E+00	4.91%	3.335E+00	2.693E-01	3.34E+00	4.50%
CS-137	5.424E+01	3.064E-01	5.42E+01	47.00%	3.616E+01	2.683E-01	3.62E+01	48.74%
EU-155	8.057E-02	5.829E-01	5.829E-01	0.51%	4.595E-02	4.476E-01	4.476E-01	0.60%
H-3	2.845E+01	1.008E+01	2.85E+01	24.66%	3.441E+00	9.854E+00	9.854E+00	13.28%
I-129	6.859E-02	2.777E-01	2.777E-01	0.24%	8.316E-02	2.687E-01	2.687E-01	0.36%
NB-94	1.336E-01	3.152E-01	3.152E-01	0.27%	2.923E-01	2.079E-01	2.92E-01	0.39%
NI-63	1.648E+01	1.396E+00	1.65E+01	14.28%	1.397E+01	1.395E+00	1.40E+01	18.83%
PU-238	9.437E-02	1.140E-01	1.140E-01	0.10%	7.927E-02	7.159E-02	7.93E-02	0.11%
PU-239	9.854E-02	6.676E-02	9.85E-02	0.09%	1.321E-01	7.159E-02	1.32E-01	0.18%
SR-90	7.192E+00	6.492E-01	7.19E+00	6.23%	7.437E+00	6.639E-01	7.44E+00	10.03%
U-236	4.707E-02	7.696E-02	7.696E-02	0.07%	4.962E-02	4.482E-02	4.96E-02	0.07%
			1.15E+02	100.00%			7.42E+01	100.00%

	MEAN	STANDARD DEVIATION
AM-241	0.15%	0.09%
AM243	0.16%	0.10%
C-14	2.11%	1.51%
CM-245	0.22%	0.11%
CO-60	1.68%	1.94%
CS-137	58.50%	21.34%
EU-155	0.76%	0.38%
H-3	22.68%	19.00%
I-129	0.53%	0.30%
NB-94	0.30%	0.19%
NI-63	6.96%	6.56%
PU-238	0.17%	0.18%
PU-239	0.16%	0.13%
SR-90	5.49%	3.08%
U-236	0.12%	0.09%

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment B

Approach and Basis for Development of Site-Specific Derived Concentration Guideline Levels (DCGL)

1.0 Purpose

Document the approach, methodology and bases for the establishment of site-specific Derived Concentration Guideline Levels (DCGL) and to document the actual DCGL(s) and area factors to be used during the performance of Final Status Survey of the Plum Brook Reactor Facility (PBRF).

2.0 References

2.1 Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation"

2.2 Draft Regulatory Guide DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination" (NRC 1998a)

2.3 NUREG-1549, "Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination" (NRC 1998b)

2.4 PBRF Decommissioning Plan

2.5 NUREG-1757 Vol. 2, "Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria" (NRC 2003)

2.6 NUREG-5512, Vol. 3, "Parameter Analysis" (NRC 1999)

2.7 NUREG/CR-6697, "Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes" (NRC 2000)

2.8 Federal Guidance Report No. 11 (FGR 11), "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion"

2.9 Federal Guidance Report No. 12 (FGR 12), "External Exposure to Radionuclides in Air, Water and Soil"

2.10 NUREG/CR-6377 (PNL-11408), Krupka, K.M., and R.J. Serne. 1998. "Effects on Radionuclide Conecentrations by Cement/Groundwater Interactions in Support of Performance Assessment of Low-Level Radioactive Waste Disposal Facilities"

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2.18 National Climactic Data Center, NCDC, http://www.ncdc.noaa.gov/oa/ncdc.html.

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2.21 US Department of Energy, 2001. User's Manual for RESRAD Version 6. Office of Scientific and Technical Information, Oak Ridge, TN.

3.0 DCGL Approach

Consistent with 10 CFR Part 20, decommissioning means reducing residual radioactivity to a level that permits termination of the license and release of the site for unrestricted use. The PBRF license would be terminated after NASA demonstrates that the site meets the criteria for decommissioning specified in 10 CFR Part 20, Subpart E, "Radiological Criteria for License Termination." The two radiological criteria for unrestricted use specified in 10 CFR 20.1402 are: (1) the TEDE from residual radioactivity that is distinguishable from background radiation must not be greater than 25 mrem/yr to the Average Member of the Critical Group (AMCG) and (2) residual radioactivity levels must be ALARA.

According to NUREG-1549, "Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination" (NRC 1998b), a licensee can demonstrate compliance with the dose criterion either by using a generic screening model or by using site-specific analyses. As recommended by Draft Regulatory Guide DG-4006, "Demonstrating Compliance with the Radiological Criteria for License Termination" (NRC 1998a), this attachment presents the methodology and approach used for the development of site-specific DCGLs. This document also presents the estimated DCGLs for surface soils, building surfaces, and subsurface structures at the PBRF. The DCGLs will be used during the final radiation survey to demonstrate compliance with the two unrestricted use criteria previously specified.

The Decommissioning Plan for the PBRF presents the proposed methodology for demonstrating that residual contamination levels are ALARA. The methodology follows the guidance in DG-4006 and involves comparing the costs and benefits of postulated decommissioning actions. The Decommissioning Plan also presents options for using DCGLs for specific portions of the PBRF and the timing of the final status survey, including the identification of the criteria that will be used for selecting DCGLs for specific portions of the PBRF.

4.0 DCGL Methodology

This section presents the methodology used in the calculation of DCGLs (the level of residual contamination that would produce a TEDE of 25 mrem/yr to the AMCG). DCGLs were estimated using existing characterization data. DCGL estimates are based on the analysis of scenarios that could reasonably be expected to occur if a site is released for unrestricted use. A scenario is defined as a set of release modes, receptor metabolic and behavioral characteristics, environmental transport pathways, and exposure modes that result in dose to an individual or population. The dose analysis performed assumes the PBRF site is released for unrestricted use and evaluates the case of members of the public using the site. In actuality, NASA has no plans to sell this property after license termination, so realistic receptors would be members of the public located offsite and NASA employees working onsite after license termination. Thus, unrestricted use of the PBRF site is conservative and bounds the realistically expected scenario.

NRC has published guidance on methods for dose analysis supporting license termination under 10 CFR Part 20 (NUREG/CR-5512 [Kennedy and Strenge 1992], DG-4006, NUREG-1549, and NUREG-1757 Vol. 2, "Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria" [NRC 2003]). The guidance allows using either generic screening or site-specific dose assessment in the decision framework. Under the generic screening approach, NRC has identified pathways, scenarios, models, and model parameter values, and has provided analysis results in the form of levels of contamination consistent with the 10 CFR Part 20, Subpart E, dose criteria. The pathways and scenarios constitute the residential farmer and building reuse scenarios. The NRC generic screening analysis of the residential farmer scenario is based on the assumption that all contamination has been distributed into the upper 15 cm (6 in.) of soil. Among the options presented for site-specific analysis is the use of site-specific parameter values and existing models other than the generic NRC model. The guidance recommends that the licensee provide information supporting use of site-specific data or models other than the generic NRC model. Because the generic screening model addresses subsurface contamination through assumed redistribution to surface soil, it is very conservative for the case of residual contamination of subsurface structures. To provide a consistent level of analysis for the contamination of surface soil, building surface, and subsurface structures, a site-specific analysis approach was used for the PBRF.

The dose model selected for analyzing residual soil contamination, RESRAD Version 6.0 (Yu et al. 2000), has been formally accepted by the NRC for analysis of residential farmer scenarios. The dose model selected for analyzing residual building surface contamination, RESRAD-BUILD Version 3.22 (Yu et al. 2000), addresses pathways discussed in NRC guidance and is widely used by the U.S. Department of Energy (DOE) and the U.S. Department of Defense when analyzing building reuse scenarios. These two site-specific models include all pathways and exposure modes included in the NRC generic screening models. No conditions outside those incorporated in the site-specific models are expected to occur at the PBRF. The residential farmer scenario presumes that both the residence and garden are located on contaminated soil. Thus, the site-specific modeling is appropriate for assessing doses because of contamination of soil and building surfaces.

The RESRAD Version 6.21 (Yu et al. 2002) model was used to analyze residual subsurface structure contamination to allow a sensitivity analysis to be conducted for the concrete K_d values. In this case, concrete K_d is the most sensitive parameter. No conditions outside those incorporated in the site-specific model are expected to occur at the PBRF, and no pathways have been eliminated. Thus, the site-specific model is appropriate for assessing dose because of residual contamination associated with subsurface structures.

Using existing characterization information, site-specific pathway scenarios were used to calculate DCGLs and to develop estimates of dose over time for the AMCG at the PBRF. The site-specific DCGLs were developed by considering PBRF soils and hydrology.

5.0 DCGL Bases

5.1 Residual Contamination in Surface Soils

NRC regulatory guidance (DG-4006) recommends analysis of a residential farmer scenario as the basis for the DCGLs for residual contamination in site-wide surface soil. In the residential farmer scenario, an individual could contact residual contamination by establishing a home and garden on contaminated soil or by using groundwater that comes in contact with the residual contamination. The primary release modes are partitioning of contaminants from soil into infiltrating water and resuspension by wind. The environmental transport pathways include ground water transport; translocation into plants, animals, and fish; and atmospheric dispersion. Exposure modes include ingestion of water, crops, animal products, and fish; direct external exposure from the ground; inhalation of airborne material; and inadvertent ingestion of soil.

NUREG-1549 identifies DCGLs (i.e., soil concentrations that would result in a TEDE of 25 mrem/yr to the AMCG) for a generic, screening-level exposure scenario. More realistic site-specific DCGLs for the PBRF were developed using RESRAD Version 6.21, a computer code developed by DOE and commonly used to estimate residual contamination in soils. The site-specific DCGLs were calculated based on many variables that characterize the receptors, environmental pathways, and modes of exposure. The estimates of physical, behavioral, and metabolic parameter values were developed from either site measurements or literature review.

In support of the PBRF project and resident farmer DCGL development, available hydrogeologic information was consolidated in a report by the US Army Corps of Engineers entitled "Hydrogeological Report Plum Brook Reactor Facility Sandusky, Ohio". This report summarized available information about the geologic and hydrogeologic conditions that exist both regionally and within the PBRF. The following excerpts from the hydrogeologic report were used to develop site-specific RESRAD inputs as shown in Tables B-1 through B-4. Note that surface soil dose is insensitive to the hydrogeological parameters but site specific values are provided for completeness.

Bedrock that subcrops at the PBRF consists of Devonian Delaware Limestone and the overlying Devonian Plum Brook Shale Member of the Olentangy Shale. The majority of the site is underlain by Olentangy Shale, with the subcrop of Delaware Limestone limited to the northern and southeastern portion of the PBRF. Underlying the Delaware Limestone is a thick section of predominantly carbonate bedrock consisting of the Columbus Limestone and the Detroit River Formation.

The bedrock surface at the PBS generally slopes toward the north, although the PBS is located in an area where an apparent bowl-shaped feature is present. In-filling of the bedrock depression has resulted in a similar thickening of unconsolidated deposits at the PBRF.

Unconsolidated deposits consist mostly of glacial till that occurs as a thin veneer over the bedrock surface. The thickness of these materials at the PBRF is typically about 25 ft. Native surficial deposits at the PBRF have been extensively disturbed. Boring logs for the PBRF test borings and monitoring wells show that the unconsolidated deposits consist predominantly of cohesive soil, with some relatively thin, discontinuous granular units interbedded. The pro-glacial lacustrine depositional environment in which these deposits formed tends to homogenize the deposits through wave reworking. While localized lenses of granular materials do exist, it does not appear that these lenses are continuous across the site, and these units should not be considered to be indicative of the typical site stratigraphy.
The United States Department of Agriculture, Natural Resources Conservation Service (2002) has recently revised the Soil Survey of Erie County, Ohio. The soil within the 27-acre PBRF is mapped as Udorthents, disturbed soil that has been affected by construction activities. Review of the soils surrounding the PBRF provides insight regarding what was likely present prior to disturbance. The soils in the immediate vicinity of the PBRF consist of Colwood Loam, 0-1 percent slopes (CmA); Elnora loamy fine sand, 0-4 percent slopes (EnA); Gilford fine sandy loam, 0-1 percent slopes (GdA); Oakville loamy fine sand, 0-6 percent slopes (Oab), and Udorthents, loamy, 0-6 percent slopes (UdB). These undisturbed soils are composed of loam, loamy fine sand, fine sandy loam, and loamy fine sand, respectively.

The surficial soil at the PBRF has been extensively disturbed. In addition, the entire site was reportedly regraded to promote surface water to flow to the southeast corner of the PBRF. These excavation and grading activities have resulted in the entire PBRF being mapped by Natural Resources Conservation Service as Udorthents.
Photographs during construction show stockpiled soil that was

presumably used to backfill around the structures and to support the regrading activity. Therefore, it is likely that the surficial materials at the PBRF are a mixture of variable thickness composed of the entire section of unconsolidated deposits, which at depth predominantly consists of cohesive soils.

Hydraulic conductivity for the mixed unconsolidated deposits ranges from 49 to 270 meters/year (m/yr), gradient ranges from 0.005 to 0.006 ft/ft, and the porosity is expected to range from about 0.35 to 0.70 (Freeze and Cherry, 1979). The hydraulic conductivity of the Delaware Limestone ranges from 3 to 188 m/yr, and the gradient ranges from 0.002 to 0.003 ft/ft. The site-specific effective porosity of the Delaware Limestone has not been established. Therefore, a published value for limestone must be used to calculate groundwater flow velocity: 0.01 to 0.3 (Fetter, 1988).

All the other parameters used in the dose analysis were generic screening values or a most conservative value was chosen. These parameters were estimated based on NRC and DOE guidance for generic screening (i.e., the NUREG-1549 analysis and the RESRAD computer code) and are considered to be prudently conservative. Using a water table drop rate of 0 m/yr is also prudently conservative because it minimizes travel time through the unsaturated zone for the observed thickness of the zone. Using observed values for other site-specific parameters is reasonable because it is consistent with existing conditions and does not introduce a judgment bias that may be conservative or non-conservative depending on the intricacies of pathway analysis for individual radionuclides. Wherever possible, NRC-recommended parameter values were used unless site-specific data were available. In the absence of either site-specific and NRC-recommended values, RESRAD default values were used. The parameter values used in the analysis of the PBRF residential farmer scenario are presented in Tables B-1 through B-8. The generic values used for the most dose-sensitive parameter (i.e., the distribution coefficient), are relatively high. This results in retaining radionuclides in soil rather than removing them by groundwater, which produces conservative dose estimates through the external exposure pathway for the radionuclides controlling dose at the PBRF. The radiation dose limit and time for calculations are 25 mrem/yr and 1000 years, respectively, as specified in 10 CFR 20.1401 and 20.1402.

Table B-1. Residential Farmer Scenario: Contaminated Zone Parameters

Parameter	Parameter Value	Source
Area of contaminated zone	109100 m^2 for controlled area including: • 102400 m^2 for PBRF • 6700 m^2 for Pentolite Ditch	Teledyne Isotopes, 1987.
Thickness of contaminated zone	1 m	Conservative thickness to maximize dose
Length parallel to aquifer flow	365 m	Teledyne Isotopes, 1987.
Radiation dose limit	25 mrem/yr	10 CFR 20.1402
Time since placement of material	0 years	Distribution coefficients available
Time for calculations	Through 1000 years	10 CFR 20.1402

Table B-2. Resident Farmer Scenario: Cover and Contaminated Zone Hydrologic Data

Parameter	Parameter Value	Source
Density of contaminated zone	1.522 g/cm^3	Hydrogeologic Report PBRF, 2004. *Average value used unconsolidated deposits.*
Contaminated zone erosion rate	0.001 m/yr	RESRAD
Contaminated zone total porosity	0.45	Groundwater Hydrology and Hydraulics, 1977.
Contaminated zone field capacity	0.20	RESRAD
Contaminated zone hydraulic conductivity	270 m/yr	Hydrogeologic Report PBRF, 2004. *Most conservative value unconsolidated deposits.*
Contaminated zone b parameter	7.12	"Empirical Equations for Some Soil Hydraulic Properties", 1978. *Sandy clay loam*
Evapotranspiration coefficient	0.5	RESRAD
Precipitation	0.86 m/yr	National Climactic Data Center - Ohio
Irrigation	1.04 m/yr	NUREG 1549
Irrigation mode	Overhead	RESRAD
Runoff coefficient	0.3	Handbook on the Principles of Hydrology, 1970.
Watershed area for stream or pond	1×10^6 m^2	RESRAD

Table B-3. Residential Farmer Scenario: Saturated Zone Hydrologic Data

Parameter	Parameter Value	Source
Density of saturated zone	1.522 g/cm^3	Hydrogeologic Report PBRF, 2004. *Average value used unconsolidated deposits.*
Saturated zone total porosity	0.45	Groundwater Hydrology and Hydraulics, 1977.
Saturated zone effective porosity	0.20	Groundwater Hydrology and Hydraulics, 1977.
Saturated zone hydraulic conductivity	270 m/yr	Hydrogeologic Report PBRF, 2004. *Most conservative value unconsolidated deposits.*
Saturated zone hydraulic gradient	0.005 m/m	Hydrogeologic Report PBRF, 2004.
Saturated zone b parameter	NA	
Water table drop rate	0.0 m/yr	Most conservative – minimizes transport time
Well pump intake depth	8 (m below water table)	Hydrogeologic Report PBRF, 2004
Mixing model	Nondispersion	RESRAD
Individual use of groundwater	118 m^3/yr	NUREG 1549

Table B-4. Residential Farmer Scenario: Uncontaminated and Unsaturated Zone Hydrologic Data

Parameter	Parameter Value	Source
Number of unsaturated zone strata	1	Hydrogeologic Report PBRF, 2004.
Unsaturated zone thickness	3.0 m	Hydrogeologic Report PBRF, 2004.
Unsaturated zone soil density	1.522 g/cm^3	Hydrogeologic Report PBRF, 2004. *Average value used unconsolidated deposits.*
Unsaturated zone total porosity	0.45	Groundwater Hydrology and Hydraulics, 1977.
Unsaturated zone effective porosity	0.20	Groundwater Hydrology and Hydraulics, 1977.
Unsaturated zone b parameter	7.12	"Empirical Equations for Some Soil Hydraulic Properties", 1978. *Sandy clay loam*
Unsaturated zone hydraulic conductivity	270 m/yr	Hydrogeologic Report PBRF, 2004. *Most conservative value unconsolidated deposits.*

Table B-5. Residential Farmer Scenario: Distribution Coefficients

Element	Parameter Value* (mL/g)
C	21
Fe	891
Co	1,000
Ni	37
Sr	32
Tc	7
Cs	447
Eu	955

* Source: NUREG-1549.

Table B-6. Residential Farmer Scenario: Dust Inhalation and External Gamma Parameters

Parameter	Parameter Value	Source
Inhalation rate	8400 m^3/yr	NUREG-1549[a]
Mass loading for inhalation	6×10^{-6} g/m^3	NUREG-1549[b]
Dilution length for airborne dust	3 m	RESRAD[c]
Exposure duration	365.25 days	NUREG-1549
Shielding factor, inhalation	0.40	RESRAD
Shielding factor, external gamma	0.47	NUREG-1549[d]
Fraction of time indoors, onsite	0.66	NUREG-1549
Fraction of time outdoors, onsite	0.11	NUREG-1549
Shape factor, external gamma	1	RESRAD
Fraction of annular areas	0	RESRAD

a. NUREG-1549.

b. Activity and time average of NUREG-1549 values.

c. RESRAD.

d. Sum of the product of the means for the fraction of time and shielding factor for outdoor and indoor exposure.

Table B-7. Residential Farmer Scenario: Ingestion Pathway, Data Dietary Parameters

Parameter	Parameter Value	Source
Fruit, vegetable, and grain consumption rate	78 kg/yr	NUREG-1549[a,b]
Leafy vegetable consumption rate	15 kg/yr	NUREG-1549
Milk consumption	118 L/yr	NUREG-1549
Meat and poultry consumption	52 kg/yr	NUREG-1549[c]
Fish consumption	16 kg/yr	NUREG-1549
Soil ingestion rate	18.3 g/yr	NUREG-1549
Drinking water intake	478 L/yr	NUREG-1549
Fraction of drinking water from site	1	RESRAD[d]
Fraction of aquatic load from site	0.5	RESRAD

a. Sum of individual means for other vegetables, fruit, and grain.

b. NUREG-1549.

c. Sum of individual means for meat and poultry.

d. RESRAD.

Table B-8. Residential Farmer Scenario: Ingestion Pathway Data, Nondietary Parameters

Parameter	Parameter Value	Source
Livestock fodder intake for meat	8.5 kg/day	NUREG-1549[a]
Livestock fodder intake for milk	17 kg/day	NUREG-1549[b]
Livestock water intake for meat	50 L/day	RESRAD[c]
Livestock water intake for milk	160 L/day	RESRAD
Livestock soil intake	0.5 kg/day	RESRAD
Mass loading for foliar deposition	4×10^{-4} g/m^3	NUREG-1549[d]
Depth of soil mixing layer	0.15 m	NUREG-1549
Depth of roots	0.9 m	RESRAD
Drinking water fraction from groundwater	1	RESRAD
Livestock water fraction from groundwater	1	NUREG-1549
Irrigation fraction from groundwater	1	RESRAD

a. NUREG-1549.

b. Sum of individual medians for forage, hay, and grain.

c. RESRAD.

d. Value for gardening.

The parameters identified in Tables B-1 through B-8 were used in the RESRAD code to determine the corresponding radionuclides concentrations in soil (i.e., DCGLs). Table B-9 presents the DCGLs for the radionuclides that may present at PBRF.

Table B-9. DCGLs for Surface Soils

Radionuclide	Site-Specific DCGL[a] (pCi/g)
Co-60	3.8
Cs-137	14.7
Eu-152	8.8
Eu-154	8.2
Fe-55	7.1 E+04
Ni-59	1.4 E+04
Ni-63	5.4 E+03
Sr-90	5.4

a. Calculated by RESRAD using the parameters specified in Tables B-1 through B-8.

5.2 Residual Contamination in Buildings

The PBRF buildings that were largely uncontaminated by past operations may be demolished during decommissioning and may be used as clean, hard fill to backfill the subsurface structures. The PBRF buildings having residual contamination may be decontaminated, surveyed, and demolished. If used as a source of fill material, the FSS survey will determine that the buildings meet the criteria for unrestricted release. After a survey of the subsurface structures demonstrates that these areas are suitable for free release, the demolition debris will be placed in the below grade cavities of the buildings. The building reuse scenario was used to develop DCGLs supporting release of PBRF buildings, such as the Reactor Office and Laboratory Building (Building 1141), which is known to have low levels of residual contamination.

In the building reuse scenario, residual contamination is assumed to be located on building surfaces (i.e., walls, floors, and ceilings). Exposure modes include direct external exposure, inhalation, and ingestion.

To analyze residual contamination in PBRF buildings, a site-specific analysis was conducted using RESRAD-BUILD 3.22. The RESRAD-BUILD parameters were selected in accordance with the methods recommended in NUREG-1757 Vol. 2. The parameters were categorized as behavioral, metabolic, or physical. The

behavioral and metabolic parameters selected were the default values from NUREG-5512, Vol. 3 or the NRC screening code DandD 2.1.0. Because of differences between the RESRAD-BUILD and NUREG-5512 dose assessment models, some parameters required by the RESRAD-BUILD code are not provided in NUREG-5512 Vol. 3. The RESRAD-BUILD specific parameters were derived from NUREG/CR-6697. The average or most likely value was selected to represent the average member of the critical group.

Physical parameters that were not site specific, such as the assumed room dimensions, or selected to be consistent with NUREG/CR-5512 model assumptions (such as evaluating one room for the building occupancy scenario) were selected to be conservative. Physical parameters that did not have a clearly conservative value were evaluated using the probabilistic module of RESRAD-BUILD to determine whether the dose was sensitive to the parameter. The only parameter requiring a sensitivity analysis was the "Lifetime or Time of Source Removal" (Source Lifetime). This represents the time over which surface contamination is removed.

The default parameter distribution function (PDF) from NUREG/CR-6697, Attachment C, Section 8.8, was used for the sensitivity analysis of the Source Lifetime parameter. The PDF was a triangular distribution defined by a 1000 day minimum, 100,000 day maximum, and 10,000 day most likely value. The RESRAD-BUILD output for the Partial Rank Correlation Coefficient (PRCC) was used to evaluate the sensitivity of dose to the parameter. The PRCC is one of the recommended methods in NUREG-1757 Section I.7.5. In addition, precedence has been set for the use of PRCC in other previously submitted and approved decommissioning plans. If the PRCC exceeded the absolute value of 0.10, then the dose was considered sensitive to the parameter and either the 25^{th} or 75^{th} quantile of the PDF was selected as the deterministic parameter. The 25^{th} quantile was used if the dose was negatively correlated, i.e., dose increased as the parameter decreased. The 75^{th} quantile was used if the dose was positively correlated, i.e., dose increased as the parameter increased. A negative correlation was indicated by a negative PRCC result and a positive correlation by a positive PRCC. The 25^{th} quantile for source lifetime was 18,200 days and the 75^{th} quantile was 52,700 days. All of the nuclides were sensitive to the Source Lifetime parameter. Table B-10 lists the nuclides according to whether the dose was positively or negatively correlated. In general, a nuclide was positively correlated if the primary dose pathway was direct radiation and negatively correlated if the direct radiation dose was not significant.

Table B-10. Results of Sensitivity Analysis for Source Lifetime Parameter

Positive PRCC 75th Quantile	Negative PRCC 25th Quantile
C-14	Fe-55
Co-60	Ni-59
Cs-137	Ni-63
Eu-152	Sr-90
Eu-154	Tc-99
I-129	H-3
Nb-94	Pu-241
	Pu-238
	Cm-243
	Am-241
	Eu-155
	Pu-239
	U-234
	U-235
	U-236
	U-238

Table B-11 lists all of the parameters used in the site-specific RESRAD-BUILD analysis and provides the reference and justification as appropriate. The room dimensions of 15 m [49 ft] long, 5 m [16 ft] wide, and 3 m [10 ft] high represent the largest room expected to have residual contamination and is considered prudently conservative since it maximizes direct radiation from the floor and the largest wall because of the relative narrowness of the room. The bases provided in Table B-11 for the parameter selections are self-explanatory with one exception, i.e., Direct Ingestion.

The Direct Ingestion parameter of 4.07E-07 hr^{-1} was selected to ensure consistency with the NRC recommended Effective Transfer Rate for Ingestion provided in NUREG/CR-5512 Vol. 3, Section 5.2.3. The recommended Effective Transfer Rate is 1.1E-04 m^2/h and applies to loose source surface contamination. RESRAD-BUILD does not have a direct analogy to the Effective Transfer Rate from the source. However, the Direct Ingestion parameter can be modified to result in the same ingestion intake as would occur using the NUREG/CR-5512 model and the Effective Transfer rate. This is accomplished by dividing the 1.1E-04 m^2/h value by the total source area for the room, i.e., 270 m^2. RESRAD-BUILD calculates the ingestion intake for each of the six sources (4 walls, floor, and ceiling) by calculating the total inventory (activity/area multiplied by the area) of each source and then multiplying by the Direct Ingestion parameter. The 4.07E-07 hr^{-1}

parameter will result in an ingestion rate equal to 1.1E-04 m^2/hr when the results of all six sources are summed.

The RESRAD-BUILD dose assessment results are contained in three reports that are available for review as needed. The first contains the nuclides requiring a Source Lifetime parameter of 52,700 days, the second those requiring a Source Lifetime of 18,200 days, and a third containing the results for H-3. The DCGLs were calculated by dividing the 25 mrem/yr criteria by the nuclide specific unitized dose factors. The term unitized dose factor was used because the source term was 1 dpm/100 cm^2 for each radionuclide.

Table B-12 provides the DCGLs for the Building Reuse scenario.

Table B-11. Building Reuse Scenario: Parameter Values

No	Parameter (unit)	Type[a]	Value/Distribution	Source	Comments/Justification
1	Exposure duration (days)	B	365.25	NUREG/CR-5512, V3 S5.2.1	Accounts for leap year
2	Indoor fraction	B	0.267	NUREG/CR-5512, V3 S5.2.2	Equal to 97.5 day/year, or 45 hour/week; average value
3	Evaluation time (year)	P	0		
4	Number of rooms	P	1	NUREG/CR-5512, V1	Building occupancy scenario assumes only one contaminated room
5	Deposition velocity (m/sec)	P	2.7E-06	NUREG/CR-6697, C, 7.5	Minimum value selected to maximize airborne concentration
6	Resuspension Rate (sec^{-1})	P	1.4E-05	NUREG/CR-6697, C, 7.2	Maximum value selected to maximize airborne concentration
7	Air exchange rate for building and room (hr^{-1})	B	0.8	NUREG/CR-6697, C, 7.4	Most likely value
8	Room area (m^2)	P	75	Site-specific model	Largest unit expected at PBRF
9	Room height (m)	P	3	Site-specific model	Largest unit expected at PBRF
10	Time fraction	B	1.0	NUREG/CR-5512, V1	Building occupancy scenario assumes all time is spent at one receptor location
11	Breathing rate (m^3/day)	B	33.6	NUREG/CR-5512, V3 S5.3	Equal to 1.4 m^3/hr which is median value and DandD V2.1 default
12	Indirect ingestion rate (m^2/hr)	B	0.00E+00	NUREG/CR-5512, V3 S5.2.3	Indirect ingestion not modeled in building occupancy scenario
13	Receptor location: x,y,z (m)	B	7.5, 2.5, 1	Site-specific model	Occupant located at center of room area with exposure at 1m height
14	Shielding thickness (cm)	P	0	Site-specific model	No shielding is assumed
15	Shielding density (g/cc)	P	0	Site-specific model	No shielding is assumed
16	Shielding material	P	None	Site-specific model	No shielding is assumed
17	Number of sources	P	6	Site-specific model	All room surfaces assumed to be equally and uniformly contaminated
18	External dose conversion factor (mrem/yr)/(pCi/m^2)	M	RESRAD-BUILD defaults	FGR 12	
19	Air submersion dose conversion factor ((mrem/yr)/(pCi/m^3)	M	RESRAD-BUILD defaults	FGR 12	
20	Inhalation dose conversion factors (mrem/pCi)	M	RESRAD-BUILD defaults	FGR 11	
21	Ingestion dose conversion factors (mrem/pCi)	M	RESRAD-BUILD defaults	FGR 11	
	1. Wall				
22		P	Area	Site-specific model	
23	Direction	P	X	Site-specific model	
24	Location of center of source: x,y,z (m)	P	0, 2.5, 1.5	Site-specific model	
25	Area (m^2)	P	15	Site-specific model	Wall area is 5 m by 3 m
26	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
27	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
28	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
29	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
30	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit sourceof 1 dpm/100 cm^2 to allow for

No	Parameter (unit)	Type[a]	Value/Distribution	Source	Comments/Justification
					proportional DCGL calculation
	2.Wall				
31		P	Area	Site-specific model	
32	Direction	P	X	Site-specific model	
33	Location of center of source: x,y,z (m)	P	15, 2.5, 1.5	Site-specific model	
34	Area (m^2)	P	15	Site-specific model	Wall is 5 m by 3 m
35	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
36	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
37	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
38	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
39	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit source to allow for proportional DCGL calculation
	3. Wall				
40	Type	P	Area	Site-specific model	
41	Direction	P	Y	Site-specific model	
42	Location of center of source: x,y,z (m)	P	7.5, 0, 1.5	Site-specific model	
43	Area (m^2)	P	45	Site-specific model	Wall area is 15 m by 3 m
44	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
45	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
46	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
47	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
48	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit source to allow for proportional DCGL calculation
	4. Wall				
49	Type	P	Area	Site-specific model	
50	Direction	P	Y	Site-specific model	
51	Location of center of source: x,y,z (m)	P	7.5, 5, 1.5	Site-specific model	
52	Area (m^2)	P	45	Site-specific model	Wall area is 15 m by 3 m
53	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
54	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
55	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
56	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
57	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit source to allow for proportional DCGL calculation
	5. Floor				
58	Type	P	Area	Site-specific model	

No	Parameter (unit)	Type[a]	Value/Distribution	Source	Comments/Justification
59	Direction	P	Z	Site-specific model	
60	Location of center of source: x,y,z (m)	P	7.5, 2.5, 0	Site-specific model	
61	Area (m^2)	P	75	Site-specific model	Floor area is 5 m by 15 m
62	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
63	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
64	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
65	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
66	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit source to allow for proportional DCGL calculation
	6. Ceiling				
67	Type	P	Area	Site-specific model	
68	Direction	P	Z	Site-specific model	
69	Location of center of source: x,y,z (m)	P	7.5, 2.5, 3	Site-specific model	
70	Area (m^2)	P	75	Site-specific model	Ceiling area is 15 m by 5 m
71	Air fraction for H-3	B	1.00	NUREG/CR-6697, C, 8.6	Recommended value for gaseous form of H-3
	Air fraction (for all radionuclides except H-3)	B	0.07	NUREG/CR-6697, C, 8.6	Upper bound for contaminated noncombustible solids
72	Direct ingestion (hr^{-1})	B	4.07E-07	NUREG/CR-5512, V3 S5.2.3	Equal to 1.1E-4 m^2/hr divided by total source area of 270 m^2
73	Removable fraction	P	0.1	NUREG-1757, V2 SI.6.3.1	Default parameter value for loose fraction from DandD 2.1
74	Lifetime or time for source removal (days)	P	Nuclide Specific	NUREG/CR-6697, C, 8.8	
75	Radionuclide Concentration (pCi/m^2)	P	45	Site-specific model	Initial concentration is unit source to allow for proportional DCGL calculation

Notes:

[a] P = physical, B = behavioral, M = metabolic; [NUREG/CR-6676, App. B, Table B.3]

Table B-12. DCGLs for Building Reuse Scenario

Radionuclide	DCGL (dpm/100 cm^2)
C-14	1.0E+07
Fe-55	4.0E+07
Co-60	11,000
Ni-59	9.9E+07
Ni-63	3.6E+07
Sr-90	136,200
Tc-99	1.4E+07
Cs-137	40,500
Eu-152	24,300
Eu-154	4500
H-3	3.2E+08
Pu-241	228,000
Pu-238	4900
Cm-243/244	6100
Am-241	4300
Eu-155	395,000
I-129	67,800
Nb-94	15,800
Pu-239	4400
U-234	31,500
U-235	27,100
U-236	33,200
U-238	32,900

5.3 Residual Contamination in Subsurface Structures

Decontamination and decommissioning of below grade PBRF structures (e.g., the Reactor Building [Building 1111]) will include decontamination of surfaces to building reuse DCGLs and offsite disposal of decontamination waste, removing decontaminated above grade and below grade structures down to 1 m (3 ft) below grade, backfilling belowground cavities with rubble generated from demolishing decontaminated above grade and below grade structures, and installing a cover over the backfilled area.

Residual activity in the belowground portions of the various structures could be from several sources: in crushed concrete from aboveground structures, in remaining portions of the biological shield, on the surfaces of the canals and quadrants.

The resident farmer scenario was used for the Subsurface Structure dose assessment. RESRAD 6.21 was used for the assessment with certain parameter modifications, as listed below, to model the source in the saturated zone. The area used in the dose assessment was a 70-m (230-ft) cylinder (the approximate diameter of the subsurface structures), which extended vertically downward a distance of 3 m (10 ft) placing the contaminated zone directly on top of the saturated zone. The thickness of the contaminated zone is taken as 3 m (10 ft) to maximize dose through the external exposure and crop pathways. The well could be conceptualized as either in the center of the contaminated zone or located on the down gradient edge of the 70-m (230 ft.) diameter cylinder because the mass balance (MB) water transport model was used. The MB model eliminates the inappropriate dilution found in the Non-Dispersion Model that does not apply to the saturated zone equilibrium assumption of the Subsurface Structure fill model. Note that the hydrological parameters used were those provided in the Decommissioning Plan, which in some cases differ slightly from the final parameters listed in Tables B-1 through B-3. However, these parameters have no effect on the resulting water concentrations from the Subsurface Structure model because the model was designed to simulate concrete in an equilibrium saturated condition and not flow through an unsaturated contaminated zone.

The dose assessment and DCGL development for the Subsurface Structure scenario was performed using RESRAD 6.21 and the deterministic parameters from the surface soil scenario with seven changes as listed below. The unsaturated zone depth, time since material placement, and contaminated zone hydraulic conductivity parameters were selected to allow RESRAD to model a saturated condition.

1. MB water transport model used,
2. unsaturated zone depth 0 m,
3. contaminated zone 3 m,
4. contaminated zone area 3850 m^2,
5. time since material placement 1 yr,
6. contaminated zone hydraulic conductivity 0.86 m/y, and
7. concrete K_ds used in place of soil K_ds .

A dose assessment was also performed assuming a 1m cover is in place, which is the actual planned end state for the site. The "no cover" condition was assumed to be conservative for all radionuclides. The 1m cover analysis was performed to ensure that this assumption was correct. As shown in Table B-14, the 1m cover assumption results in a lower DCGL for one radionuclide, i.e., H-3.

Concrete K_ds were used to model the concrete debris to be placed in the subsurface structures. Table B-13 provides the range of concrete K_ds for each of the radionuclides that were reported as above detection limits in smear samples of PBRF concrete and represent greater than 0.05% of the smear radionuclide mixture. The final list of radionuclides considered for FSS will include only those radionuclides considered significant per NUREG-1757, Vol. 3.

The K_d ranges were derived from the following three references:

1. Krupka, K.M., and R.J. Serne. 1998. *Effects on Radionuclide Conecentrations by Cement/Groundwater Interactions in Support of Performance Assessment of Low-Level Radioactive Waste Disposal Facilities.* NUREG/CR-6377 (PNL-11408).
2. Mattigod, S.V., et. al., 2002. Radionuclide *Desorption and Leaching Tests for Concrete Cores from Haddam Neck Nuclear Plant Facilities.* Final Letter Report, Battelle, Pacific Northwest Laboratory.
3. Fuhrmann, M., Sullivan, T, 1999. *Leaching and Sorption of Radionuclides: Structural Concrete from Maine Yankee Nuclear Power Station.* Final Letter Report, Brookhaven National Laboratory.

K_d parameter distribution functions (PDFs) were developed for each radionuclide based on the range of potential values. Table B-13 provides the PDFs and defining numerical parameters. NUREG/CR-6697, Appendix A states that the uniform or loguniform distribution is useful if little is known about the distribution except the minimum and maximum, which is the condition arising from compiling the data from the above references. The loguniform is more appropriate when there is a wide range between the minimum and maximum. Accordingly, the loguniform PDF was selected if the range exceeded a factor of 10. Otherwise, the uniform distribution was used. The three exceptions were Sr-90, Cs-137, and Tc-99. Because the K_d ranges were numerically low, i.e., 10, 18, and 21 for Sr-90, Cs-137, and Tc-99, respectively, the uniform distribution was used.

Consistent with the recommendations in NUREG-1757, Vol. 2, an uncertainty analysis was performed to determine if the calculated dose was sensitive to the concrete K_d. The uncertainty analysis was performed using the probabilistic module of RESRAD 6.21 with radionuclide specific PDFs. The RESRAD output report of the Partial Rank Correlation Coefficient (PRCC) for the peak of the mean dose was reviewed. A decision criterion of the absolute value of 0.25 was selected for the PRCC test. The 0.1 and 0.25 values were found acceptable by the NRC through the approval of the Connecticut Yankee License Termination Plan (LTP). The results showed that the PRCC was less than -0.25 for all radionuclides indicating that the parameter was sensitive and the dose negatively correlated to the K_d (i.e., the dose went up as the K_d went down). Because the dose was negatively correlated, the 25th quantile value of each PDF was used as the deterministic K_d parameter in the subsurface structure dose model. See Table B-13 for the 25th quantile K_d values.

The dose assessment was performed with and without a 1 meter cover. As expected, the dose was higher with no cover with the exception of H-3 where the dose was higher with the cover in place. This is due to the unique characteristics of H-3 and the corresponding unique RESRAD environmental transport model. The highest H-3 dose was used for the PBRF DCGL calculation as shown in Table B-14, Column 4.

RESRAD output report for the Subsurface Structure dose assessments are contained in a separate report available for review as needed. The RESRAD output report contains the maximum dose results (at t = 0y). The RESRAD output report also contains the RESRAD dose results for the evaluation with 1 m cover at the time of maximum dose (t = 0y).

Table B-13. Concrete K_ds (ml/g) for Subsurface Structure Model Dose Assessment

Radionuclide	Literature[1]	CY[2]	Maine[3]	Plum Brook K_d PDF	25th Quantile K_d
C	10 - 500			10 - 500 Loguniform[4]	26
Fe	10 - 100	7 - 18		7 - 100 Loguniform	13
Co	10 - 100	180 - 32500		10 – 100 Loguniform	17
Ni	10 - 100	10 - 61		10 - 100 Uniform[5]	32
Sr	1 - 3	10 - 11[1]	0.7 - 1.3	1 - 11 Uniform	3.5
Tc	0 - 100	6 – 21		0 – 21 Uniform	5.2
Cs	2 - 20	34 - 26800	2.9 - 3.3	2 – 20 Uniform	6.5
Eu	200 - 1000			200 - 1000 Uniform	400
Pu	500 - 5000			500 - 5000 Uniform	1625
Cm	200 - 1000			200 - 1000 Uniform	400
Am	200 - 5000	>230 - >1750		200 - 5000 Loguniform	445
I	1 - 10			1 -10 Uniform	3.2
Nb	100 -1000			100 - 1000 Uniform	325
U	100 - 2000			100 - 2000 Loguniform	212

Footnotes:

1. Krupka 1998 and Bradbury 1998
2. Mattigod 2002
3. Fuhrman 1999
4. Minimum and maximum values of distribution
5. Minimum and maximum of distribution

[1] CY K_d value for Sr-90 was confirmed by an independent review by Brookhaven National Laboratory

The DCGL calculation was performed by dividing 25 mrem/y by the unitized dose factors from the RESRAD output report (and the corresponding output page for the 1 m cover evaluation). The term unitized dose factor is used because the source term was 1 pCi/g for each radionuclide. The DCGLs are listed in Table B-14. The radionuclides listed in Table B-14 represent all radionuclides that were reported as above detection limits in smear samples of PBRF concrete.

The final list of radionuclides considered for FSS will include only those that are considered significant per NUREG-1757, Vol. 3.

Table B-14. DCGLs for Subsurface Structures

Radionuclide	DCGL No Cover (pCi/g)	DCGL 1 m Cover (pCi/g)	PBRF DCGL (pCi/g)
C-14	17	85	17
Fe-55	685	691	685
Co-60	3.3	17	3.3
Ni-59	2134	2,495	2134
Ni-63	779	911	779
Sr-90	0.6	0.7	0.6
Tc-99	25	87	25
Cs-137	2.2	2.6	2.2
Eu-152	9.4	2,074	9.4
Eu-154	8.6	1,426	8.6
H-3	357	166	166
Pu-241	472	552	472
Pu-238	13	17	13
Cm-243/244	4.8	5.3	4.8
Am-241	3.8	4.0	3.8
Eu-155	354	9,184	354
I-129	0.27	0.27	0.27
Nb-94	6.6	1,504	6.6
Pu-239	12	15	12
U-234	22	24	22
U-235	18	25	18
U-236	23	25	23
U-238	22	25	22

The last step in the subsurface structure DCGL calculation is the conversion of the pCi/g volumetric $DCGL_v$ to an Effective Surface DCGL ($DCGL_{ES}$). This allows the FSS to be performed using surface activity measurements and the inclusion of the source term that is present on the subsurface structure surfaces.

The $DCGL_{ES}$ is calculated using the following basic relationship:

$DCGL_V$ (pCi/g) = Radionuclide Inventory / Concrete Debris Mass

Where:

Inventory = (SA m^2)(10,000 cm^2/m^2)($DCGL_{ES}$ dpm/100 cm^2)(1 pCi/2.22 dpm)

Concrete Debris Mass = (V m^3)(1E+06 cm^3/m^3)(1-η)(2.4 g/cm^3)

SA = Structure surface area requiring FSS (internal surfaces above and below grade) (m^2)

η = porosity (0.41)

V = Volume of fill required (m^3)

Combining conversion factors and rearranging terms results on the following equation for calculating the $DCGL_{ES}$:

$DCGL_{ES}$ dpm/100 cm^2 = 31,435 ($DCGL_V$ pCi/g) (V m^3/SA m^2)

The vast majority of the structure contamination is in the Reactor Building (1111), Reactor Hot Lab (1112), Reactor Primary Pump House (1134), and Reactor Office and Lab Building (1141). These buildings are essentially connected and during demolition the debris from these structures will be expected to mix together. Because of the aforementioned, the V/SA ratio will be based on an average of these four buildings. The $DCGL_{ES}$ values calculated using this V/SA ratio will conservatively apply to all subsurface structures. The result is conservative because it is very unlikely the actual inventory of residual radioactivity remaining on any structure surfaces will approach the calculated inventory assuming uniform contamination at the $DCGL_{ES}$ level. This ensures with high confidence that the Subsurface Structure volumetric DCGL will not be exceeded. The V/SA ratios are listed in Table B-15.

Table B-15. Structure V/SA ratios

Structure	V/SA Ratio (m^3/m^2)
Reactor Building (1111)	2.91
Hot Laboratory Building (1112)	1.19
Primary Pump House (1134)	1.27
Reactor Office and Laboratory Building (1141)	1.65
Average	1.76

Table B-16 lists the $DCGL_{ES}$ and the Building Reuse DCGL values for each radionuclide that was reported as above detection limits in smear samples of PBRF concrete. The final list of radionuclides considered for FSS will include only those that have a significant dose per NUREG-1757, Vol. 3.

The $DCGL_{ES}$ values were compared to the Building Reuse DCGLs and the more conservative of the two values designated as $DCGL_{FSS}$ as shown in Column 4 of Table B-16. The $DCGL_{FSS}$ is the surface activity level that will be used during FSS to determine compliance with the 25 mrem/yr unrestricted use criteria.

The use of the $DCGL_{FSS}$ value is a conservative approach when the $DCGL_{ES}$ is limiting because the radionuclide inventory expected to actually to be present on building surfaces at the time of demolition is much lower than that used in either the DCGL or the $DCGL_{ES}$ calculations, which assume uniform contamination at either level.

If deemed necessary, the Building Reuse DCGLs could be applied for radionuclides where the $DCGL_{ES}$ is limiting. This would require a separate calculation to be performed, based on actual FSS measurement results, to confirm that the radionuclide specific inventory divided by the fill volume is less than the Subsurface Structure volumetric DCGL. For the four structures listed in Table B-15, this confirmation would be based on the average residual surface radioactivity level in the four structures (and the combined subsurface structure volumes). For all other structures the confirmation would be structure specific.

Table B-16. Building Reuse DCGLs, Subsurface Structure Effective Surface DCGLs, and $DCGL_{FSS}$ Values

Radionuclide	Building Reuse DCGL (dpm/100 cm²) (from Table B-12)	Subsurface Structure Effective Surface $DCGL_{ES}$ (dpm/100 cm²)	*$DCGL_{FSS}$ (dpm/100 cm²)*
C-14	1.0E+07	940,500	*940,500*
Fe-55	4.0E+07	3.7E+07	*3.7E+07*
Co-60	11,000	182,500	*11,000*
Ni-59	9.9E+07	8.0E+07	*8.0E+07*
Ni-63	3.6E+07	4.3E+07	*3.6E+07*
Sr-90	136,200	33,100	*33,100*
Tc-99	1.4E+07	1.3E+06	*1.3E+06*
Cs-137	40,500	121,700	*40,500*
Eu-152	24,300	520,000	*24,300*
Eu-154	4,500	475,800	*4,500*
H-3	3.2E+08	9.1E+06	*9.1E+06*
Pu-241	228,000	2.6E+07	*228,000*
Pu-238	4,900	719,200	*4,900*
Cm-243/244	6,100	265,500	*6,100*
Am-241	4,300	210,200	*4,300*
Eu-155	395,000	1.9E+07	*395,000*
I-129	67,800	14,900	*14,900*
Nb-94	15,800	365,100	*15,800*
Pu-239	4,400	663,900	*4,400*
U-234	31,500	1.2E+06	*31,500*
U-235	27,100	995,800	*27,100*
U-236	33,200	1.2E+06	*33,200*
U-238	32,900	1.2E+06	*32,900*

6.0 Area Factors

Area factors (AFs) were developed for the Surface Soil and Building Reuse scenarios. The Building Reuse AFs also apply to the Subsurface Structure $DCGL_{ES}$ values. The AFs were calculated using Co-60 to ensure the values are conservative for all radionuclides. The AF for the direct exposure pathway is lower than that for the ingestion and inhalation pathways and Co-60 generates the highest direct exposure per pCi/g.

The AFs for Surface Soil were calculated by first running the RESRAD code with the Surface Soil parameters and a source area of 2000 m^2. The 2,000 m^2 source area was selected since this is the maximum survey unit size for a Class 1 area. RESRAD was then run using source areas ranging from 1 m^2 to 250 m^2 to represent the elevated area sizes. RESRAD dose reports used for the calculations are available for review as needed.

The AFs were calculated by dividing the dose result for the 2,000 m^2 source area by the dose results for the smaller elevated areas. The Surface Soil AFs are shown in Table B-17.

The AFs for Building Reuse were calculated in an analogous manner except that an initial source area of 75 m^2 was selected to represent the floor area for the room size used in the RESRAD-BUILD modeling for the Building Reuse scenario. The elevated areas evaluated ranged from 0.25 m^2 to 50 m^2. The RESRAD-BUILD dose reports used for the calculations are available for review as needed. The Building Reuse AFs are listed in Table B-18.

Table B-17 Surface Soil Area Factors

Elevated Area (m^2)	1	2	3	5	10	15	25	100	250	2000
Area Factor	10.4	6.2	4.7	3.4	2.3	1.9	1.6	1.2	1.1	1

Table B-18 Building Reuse Area Factors

Elevated Area (m^2)	0.25	0.50	1	2	4	6	8	10	15	25	50	75
Area Factor	40.2	20.8	11.1	6.2	3.6	2.8	2.4	2.1	1.7	1.4	1.1	1

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment C
Embedded Piping Dose Assessment & DCGL Calculation

1.0 Purpose

This attachment provides a discussion on the decision to leave selected sections of Plum Brook Reactor Facility (PBRF) embedded and buried piping in place, describes the conceptual dose model, and presents the Derived Concentration Guideline Level (DCGL) values and area factors to be used during final status surveys.

2.0 References

2.1 NUREG-1757, Volume 2, Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria

2.2 MWH Constructors, Radionuclide Composition and Activity Ratios in Primary Coolant Piping, Transmittal No. PBRF-05-0285, March 24,2005

2.3 Grove Software Inc., MicroShield® User's Manual, Version 7, 2005

2.4 IAEA, Engineering Compendium on Radiation Shielding, Vol. 1, Springer-Verlag New York, 1968.

2.5 NASA Plum Brook Station Drawing PF-00375, Reactor Building Process Piping North Half - Plan -25 ft. Elevation, 08/27/56

2.6 NASA Plum Brook Station Drawing PF-00376, Reactor Building Process Piping, South Half - Plan -25 ft. Elevation, 08/27/56

2.7 NASA Plum Brook Station Drawing PF-00385, Reactor Building Process Piping, Pump Room Plan & Sections. Revised 04/03/67

2.8 NASA Plum Brook Station Drawing PF-04645, Process Piping Tunnel Header & Drains Below First Floor - Plan & Sections, 09/09/57

2.9 ICRP, Publication 74, Conversion Coefficients for Use in Radiological Protection against External Radiation, Elsevier, 1997 (Also ICRU Report No. 51, 1987

2.10 Portland General Electric Co., Final Survey Report, Embedded Piping, December, 2004

3.0 Discussion

PBRF has performed an assessment of safety, radioactive waste generation, and cost associated with the removal of embedded and buried piping. PBRF has concluded that the increased risk from industrial safety, time and physical logistics of removing the piping, and cost would justify leaving some piping in place. Therefore, designated sections of embedded and buried piping will be remediated in place and undergo FSS.

3.1 Industrial Safety

A study was performed to determine the industrial safety risks associated with removal of embedded and buried piping. A summary of the activities which elevate the safety risks during removal of embedded and buried piping outside those traditionally associated with reactor decommissioning projects include:

- A large percentage of piping is located fifteen (15) to thirty-five (35) feet below grade. Working beneath the ground, the site labor forces must rely on the soil stabilization system to prevent a cave-in or a sudden onrush of groundwater into the work area.

- The removal of piping in many areas entails the use of large hydraulic hammers (hoe-rams) for extended periods of time. The utilization of hoe-rams has the potential to increase fugitive dust emissions potentially creating silica exposures to labor forces, significantly increases noise levels throughout the facility, increase the risk to injury by flying debris, building collapse and worker becoming pinched by heavy equipment.

- Piping and rebar will have to be cut using torches which increases the risk of a fire.

- The packaging and handling of large quantities of waste debris and operation of heavy equipment increases the risk of an industrial accident.

3.2 Waste Generation

The removal of the embedded and buried piping will generate significant quantities of potential radioactive waste. The waste will have to be surveyed and sampled and either staged for backfill, if the material meets the release limits, or packaged and shipped to a waste processor. An estimated 3,565,100 pounds of potential radioactive waste, including soil, concrete, and steel will be generated during removal of just the Primary Cooling Loop and Quadrant and Canal piping.

3.3 Cost

The cost of removing the piping is high and far more costly than justified by the Nuclear Regulatory Commission (NRC) $2000/person-rem ALARA standard. The operational phase of removing the Primary Cooling Loop was estimated to consume fifty-nine (59) weeks of schedule duration at an estimated cost of eight million to ten million dollars ($8,000,000-$10,000,000). The addition of removing the embedded Quadrant and Canal piping would have further increased that cost by approximately one million to one million, two hundred fifty thousand dollars (~$1,000,000-$1,250,000). In total, the estimated costs associated with removing the PBRF's embedded piping systems would have ranged, more or less, from nine million dollars to eleven million, two hundred fifty thousand dollars ($9,000,000-$11,250,000).

Once the preliminary estimates of costs associated with the removal of the PBRF embedded systems were thoroughly evaluated, it was decided that the more prudent and logical course of action would be that of surveying the embedded piping conduits, decontaminating the same as necessary to either meet the DCGL values or ALARA, and subsequently leave the embedded piping in place. The costs associated with the in-situ decontamination of the embedded Primary Cooling Loop, Quadrant and Canal piping, and some sections of buried piping was estimated to range from two million to four millions dollars ($2,000,000-$4,000,000), depending upon the number of access points that need to be cut into the concrete to gain access to piping through floor traps and piping connected by "Tee"s and mitered elbows.

4.0 Embedded Piping versus Buried Piping

Embedded piping (EP) is any pipe situated below the minus three (-3) foot elevation that is totally encased in concrete or piping directly beneath building floors that may not be totally encased in concrete, but contained within the structural foundation of the building.1 Examples include Containment Vessel Quadrant and Canal drain piping and remaining sections of the Primary Cooling Loop. Buried piping is any pipe buried in soil and situated outside the structural foundation of a building, such as storm drains.

4.1 Embedded Piping DCGL Values

Embedded piping DCGL values were derived by developing a conservative conceptual model of piping layouts based on an extensive review of PBRF drawings and facility walk-downs. The calculations were performed using the dose calculation software MicroShield®. Individual DCGL values were calculated for PBRF gamma-emitting radionuclides observed in PBRF embedded piping surface deposits. The DCGL values represent surface activity concentrations that correspond to an annual dose of one millirem per year (1 mrem/yr) to a future building occupant assuming that an individual occupies the facility and is exposed for 2340 hours per year. The PBRF methodology for determining DCGL values is provided in Sections 5.0 through 8.0. The EP DCGL values are provided in Table C-4.

4.2 Buried Piping DCGL Values

The DCGL values for buried piping will be the same as the structure DCGL values. Refer to Attachment B of the FSSP.

1 The Trojan Decommissioning Project followed a similar approach for disposition of piping that was located beneath structures, but not necessarily embedded in concrete. This piping was inspected, cleaned, surveyed to embedded piping DCGL values and grouted in place after regulatory review and inspection/surveys of selected piping. (See Reference 2.10)

5.0 Embedded Piping Conceptual Dose Model

The EP configuration that delivers the highest dose to a future building occupant was used in the dose model. This individual is assumed to occupy the walkway between Canal F and the Pump Room at the Reactor Building -25 ft. elevation and is exposed to a group of pipes (a pipe cluster) embedded in the concrete beneath the walkway. Plant drawings were reviewed and inspections performed to confirm that the pipe cluster located beneath the Canal F - Pump Room Walkway represents the most conservative case. That is, this pipe cluster is the highest concentration of embedded pipes to which a future building occupant could be exposed while occupying a single location in the facility. Table C-1 describes the piping layout used in the dose model. Figures C-1 and C-2 provide views of the piping model layout and location of the dose point (one meter above the walkway floor) relative to the piping.

Table C-1

Description of Pipe Cluster in Canal F - Pump Room Walkway

Piping Run ID	Description	ID (in.)	Length (ft)	Horizontal Offset From Dose Point CL (ft)	Pipe CL Depth (in.)	Pipe Top Surf Depth Below floor (in.)
1.21	Canal H Drain	6	81	1.5	16	13.25
1.23	Canal G Drain	6	42	1.5	16	13.25
1.24	Canal G Purge	3	39	3	16	14.75
1.25	Canal F Drain	6	20	4.5	16	13.25
1.26	Canal F Purge	3	19.5	6	16	14.75
1.641	Canal F&G OF Header [1]	8	25	3	38	34.25
1.81	Canal K Floor Drain	6	25	6	25	22.25
1.82	Canal J & HDS Riser [2]	3	25	4.5	25	23.75
1.83	HDS Floor Drain	4	25	7	38	36.25
Average Dimensions =>		5.0	33.5		22.9	20.6

Table C-1 Notes:

1. Overflow Header
2. Hot Drain System Riser

A review was conducted to identify other piping configurations that could represent potential exposures comparable to or possibly greater than the 9-pipe cluster described above. Plum Brook Reactor Facility drawings were reviewed and walk-downs conducted to identify locations with potential for exposure to clusters of embedded pipes, which terminate at wall surfaces in areas of the facility that could be occupied. A cluster of 10 pipes that terminate in a pipe trench located in the Reactor Building, -25 foot elevation was identified. During facility operation, these pipes emerged from concrete and were

connected to a drain manifold in a trench (Quad & Canal Drains). After shutdown, the exposed piping has been removed and the pipe-ends cut flush with the trench wall. The trench is of such dimensions that an individual could occupy the trench and be exposed to gamma radiation emanating from the pipes (piping end-view exposure geometry). The layout of the conceptual model used to calculate doses from end-view exposure to the former drain manifold piping is shown in Figures C-3 and C-4.

6.0 Dose Calculations for 9-Pipe Cluster

All dose calculations reported herein were performed using MicroShield® Version 5.04. For the primary DCGL dose calculations, MicroShield® geometry option 10 was used for the 9-pipe cluster Canal F - Pump Room Walkway model.2 This is a cylindrical surface source with external dose point. The following assumptions were used to establish the MicroShield® case runs and for determination of DCGL values:

- The dose receptor (dose point) is located one meter above the walkway floor surface on the longitudinal centerline of the pipe cluster and at a distance midway between the pipe ends.
- The 9 pipes lie in parallel runs (parallel to each other and to the floor surface) at the same elevation. Per review of PBRF drawings (References 2.5, 2.6, 2.7, & 2.8), the actual pipe centerline depths range from 16 to 38 inches and the average depth is 22.9 inches.
- The concrete in which the piping is embedded is modeled as a concrete slab shield (density 2.4 g/cc), 12 in. thick, placed between the top pipe surface and the floor elevation.
- All the pipes are cleaned by vacuuming and pressure blasting or mechanical means to remove loose scale and loosely adherent surface contamination. The pipes are filled with grout (concrete) with density 1.8 g/cc.
- The pipes are all assumed to be 25 ft. in length. Note that the pipe lengths vary from 19.5 to 81 ft. with average length of 33.5 ft. It is found that the calculated dose is not sensitive to pipe length as the length is increased beyond 20 ft.
- The pipe wall is modeled as a ¼ in. thick (0.65 cm) cylindrical shield. This corresponds to Schedule 40 piping wall thickness for 5 in. piping, the average ID of the 9-pipe cluster. Note that the actual piping is all Schedule 80 (0.95 cm. wall thickness) [Reference 2.5, PF-00375].

2 The MicroShield® code has several standard options for combinations of source and shield configurations. These are called "geometries". The geometry used for the default case, Geometry 10 is suitable for dose-receptor points external to the piping and located at positions that lie between the pipe ends (within the two planes perpendicular to the pipe longitudinal axis).

- The "buildup" medium for the MicroShield® dose calculations is selected as the grout-filled pipe core.
- The model includes a piping corrosion layer surrounding the cylindrical surface source, modeled as "cladding" of 0.025 cm thickness.
- The only exposure pathway that is operative for embedded piping is direct dose from gamma-emitting radionuclides. All the radionuclides that may be present in piping residual contamination are fixed in place by the grout and are not available for transport to ground water or to ingestion or inhalation pathways to a future building occupant.
- This DCGL calculation uses MicroShield® case run output dose rates in units of mSv/h (Deep Dose Equivalent Rate). The MicroShield® code uses dose conversion factors from ICRP Publication 74, 1997 (Reference 2.9). The output dose rates are then converted to mrem/hr (100 mrem/hr per mSv/h).

The MicroShield® source, dose point coordinates and shield dimensions are summarized in Table C-2.

Table C-2

Dose Calculation Model Dimensions

Source Dimensions (cm)		Dose Point Coordinates (cm)			Shields (cm)		
Pipe Length	Radius [1]	X [2]	Y [3]	Z [4]	Wall Clad	Pipe Wall	Concrete
762 (25 ft.)	Pipe-specific	Pipe-specific	381 (12.5 ft.)	Pipe-specific	0.025	0.65	30.48 (1 ft)

Table C-2 Notes:

1. This is the radius in cm. corresponding to each pipe ID.
2. The x coordinate is the total distance from the center axis of each pipe to the dose point. This includes the pipe radius, wall clad, pipe wall-shield thickness, the 12 in. concrete slab-shield thickness and the 1-meter distance from floor surface to the dose point (receptor center-height above the floor).
3. The y coordinate places the dose point at the center of the pipe lengths.
4. The z coordinate is the offset distance from the centerline of each pipe to the pipe cluster centerline (the dose point is located directly above the pipe cluster centerline).

The dose from each pipe was calculated individually for seven gamma-emitting radionuclides found to be present in primary cooling water piping in 2005 (Reference 2.2). The dose was calculated for unit activity (one dpm/100-cm^2 or 4.5E-09 μCi/cm^2). The dose to the receptor from each radionuclide is obtained as the sum of the contributions from each

piping run in the 9-pipe cluster. The results are shown in Table C-3. The MicroShield® case run reports are provided in Addendum 1.

It is noted that DCGL values for radionuclides that emit only beta particles are not calculated for embedded piping, even though several have been measured in piping deposits. They do not contribute to the dose to future building occupants because the piping that remains in place is filled with grout. However their presence must be accounted for when direct beta surface activity measurements are used for FSS of embedded piping.

Table C-3

Calculated Doses from Principal Gamma Emitting Radionuclides

Canal F - Pump Room Walkway 9-pipe Cluster

Piping Line No.	mrem/hr per dpm/100-cm^2					
	Co-60	Cs-137	Eu-152	Eu-154	Ag-108m	Nb-94
1.21	5.54E-10	3.90E-11	1.82E-10	2.50E-10	1.11E-10	1.58E-10
1.23	5.54E-10	3.90E-11	1.82E-10	2.50E-10	1.11E-10	1.58E-10
1.24	1.79E-10	1.08E-11	5.84E-11	8.08E-11	3.13E-11	4.60E-11
1.25	8.64E-11	3.60E-12	2.79E-11	3.95E-11	1.10E-11	1.74E-11
1.26	1.76E-11	5.33E-13	5.68E-12	8.19E-12	1.71E-12	2.87E-12
1.641	2.90E-10	1.64E-11	9.42E-11	1.31E-10	4.79E-11	7.11E-11
1.81	2.43E-11	7.02E-13	7.87E-12	1.14E-11	2.27E-12	3.83E-12
1.82	6.12E-11	2.70E-12	1.97E-11	2.79E-11	8.16E-12	1.28E-11
1.83	8.29E-12	1.87E-13	2.71E-12	3.97E-12	6.32E-13	1.11E-12
Total	1.77E-09	1.13E-10	5.81E-10	8.03E-10	3.25E-10	4.71E-10

Table C-3 Notes:

The dose rates from I-129 (9.89E-35 mrem/hr), Sn-126 (1.45E-17 mrem/hr) and Eu-155 (4.10E-16 mrem/hr) were calculated, but are found to be at least 5 orders of magnitude below the dose rates from the other gamma emitting radionuclides. They are of no consequence and are eliminated from further consideration.

7.0 Embedded Piping DCGL Values

To obtain individual radionuclide DCGL values, the dose rate for each radionuclide is converted to annual dose by multiplying by 2340 h/y, the exposure-hours for the occupant in the building occupancy scenario. The DCGL values are then obtained as the

reciprocal of the annual dose. The results of these calculations are provided in Table C-4. The individual radionuclide DCGL values range from 2.408E05 dpm/100-cm^2 for Co-60 to 3.785E06 dpm/100-cm^2 for Cs-137. The calculated doses and DCGL values are strongly dependent on the thickness of concrete shielding that surrounds the embedded piping. The concrete typically provides a minimum of 12 to 14 inches of shielding for the piping.

Table C-4

Individual Radionuclide DCGL Values for Embedded Piping

Radionuclide	Dose from all Pipes (mrem/hr)	Annual Dose to Building Occupant (mrem/yr)	DCGL (dpm/100-cm^2 per mrem/yr)
Co-60	1.77E-09	4.17E-06	2.408E+05
Eu-154	8.03E-10	1.89E-06	5.325E+05
Eu-152	5.81E-10	1.37E-06	7.352E+05
Nb-94	4.71E-10	1.11E-06	9.082E+05
Ag-108m	3.25E-10	7.60E-07	1.312E+06
Cs-137	1.13E-10	2.64E-07	3.785E+06

8.0 Evaluation of Alternative Exposure Scenario

The potential dose to a future building occupant was evaluated for the cluster of 10 pipes with pipe-ends terminating at the face of the Reactor Building Pump Room trench. The layout shown in Figures C-3 and C-4 were used to set up the MicroShield® dose calculation model. The piping dose model and assumptions are very similar to the approach followed in calculating dose rates to a future building occupant from the 9-pipe cluster beneath the Canal F - Pump Room walkway. The specific assumptions for this scenario are:

- The dose receptor is located one meter above the Pump Room trench floor and one meter from the trench wall where the piping runs terminate. With reference to Figure C-3, the distance from the pipe cluster horizontal centerline to the elevation of the dose point is 67 cm.

- The 10 pipes are all horizontal and their centerlines are at an elevation of 13 inches (33 cm.) above the trench floor. The pipe centerline separation distance is 1 ft. 9 inches (53.3 cm.).

- The pipes are modeled as 10 ft long cylindrical surface sources using MicroShield® Geometry 10, Cylinder Surface with external dose point.

- The shielding provided by the concrete surrounding each pipe is modeled as a cylindrical annular shield that surrounds the surface source. In MicroShield®, when the external dose point lies outside the space between the ends of a cylindrical source (a pipe), compromises are required. The code does not accommodate more than one cylindrical material surrounding the source. Thus, the concrete replaces the steel pipe wall in the model setup. This is conservative, because the calculated doses would be lower, if the shielding effect of the piping wall could be accounted for.

To demonstrate that this exposure scenario does not yield limiting case DCGL values, it is sufficient to show that the dose rate for Co-60 is less than from the Canal F - Pump Room Walkway embedded pipe cluster. This result is shown in Table C-5. It is seen that the calculated dose rate is 3.06E-12 mrem/hr is much less than the Co-60 dose rate obtained from the Walkway floor Co-60 dose rate of 1.77E-09 mrem/hr.

Table C-5

Summary of Dose Calculations for Pump Room Trench Occupancy Scenario

Pipe Run No.	Pipe ID (in)	Dose Point X Dimension (cm)	Dose Point Z Dimension (cm)	Dose Rate (mrem/hr)
1.36	10	53.3	0	4.225E-13
1.35	3	62.2	53.3	1.305E-12
1.34	10	53.3	106.6	5.920E-15
1.33	3	62.2	160	8.646E-15
1.32	10	53.3	214	8.157E-19
1.31	3	62.2	266.5	1.113E-17
1.37	3	62.2	53.3	1.305E-12
1.38	10	53.3	106.6	5.920E-15
1.39	3	62.2	160	8.646E-15
1.395	10	53.3	214	8.157E-19
			Total	3.062E-12

The MicroShield® case-run reports for the Pump Room Pipe Trench cluster are provided in Addendum 2. It is noted that due to the symmetry of the piping layout, it is necessary to calculate the doses for only 6 of the 10 pipes. As shown in Figure C-3, there are four pairs of pipes with identical diameters and separation distance on either side of the cluster centerline.

9.0 Area Factors

Area factors provide a method to evaluate localized areas encountered in the Final Status Survey of embedded piping that exceed the DCGL (i.e., the elevated area comparison). A working definition of area factor is the multiple of the DCGL that may be permitted in a localized area of specified dimensions such that the basic dose criterion (25 mrem/yr) is not exceeded. The area factors derived in this attachment are based on several assumptions. They are:

- A run of piping is considered to be a survey unit.
- The length of piping that contains elevated activity is analogous to the area containing elevated activity in a structural survey unit.
- The dose from Co-60 per unit activity in embedded piping exceeds that from any of the other gamma-emitting radionuclides observed in PBRF embedded piping. Thus, area factors that are based on the dose from Co-60 will be conservative. That is, the use of area factors derived on this basis will not result in doses that are greater than the dose criterion regardless of the radionuclide mixture that is present.

Area factors are calculated using the conceptual dose model described in Section 5.0 and using the same method for calculating doses as described in Section 6.0. It is seen from the dose calculation results in Table C-4, that most of the dose to the future building occupant is received from four of the 9 pipes in the pipe cluster, approximately 85%. Therefore, it is a reasonable approximation to calculate the dose delivered from various lengths of these four pipes in the derivation of embedded piping area factors. Area factors are calculated for lengths of 1, 2, 5, and 10 feet. They are obtained as ratios of the dose rate from the four pipes of lengths 1, 2, 5, and 10 feet to the total dose rate from the entire length of all the pipes (1.77E-09 mrem/hr from Co-60).

The results of the area factor calculations are presented in Table C-6. Figure C-5 shows area factor versus length of elevated section of piping.3 The MicroShield® case run reports for area factors are provided in Addendum 3.

3 An additional conservatism in the area factors is from the use of the combined dose from four pipe runs in the calculation. From physical principles, the average dose contribution from a single pipe of the specified lengths could be used, rather that the sum of the dose contributions.

Table C-6

Embedded Piping Area Factors

Pipe Length (ft)	Total Dose from Pipes of Specified Length (mrem/hr)	Area Factor
1	3.013E-10	5.9
2	5.834E-10	3.0
5	1.197E-09	1.5
10	1.531E-09	1.2
Total dose rate from all EP =>	1.77E-09	

Figure C-1

Conceptual Model for Embedded Piping DCGL - Dose Calculation
Canal F - Pump Room Walkway 9-Pipe Cluster Cross-section View

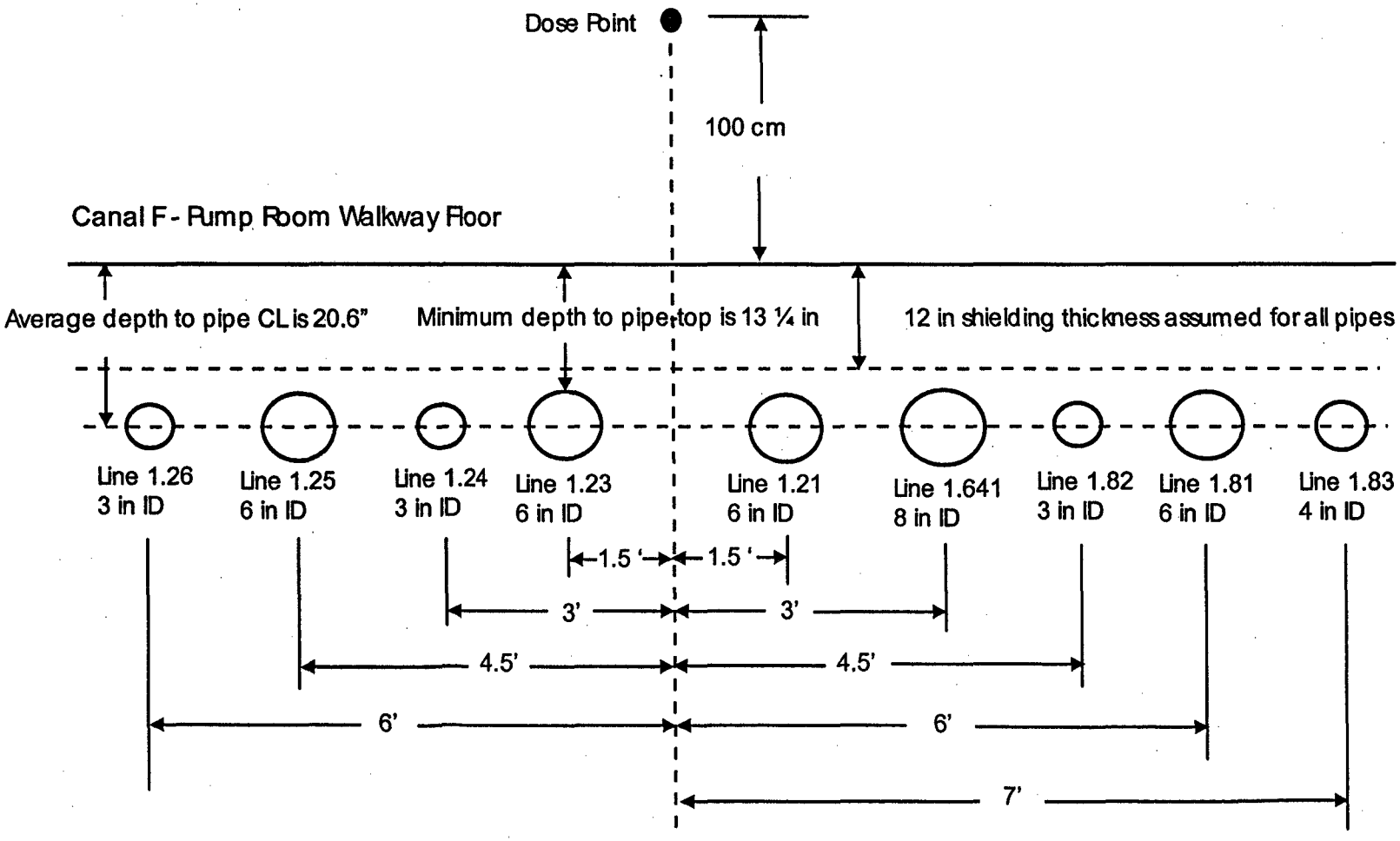


Figure C-2

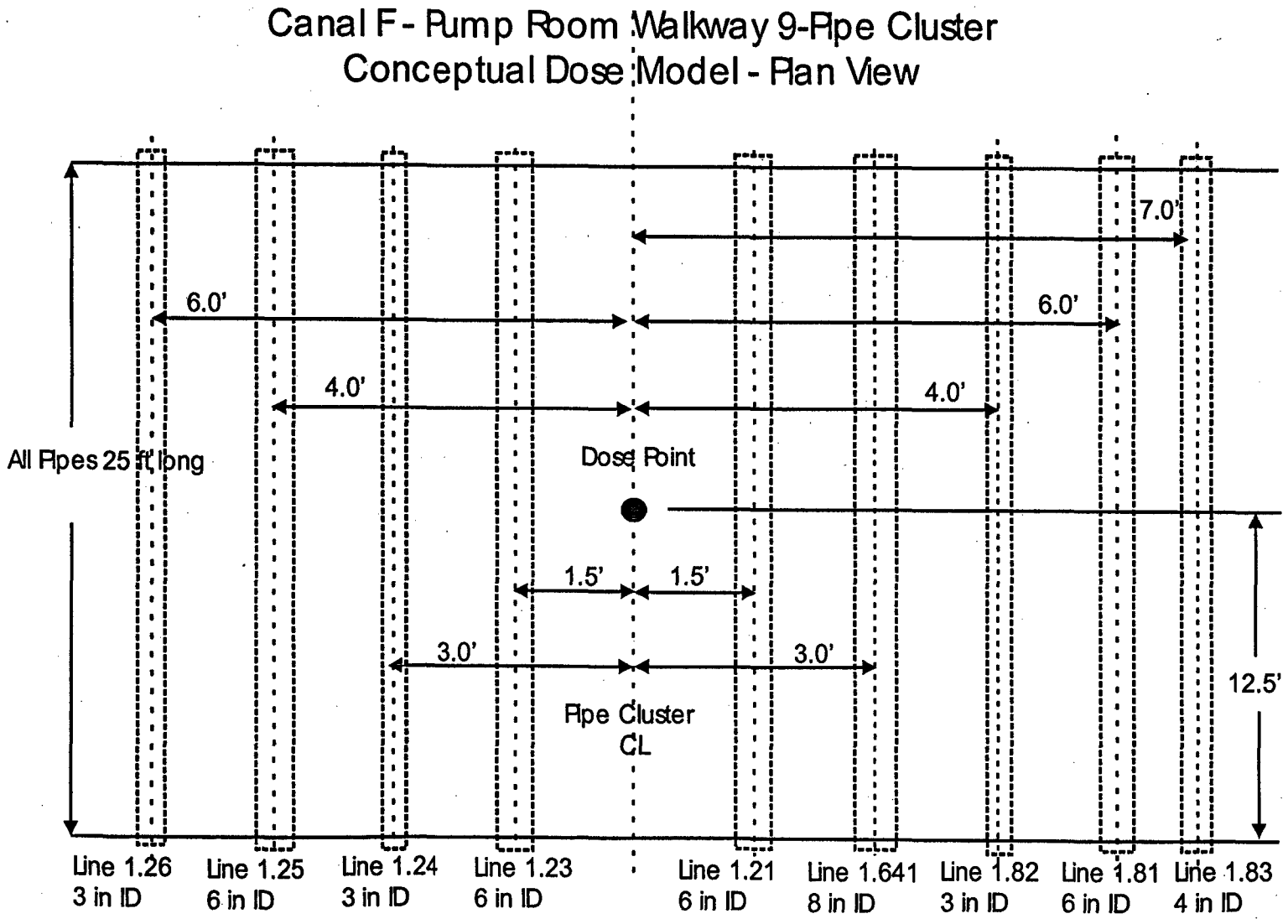

Canal F - Pump Room Walkway 9-Pipe Cluster
Conceptual Dose Model - Plan View
7.0'
6.0'
6.0'
4.0'
4.0'
All Pipes 25 ft long
Dose Point
1.5'
1.5'
3.0'
3.0'
12.5'
Pipe Cluster
CL
Line 1.26
3 in ID
Line 1.25
6 in ID
Line 1.24
3 in ID
Line 1.23
6 in ID
Line 1.21
6 in ID
Line 1.641
8 in ID
Line 1.82
3 in ID
Line 1.81
6 in ID
Line 1.83
4 in ID

Figure C-3

Layout for Dose Model of Reactor Building
Pump Room Quad and Canal Drain Manifold Pipe Trench
(Section View at Trench Wall showing Pipe-Ends)

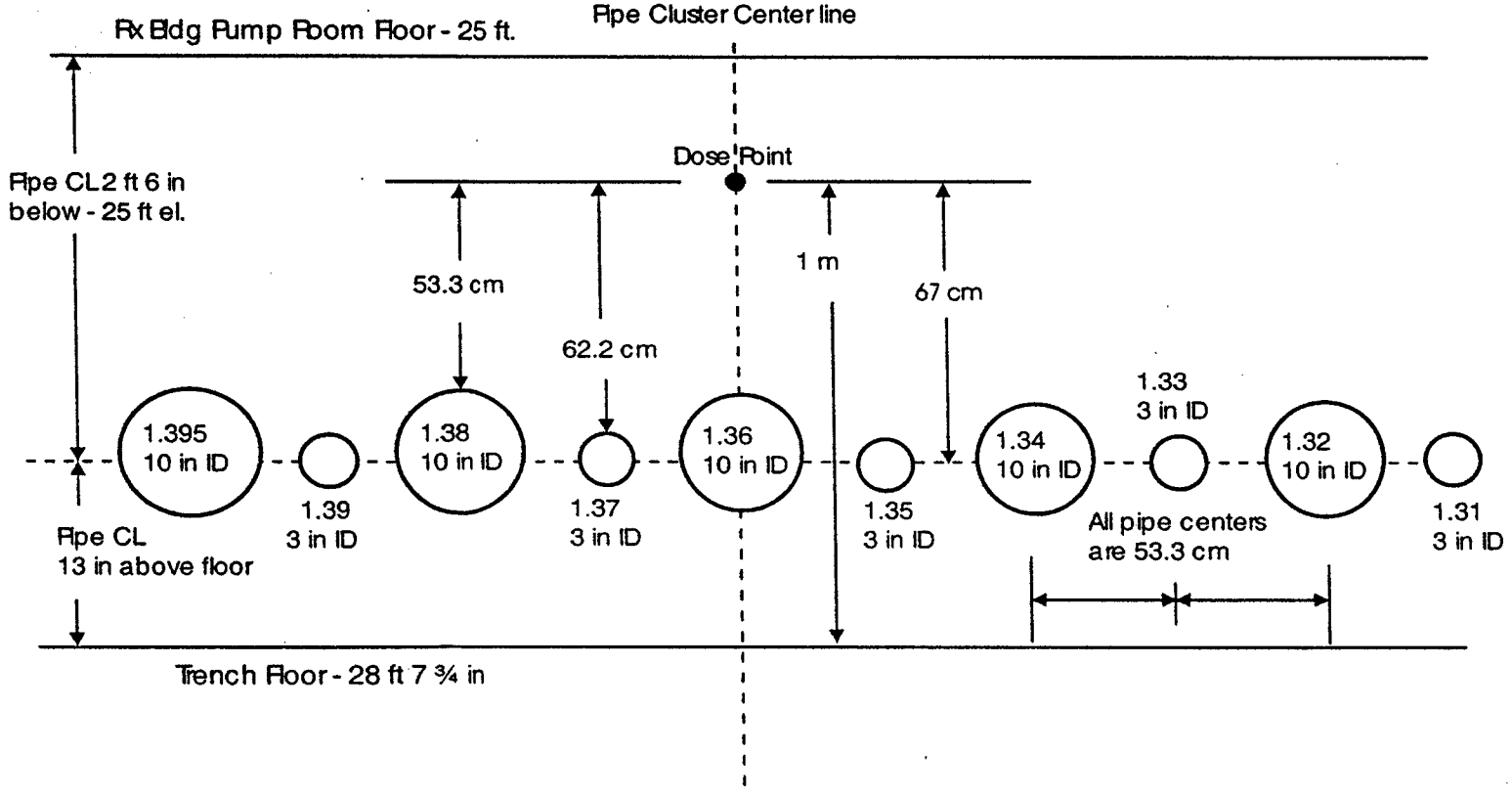


Figure C-4-

Pump Room Quad & Canal Drain Manifold Pipe Trench
Conceptual Dose Model - Plan View

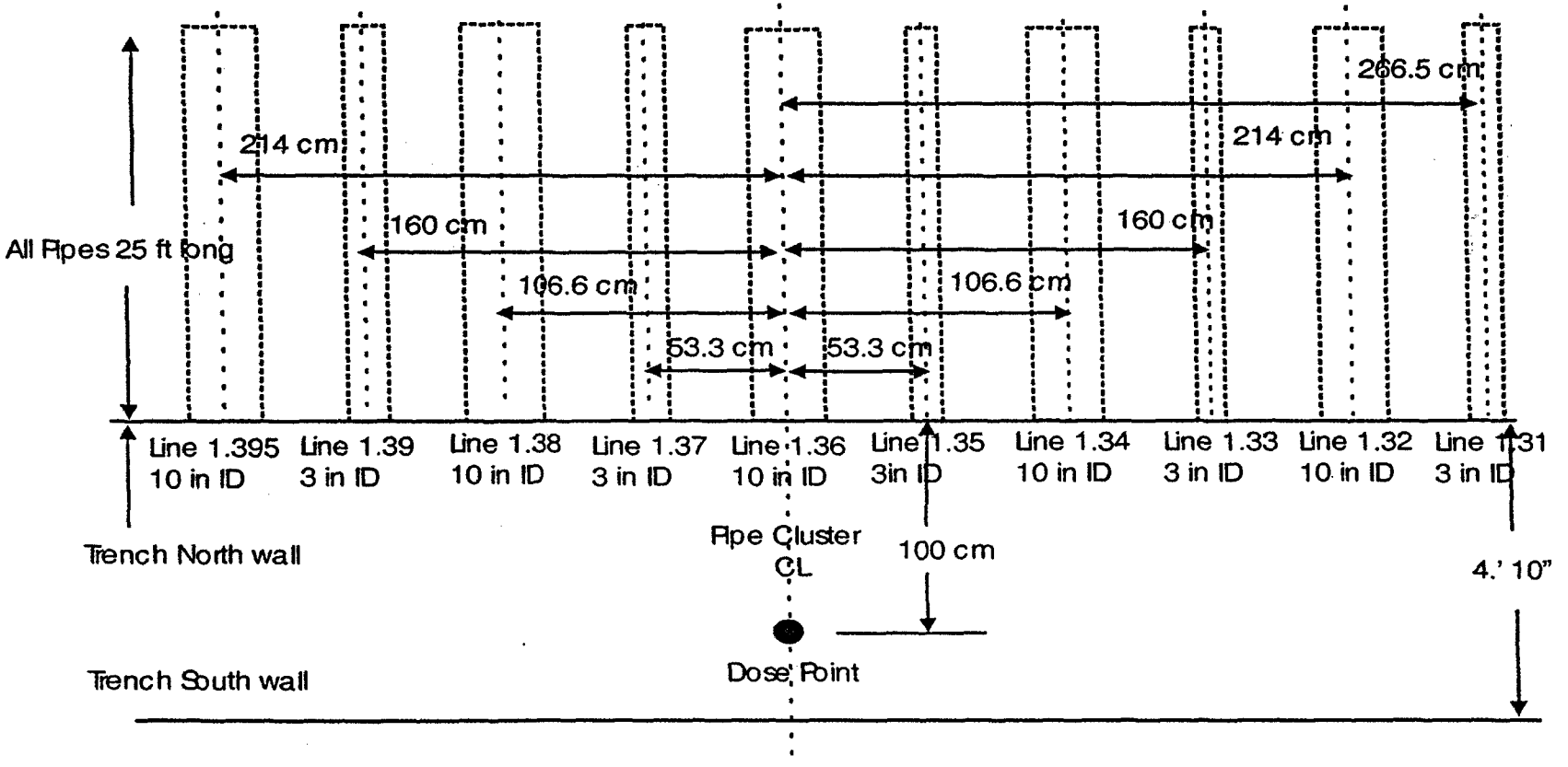
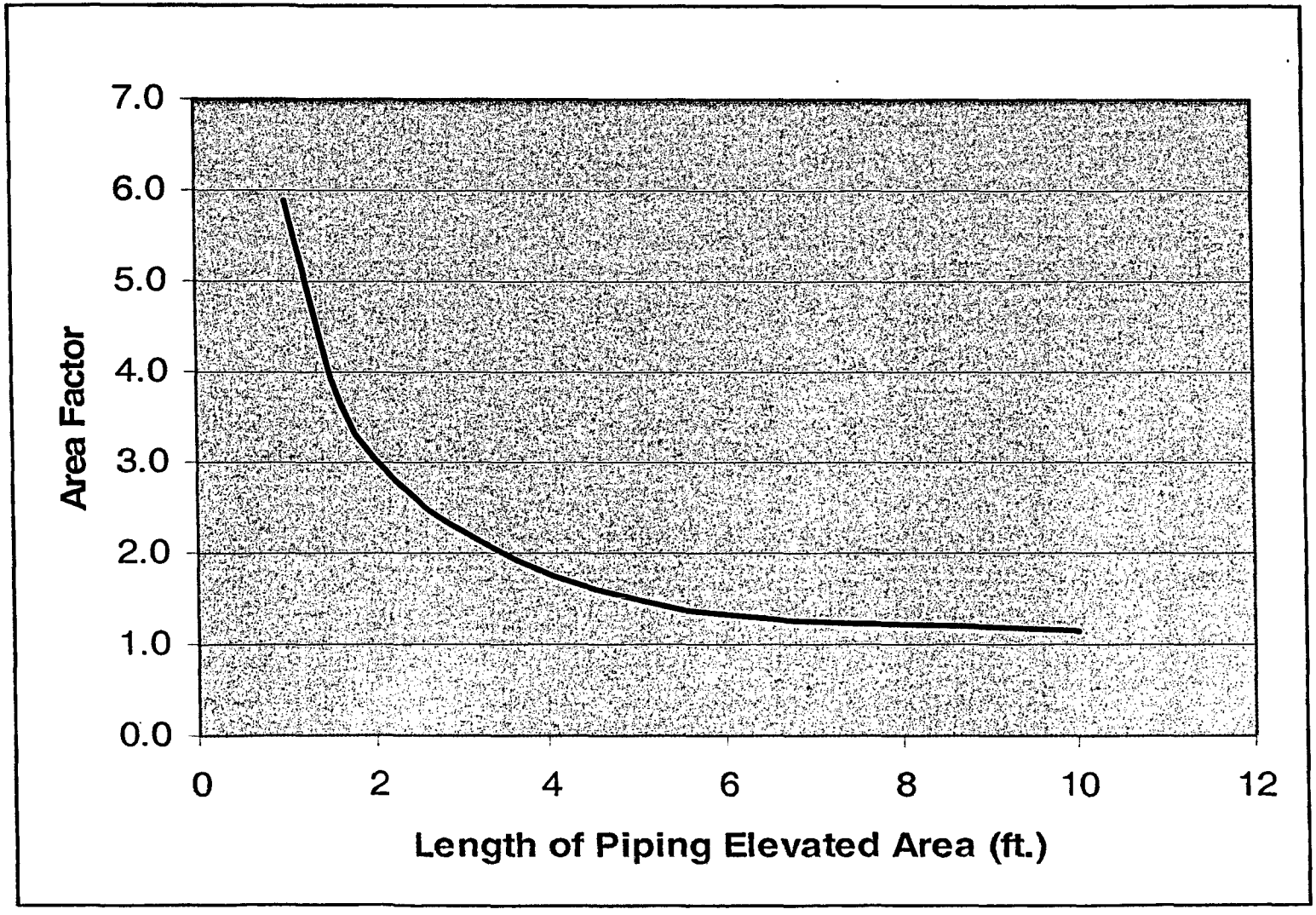


Figure C-5

Embedded Piping Area Factors



Final Status Survey Plan
For the
Plum Brook Reactor Facility

Attachment C
Embedded Piping Dose Assessment & DCGL Calculation

Addendum 1
MicroShield Case Run Reports for Canal F Pump Room Walkway Pipe Cluster

MicroShield Case Run Reports for Canal F - Pump Room Walkway Pipe Cluster

Index

Run Date	Case Title	Description	File Name	Result (mrem/hr)
12/19/2005	Line 1.21 A2	Revised Model DCGL Calc - Co-60 Unit Act w sched 40 & 12 in shld	PB121903	5.54E-10
12/21/2005	Line 1.21 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122101	3.90E-11
12/21/2005	Line 1.21 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122102	1.82E-10
12/21/2005	Line 1.21 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122103	2.50E-10
12/21/2005	Line 1.21 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122104	1.11E-10
12/21/2005	Line 1.21 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122105	1.58E-10
12/29/2005	Line 1.21 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122901	2.10E-35
1/4/2006	Line 1.21 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010401	5.55E-18
12/29/2005	Line 1.21 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122903	6.42E-11
12/29/2005	Line 1.21 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122904	1.84E-16
12/19/2005	Line 1.23 A2	Revised Model DCGL Calc - Co-60 Unit Act w sched 40 & 12 in shld	PB121907	5.54E-10
12/21/2005	Line 1.23 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122106	3.90E-11
12/21/2005	Line 1.23 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122107	1.82E-10
12/21/2005	Line 1.23 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122108	2.50E-10
12/21/2005	Line 1.23 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122109	1.11E-10
12/21/2005	Line 1.23 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122110	1.58E-10
12/29/2005	Line 1.23 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122905	2.10E-35
1/4/2006	Line 1.23 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010402	5.55E-18
12/29/2005	Line 1.23 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122907	6.42E-11
12/29/2005	Line 1.23 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122908	1.84E-16
12/19/2005	Line 1.24 A2	Revised Model DCGL Calc - Co-60 Unit Act w sched 40 & 12 in shld	PB121909	1.79E-10
12/21/2005	Line 1.24 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122111	1.08E-11
12/21/2005	Line 1.24 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122112	5.84E-11

MicroShield Case Run Reports for Canal F - Pump Room Walkway Pipe Cluster

Index

Run Date	Case Title	Description	File Name	Result (mrem/hr)
12/21/2005	Line 1.24 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122113	8.08E-11
12/21/2005	Line 1.24 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122114	3.13E-11
12/21/2005	Line 1.24 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122115	4.60E-11
12/29/2005	Line 1.24 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122909	9.09E-36
12/29/2005	Line 1.24 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB122910	2.89E-19
12/29/2005	Line 1.24 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122911	1.83E-11
1/4/2006	Line 1.24J	Revised Model Calc - EU-155 Unit Act w Sched 40 & 12 in conc shield	PB010403	1.53E-17
12/19/2005	Line 1.25 A2	Revised Model DCGL Calc - Co-60 Unit Act w sched 40 & 12 in shld	PB121911	8.64E-11
12/21/2005	Line 1.25 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122116	3.60E-12
12/21/2005	Line 1.25 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122117	2.79E-11
12/21/2005	Line 1.25 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122118	3.95E-11
12/21/2005	Line 1.25 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122119	1.10E-11
12/21/2005	Line 1.25 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122120	1.74E-11
12/29/2005	Line 1.25 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122913	1.43E-35
1/4/2006	Line 1.25 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010404	1.04E-20
12/29/2005	Line 1.25 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122915	6.58E-12
12/29/2005	Line 1.25 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122916	9.69E-19
12/19/2005	Line 1.26 A2	Revised Model Calc - Co-60 Unit Act w Sched 40 & 12 in conc shield	PB121913	1.76E-11
12/21/2005	Line 1.26 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122121	5.33E-13
12/21/2005	Line 1.26 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122122	5.68E-12
12/21/2005	Line 1.26 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122123	8.19E-12
12/21/2005	Line 1.26 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122124	1.71E-12
12/21/2005	Line 1.26 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122125	2.87E-12

MicroShield Case Run Reports for Canal F - Pump Room Walkway Pipe Cluster

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Run Date	Case Title	Description	File Name	Result (mrem/hr)
12/29/2005	Line 1.26 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122917	5.78E-36
1/4/2006	Line 1.26 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010405	1.08E-22
12/29/2005	Line 1.26 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122919	1.03E-12
12/29/2005	Line 1.26 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122920	2.04E-20
12/19/2005	Line 1.641 A2	Revised Model Calc - Co-60 Unit Act w Sched 40 & 12 in conc shield	PB121915	2.90E-10
12/21/2005	Line 1.641 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122126	1.64E-11
12/21/2005	Line 1.641 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122127	9.42E-11
12/21/2005	Line 1.641 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122128	1.31E-10
12/21/2005	Line 1.641 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122129	4.79E-11
12/21/2005	Line 1.641 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122130	7.11E-11
12/29/2005	Line 1.641 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122921	2.33E-35
1/4/2006	Line 1.641 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010406	4.96E-19
12/29/2005	Line 1.641 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122923	2.81E-11
12/29/2005	Line 1.641 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122924	2.49E-17
12/19/2005	Line 1.81 A2	Revised Model Calc - Co-60 Unit Act w Sched 40 & 12 in conc shield	PB121917	2.43E-11
12/21/2005	Line 1.81 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122131	7.02E-13
12/21/2005	Line 1.81 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122132	7.87E-12
12/21/2005	Line 1.81 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122133	1.14E-11
12/21/2005	Line 1.81 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122134	2.27E-12
12/21/2005	Line 1.81 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122135	3.83E-12
12/29/2005	Line 1.81 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122925	1.14E-35
1/4/2006	Line 1.81 H	Revised Model Calc - Sn-126 Sb-126) Unit Act w Sched 40 & 12 in conc shield	PB010407	1.35E-22
12/29/2005	Line 1.81 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122927	1.37E-12

MicroShield Case Run Reports for Canal F - Pump Room Walkway Pipe Cluster

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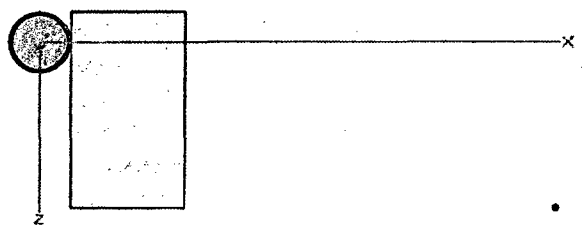
Run Date	Case Title	Description	File Name	Result (mrem/hr)
12/29/2005	Line 1.81 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122928	2.56E-20
12/19/2005	Line 1.82 A2	Revised Model Calc - Co-60 Unit Act w Sched 40 & 12 in conc shield	PB121919	6.12E-11
12/21/2005	Line 1.82 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122136	2.70E-12
12/21/2005	Line 1.82 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122137	1.97E-11
12/21/2005	Line 1.82 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122138	2.79E-11
12/21/2005	Line 1.82 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122139	8.16E-12
12/21/2005	Line 1.82 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122140	1.28E-11
12/29/2005	Line 1.82 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122929	7.29E-36
1/4/2006	Line 1.82 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010408	7.71E-21
12/29/2005	Line 1.82 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122931	4.87E-12
12/29/2005	Line 1.82 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122932	7.31E-19
12/19/2005	Line 1.83 A2	Revised Model Calc - Co-60 Unit Act w Sched 40 & 12 in conc shield	PB121921	8.29E-12
12/21/2005	Line 1.83 B	Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in conc shield	PB122141	1.87E-13
12/21/2005	Line 1.83 C	Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in conc shield	PB122142	2.71E-12
12/21/2005	Line 1.83 D	Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in conc shield	PB122143	3.97E-12
1/2/2006	Line 1.83 E	Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in conc shield	PB122144	6.32E-13
12/21/2005	Line 1.83 F	Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in conc shield	PB122145	1.11E-12
12/29/2005	Line 1.83 G	Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in conc shield	PB122933	6.59E-36
1/4/2006	Line 1.83 H	Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in conc shield	PB010409	5.32E-24
12/29/2005	Line 1.83 I	Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in conc shield	PB122935	3.82E-13
12/29/2005	Line 1.83 J	Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in conc shield	PB122936	1.67E-21

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DC ile : PB121903.MS5
Rur te : December 19, 2005
Run Time: 10:34:32 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.909e-04	3.041e-13	5.389e-12	5.872e-16	1.040e-14
1.1732	6.074e+00	1.656e-08	1.527e-07	2.959e-11	2.728e-10
1 3325	6.074e+00	2.723e-08	2.171e-07	4.723e-11	3.766e-10
1 ALS:	1.215e+01	4.378e-08	3.697e-07	7.682e-11	6.494e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121903.MS5
Case Title: Line 1.21 A2
This case was run on Monday, December 19, 2005 at 10:34:32 AM
Dose Point # 1 - (138.78,381,45.7) cm

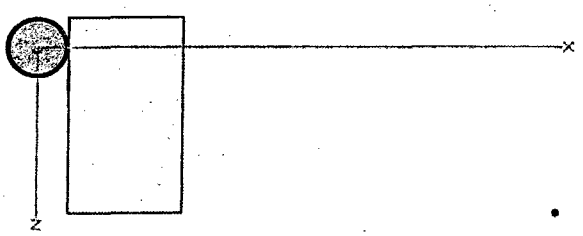
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.454e-008	2.930e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.378e-008	3.697e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.682e-011	6.494e-010
Absorbed Dose Rate in Air	mGy/hr	6.707e-013	5.670e-012
"	mrad/hr	6.707e-011	5.670e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.614e-013	6.438e-012
o Opposed	"	6.558e-013	5.542e-012
o Rotational	"	6.558e-013	5.542e-012
o Isotropic	"	5.858e-013	4.950e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.105e-013	6.854e-012
o Opposed	"	7.804e-013	6.598e-012
o Rotational	"	7.804e-013	6.598e-012
o Isotropic	"	6.206e-013	5.246e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.856e-013	5.797e-012
o Posterior/Anterior	"	6.316e-013	5.339e-012
o Lateral	"	5.024e-013	4.244e-012
o Rotational	"	5.687e-013	4.807e-012
o Isotropic	"	5.034e-013	4.253e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122101.MS5
Run Date : December 21, 2005
Run Time: 1:04:33 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 B
Description: Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ba-137m	1.5531e-010	5.7464e+000	4.2570e-009	1.5751e-004
Cs-137	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.190e-01	8.159e-60	1.246e-34	6.796e-62	1.038e-36
0.0322	2.195e-01	4.883e-58	2.389e-34	3.930e-60	1.923e-36
0.0364	7.987e-02	1.780e-45	1.331e-34	1.012e-47	7.564e-37
.516	5.171e+00	1.291e-09	2.431e-08	2.503e-12	4.713e-11

Page : 2
DOS File : PB122101.MS5
Run Date : December 21, 2005
Run Time: 1:04:33 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	5.589e+00	1.291e-09	2.431e-08	2.503e-12	4.713e-11

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122101.MS5
Case Title: Line 1.21 B
This case was run on Wednesday, December 21, 2005 at 1:04:33 PM
Dose Point # 1 - (138.78,381,45.7) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.952e-009	3.674e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.291e-009	2.431e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.503e-012	4.713e-011
Absorbed Dose Rate in Air	mGy/hr	2.186e-014	4.114e-013
"	mrad/hr	2.186e-012	4.114e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.588e-014	4.871e-013
o Opposed	"	2.072e-014	3.900e-013
o Rotational	"	2.072e-014	3.900e-013
o Isotropic	"	1.832e-014	3.449e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.750e-014	5.177e-013
o Opposed	"	2.612e-014	4.917e-013
o Rotational	"	2.612e-014	4.917e-013
o Isotropic	"	1.958e-014	3.687e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.288e-014	4.307e-013
o Posterior/Anterior	"	2.020e-014	3.802e-013
o Lateral	"	1.498e-014	2.819e-013
o Rotational	"	1.805e-014	3.397e-013
o Isotropic	"	1.536e-014	2.892e-013

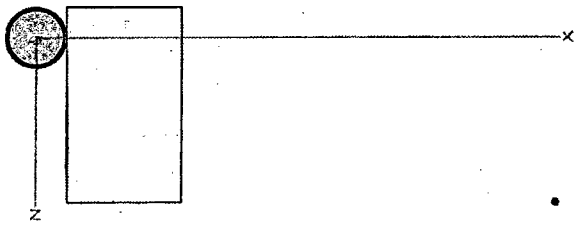
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122102.MS5
Ru ate : December 21, 2005
Run Time: 1:09:19 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 C
Description: Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-152	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	3.594e+00	1.418e-36	8.333e-33	6.272e-39	3.686e-35

Page : 2
DOS File : PB122102.MS5
Run Date : December 21, 2005
Run Time: 1:09:19 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	8.987e-01	3.132e-26	2.928e-25	8.342e-29	7.801e-28
0.1	1.727e+00	4.074e-15	2.024e-13	6.233e-18	3.096e-16
0.2	4.552e-01	3.440e-13	2.243e-11	6.072e-16	3.959e-14
0.3	1.642e+00	1.054e-11	5.126e-10	1.999e-14	9.723e-13
0.4	3.817e-01	9.797e-12	3.474e-10	1.909e-14	6.769e-13
0.5	3.426e-02	2.465e-12	6.636e-11	4.839e-15	1.303e-13
0.6	2.576e-01	4.189e-11	8.937e-10	8.176e-14	1.744e-12
0.8	1.082e+00	6.109e-10	9.029e-09	1.162e-12	1.717e-11
1.0	2.599e+00	3.719e-09	4.152e-08	6.855e-12	7.654e-11
1.5	1.409e+00	9.875e-09	6.928e-08	1.661e-11	1.166e-10
TOTALS:	1.408e+01	1.427e-08	1.217e-07	2.476e-11	2.138e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122102.MS5
Case Title: Line 1.21 C
This case was run on Wednesday, December 21, 2005 at 1:09:19 PM
Dose Point # 1 - (138.78,381,45.7) cm

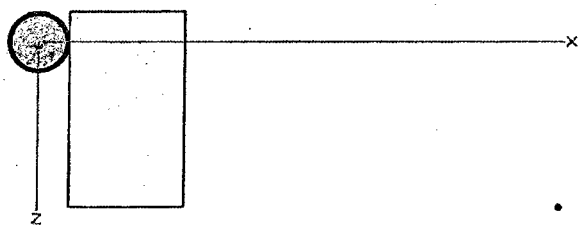
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.120e-008	1.033e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.427e-008	1.217e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.476e-011	2.138e-010
Absorbed Dose Rate in Air	mGy/hr	2.161e-013	1.867e-012
"	mrad/hr	2.161e-011	1.867e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.459e-013	2.131e-012
o Opposed	"	2.120e-013	1.824e-012
o Rotational	"	2.120e-013	1.824e-012
o Isotropic	"	1.895e-013	1.628e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.610e-013	2.265e-012
o Opposed	"	2.517e-013	2.180e-012
o Rotational	"	2.517e-013	2.180e-012
o Isotropic	"	2.002e-013	1.724e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.212e-013	1.914e-012
o Posterior/Anterior	"	2.039e-013	1.757e-012
o Lateral	"	1.626e-013	1.392e-012
o Rotational	"	1.837e-013	1.582e-012
o Isotropic	"	1.627e-013	1.396e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122103.MS5
Run Date : December 21, 2005
Run Time: 1:12:29 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 D
Description: Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-154	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	1.236e+00	4.878e-37	2.866e-33	2.158e-39	1.268e-35

Page : 2
DOS File : PB122103.MS5
Run Date : December 21, 2005
Run Time: 1:12:29 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	3.140e-01	1.094e-26	1.023e-25	2.915e-29	2.726e-28
0.1	2.458e+00	5.798e-15	2.880e-13	8.871e-18	4.406e-16
0.2	4.148e-01	3.136e-13	2.044e-11	5.534e-16	3.608e-14
0.4	4.334e-02	1.112e-12	3.944e-11	2.167e-15	7.685e-14
0.5	1.315e-02	9.463e-13	2.547e-11	1.857e-15	5.000e-14
0.6	4.900e-01	7.968e-11	1.700e-09	1.555e-13	3.318e-12
0.8	2.369e+00	1.338e-09	1.978e-08	2.545e-12	3.761e-11
1.0	1.869e+00	2.674e-09	2.985e-08	4.929e-12	5.503e-11
1.5	2.370e+00	1.661e-08	1.165e-07	2.795e-11	1.961e-10
TOTALS:	1.158e+01	2.070e-08	1.679e-07	3.558e-11	2.922e-10

icroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122103.MS5
Case Title: Line 1.21 D
This case was run on Wednesday, December 21, 2005 at 1:12:29 PM
Dose Point # 1 - (138.78,381,45.7) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.556e-008	1.353e-007
Photon Energy Fluence Rate	MeV/cm²/sec	2.070e-008	1.679e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.558e-011	2.922e-010
Absorbed Dose Rate in Air	mGy/hr	3.106e-013	2.551e-012
"	mrad/hr	3.106e-011	2.551e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.528e-013	2.906e-012
o Opposed	"	3.053e-013	2.499e-012
o Rotational	"	3.053e-013	2.499e-012
o Isotropic	"	2.733e-013	2.233e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.741e-013	3.085e-012
o Opposed	"	3.613e-013	2.974e-012
o Rotational	"	3.613e-013	2.974e-012
o Isotropic	"	2.883e-013	2.361e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.176e-013	2.612e-012
o Posterior/Anterior	"	2.934e-013	2.405e-012
o Lateral	"	2.351e-013	1.915e-012
o Rotational	"	2.646e-013	2.167e-012
o Isotropic	"	2.349e-013	1.916e-012

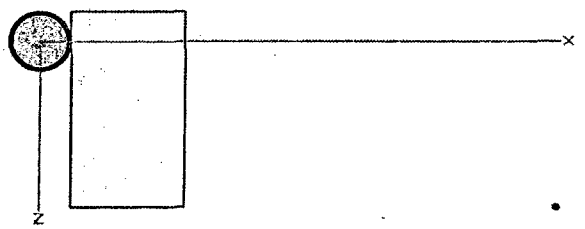
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122104.MS5
Run Date : December 21, 2005
Run Time: 1:21:22 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ag-108m	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	3.984e+00	3.590e-187	1.575e-33	1.244e-188	5.457e-35

Page : 2
DOS File : PB122104.MS5
Run Date : December 21, 2005
Run Time: 1:21:22 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.290e-06	3.735e-73	1.128e-39	3.702e-75	1.118e-41
0.08	4.305e-01	2.032e-17	6.656e-16	3.216e-20	1.053e-18
0.4	5.460e+00	1.401e-10	4.969e-09	2.730e-13	9.681e-12
0.6	5.491e+00	8.929e-10	1.905e-08	1.743e-12	3.719e-11
0.8	5.497e+00	3.105e-09	4.589e-08	5.906e-12	8.729e-11
TOTALS:	2.086e+01	4.138e-09	6.991e-08	7.922e-12	1.342e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122104.MS5
Case Title: Line 1.21 E
This case was run on Wednesday, December 21, 2005 at 1:21:22 PM
Dose Point # 1 - (138.78,381,45.7) cm

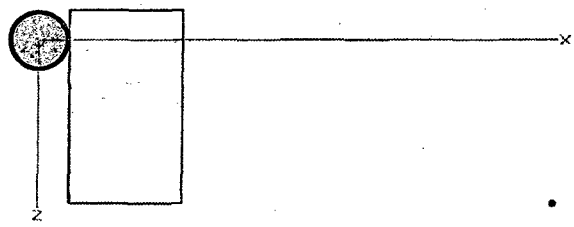
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	5.720e-009	1.015e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.138e-009	6.991e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.922e-012	1.342e-010
Absorbed Dose Rate in Air	mGy/hr	6.916e-014	1.171e-012
"	mrad/hr	6.916e-012	1.171e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.125e-014	1.382e-012
o Opposed	"	6.590e-014	1.114e-012
o Rotational	"	6.590e-014	1.114e-012
o Isotropic	"	5.826e-014	9.850e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.661e-014	1.470e-012
o Opposed	"	8.249e-014	1.399e-012
o Rotational	"	8.249e-014	1.399e-012
o Isotropic	"	6.233e-014	1.054e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.214e-014	1.225e-012
o Posterior/Anterior	"	6.419e-014	1.087e-012
o Lateral	"	4.818e-014	8.119e-013
o Rotational	"	5.739e-014	9.708e-013
o Isotropic	"	4.914e-014	8.297e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122105.MS5
Rl ate : December 21, 2005
Run Time: 1:23:24 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Nb-94	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	2.148e-03	2.567e-278	6.819e-37	1.386e-279	3.681e-38
0.0175	4.115e-03	1.690e-273	1.319e-36	8.951e-275	6.984e-38
0.0196	1.209e-03	3.203e-201	4.633e-37	1.182e-202	1.710e-38
0 7026	6.074e+00	1.969e-09	3.433e-08	3.797e-12	6.621e-11
711	6.074e+00	4.910e-09	6.513e-08	9.241e-12	1.226e-10

Page : 2
DOS File : PB122105.MS5
Run Date : December 21, 2005
Run Time: 1:23:24 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.216e+01	6.879e-09	9.946e-08	1.304e-11	1.888e-10

icroShield v5.04 (5.04-00362) **12/21/0!**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122105.MS5
Case Title: Line 1.21 F
This case was run on Wednesday, December 21, 2005 at 1:23:24 PM
Dose Point # 1 - (138.78,381,45.7) cm

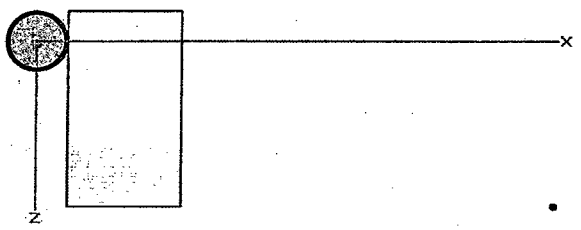
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.439e-009	1.236e-007
Photon Energy Fluence Rate	MeV/cm²/sec	6.879e-009	9.946e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.304e-011	1.888e-010
Absorbed Dose Rate in Air	mGy/hr	1.138e-013	1.648e-012
"	mrad/hr	1.138e-011	1.648e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.325e-013	1.920e-012
o Opposed	"	1.090e-013	1.577e-012
o Rotational	"	1.090e-013	1.577e-012
o Isotropic	"	9.639e-014	1.395e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.416e-013	2.052e-012
o Opposed	"	1.351e-013	1.958e-012
o Rotational	"	1.351e-013	1.958e-012
o Isotropic	"	1.031e-013	1.492e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.181e-013	1.710e-012
o Posterior/Anterior	"	1.059e-013	1.532e-012
o Lateral	"	8.040e-014	1.162e-012
o Rotational	"	9.477e-014	1.371e-012
o Isotropic	"	8.163e-014	1.180e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122901.MS5
Rt ate : December 29, 2005
Run Time: 2:03:16 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
I-129	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	1.212e+00	4.389e-70	1.007e-33	4.593e-72	1.054e-35
0.0298	2.249e+00	4.520e-68	1.925e-33	4.579e-70	1.951e-35
0.0336	7.995e-01	2.067e-52	1.005e-33	1.471e-54	7.150e-36
0 0396	4.568e-01	3.486e-38	1.022e-33	1.584e-40	4.643e-36

Page : 2
DOS File : PB122901.MS5
Run Date : December 29, 2005
Run Time: 2:03:16 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.718e+00	3.486e-38	4.959e-33	1.584e-40	4.184e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122901.MS5
Case Title: Line 1.21 G
This case was run on Thursday, December 29, 2005 at 2:03:16 PM
Dose Point # 1 - (138.78,381,45.7) cm

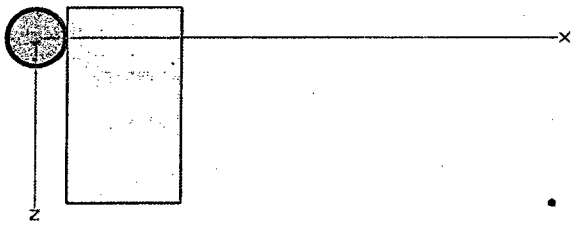
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.807e-037	1.546e-031
Photon Energy Fluence Rate	MeV/cm²/sec	3.486e-038	4.959e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.584e-040	4.184e-035
Absorbed Dose Rate in Air	mGy/hr	1.383e-042	3.652e-037
"	mrad/hr	1.383e-040	3.652e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.979e-042	4.181e-037
o Opposed	"	9.969e-043	2.097e-037
o Rotational	"	9.026e-043	1.789e-037
o Isotropic	"	8.635e-043	1.662e-037
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.991e-042	4.557e-037
o Opposed	"	1.375e-042	3.134e-037
o Rotational	"	1.375e-042	3.134e-037
o Isotropic	"	1.009e-042	2.316e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.154e-042	1.875e-037
o Posterior/Anterior	"	6.976e-043	9.692e-038
o Lateral	"	3.854e-043	5.231e-038
o Rotational	"	6.273e-043	9.630e-038
o Isotropic	"	5.142e-043	7.979e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010401.MS5
Run Date : January 4, 2006
Run Time: 7:40:17 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Sn-126	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.02	4.702e-01	4.237e-188	1.859e-34	1.468e-189	6.440e-36

Page : 2
DOS File : PB010401.MS5
Run Date : January 4, 2006
Run Time: 7:40:17 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.779e+00	5.151e-67	1.555e-33	5.105e-69	1.541e-35
0.04	3.034e-02	1.197e-38	7.035e-35	5.295e-41	3.111e-37
0.06	5.821e-01	1.833e-21	3.141e-20	3.640e-24	6.240e-23
0.08	2.789e+00	1.317e-16	4.313e-15	2.084e-19	6.825e-18
TOTALS:	5.650e+00	1.317e-16	4.313e-15	2.084e-19	6.825e-18

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010401.MS5
Case Title: Line 1.21 H
This case was run on Wednesday, January 4, 2006 at 7:40:17 AM
Dose Point # 1 - (138.78,381,45.7) cm

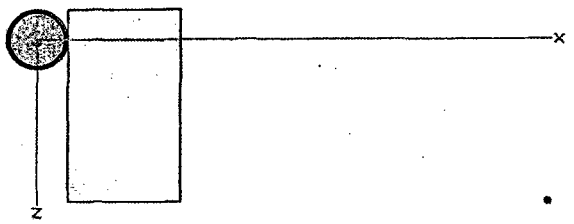
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.646e-015	5.391e-014
Photon Energy Fluence Rate	MeV/cm²/sec	1.317e-016	4.313e-015
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.084e-019	6.825e-018
Absorbed Dose Rate in Air	mGy/hr	1.819e-021	5.958e-020
"	mrad/hr	1.819e-019	5.958e-018
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.182e-021	1.042e-019
o Opposed	"	1.695e-021	5.551e-020
o Rotational	"	1.647e-021	5.395e-020
o Isotropic	"	1.636e-021	5.357e-020
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.153e-021	1.033e-019
o Opposed	"	2.317e-021	7.589e-020
o Rotational	"	2.317e-021	7.589e-020
o Isotropic	"	1.701e-021	5.570e-020
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.673e-021	8.753e-020
o Posterior/Anterior	"	2.039e-021	6.676e-020
o Lateral	"	1.256e-021	4.115e-020
o Rotational	"	1.736e-021	5.687e-020
o Isotropic	"	1.404e-021	4.600e-020

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122903.MS5
Run Date : December 29, 2005
Run Time: 2:10:45 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Zr-95	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	2.652e+00	9.792e-10	1.643e-08	1.883e-12	3.159e-11
0.7567	3.362e+00	1.499e-09	2.378e-08	2.869e-12	4.551e-11
TOTALS:	6.014e+00	2.478e-09	4.020e-08	4.751e-12	7.709e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122903.MS5
Case Title: Line 1.21 I
This case was run on Thursday, December 29, 2005 at 2:10:45 PM
Dose Point # 1 - (138.78,381,45.7) cm

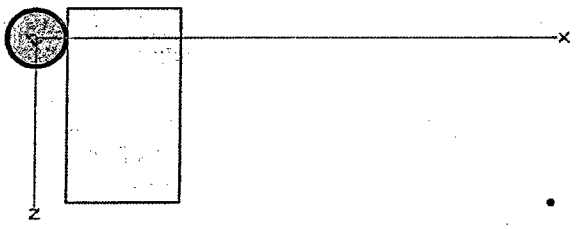
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.333e-009	5.410e-008
Photon Energy Fluence Rate	MeV/cm²/sec	2.478e-009	4.020e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.751e-012	7.709e-011
Absorbed Dose Rate in Air	mGy/hr	4.148e-014	6.730e-013
"	mrad/hr	4.148e-012	6.730e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.862e-014	7.890e-013
o Opposed	"	3.954e-014	6.416e-013
o Rotational	"	3.954e-014	6.416e-013
o Isotropic	"	3.495e-014	5.671e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.191e-014	8.423e-013
o Opposed	"	4.947e-014	8.026e-013
o Rotational	"	4.947e-014	8.026e-013
o Isotropic	"	3.740e-014	6.069e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.319e-014	7.007e-013
o Posterior/Anterior	"	3.846e-014	6.241e-013
o Lateral	"	2.892e-014	4.692e-013
o Rotational	"	3.440e-014	5.582e-013
o Isotropic	"	2.947e-014	4.782e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122904.MS5
Ru ate : December 29, 2005
Run Time: 2:13:27 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-155	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)3	1.933e-02	5.599e-69	1.690e-35	5.549e-71	1.675e-37

Page : 2
DOS File : PB122904.MS5
Run Date : December 29, 2005
Run Time: 2:13:27 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.101e+00	4.345e-37	2.553e-33	1.922e-39	1.129e-35
0.05	3.581e-01	1.248e-26	1.167e-25	3.324e-29	3.109e-28
0.06	7.878e-02	2.480e-22	4.251e-21	4.926e-25	8.444e-24
0.08	1.886e+00	8.905e-17	2.917e-15	1.409e-19	4.615e-18
0.1	1.256e+00	2.962e-15	1.471e-13	4.532e-18	2.251e-16
TOTALS:	4.699e+00	3.051e-15	1.501e-13	4.673e-18	2.297e-16

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122904.MS5
Case Title: Line 1.21 J
This case was run on Thursday, December 29, 2005 at 2:13:27 PM
Dose Point # 1 - (138.78,381,45.7) cm

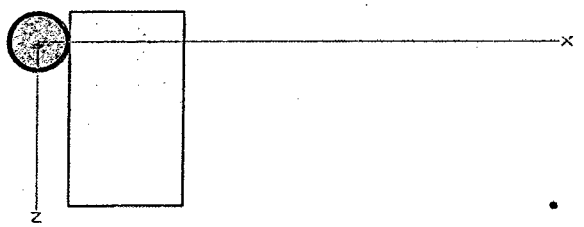
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.074e-014	1.508e-012
Photon Energy Fluence Rate	MeV/cm²/sec	3.051e-015	1.501e-013
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.673e-018	2.297e-016
Absorbed Dose Rate in Air	mGy/hr	4.079e-020	2.006e-018
"	mrad/hr	4.079e-018	2.006e-016
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.827e-020	3.355e-018
o Opposed	"	3.740e-020	1.839e-018
o Rotational	"	3.737e-020	1.838e-018
o Isotropic	"	3.619e-020	1.779e-018
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.782e-020	3.333e-018
o Opposed	"	5.254e-020	2.583e-018
o Rotational	"	5.254e-020	2.583e-018
o Isotropic	"	3.826e-020	1.881e-018
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.865e-020	2.883e-018
o Posterior/Anterior	"	4.595e-020	2.259e-018
o Lateral	"	2.836e-020	1.394e-018
o Rotational	"	3.925e-020	1.930e-018
o Isotropic	"	3.124e-020	1.535e-018

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
Data File : PB121907.MS5
Run Date : December 19, 2005
Run Time: 10:58:55 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Co-60	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.909e-04	3.041e-13	5.389e-12	5.872e-16	1.040e-14
1.1732	6.074e+00	1.656e-08	1.527e-07	2.959e-11	2.728e-10
1.3325	6.074e+00	2.723e-08	2.171e-07	4.723e-11	3.766e-10
TOTALS:	1.215e+01	4.378e-08	3.697e-07	7.682e-11	6.494e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121907.MS5
Case Title: Line 1.23 A2
This case was run on Monday, December 19, 2005 at 10:58:55 AM
Dose Point # 1 - (138.78,381,45.7) cm

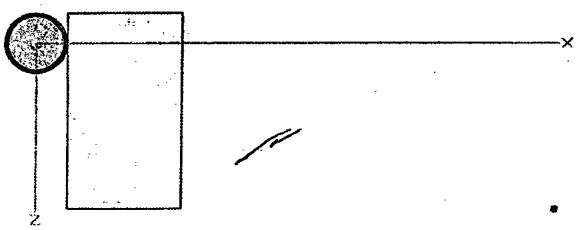
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.454e-008	2.930e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.378e-008	3.697e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.682e-011	6.494e-010
Absorbed Dose Rate in Air	mGy/hr	6.707e-013	5.670e-012
"	mrad/hr	6.707e-011	5.670e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.614e-013	6.438e-012
o Opposed	"	6.558e-013	5.542e-012
o Rotational	"	6.558e-013	5.542e-012
o Isotropic	"	5.858e-013	4.950e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.105e-013	6.854e-012
o Opposed	"	7.804e-013	6.598e-012
o Rotational	"	7.804e-013	6.598e-012
o Isotropic	"	6.206e-013	5.246e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.856e-013	5.797e-012
o Posterior/Anterior	"	6.316e-013	5.339e-012
o Lateral	"	5.024e-013	4.244e-012
o Rotational	"	5.687e-013	4.807e-012
o Isotropic	"	5.034e-013	4.253e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122106.MS5
Rt ate : December 21, 2005
Run Time: 1:29:02 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 B
Description: Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ba-137m	1.5531e-010	5.7464e+000	4.2570e-009	1.5751e-004
Cs-137	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.190e-01	8.159e-60	1.246e-34	6.796e-62	1.038e-36
0.0322	2.195e-01	4.883e-58	2.389e-34	3.930e-60	1.923e-36
0.0364	7.987e-02	1.780e-45	1.331e-34	1.012e-47	7.564e-37
516	5.171e+00	1.291e-09	2.431e-08	2.503e-12	4.713e-11

Page : 2
DOS File : PB122106.MS5
Run Date : December 21, 2005
Run Time: 1:29:02 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	5.589e+00	1.291e-09	2.431e-08	2.503e-12	4.713e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122106.MS5
Case Title: Line 1.23 B
This case was run on Wednesday, December 21, 2005 at 1:29:02 PM
Dose Point # 1 - (138.78,381,45.7) cm

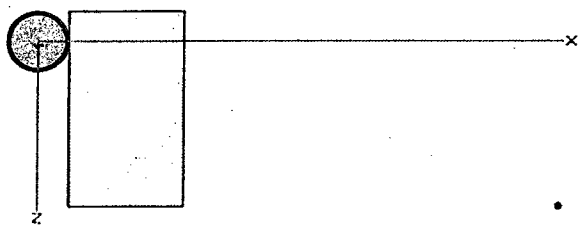
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.952e-009	3.674e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.291e-009	2.431e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.503e-012	4.713e-011
Absorbed Dose Rate in Air	mGy/hr	2.186e-014	4.114e-013
"	mrad/hr	2.186e-012	4.114e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.588e-014	4.871e-013
o Opposed	"	2.072e-014	3.900e-013
o Rotational	"	2.072e-014	3.900e-013
o Isotropic	"	1.832e-014	3.449e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.750e-014	5.177e-013
o Opposed	"	2.612e-014	4.917e-013
o Rotational	"	2.612e-014	4.917e-013
o Isotropic	"	1.958e-014	3.687e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.288e-014	4.307e-013
o Posterior/Anterior	"	2.020e-014	3.802e-013
o Lateral	"	1.498e-014	2.819e-013
o Rotational	"	1.805e-014	3.397e-013
o Isotropic	"	1.536e-014	2.892e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122107.MS5
Run Date : December 21, 2005
Run Time : 1:30:33 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 C
Description: Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-152	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	3.594e+00	1.418e-36	8.333e-33	6.272e-39	3.686e-35

Page : 2
DOS File : PB122107.MS5
Run Date : December 21, 2005
Run Time: 1:30:33 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	8.987e-01	3.132e-26	2.928e-25	8.342e-29	7.801e-28
0.1	1.727e+00	4.074e-15	2.024e-13	6.233e-18	3.096e-16
0.2	4.552e-01	3.440e-13	2.243e-11	6.072e-16	3.959e-14
0.3	1.642e+00	1.054e-11	5.126e-10	1.999e-14	9.723e-13
0.4	3.817e-01	9.797e-12	3.474e-10	1.909e-14	6.769e-13
0.5	3.426e-02	2.465e-12	6.636e-11	4.839e-15	1.303e-13
0.6	2.576e-01	4.189e-11	8.937e-10	8.176e-14	1.744e-12
0.8	1.082e+00	6.109e-10	9.029e-09	1.162e-12	1.717e-11
1.0	2.599e+00	3.719e-09	4.152e-08	6.855e-12	7.654e-11
1.5	1.409e+00	9.875e-09	6.928e-08	1.661e-11	1.166e-10
TOTALS:	1.408e+01	1.427e-08	1.217e-07	2.476e-11	2.138e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122107.MS5
Case Title: Line 1.23 C
This case was run on Wednesday, December 21, 2005 at 1:30:33 PM
Dose Point # 1 - (138.78,381,45.7) cm

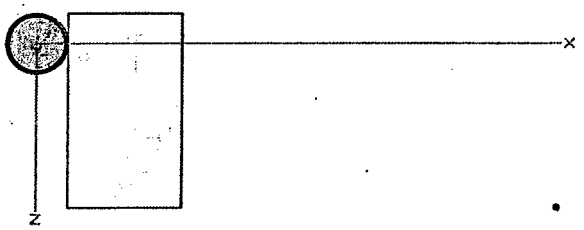
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.120e-008	1.033e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.427e-008	1.217e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.476e-011	2.138e-010
Absorbed Dose Rate in Air	mGy/hr	2.161e-013	1.867e-012
"	mrad/hr	2.161e-011	1.867e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.459e-013	2.131e-012
o Opposed	"	2.120e-013	1.824e-012
o Rotational	"	2.120e-013	1.824e-012
o Isotropic	"	1.895e-013	1.628e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.610e-013	2.265e-012
o Opposed	"	2.517e-013	2.180e-012
o Rotational	"	2.517e-013	2.180e-012
o Isotropic	"	2.002e-013	1.724e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.212e-013	1.914e-012
o Posterior/Anterior	"	2.039e-013	1.757e-012
o Lateral	"	1.626e-013	1.392e-012
o Rotational	"	1.837e-013	1.582e-012
o Isotropic	"	1.627e-013	1.396e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122108.MS5
Run Date : December 21, 2005
Run Time : 1:32:17 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 D
Description: Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-154	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	1.236e+00	4.878e-37	2.866e-33	2.158e-39	1.268e-35

Page : 2
DOS File : PB122108.MS5
Run Date : December 21, 2005
Run Time: 1:32:17 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	3.140e-01	1.094e-26	1.023e-25	2.915e-29	2.726e-28
0.1	2.458e+00	5.798e-15	2.880e-13	8.871e-18	4.406e-16
0.2	4.148e-01	3.136e-13	2.044e-11	5.534e-16	3.608e-14
0.4	4.334e-02	1.112e-12	3.944e-11	2.167e-15	7.685e-14
0.5	1.315e-02	9.463e-13	2.547e-11	1.857e-15	5.000e-14
0.6	4.900e-01	7.968e-11	1.700e-09	1.555e-13	3.318e-12
0.8	2.369e+00	1.338e-09	1.978e-08	2.545e-12	3.761e-11
1.0	1.869e+00	2.674e-09	2.985e-08	4.929e-12	5.503e-11
1.5	2.370e+00	1.661e-08	1.165e-07	2.795e-11	1.961e-10
TOTALS:	1.158e+01	2.070e-08	1.679e-07	3.558e-11	2.922e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122108.MS5
Case Title: Line 1.23 D
This case was run on Wednesday, December 21, 2005 at 1:32:17 PM
Dose Point # 1 - (138.78,381,45.7) cm

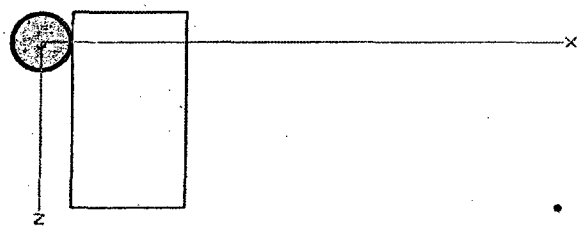
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.556e-008	1.353e-007
Photon Energy Fluence Rate	MeV/cm²/sec	2.070e-008	1.679e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.558e-011	2.922e-010
Absorbed Dose Rate in Air	mGy/hr	3.106e-013	2.551e-012
"	mrad/hr	3.106e-011	2.551e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.528e-013	2.906e-012
o Opposed	"	3.053e-013	2.499e-012
o Rotational	"	3.053e-013	2.499e-012
o Isotropic	"	2.733e-013	2.233e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.741e-013	3.085e-012
o Opposed	"	3.613e-013	2.974e-012
o Rotational	"	3.613e-013	2.974e-012
o Isotropic	"	2.883e-013	2.361e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.176e-013	2.612e-012
o Posterior/Anterior	"	2.934e-013	2.405e-012
o Lateral	"	2.351e-013	1.915e-012
o Rotational	"	2.646e-013	2.167e-012
o Isotropic	"	2.349e-013	1.916e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122109.MS5
Run Date : December 21, 2005
Run Time: 1:33:55 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 E
Description: Revised Model Calc - Ag-108m Unit Act w Sched 40 & 12 in Shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ag-108m	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
02	3.984e+00	3.590e-187	1.575e-33	1.244e-188	5.457e-35

Page : 2
DOS File : PB122109.MS5
Run Date : December 21, 2005
Run Time: 1:33:55 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.290e-06	3.735e-73	1.128e-39	3.702e-75	1.118e-41
0.08	4.305e-01	2.032e-17	6.656e-16	3.216e-20	1.053e-18
0.4	5.460e+00	1.401e-10	4.969e-09	2.730e-13	9.681e-12
0.6	5.491e+00	8.929e-10	1.905e-08	1.743e-12	3.719e-11
0.8	5.497e+00	3.105e-09	4.589e-08	5.906e-12	8.729e-11
TOTALS:	2.086e+01	4.138e-09	6.991e-08	7.922e-12	1.342e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122109.MS5
Case Title: Line 1.23 E
This case was run on Wednesday, December 21, 2005 at 1:33:55 PM
Dose Point # 1 - (138.78,381,45.7) cm

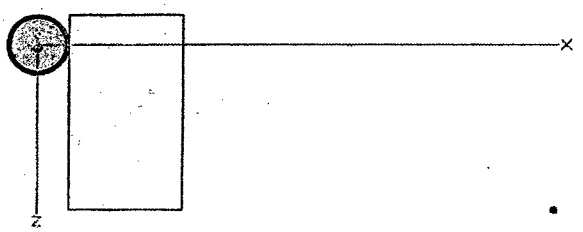
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	5.720e-009	1.015e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.138e-009	6.991e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.922e-012	1.342e-010
Absorbed Dose Rate in Air	mGy/hr	6.916e-014	1.171e-012
"	mrad/hr	6.916e-012	1.171e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.125e-014	1.382e-012
o Opposed	"	6.590e-014	1.114e-012
o Rotational	"	6.590e-014	1.114e-012
o Isotropic	"	5.826e-014	9.850e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.661e-014	1.470e-012
o Opposed	"	8.249e-014	1.399e-012
o Rotational	"	8.249e-014	1.399e-012
o Isotropic	"	6.233e-014	1.054e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.214e-014	1.225e-012
o Posterior/Anterior	"	6.419e-014	1.087e-012
o Lateral	"	4.818e-014	8.119e-013
o Rotational	"	5.739e-014	9.708e-013
o Isotropic	"	4.914e-014	8.297e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122110.MS5
Ru ate : December 21, 2005
Run Time: 1:35:45 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 F
Description: Revised Model Calc - Nb-94 Unit Act w Sched 40 & 12 in Shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Nb-94	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	2.148e-03	2.567e-278	6.819e-37	1.386e-279	3.681e-38
0.0175	4.115e-03	1.690e-273	1.319e-36	8.951e-275	6.984e-38
0.0196	1.209e-03	3.203e-201	4.633e-37	1.182e-202	1.710e-38
0 7026	6.074e+00	1.969e-09	3.433e-08	3.797e-12	6.621e-11
711	6.074e+00	4.910e-09	6.513e-08	9.241e-12	1.226e-10

Page : 2
DOS File : PB122110.MS5
Run Date : December 21, 2005
Run Time: 1:35:45 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.216e+01	6.879e-09	9.946e-08	1.304e-11	1.888e-10

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122110.MS5
Case Title: Line 1.23 F
This case was run on Wednesday, December 21, 2005 at 1:35:45 PM
Dose Point # 1 - (138.78,381,45.7) cm

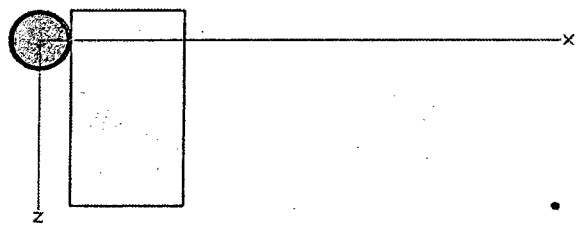
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.439e-009	1.236e-007
Photon Energy Fluence Rate	MeV/cm²/sec	6.879e-009	9.946e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.304e-011	1.888e-010
Absorbed Dose Rate in Air	mGy/hr	1.138e-013	1.648e-012
"	mrad/hr	1.138e-011	1.648e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.325e-013	1.920e-012
o Opposed	"	1.090e-013	1.577e-012
o Rotational	"	1.090e-013	1.577e-012
o Isotropic	"	9.639e-014	1.395e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.416e-013	2.052e-012
o Opposed	"	1.351e-013	1.958e-012
o Rotational	"	1.351e-013	1.958e-012
o Isotropic	"	1.031e-013	1.492e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.181e-013	1.710e-012
o Posterior/Anterior	"	1.059e-013	1.532e-012
o Lateral	"	8.040e-014	1.162e-012
o Rotational	"	9.477e-014	1.371e-012
o Isotropic	"	8.163e-014	1.180e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122905.MS5
Run Date : December 29, 2005
Run Time: 2:22:38 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 G
Description: Revised Model Calc - I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	1.212e+00	4.389e-70	1.007e-33	4.593e-72	1.054e-35
0.0298	2.249e+00	4.520e-68	1.925e-33	4.579e-70	1.951e-35
0.0336	7.995e-01	2.067e-52	1.005e-33	1.471e-54	7.150e-36
0.0396	4.568e-01	3.486e-38	1.022e-33	1.584e-40	4.643e-36

Page : 2
DOS File : PB122905.MS5
Run Date : December 29, 2005
Run Time: 2:22:38 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.718e+00	3.486e-38	4.959e-33	1.584e-40	4.184e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122905.MS5
Case Title: Line 1.23 G
This case was run on Thursday, December 29, 2005 at 2:22:38 PM
Dose Point # 1 - (138.78,381,45.7) cm

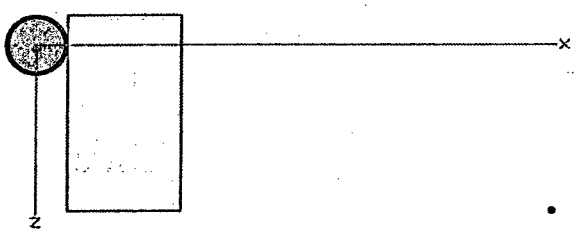
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.807e-037	1.546e-031
Photon Energy Fluence Rate	MeV/cm²/sec	3.486e-038	4.959e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.584e-040	4.184e-035
Absorbed Dose Rate in Air	mGy/hr	1.383e-042	3.652e-037
"	mrad/hr	1.383e-040	3.652e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.979e-042	4.181e-037
o Opposed	"	9.969e-043	2.097e-037
o Rotational	"	9.026e-043	1.789e-037
o Isotropic	"	8.635e-043	1.662e-037
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.991e-042	4.557e-037
o Opposed	"	1.375e-042	3.134e-037
o Rotational	"	1.375e-042	3.134e-037
o Isotropic	"	1.009e-042	2.316e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.154e-042	1.875e-037
o Posterior/Anterior	"	6.976e-043	9.692e-038
o Lateral	"	3.854e-043	5.231e-038
o Rotational	"	6.273e-043	9.630e-038
o Isotropic	"	5.142e-043	7.979e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010402.MS5
Run Date : January 4, 2006
Run Time: 7:55:14 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 H
Description: Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Sn-126	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
02	4.702e-01	4.237e-188	1.859e-34	1.468e-189	6.440e-36

Page : 2
DOS File : PB010402.MS5
Run Date : January 4, 2006
Run Time: 7:55:14 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.779e+00	5.151e-67	1.555e-33	5.105e-69	1.541e-35
0.04	3.034e-02	1.197e-38	7.035e-35	5.295e-41	3.111e-37
0.06	5.821e-01	1.833e-21	3.141e-20	3.640e-24	6.240e-23
0.08	2.789e+00	1.317e-16	4.313e-15	2.084e-19	6.825e-18
TOTALS:	5.650e+00	1.317e-16	4.313e-15	2.084e-19	6.825e-18

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010402.MS5
Case Title: Line 1.23 H
This case was run on Wednesday, January 4, 2006 at 7:55:14 AM
Dose Point # 1 - (138.78,381,45.7) cm

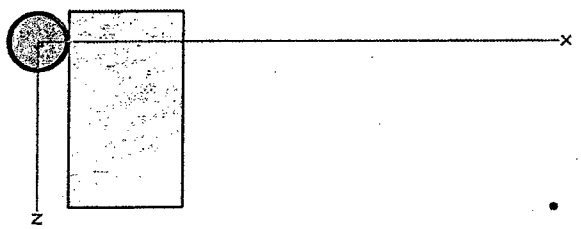
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.646e-015	5.391e-014
Photon Energy Fluence Rate	MeV/cm²/sec	1.317e-016	4.313e-015
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.084e-019	6.825e-018
Absorbed Dose Rate in Air	mGy/hr	1.819e-021	5.958e-020
"	mrad/hr	1.819e-019	5.958e-018
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.182e-021	1.042e-019
o Opposed	"	1.695e-021	5.551e-020
o Rotational	"	1.647e-021	5.395e-020
o Isotropic	"	1.636e-021	5.357e-020
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.153e-021	1.033e-019
o Opposed	"	2.317e-021	7.589e-020
o Rotational	"	2.317e-021	7.589e-020
o Isotropic	"	1.701e-021	5.570e-020
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.673e-021	8.753e-020
o Posterior/Anterior	"	2.039e-021	6.676e-020
o Lateral	"	1.256e-021	4.115e-020
o Rotational	"	1.736e-021	5.687e-020
o Isotropic	"	1.404e-021	4.600e-020

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122907.MS5
Rt ate : December 29, 2005
Run Time: 2:27:29 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 I
Description: Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Zr-95	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	2.652e+00	9.792e-10	1.643e-08	1.883e-12	3.159e-11
0.7567	3.362e+00	1.499e-09	2.378e-08	2.869e-12	4.551e-11
TOTALS:	6.014e+00	2.478e-09	4.020e-08	4.751e-12	7.709e-11

MicroShield v5.04 (5.04-00362) **12/29/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122907.MS5
Case Title: Line 1.23 I
This case was run on Thursday, December 29, 2005 at 2:27:29 PM
Dose Point # 1 - (138.78,381,45.7) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.333e-009	5.410e-008
Photon Energy Fluence Rate	MeV/cm²/sec	2.478e-009	4.020e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.751e-012	7.709e-011
Absorbed Dose Rate in Air	mGy/hr	4.148e-014	6.730e-013
"	mrad/hr	4.148e-012	6.730e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.862e-014	7.890e-013
o Opposed	"	3.954e-014	6.416e-013
o Rotational	"	3.954e-014	6.416e-013
o Isotropic	"	3.495e-014	5.671e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.191e-014	8.423e-013
o Opposed	"	4.947e-014	8.026e-013
o Rotational	"	4.947e-014	8.026e-013
o Isotropic	"	3.740e-014	6.069e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.319e-014	7.007e-013
o Posterior/Anterior	"	3.846e-014	6.241e-013
o Lateral	"	2.892e-014	4.692e-013
o Rotational	"	3.440e-014	5.582e-013
o Isotropic	"	2.947e-014	4.782e-013

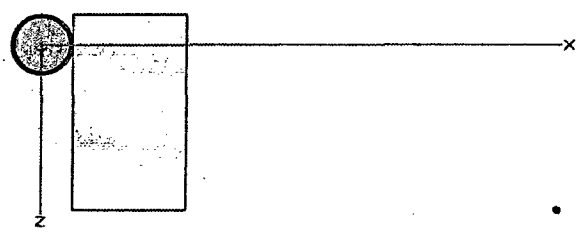
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122908.MS5
Run Date : December 29, 2005
Run Time: 2:29:31 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 J
Description: Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	45.7 cm
	4 ft 6.6 in	12 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-155	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)3	1.933e-02	5.599e-69	1.690e-35	5.549e-71	1.675e-37

Page : 2
DOS File : PB122908.MS5
Run Date : December 29, 2005
Run Time: 2:29:31 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.101e+00	4.345e-37	2.553e-33	1.922e-39	1.129e-35
0.05	3.581e-01	1.248e-26	1.167e-25	3.324e-29	3.109e-28
0.06	7.878e-02	2.480e-22	4.251e-21	4.926e-25	8.444e-24
0.08	1.886e+00	8.905e-17	2.917e-15	1.409e-19	4.615e-18
0.1	1.256e+00	2.962e-15	1.471e-13	4.532e-18	2.251e-16
TOTALS:	4.699e+00	3.051e-15	1.501e-13	4.673e-18	2.297e-16

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122908.MS5
Case Title: Line 1.23 J
This case was run on Thursday, December 29, 2005 at 2:29:31 PM
Dose Point # 1 - (138.78,381,45.7) cm

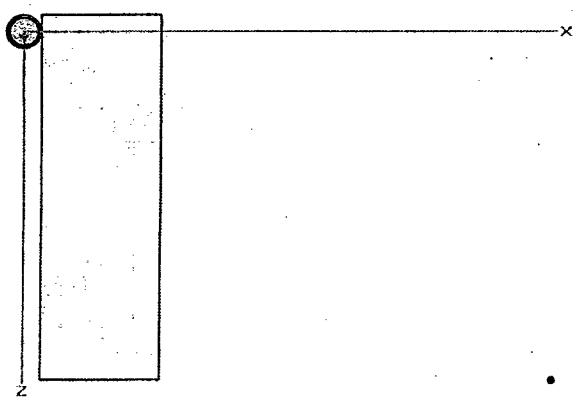
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.074e-014	1.508e-012
Photon Energy Fluence Rate	MeV/cm²/sec	3.051e-015	1.501e-013
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.673e-018	2.297e-016
Absorbed Dose Rate in Air	mGy/hr	4.079e-020	2.006e-018
"	mrad/hr	4.079e-018	2.006e-016
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.827e-020	3.355e-018
o Opposed	"	3.740e-020	1.839e-018
o Rotational	"	3.737e-020	1.838e-018
o Isotropic	"	3.619e-020	1.779e-018
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.782e-020	3.333e-018
o Opposed	"	5.254e-020	2.583e-018
o Rotational	"	5.254e-020	2.583e-018
o Isotropic	"	3.826e-020	1.881e-018
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.865e-020	2.883e-018
o Posterior/Anterior	"	4.595e-020	2.259e-018
o Lateral	"	2.836e-020	1.394e-018
o Rotational	"	3.925e-020	1.930e-018
o Isotropic	"	3.124e-020	1.535e-018

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
D(ile : PB121909.MS5
Rur te : December 19, 2005
Run ime: 11:05:13 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	4.954e-04	7.277e-14	1.510e-12	1.405e-16	2.916e-15
1.1732	3.037e+00	4.717e-09	4.857e-08	8.429e-12	8.679e-11
1.3325	3.037e+00	8.038e-09	7.095e-08	1.395e-11	1.231e-10
T ALS:	6.075e+00	1.275e-08	1.195e-07	2.237e-11	2.099e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121909.MS5
Case Title: Line 1.24 A2
This case was run on Monday, December 19, 2005 at 11:05:13 AM
Dose Point # 1 - (134.97,381,91.44) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.005e-008	9.464e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.275e-008	1.195e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.237e-011	2.099e-010
Absorbed Dose Rate in Air	mGy/hr	1.953e-013	1.832e-012
"	mrad/hr	1.953e-011	1.832e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.217e-013	2.080e-012
o Opposed	"	1.910e-013	1.791e-012
o Rotational	"	1.910e-013	1.791e-012
o Isotropic	"	1.706e-013	1.600e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.360e-013	2.215e-012
o Opposed	"	2.273e-013	2.132e-012
o Rotational	"	2.273e-013	2.132e-012
o Isotropic	"	1.808e-013	1.695e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.997e-013	1.873e-012
o Posterior/Anterior	"	1.840e-013	1.725e-012
o Lateral	"	1.463e-013	1.372e-012
o Rotational	"	1.657e-013	1.554e-012
o Isotropic	"	1.466e-013	1.375e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122111.MS5
Ru te : December 21, 2005
Run ime: 1:45:09 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 B
Description: Revised Model Calc. - Cs-137 Unit Act w Sched 40 & 12 in Shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ba-137m	7.7654e-011	2.8732e+000	4.2570e-009	1.5751e-004
Cs-137	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	5.948e-02	1.933e-65	5.403e-35	1.610e-67	4.500e-37
0.0322	1.097e-01	1.659e-63	1.036e-34	1.335e-65	8.337e-37
0.0364	3.994e-02	1.318e-49	5.773e-35	7.489e-52	3.280e-37
0.616	2.585e+00	3.035e-10	6.721e-09	5.884e-13	1.303e-11

Page : 2
DOS File : PB122111.MS5
Run Date : December 21, 2005
Run Time: 1:45:09 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.794e+00	3.035e-10	6.721e-09	5.884e-13	1.303e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122111.MS5
Case Title: Line 1.24 B
This case was run on Wednesday, December 21, 2005 at 1:45:09 PM
Dose Point # 1 - (134.97,381,91.44) cm

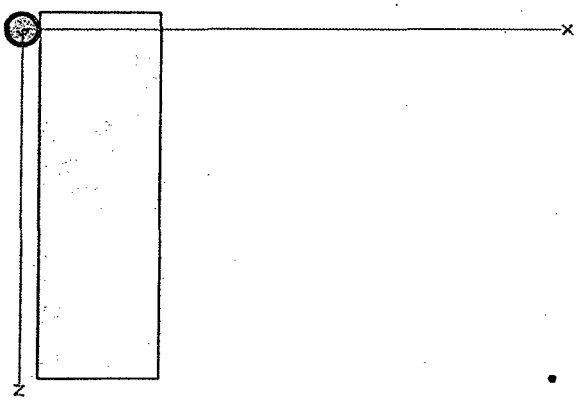
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.587e-010	1.016e-008
Photon Energy Fluence Rate	MeV/cm²/sec	3.035e-010	6.721e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.884e-013	1.303e-011
Absorbed Dose Rate in Air	mGy/hr	5.137e-015	1.137e-013
"	mrad/hr	5.137e-013	1.137e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.082e-015	1.347e-013
o Opposed	"	4.869e-015	1.078e-013
o Rotational	"	4.869e-015	1.078e-013
o Isotropic	"	4.306e-015	9.534e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.464e-015	1.431e-013
o Opposed	"	6.139e-015	1.359e-013
o Rotational	"	6.139e-015	1.359e-013
o Isotropic	"	4.603e-015	1.019e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.378e-015	1.191e-013
o Posterior/Anterior	"	4.747e-015	1.051e-013
o Lateral	"	3.520e-015	7.794e-014
o Rotational	"	4.242e-015	9.392e-014
o Isotropic	"	3.611e-015	7.996e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122112.MS5
Run Date : December 21, 2005
Run Time: 1:48:57 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 C
Description: Revised Model Calc. - Eu-152 Unit Act w Sched 40 & 12 in Shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-152	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	1.797e+00	5.750e-40	3.614e-33	2.543e-42	1.598e-35

Page : 2
DOS File : PB122112.MS5
Run Date : December 21, 2005
Run Time: 1:48:57 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	4.493e-01	1.622e-28	1.584e-27	4.320e-31	4.220e-30
0.1	8.635e-01	2.796e-16	1.693e-14	4.278e-19	2.591e-17
0.2	2.276e-01	4.533e-14	3.792e-12	8.001e-17	6.693e-15
0.3	8.212e-01	1.744e-12	1.067e-10	3.309e-15	2.025e-13
0.4	1.909e-01	1.864e-12	8.121e-11	3.632e-15	1.582e-13
0.5	1.713e-02	5.178e-13	1.678e-11	1.016e-15	3.293e-14
0.6	1.288e-01	9.480e-12	2.399e-10	1.850e-14	4.682e-13
0.8	5.408e-01	1.539e-10	2.629e-09	2.927e-13	5.001e-12
1.0	1.300e+00	1.009e-09	1.275e-08	1.860e-12	2.350e-11
1.5	7.046e-01	3.006e-09	2.317e-08	5.058e-12	3.898e-11
TOTALS:	7.040e+00	4.183e-09	3.899e-08	7.238e-12	6.835e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122112.MS5
Case Title: Line 1.24 C
This case was run on Wednesday, December 21, 2005 at 1:48:57 PM
Dose Point # 1 - (134.97,381,91.44) cm

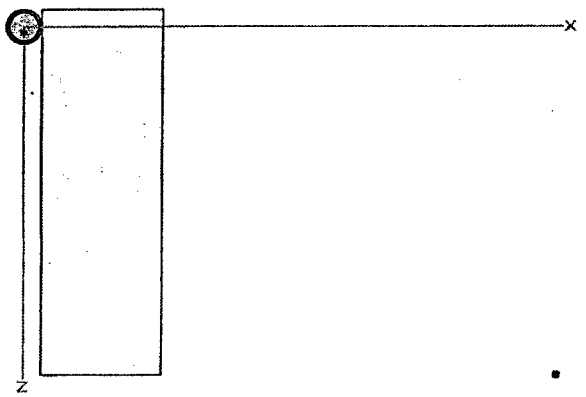
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.233e-009	3.249e-008
Photon Energy Fluence Rate	MeV/cm²/sec	4.183e-009	3.899e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.238e-012	6.835e-011
Absorbed Dose Rate in Air	mGy/hr	6.319e-014	5.967e-013
"	mrad/hr	6.319e-012	5.967e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.183e-014	6.805e-013
o Opposed	"	6.201e-014	5.835e-013
o Rotational	"	6.201e-014	5.835e-013
o Isotropic	"	5.545e-014	5.209e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.624e-014	7.232e-013
o Opposed	"	7.355e-014	6.963e-013
o Rotational	"	7.355e-014	6.963e-013
o Isotropic	"	5.858e-014	5.515e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.464e-014	6.116e-013
o Posterior/Anterior	"	5.963e-014	5.620e-013
o Lateral	"	4.764e-014	4.458e-013
o Rotational	"	5.375e-014	5.060e-013
o Isotropic	"	4.764e-014	4.468e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122113.MS5
Run Date : December 21, 2005
Run Time: 1:50:31 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 D
Description: Revised Model Calc. - Eu-154 Unit Act w Sched 40 & 12 in Shl
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-154	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	6.181e-01	1.978e-40	1.243e-33	8.748e-43	5.497e-36

Page : 2
DOS File : PB122113.MS5
Run Date : December 21, 2005
Run Time: 1:50:31 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.570e-01	5.666e-29	5.536e-28	1.509e-31	1.475e-30
0.1	1.229e+00	3.980e-16	2.410e-14	6.089e-19	3.687e-17
0.2	2.074e-01	4.131e-14	3.456e-12	7.292e-17	6.099e-15
0.4	2.167e-02	2.117e-13	9.220e-12	4.124e-16	1.796e-14
0.5	6.576e-03	1.988e-13	6.440e-12	3.901e-16	1.264e-14
0.6	2.450e-01	1.803e-11	4.563e-10	3.519e-14	8.906e-13
0.8	1.184e+00	3.371e-10	5.759e-09	6.411e-13	1.095e-11
1.0	9.343e-01	7.256e-10	9.166e-09	1.337e-12	1.690e-11
1.5	1.185e+00	5.057e-09	3.897e-08	8.508e-12	6.557e-11
TOTALS:	5.789e+00	6.138e-09	5.437e-08	1.052e-11	9.434e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122113.MS5
Case Title: Line 1.24 D
This case was run on Wednesday, December 21, 2005 at 1:50:31 PM
Dose Point # 1 - (134.97,381,91.44) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.549e-009	4.316e-008
Photon Energy Fluence Rate	MeV/cm²/sec	6.138e-009	5.437e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.052e-011	9.434e-011
Absorbed Dose Rate in Air	mGy/hr	9.186e-014	8.236e-013
"	mrad/hr	9.186e-012	8.236e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.043e-013	9.376e-013
o Opposed	"	9.036e-014	8.075e-013
o Rotational	"	9.036e-014	8.075e-013
o Isotropic	"	8.090e-014	7.218e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.106e-013	9.952e-013
o Opposed	"	1.068e-013	9.598e-013
o Rotational	"	1.068e-013	9.598e-013
o Isotropic	"	8.533e-014	7.628e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	9.389e-014	8.432e-013
o Posterior/Anterior	"	8.680e-014	7.767e-013
o Lateral	"	6.966e-014	6.193e-013
o Rotational	"	7.831e-014	7.001e-013
o Isotropic	"	6.957e-014	6.197e-013

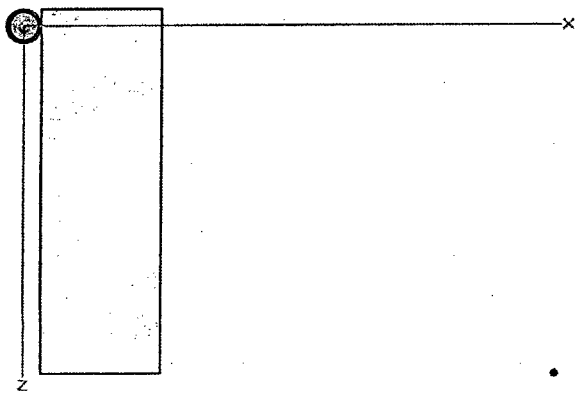
Page

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122114.MS5
Ru ate : December 21, 2005
Run Time: 2:10:25 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 E
Description: Revised Model Calc Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ag-108m	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	1.992e+00	1.913e-206	6.831e-34	6.626e-208	2.366e-35

Page : 2
DOS File : PB122114.MS5
Run Date : December 21, 2005
Run Time: 2:10:25 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	6.449e-07	1.192e-79	4.890e-40	1.182e-81	4.846e-42
0.08	2.152e-01	9.096e-19	3.469e-17	1.439e-21	5.489e-20
0.4	2.730e+00	2.666e-11	1.161e-09	5.195e-14	2.263e-12
0.6	2.745e+00	2.021e-10	5.113e-09	3.944e-13	9.981e-12
0.8	2.749e+00	7.822e-10	1.336e-08	1.488e-12	2.542e-11
TOTALS:	1.043e+01	1.011e-09	1.964e-08	1.934e-12	3.766e-11

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122114.MS5
Case Title: Line 1.24 E
This case was run on Wednesday, December 21, 2005 at 2:10:25 PM
Dose Point # 1 - (134.97,381,91.44) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.381e-009	2.813e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.011e-009	1.964e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.934e-012	3.766e-011
Absorbed Dose Rate in Air	mGy/hr	1.689e-014	3.288e-013
"	mrad/hr	1.689e-012	3.288e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.982e-014	3.875e-013
o Opposed	"	1.610e-014	3.129e-013
o Rotational	"	1.610e-014	3.129e-013
o Isotropic	"	1.423e-014	2.767e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.114e-014	4.125e-013
o Opposed	"	2.013e-014	3.926e-013
o Rotational	"	2.013e-014	3.926e-013
o Isotropic	"	1.523e-014	2.960e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.760e-014	3.436e-013
o Posterior/Anterior	"	1.567e-014	3.051e-013
o Lateral	"	1.178e-014	2.282e-013
o Rotational	"	1.402e-014	2.726e-013
o Isotropic	"	1.201e-014	2.331e-013

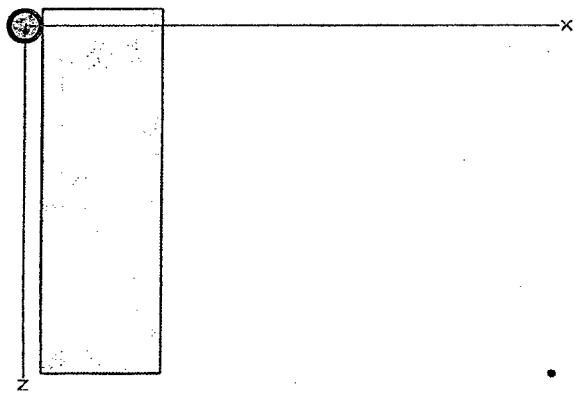
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122115.MS5
Ru ate : December 21, 2005
Run Time: 2:04:46 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 F
Description: Revised Model Calc. - Nb-94 Unit Act w Sched 40 & 12 in Sh
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Nb-94	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	1.074e-03	4.704e-307	2.957e-37	2.539e-308	1.596e-38
0.0175	2.057e-03	9.585e-302	5.718e-37	5.076e-303	3.028e-38
0.0196	6.044e-04	1.268e-221	2.009e-37	4.682e-223	7.416e-39
0 7026	3.037e+00	4.733e-10	9.655e-09	9.128e-13	1.862e-11
711	3.037e+00	1.274e-09	1.937e-08	2.397e-12	3.646e-11

Page : 2
DOS File : PB122115.MS5
Run Date : December 21, 2005
Run Time: 2:04:46 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.078e+00	1.747e-09	2.903e-08	3.310e-12	5.508e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122115.MS5
Case Title: Line 1.24 F
This case was run on Wednesday, December 21, 2005 at 2:04:46 PM
Dose Point # 1 - (134.97,381,91.44) cm

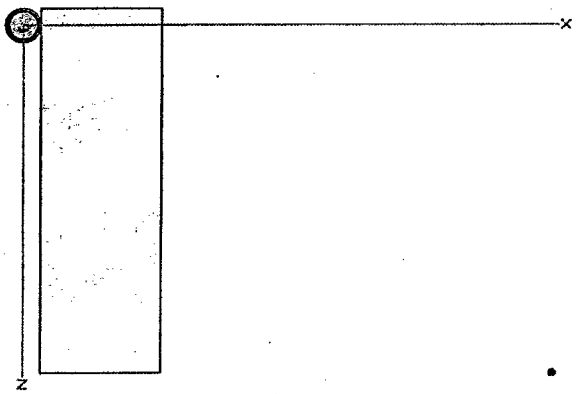
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.136e-009	3.598e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.747e-009	2.903e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.310e-012	5.508e-011
Absorbed Dose Rate in Air	mGy/hr	2.890e-014	4.808e-013
"	mrad/hr	2.890e-012	4.808e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.362e-014	5.600e-013
o Opposed	"	2.768e-014	4.602e-013
o Rotational	"	2.768e-014	4.602e-013
o Isotropic	"	2.447e-014	4.069e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.595e-014	5.986e-013
o Opposed	"	3.430e-014	5.710e-013
o Rotational	"	3.430e-014	5.710e-013
o Isotropic	"	2.619e-014	4.354e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.996e-014	4.989e-013
o Posterior/Anterior	"	2.688e-014	4.470e-013
o Lateral	"	2.042e-014	3.391e-013
o Rotational	"	2.406e-014	4.002e-013
o Isotropic	"	2.073e-014	3.445e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122909.MS5
Run Date : December 29, 2005
Run Time: 2:36:06 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 G
Description: Revised Model Calc. - I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	6.061e-01	6.977e-77	4.366e-34	7.301e-79	4.569e-36
0.0298	1.124e+00	1.092e-74	8.349e-34	1.107e-76	8.458e-36
0.0336	3.998e-01	2.344e-57	4.359e-34	1.667e-59	3.100e-36
0.0396	2.284e-01	1.196e-41	4.431e-34	5.435e-44	2.013e-36

Page : 2
DOS File : PB122909.MS5
Run Date : December 29, 2005
Run Time: 2:36:06 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.359e+00	1.196e-41	2.150e-33	5.435e-44	1.814e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122909.MS5
Case Title: Line 1.24 G
This case was run on Thursday, December 29, 2005 at 2:36:06 PM
Dose Point # 1 - (134.97,381,91.44) cm

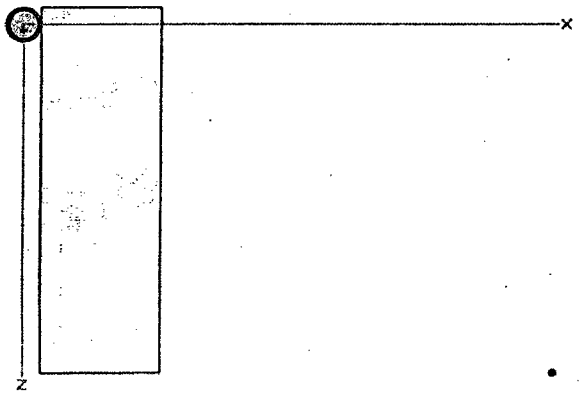
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.022e-040	6.702e-032
Photon Energy Fluence Rate	MeV/cm²/sec	1.196e-041	2.150e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.435e-044	1.814e-035
Absorbed Dose Rate in Air	mGy/hr	4.745e-046	1.584e-037
"	mrad/hr	4.745e-044	1.584e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.792e-046	1.813e-037
o Opposed	"	3.421e-046	9.094e-038
o Rotational	"	3.097e-046	7.757e-038
o Isotropic	"	2.963e-046	7.205e-038
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.834e-046	1.976e-037
o Opposed	"	4.717e-046	1.359e-037
o Rotational	"	4.717e-046	1.359e-037
o Isotropic	"	3.462e-046	1.004e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.960e-046	8.128e-038
o Posterior/Anterior	"	2.394e-046	4.203e-038
o Lateral	"	1.322e-046	2.268e-038
o Rotational	"	2.153e-046	4.176e-038
o Isotropic	"	1.764e-046	3.460e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122911.MS5
Run Date : December 29, 2005
Run Time : 2:42:27 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 I
Description: Revised Model Calc - Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Zr-95	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	1.326e+00	2.380e-10	4.659e-09	4.577e-13	8.958e-12
0.7567	1.681e+00	3.702e-10	6.824e-09	7.085e-13	1.306e-11
TOTALS:	3.007e+00	6.082e-10	1.148e-08	1.166e-12	2.202e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122911.MS5
Case Title: Line 1.24 I
This case was run on Thursday, December 29, 2005 at 2:42:27 PM
Dose Point # 1 - (134.97,381,91.44) cm

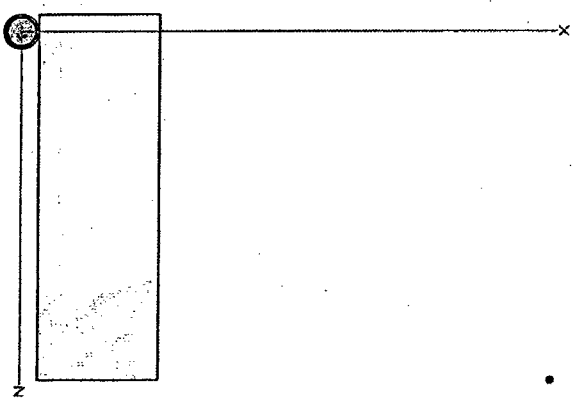
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.178e-010	1.545e-008
Photon Energy Fluence Rate	MeV/cm²/sec	6.082e-010	1.148e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.166e-012	2.202e-011
Absorbed Dose Rate in Air	mGy/hr	1.018e-014	1.922e-013
"	mrad/hr	1.018e-012	1.922e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.193e-014	2.254e-013
o Opposed	"	9.705e-015	1.832e-013
o Rotational	"	9.705e-015	1.832e-013
o Isotropic	"	8.578e-015	1.620e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.274e-014	2.406e-013
o Opposed	"	1.214e-014	2.292e-013
o Rotational	"	1.214e-014	2.292e-013
o Isotropic	"	9.181e-015	1.733e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.060e-014	2.001e-013
o Posterior/Anterior	"	9.441e-015	1.783e-013
o Lateral	"	7.098e-015	1.340e-013
o Rotational	"	8.444e-015	1.594e-013
o Isotropic	"	7.233e-015	1.366e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010403.MS5
Run Date : January 4, 2006
Run Time: 7:59:23 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 H
Description: Revised Model Calc - Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Sn-126	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	2.351e-01	2.258e-207	8.062e-35	7.820e-209	2.792e-36

Page : 2
DOS File : PB010403.MS5
Run Date : January 4, 2006
Run Time: 7:59:23 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	8.893e-01	1.644e-73	6.743e-34	1.630e-75	6.683e-36
0.04	1.517e-02	4.854e-42	3.051e-35	2.147e-44	1.349e-37
0.06	2.911e-01	3.017e-23	5.881e-22	5.993e-26	1.168e-24
0.08	1.395e+00	5.894e-18	2.247e-16	9.326e-21	3.557e-19
TOTALS:	2.825e+00	5.894e-18	2.247e-16	9.327e-21	3.557e-19

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010403.MS5
Case Title: Line 1.24 H
This case was run on Wednesday, January 4, 2006 at 7:59:23 AM
Dose Point # 1 - (134.97,381,91.44) cm

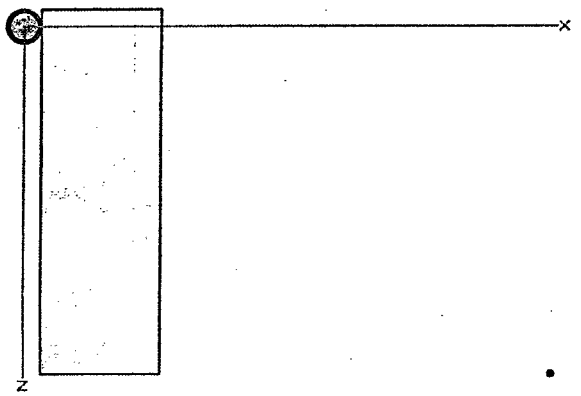
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.367e-017	2.809e-015
Photon Energy Fluence Rate	MeV/cm²/sec	5.894e-018	2.247e-016
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	9.327e-021	3.557e-019
Absorbed Dose Rate in Air	mGy/hr	8.142e-023	3.105e-021
"	mrad/hr	8.142e-021	3.105e-019
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.424e-022	5.431e-021
o Opposed	"	7.585e-023	2.893e-021
o Rotational	"	7.373e-023	2.812e-021
o Isotropic	"	7.320e-023	2.791e-021
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.411e-022	5.380e-021
o Opposed	"	1.037e-022	3.954e-021
o Rotational	"	1.037e-022	3.954e-021
o Isotropic	"	7.612e-023	2.903e-021
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.196e-022	4.561e-021
o Posterior/Anterior	"	9.123e-023	3.479e-021
o Lateral	"	5.623e-023	2.144e-021
o Rotational	"	7.771e-023	2.963e-021
o Isotropic	"	6.286e-023	2.397e-021

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122912.MS5
Run Date : December 29, 2005
Run Time: 2:45:53 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 J
Description: Revised Model Calc - Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	91.44 cm
	4 ft 5.1 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-155	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
03	9.667e-03	1.787e-75	7.330e-36	1.771e-77	7.264e-38

Page : 2
DOS File : PB122912.MS5
Run Date : December 29, 2005
Run Time: 2:45:53 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	5.505e-01	1.762e-40	1.107e-33	7.791e-43	4.896e-36
0.05	1.791e-01	6.462e-29	6.313e-28	1.721e-31	1.682e-30
0.06	3.939e-02	4.083e-24	7.960e-23	8.110e-27	1.581e-25
0.08	9.431e-01	3.986e-18	1.520e-16	6.307e-21	2.405e-19
0.1	6.279e-01	2.033e-16	1.231e-14	3.111e-19	1.884e-17
TOTALS:	2.350e+00	2.073e-16	1.246e-14	3.174e-19	1.908e-17

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122912.MS5
Case Title: Line 1.24 J
This case was run on Thursday, December 29, 2005 at 2:45:53 PM
Dose Point # 1 - (134.97,381,91.44) cm

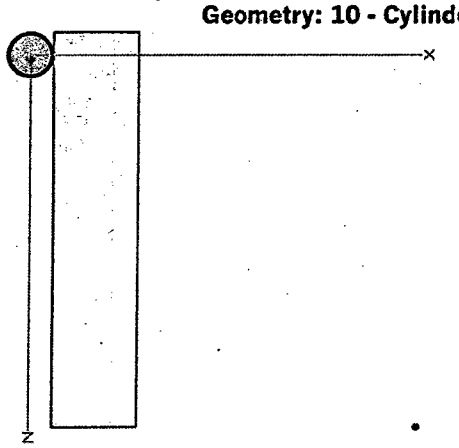
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.083e-015	1.250e-013
Photon Energy Fluence Rate	MeV/cm²/sec	2.073e-016	1.246e-014
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.174e-019	1.908e-017
Absorbed Dose Rate in Air	mGy/hr	2.771e-021	1.665e-019
"	mrad/hr	2.771e-019	1.665e-017
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.635e-021	2.785e-019
o Opposed	"	2.540e-021	1.526e-019
o Rotational	"	2.539e-021	1.526e-019
o Isotropic	"	2.458e-021	1.477e-019
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.604e-021	2.767e-019
o Opposed	"	3.569e-021	2.145e-019
o Rotational	"	3.569e-021	2.145e-019
o Isotropic	"	2.599e-021	1.562e-019
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.982e-021	2.393e-019
o Posterior/Anterior	"	3.121e-021	1.876e-019
o Lateral	"	1.926e-021	1.158e-019
o Rotational	"	2.666e-021	1.602e-019
o Isotropic	"	2.121e-021	1.275e-019

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB121911.MS5
Run Date : December 19, 2005
Run Time: 11:14:14 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.909e-04	1.951e-14	5.213e-13	3.766e-17	1.006e-15
1.1732	6.074e+00	1.764e-09	2.250e-08	3.151e-12	4.022e-11
1.3325	6.074e+00	3.243e-09	3.513e-08	5.627e-12	6.095e-11
TALS:	1.215e+01	5.007e-09	5.764e-08	8.778e-12	1.012e-10

MicroShield v5.04 (5.04-00362) **12/19/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121911.MS5
Case Title: Line 1.25 A2
This case was run on Monday, December 19, 2005 at 11:14:14 AM
Dose Point # 1 - (138.78,381,137.16) cm

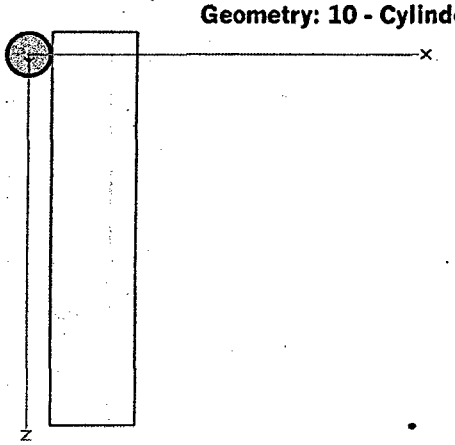
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.937e-009	4.555e-008
Photon Energy Fluence Rate	MeV/cm²/sec	5.007e-009	5.764e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.778e-012	1.012e-010
Absorbed Dose Rate in Air	mGy/hr	7.663e-014	8.832e-013
"	mrad/hr	7.663e-012	8.832e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.699e-014	1.003e-012
o Opposed	"	7.495e-014	8.636e-013
o Rotational	"	7.495e-014	8.636e-013
o Isotropic	"	6.696e-014	7.714e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.259e-014	1.067e-012
o Opposed	"	8.916e-014	1.028e-012
o Rotational	"	8.916e-014	1.028e-012
o Isotropic	"	7.093e-014	8.173e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.834e-014	9.030e-013
o Posterior/Anterior	"	7.218e-014	8.318e-013
o Lateral	"	5.743e-014	6.614e-013
o Rotational	"	6.500e-014	7.489e-013
o Isotropic	"	5.754e-014	6.628e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122116.MS5
Run Date : December 21, 2005
Run Time: 2:17:24 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 B
Description: Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ba-137m	1.5531e-010	5.7464e+000	4.2570e-009	1.5751e-004
Cs-137	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.190e-01	2.257e-73	8.498e-35	1.880e-75	7.078e-37
0.0322	2.195e-01	3.354e-71	1.629e-34	2.699e-73	1.311e-36
0.0364	7.987e-02	2.920e-55	9.080e-35	1.659e-57	5.159e-37
0.516	5.171e+00	7.886e-11	2.257e-09	1.529e-13	4.375e-12

Page : 2
DOS File : PB122116.MS5
Run Date : December 21, 2005
Run Time: 2:17:24 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	5.589e+00	7.886e-11	2.257e-09	1.529e-13	4.375e-12

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122116.MS5
Case Title: Line 1.25 B
This case was run on Wednesday, December 21, 2005 at 2:17:24 PM
Dose Point # 1 - (138.78,381,137.16) cm

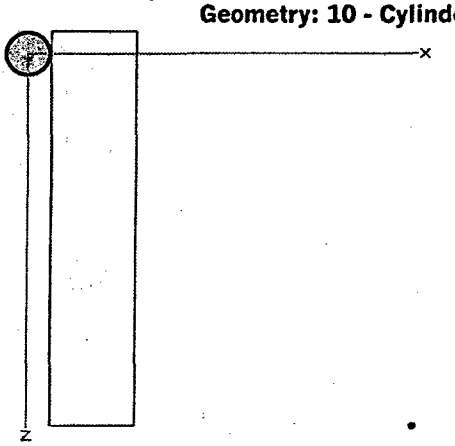
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.192e-010	3.411e-009
Photon Energy Fluence Rate	MeV/cm²/sec	7.886e-011	2.257e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.529e-013	4.375e-012
Absorbed Dose Rate in Air	mGy/hr	1.335e-015	3.819e-014
"	mrad/hr	1.335e-013	3.819e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.580e-015	4.522e-014
o Opposed	"	1.265e-015	3.620e-014
o Rotational	"	1.265e-015	3.620e-014
o Isotropic	"	1.119e-015	3.201e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.680e-015	4.806e-014
o Opposed	"	1.595e-015	4.565e-014
o Rotational	"	1.595e-015	4.565e-014
o Isotropic	"	1.196e-015	3.422e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.397e-015	3.998e-014
o Posterior/Anterior	"	1.233e-015	3.529e-014
o Lateral	"	9.146e-016	2.617e-014
o Rotational	"	1.102e-015	3.154e-014
o Isotropic	"	9.383e-016	2.685e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122117.MS5
Run Date : December 21, 2005
Run Time: 2:23:34 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 C
Description: Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Eu-152	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	3.594e+00	1.705e-44	5.683e-33	7.540e-47	2.514e-35

Page : 2
DOS File : PB122117.MS5
Run Date : December 21, 2005
Run Time: 2:23:34 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	8.987e-01	2.286e-31	2.318e-30	6.091e-34	6.175e-33
0.1	1.727e+00	1.425e-17	1.080e-15	2.179e-20	1.653e-18
0.2	4.552e-01	5.009e-15	5.689e-13	8.840e-18	1.004e-15
0.3	1.642e+00	2.624e-13	2.178e-11	4.978e-16	4.132e-14
0.4	3.817e-01	3.443e-13	2.007e-11	6.708e-16	3.911e-14
0.5	3.426e-02	1.116e-13	4.775e-12	2.190e-16	9.372e-15
0.6	2.576e-01	2.309e-12	7.607e-11	4.506e-15	1.485e-13
0.8	1.082e+00	4.526e-11	9.859e-10	8.608e-14	1.875e-12
1.0	2.599e+00	3.419e-10	5.424e-09	6.302e-13	9.998e-12
1.5	1.409e+00	1.299e-09	1.218e-08	2.185e-12	2.050e-11
TOTALS:	1.408e+01	1.689e-09	1.872e-08	2.907e-12	3.261e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122117.MS5
Case Title: Line 1.25 C
This case was run on Wednesday, December 21, 2005 at 2:23:34 PM
Dose Point # 1 - (138.78,381,137.16) cm

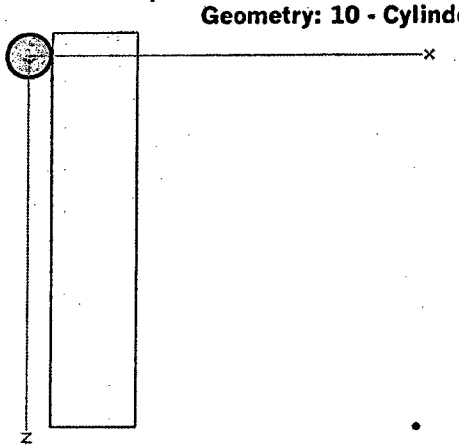
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.270e-009	1.504e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.689e-009	1.872e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.907e-012	3.261e-011
Absorbed Dose Rate in Air	mGy/hr	2.538e-014	2.847e-013
"	mrad/hr	2.538e-012	2.847e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.882e-014	3.242e-013
o Opposed	"	2.494e-014	2.789e-013
o Rotational	"	2.494e-014	2.789e-013
o Isotropic	"	2.232e-014	2.491e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.058e-014	3.443e-013
o Opposed	"	2.952e-014	3.318e-013
o Rotational	"	2.952e-014	3.318e-013
o Isotropic	"	2.356e-014	2.635e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.595e-014	2.915e-013
o Posterior/Anterior	"	2.397e-014	2.684e-013
o Lateral	"	1.920e-014	2.136e-013
o Rotational	"	2.162e-014	2.418e-013
o Isotropic	"	1.919e-014	2.139e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122118.MS5
Ru ate : December 21, 2005
Run Time: 2:24:58 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 D
Description: Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-154	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	1.236e+00	5.864e-45	1.955e-33	2.593e-47	8.646e-36

Page : 2
DOS File : PB122118.MS5
Run Date : December 21, 2005
Run Time: 2:24:58 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	3.140e-01	7.989e-32	8.099e-31	2.128e-34	2.158e-33
0.1	2.458e+00	2.027e-17	1.538e-15	3.102e-20	2.352e-18
0.2	4.148e-01	4.565e-15	5.184e-13	8.056e-18	9.150e-16
0.4	4.334e-02	3.909e-14	2.279e-12	7.616e-17	4.440e-15
0.5	1.315e-02	4.282e-14	1.833e-12	8.405e-17	3.597e-15
0.6	4.900e-01	4.391e-12	1.447e-10	8.571e-15	2.824e-13
0.8	2.369e+00	9.912e-11	2.159e-09	1.885e-13	4.107e-12
1.0	1.869e+00	2.458e-10	3.900e-09	4.531e-13	7.188e-12
1.5	2.370e+00	2.185e-09	2.049e-08	3.675e-12	3.448e-11
TOTALS:	1.158e+01	2.534e-09	2.670e-08	4.326e-12	4.607e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122118.MS5
Case Title: Line 1.25 D
This case was run on Wednesday, December 21, 2005 at 2:24:58 PM
Dose Point # 1 - (138.78,381,137.16) cm

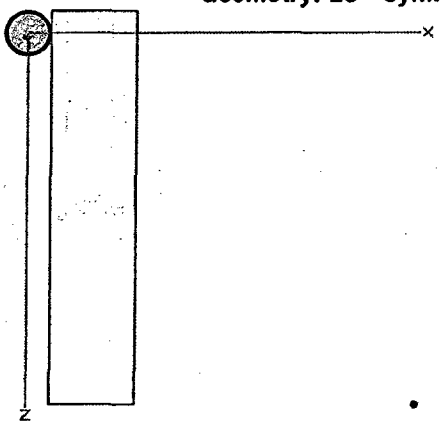
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.834e-009	2.051e-008
Photon Energy Fluence Rate	MeV/cm²/sec	2.534e-009	2.670e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.326e-012	4.607e-011
Absorbed Dose Rate in Air	mGy/hr	3.777e-014	4.022e-013
"	mrad/hr	3.777e-012	4.022e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.283e-014	4.572e-013
o Opposed	"	3.719e-014	3.949e-013
o Rotational	"	3.719e-014	3.949e-013
o Isotropic	"	3.331e-014	3.533e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.539e-014	4.850e-013
o Opposed	"	4.387e-014	4.681e-013
o Rotational	"	4.387e-014	4.681e-013
o Isotropic	"	3.511e-014	3.730e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.858e-014	4.114e-013
o Posterior/Anterior	"	3.571e-014	3.796e-013
o Lateral	"	2.872e-014	3.036e-013
o Rotational	"	3.222e-014	3.423e-013
o Isotropic	"	2.866e-014	3.035e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122119.MS5
Ru ate : December 21, 2005
Run Time: 2:28:46 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ag-108m	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
02	3.984e+00	3.279e-235	1.074e-33	1.136e-236	3.722e-35

Page : 2
DOS File : PB122119.MS5
Run Date : December 21, 2005
Run Time: 2:28:46 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.290e-06	6.584e-89	7.691e-40	6.525e-91	7.622e-42
0.08	4.305e-01	2.739e-20	1.249e-18	4.335e-23	1.976e-21
0.4	5.460e+00	4.924e-12	2.871e-10	9.595e-15	5.594e-13
0.6	5.491e+00	4.921e-11	1.621e-09	9.606e-14	3.165e-12
0.8	5.497e+00	2.300e-10	5.011e-09	4.375e-13	9.531e-12
TOTALS:	2.086e+01	2.842e-10	6.920e-09	5.432e-13	1.326e-11

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122119.MS5
Case Title: Line 1.25 E
This case was run on Wednesday, December 21, 2005 at 2:28:46 PM
Dose Point # 1 - (138.78,381,137.16) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.819e-010	9.684e-009
Photon Energy Fluence Rate	MeV/cm²/sec	2.842e-010	6.920e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.432e-013	1.326e-011
Absorbed Dose Rate in Air	mGy/hr	4.742e-015	1.157e-013
"	mrad/hr	4.742e-013	1.157e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.557e-015	1.361e-013
o Opposed	"	4.523e-015	1.102e-013
o Rotational	"	4.523e-015	1.102e-013
o Isotropic	"	3.998e-015	9.744e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.931e-015	1.450e-013
o Opposed	"	5.651e-015	1.381e-013
o Rotational	"	5.651e-015	1.381e-013
o Isotropic	"	4.278e-015	1.042e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.939e-015	1.208e-013
o Posterior/Anterior	"	4.402e-015	1.074e-013
o Lateral	"	3.313e-015	8.051e-014
o Rotational	"	3.937e-015	9.600e-014
o Isotropic	"	3.375e-015	8.215e-014

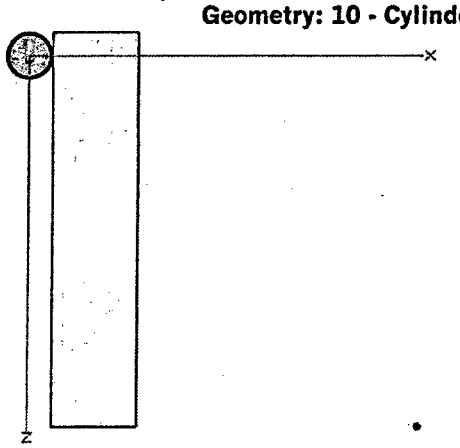
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122120.MS5
Run Date : December 21, 2005
Run Time: 2:32:47 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Nb-94	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	2.148e-03	0.000e+00	4.650e-37	0.000e+00	2.510e-38
0.0175	4.115e-03	0.000e+00	8.994e-37	0.000e+00	4.763e-38
0.0196	1.209e-03	4.082e-252	3.160e-37	1.507e-253	1.166e-38
0.7026	6.074e+00	1.279e-10	3.358e-09	2.467e-13	6.475e-12
711	6.074e+00	3.955e-10	7.629e-09	7.444e-13	1.436e-11

Page : 2
DOS File : PB122120.MS5
Run Date : December 21, 2005
Run Time: 2:32:47 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.216e+01	5.235e-10	1.099e-08	9.911e-13	2.083e-11

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122120.MS5
Case Title: Line 1.25 F
This case was run on Wednesday, December 21, 2005 at 2:32:47 PM
Dose Point # 1 - (138.78,381,137.16) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.362e-010	1.354e-008
Photon Energy Fluence Rate	MeV/cm²/sec	5.235e-010	1.099e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	9.911e-013	2.083e-011
Absorbed Dose Rate in Air	mGy/hr	8.653e-015	1.819e-013
"	mrad/hr	8.653e-013	1.819e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.006e-014	2.117e-013
o Opposed	"	8.289e-015	1.741e-013
o Rotational	"	8.289e-015	1.741e-013
o Isotropic	"	7.330e-015	1.540e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.076e-014	2.264e-013
o Opposed	"	1.027e-014	2.160e-013
o Rotational	"	1.027e-014	2.160e-013
o Isotropic	"	7.844e-015	1.648e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	8.970e-015	1.887e-013
o Posterior/Anterior	"	8.049e-015	1.691e-013
o Lateral	"	6.119e-015	1.284e-013
o Rotational	"	7.207e-015	1.514e-013
o Isotropic	"	6.210e-015	1.304e-013

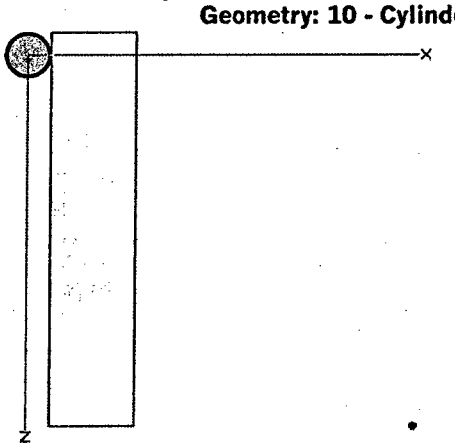
Page 1

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122913.MS5
Run Date : December 29, 2005
Run Time: 2:49:38 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	1.212e+00	1.333e-86	6.866e-34	1.395e-88	7.186e-36
0.0298	2.249e+00	3.950e-84	1.313e-33	4.002e-86	1.330e-35
0.0336	7.995e-01	2.970e-64	6.856e-34	2.113e-66	4.876e-36
0.0396	4.568e-01	2.750e-46	6.969e-34	1.249e-48	3.167e-36

Page : 2
DOS File : PB122913.MS5
Run Date : December 29, 2005
Run Time: 2:49:38 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.718e+00	2.750e-46	3.382e-33	1.249e-48	2.853e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122913.MS5
Case Title: Line 1.25 G
This case was run on Thursday, December 29, 2005 at 2:49:38 PM
Dose Point # 1 - (138.78,381,137.16) cm

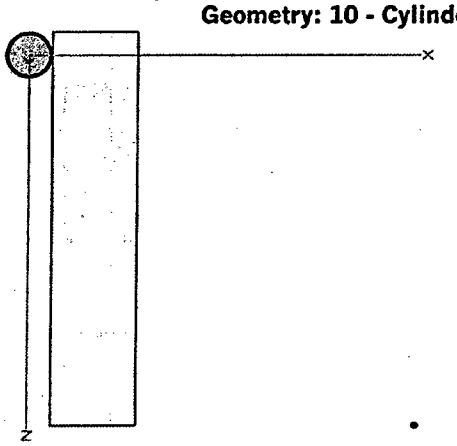
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.947e-045	1.054e-031
Photon Energy Fluence Rate	MeV/cm²/sec	2.750e-046	3.382e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.249e-048	2.853e-035
Absorbed Dose Rate in Air	mGy/hr	1.091e-050	2.491e-037
"	mrad/hr	1.091e-048	2.491e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.561e-050	2.852e-037
o Opposed	"	7.864e-051	1.430e-037
o Rotational	"	7.120e-051	1.220e-037
o Isotropic	"	6.811e-051	1.133e-037
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.571e-050	3.108e-037
o Opposed	"	1.084e-050	2.137e-037
o Rotational	"	1.084e-050	2.137e-037
o Isotropic	"	7.958e-051	1.580e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	9.103e-051	1.278e-037
o Posterior/Anterior	"	5.503e-051	6.610e-038
o Lateral	"	3.040e-051	3.568e-038
o Rotational	"	4.948e-051	6.568e-038
o Isotropic	"	4.056e-051	5.441e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010404.MS5
Rᵤ ate : January 4, 2006
Run Time: 8:04:03 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Sn-126	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	4.702e-01	3.869e-236	1.268e-34	1.340e-237	4.392e-36

Page : 2
DOS File : PB010404.MS5
Run Date : January 4, 2006
Run Time: 8:04:03 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.779e+00	9.079e-83	1.061e-33	8.997e-85	1.051e-35
0.04	3.034e-02	1.439e-46	4.798e-35	6.365e-49	2.122e-37
0.06	5.821e-01	2.323e-25	5.459e-24	4.615e-28	1.084e-26
0.08	2.789e+00	1.775e-19	8.092e-18	2.809e-22	1.281e-20
TOTALS:	5.650e+00	1.775e-19	8.092e-18	2.809e-22	1.281e-20

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010404.MS5
Case Title: Line 1.25 H
This case was run on Wednesday, January 4, 2006 at 8:04:03 AM
Dose Point # 1 - (138.78,381,137.16) cm

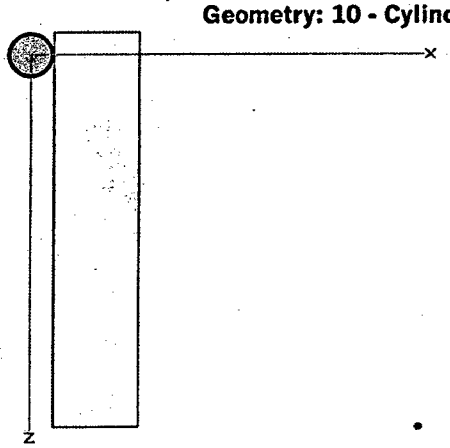
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.219e-018	1.012e-016
Photon Energy Fluence Rate	MeV/cm²/sec	1.775e-019	8.092e-018
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.809e-022	1.281e-020
Absorbed Dose Rate in Air	mGy/hr	2.452e-024	1.118e-022
"	mrad/hr	2.452e-022	1.118e-020
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.289e-024	1.955e-022
o Opposed	"	2.284e-024	1.041e-022
o Rotational	"	2.220e-024	1.012e-022
o Isotropic	"	2.204e-024	1.005e-022
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.249e-024	1.937e-022
o Opposed	"	3.123e-024	1.424e-022
o Rotational	"	3.123e-024	1.424e-022
o Isotropic	"	2.292e-024	1.045e-022
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.602e-024	1.642e-022
o Posterior/Anterior	"	2.747e-024	1.253e-022
o Lateral	"	1.693e-024	7.720e-023
o Rotational	"	2.340e-024	1.067e-022
o Isotropic	"	1.893e-024	8.630e-023

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122915.MS5
Run Date : December 29, 2005
Run Time: 2:53:47 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Zr-95	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	2.652e+00	6.562e-11	1.649e-09	1.262e-13	3.170e-12
0.7567	3.362e+00	1.050e-10	2.477e-09	2.010e-13	4.742e-12
TOTALS:	6.014e+00	1.706e-10	4.126e-09	3.271e-13	7.912e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122915.MS5
Case Title: Line 1.25 I
This case was run on Thursday, December 29, 2005 at 2:53:47 PM
Dose Point # 1 - (138.78,381,137.16) cm

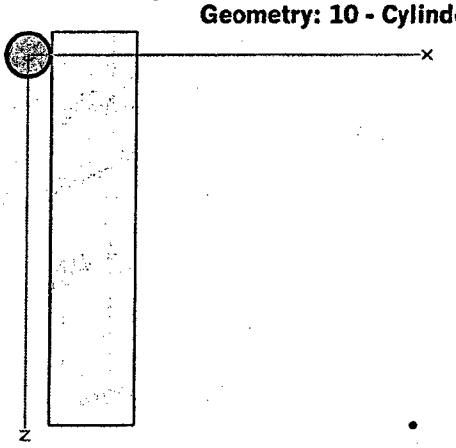
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.294e-010	5.551e-009
Photon Energy Fluence Rate	MeV/cm²/sec	1.706e-010	4.126e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.271e-013	7.912e-012
Absorbed Dose Rate in Air	mGy/hr	2.856e-015	6.907e-014
"	mrad/hr	2.856e-013	6.907e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.348e-015	8.097e-014
o Opposed	"	2.723e-015	6.584e-014
o Rotational	"	2.723e-015	6.584e-014
o Isotropic	"	2.406e-015	5.820e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.574e-015	8.644e-014
o Opposed	"	3.406e-015	8.237e-014
o Rotational	"	3.406e-015	8.237e-014
o Isotropic	"	2.576e-015	6.229e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.973e-015	7.191e-014
o Posterior/Anterior	"	2.648e-015	6.405e-014
o Lateral	"	1.991e-015	4.816e-014
o Rotational	"	2.369e-015	5.729e-014
o Isotropic	"	2.029e-015	4.907e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122916.MS5
Run Date : December 29, 2005
Run Time: 2:55:49 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.25 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	137.16 cm
	4 ft 6.6 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-155	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
03	1.933e-02	9.868e-85	1.153e-35	9.780e-87	1.143e-37

Page : 2
DOS File : PB122916.MS5
Run Date : December 29, 2005
Run Time: 2:55:49 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.101e+00	5.223e-45	1.741e-33	2.310e-47	7.701e-36
0.05	3.581e-01	9.111e-32	9.238e-31	2.427e-34	2.461e-33
0.06	7.878e-02	3.144e-26	7.387e-25	6.245e-29	1.467e-27
0.08	1.886e+00	1.200e-19	5.472e-18	1.899e-22	8.660e-21
0.1	1.256e+00	1.036e-17	7.855e-16	1.585e-20	1.202e-18
TOTALS:	4.699e+00	1.048e-17	7.910e-16	1.604e-20	1.210e-18

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122916.MS5
Case Title: Line 1.25 J
This case was run on Thursday, December 29, 2005 at 2:55:49 PM
Dose Point # 1 - (138.78,381,137.16) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.051e-016	7.924e-015
Photon Energy Fluence Rate	MeV/cm²/sec	1.048e-017	7.910e-016
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.604e-020	1.210e-018
Absorbed Dose Rate in Air	mGy/hr	1.400e-022	1.057e-020
"	mrad/hr	1.400e-020	1.057e-018
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.341e-022	1.767e-020
o Opposed	"	1.283e-022	9.685e-021
o Rotational	"	1.283e-022	9.683e-021
o Isotropic	"	1.242e-022	9.372e-021
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.326e-022	1.755e-020
o Opposed	"	1.803e-022	1.361e-020
o Rotational	"	1.803e-022	1.361e-020
o Isotropic	"	1.313e-022	9.912e-021
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.012e-022	1.518e-020
o Posterior/Anterior	"	1.577e-022	1.191e-020
o Lateral	"	9.735e-023	7.348e-021
o Rotational	"	1.347e-022	1.017e-020
o Isotropic	"	1.072e-022	8.090e-021

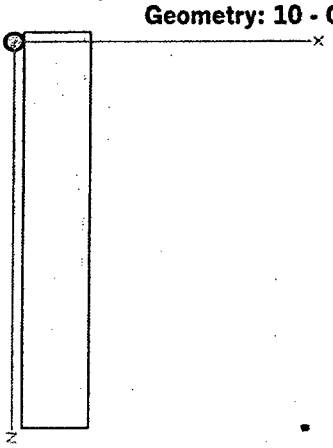
Page

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB121913.MS5
Rt ate : December 19, 2005
Run Time: 11:24:57 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Co-60	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	4.954e-04	2.365e-15	7.879e-14	4.566e-18	1.521e-16
1.1732	3.037e+00	2.935e-10	4.432e-09	5.246e-13	7.920e-12
1.3325	3.037e+00	5.773e-10	7.308e-09	1.002e-12	1.268e-11
ALS:	6.075e+00	8.708e-10	1.174e-08	1.526e-12	2.060e-11

MicroShield v5.04 (5.04-00362) **12/19/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121913.MS5
Case Title: Line 1.26 A2
This case was run on Monday, December 19, 2005 at 11:24:57 AM
Dose Point # 1 - (134.97,381,182.88) cm

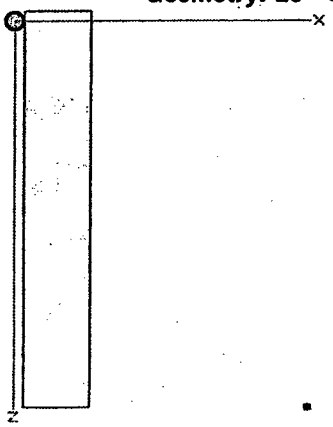
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.834e-010	9.262e-009
Photon Energy Fluence Rate	MeV/cm²/sec	8.708e-010	1.174e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.526e-012	2.060e-011
Absorbed Dose Rate in Air	mGy/hr	1.332e-014	1.798e-013
"	mrad/hr	1.332e-012	1.798e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.512e-014	2.042e-013
o Opposed	"	1.303e-014	1.758e-013
o Rotational	"	1.303e-014	1.758e-013
o Isotropic	"	1.164e-014	1.571e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.609e-014	2.173e-013
o Opposed	"	1.550e-014	2.093e-013
o Rotational	"	1.550e-014	2.093e-013
o Isotropic	"	1.233e-014	1.664e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.362e-014	1.838e-013
o Posterior/Anterior	"	1.255e-014	1.694e-013
o Lateral	"	9.987e-015	1.347e-013
o Rotational	"	1.130e-014	1.525e-013
o Isotropic	"	1.001e-014	1.350e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122121.MS5
Run Date : December 21, 2005
Run Time : 3:45:18 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 B
Description: Revised Model Calc - Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ba-137m	7.7654e-011	2.8732e+000	4.2570e-009	1.5751e-004
Cs-137	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	5.948e-02	2.447e-82	3.431e-35	2.038e-84	2.858e-37
0.0322	1.097e-01	6.519e-80	6.579e-35	5.246e-82	5.295e-37
0.0364	3.994e-02	8.361e-62	3.666e-35	4.750e-64	2.083e-37
516	2.585e+00	9.264e-12	3.324e-10	1.796e-14	6.443e-13

Page : 2
DOS File : PB122121.MS5
Run Date : December 21, 2005
Run Time: 3:45:18 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.794e+00	9.264e-12	3.324e-10	1.796e-14	6.443e-13

licroShield v5.04 (5.04-00362) **12/21/0**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122121.MS5
Case Title: Line 1.26 B
This case was run on Wednesday, December 21, 2005 at 3:45:18 PM
Dose Point # 1 - (134.97,381,182.88) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.400e-011	5.023e-010
Photon Energy Fluence Rate	MeV/cm²/sec	9.264e-012	3.324e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.796e-014	6.443e-013
Absorbed Dose Rate in Air	mGy/hr	1.568e-016	5.625e-015
"	mrad/hr	1.568e-014	5.625e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.856e-016	6.660e-015
o Opposed	"	1.486e-016	5.332e-015
o Rotational	"	1.486e-016	5.332e-015
o Isotropic	"	1.314e-016	4.715e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.973e-016	7.078e-015
o Opposed	"	1.874e-016	6.723e-015
o Rotational	"	1.874e-016	6.723e-015
o Isotropic	"	1.405e-016	5.041e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.641e-016	5.889e-015
o Posterior/Anterior	"	1.449e-016	5.198e-015
o Lateral	"	1.074e-016	3.854e-015
o Rotational	"	1.295e-016	4.645e-015
o Isotropic	"	1.102e-016	3.954e-015

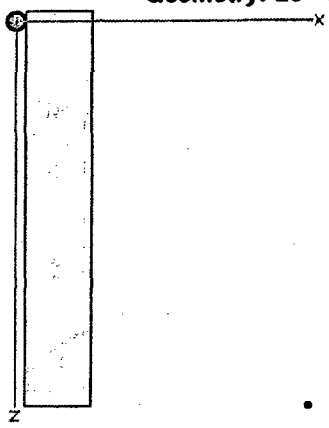
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MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122122.MS5
Run Date : December 21, 2005
Run Time: 3:50:53 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 C
Description: Revised Model Calc - Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm²	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-152	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.04	1.797e+00	7.689e-50	2.295e-33	3.401e-52	1.015e-35

Page : 2
DOS File : PB122122.MS5
Run Date : December 21, 2005
Run Time: 3:50:53 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	4.493e-01	6.370e-35	2.389e-33	1.697e-37	6.365e-36
0.1	8.635e-01	2.353e-19	2.288e-17	3.600e-22	3.501e-20
0.2	2.276e-01	2.237e-16	3.535e-14	3.947e-19	6.238e-17
0.3	8.212e-01	1.694e-14	1.920e-12	3.214e-17	3.642e-15
0.4	1.909e-01	2.807e-14	2.175e-12	5.470e-17	4.239e-15
0.5	1.713e-02	1.077e-14	5.981e-13	2.114e-17	1.174e-15
0.6	1.288e-01	2.537e-13	1.061e-11	4.952e-16	2.071e-14
0.8	5.408e-01	6.015e-12	1.608e-10	1.144e-14	3.058e-13
1.0	1.300e+00	5.202e-11	9.920e-10	9.589e-14	1.829e-12
1.5	7.046e-01	2.451e-10	2.658e-09	4.123e-13	4.472e-12
TOTALS:	7.040e+00	3.034e-10	3.826e-09	5.203e-13	6.636e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122122.MS5
Case Title: Line 1.26 C
This case was run on Wednesday, December 21, 2005 at 3:50:53 PM
Dose Point # 1 - (134.97,381,182.88) cm

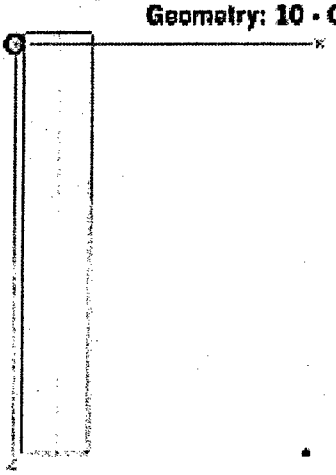
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.235e-010	2.996e-009
Photon Energy Fluence Rate	MeV/cm²/sec	3.034e-010	3.826e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.203e-013	6.636e-012
Absorbed Dose Rate in Air	mGy/hr	4.542e-015	5.794e-014
"	mrad/hr	4.542e-013	5.794e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.154e-015	6.590e-014
o Opposed	"	4.468e-015	5.682e-014
o Rotational		4.468e-015	5.682e-014
o Isotropic		4.000e-015	5.079e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.465e-015	6.997e-014
o Opposed	"	5.278e-015	6.747e-014
o Rotational		5.278e-015	6.747e-014
o Isotropic		4.219e-015	5.368e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.641e-015	5.929e-014
o Posterior/Anterior	"	4.292e-015	5.465e-014
o Lateral		3.445e-015	4.361e-014
o Rotational	"	3.872e-015	4.926e-014
o Isotropic	"	3.440e-015	4.363e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122123.MS5
Run Date : December 21, 2005
Run Time: 3:53:07 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 D
Description: Revised Model Calc - Eu-154 Unit Act w Sched 40 & 12 In Shld
Geometry: 10 - Cylinder Surface External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Eu-154	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	6.181e-01	2.645e-50	7.894e-34	1.170e-52	3.491e-36

Page : 2
DOS File : PB122123.MS5
Run Date : December 21, 2005
Run Time: 3:53:07 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.570e-01	2.226e-35	8.349e-34	5.929e-38	2.224e-36
0.1	1.229e+00	3.349e-19	3.257e-17	5.124e-22	4.982e-20
0.2	2.074e-01	2.038e-16	3.221e-14	3.597e-19	5.685e-17
0.4	2.167e-02	3.187e-15	2.470e-13	6.210e-18	4.812e-16
0.5	6.576e-03	4.134e-15	2.296e-13	8.114e-18	4.506e-16
0.6	2.450e-01	4.826e-13	2.018e-11	9.419e-16	3.939e-14
0.8	1.184e+00	1.317e-11	3.521e-10	2.506e-14	6.697e-13
1.0	9.343e-01	3.740e-11	7.132e-10	6.894e-14	1.315e-12
1.5	1.185e+00	4.122e-10	4.471e-09	6.935e-13	7.523e-12
TOTALS:	5.789e+00	4.633e-10	5.557e-09	7.885e-13	9.547e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122123.MS5
Case Title: Line 1.26 D
This case was run on Wednesday, December 21, 2005 at 3:53:07 PM
Dose Point # 1 - (134.97,381,182.68) cm

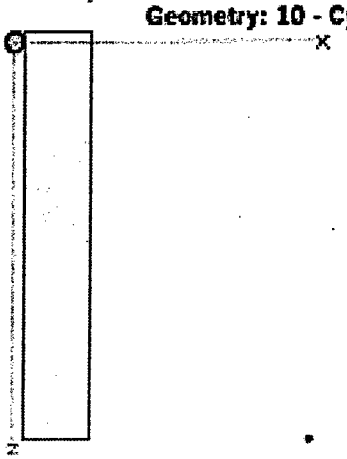
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.295e-010	4.169e-009
Photon Energy Fluence Rate	MeV/cm²/sec	4.633e-010	5.557e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.885e-013	9.547e-012
Absorbed Dose Rate in Air	mGy/hr	6.884e-015	8.335e-014
"	mrad/hr	6.884e-013	8.335e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.802e-015	9.466e-014
o Opposed	"	6.784e-015	8.194e-014
o Rotational		6.784e-015	8.194e-014
o Isotropic		6.080e-015	7.334e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.264e-015	1.004e-013
o Opposed	"	7.991e-015	9.694e-014
o Rotational		7.991e-015	9.694e-014
o Isotropic		6.405e-015	7.738e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.029e-015	8.521e-014
o Posterior/Anterior	"	6.512e-015	7.873e-014
o Lateral		5.246e-015	6.311e-014
o Rotational	"	5.878e-015	7.101e-014
o Isotropic	"	5.233e-015	6.305e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122124.MS5
Run Date : December 21, 2005
Run Time: 3:54:55 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Ag-108m	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	1.992e+00	1.510e-266	4.338e-34	5.230e-268	1.503e-35

Page : 2
DOS File : PB122124.MS5
Run Date : December 21, 2005
Run Time: 3:54:55 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	6.449e-07	2.763e-99	3.106e-40	2.739e-101	3.078e-42
0.08	2.152e-01	2.348e-22	1.293e-20	3.716e-25	2.047e-23
0.4	2.730e+00	4.015e-13	3.112e-11	7.824e-16	6.063e-14
0.6	2.745e+00	5.408e-12	2.262e-10	1.056e-14	4.414e-13
0.8	2.749e+00	3.057e-11	8.171e-10	5.815e-14	1.554e-12
TOTALS:	1.043e+01	3.638e-11	1.074e-09	6.949e-14	2.056e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122124.MS5
Case Title: Line 1.26 E
This case was run on Wednesday, December 21, 2005 at 3:54:55 PM
Dose Point # 1 - (134.97,381,182.88) cm

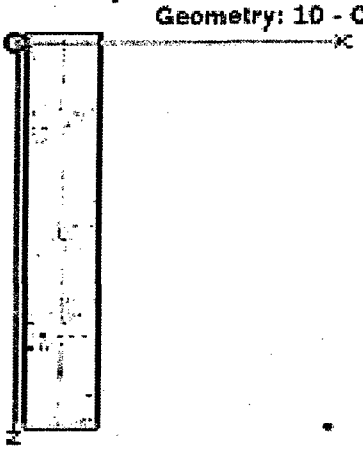
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.823e-011	1.476e-009
Photon Energy Fluence Rate	MeV/cm²/sec	3.638e-011	1.074e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.949e-014	2.056e-012
Absorbed Dose Rate in Air	mGy/hr	6.066e-016	1.795e-014
"	mrad/hr	6.066e-014	1.795e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.102e-016	2.108e-014
o Opposed	"	5.790e-016	1.711e-014
o Rotational	"	5.790e-016	1.711e-014
o Isotropic	"	5.118e-016	1.512e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.582e-016	2.247e-014
o Opposed	"	7.227e-016	2.141e-014
o Rotational	"	7.227e-016	2.141e-014
o Isotropic	"	5.476e-016	1.618e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.314e-016	1.872e-014
o Posterior/Anterior	"	5.633e-016	1.666e-014
o Lateral	"	4.245e-016	1.251e-014
o Rotational	"	5.039e-016	1.490e-014
o Isotropic		4.322e-016	1.276e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122125.MS5
Run Date : December 21, 2005
Run Time: 3:56:37 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 2	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	photons/sec	μCi/cm³	Bq/cm³
Nb-94	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	1.074e-03	0.000e+00	1.878e-37	0.000e+00	1.014e-38
0.0175	2.057e-03	0.000e+00	3.632e-37	0.000e+00	1.923e-38
0.0196	6.044e-04	2.596e-285	1.276e-37	9.584e-287	4.710e-39
0.7026	3.037e+00	1.564e-11	5.109e-10	3.016e-14	9.853e-13
0.711	3.037e+00	5.543e-11	1.301e-09	1.043e-13	2.449e-12

Page : 2
DOS File : PB122125.MS5
Run Date : December 21, 2005
Run Time: 3:56:37 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.078e+00	7.107e-11	1.812e-09	1.345e-13	3.434e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122125.MS5
Case Title: Line 1.26 F
This case was run on Wednesday, December 21, 2005 at 3:56:37 PM
Dose Point # 1 - (134.97,381,182.88) cm

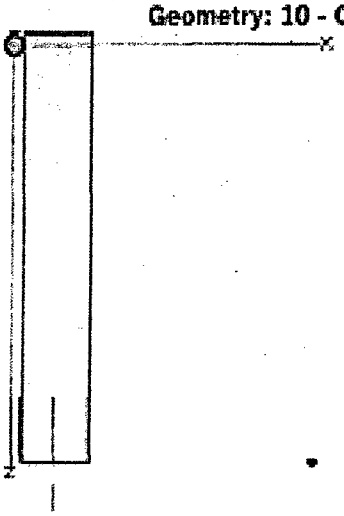
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.589e-011	2.221e-009
Photon Energy Fluence Rate	MeV/cm²/sec	7.107e-011	1.812e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.345e-013	3.434e-012
Absorbed Dose Rate in Air	mGy/hr	1.174e-015	2.998e-014
"	mrad/hr	1.174e-013	2.998e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.365e-015	3.488e-014
o Opposed	"	1.125e-015	2.871e-014
o Rotational		1.125e-015	2.871e-014
o Isotropic		9.948e-016	2.539e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.460e-015	3.730e-014
o Opposed	"	1.393e-015	3.559e-014
o Rotational		1.393e-015	3.559e-014
o Isotropic		1.064e-015	2.716e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.217e-015	3.109e-014
o Posterior/Anterior	"	1.092e-015	2.788e-014
o Lateral		8.309e-016	2.118e-014
o Rotational	"	9.780e-016	2.496e-014
o Isotropic	"	8.430e-016	2.150e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122917.MS5
Run Date : December 29, 2005
Run Time: 3:04:12 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	8.2087e-011	3.0372e+000	4.5000e-005	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	6.061e-01	1.803e-97	2.772e-34	1.887e-99	2.902e-36
0.0298	1.124e+00	1.055e-94	5.302e-34	1.069e-96	5.372e-36
0.0336	3.998e-01	4.067e-72	2.768e-34	2.893e-74	1.969e-36
0.0396	2.284e-01	9.463e-52	2.814e-34	4.300e-54	1.279e-36

Page : 2
DOS File : P8122917.MS5
Run Date : December 29, 2005
Run Time : 3:04:12 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.359e+00	9.463e-52	1.366e-33	4.300e-54	1.152e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122917.MS5
Case Title: Line 1.26 G
This case was run on Thursday, December 29, 2005 at 3:04:12 PM
Dose Point # 1 - (134.97,381,182.88) cm

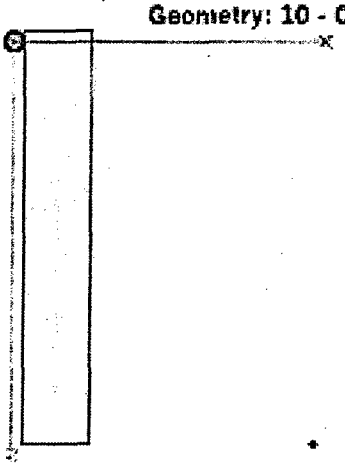
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.391e-050	4.256e-032
Photon Energy Fluence Rate	MeV/cm²/sec	9.463e-052	1.366e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.300e-054	1.152e-035
Absorbed Dose Rate in Air	mGy/hr	3.754e-056	1.006e-037
"	mrad/hr	3.754e-054	1.006e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.373e-056	1.151e-037
o Opposed	"	2.706e-056	5.776e-038
o Rotational		2.450e-056	4.926e-038
o Isotropic		2.344e-056	4.576e-038
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.406e-056	1.255e-037
o Opposed	"	3.732e-056	8.630e-038
o Rotational		3.732e-056	8.630e-038
o Isotropic		2.739e-056	6.378e-038
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.133e-056	5.162e-038
o Posterior/Anterior	"	1.894e-056	2.669e-038
o Lateral	"	1.046e-056	1.441e-038
o Rotational	"	1.703e-056	2.652e-038
o Isotropic		1.396e-056	2.197e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010405.MS5
Run Date : January 4, 2006
Run Time: 8:08:18 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Sn-126	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.92	2.351e-01	1.782e-267	5.120e-35	6.172e-269	1.773e-36

Page : 2
DOS File : PB010405.MS5
Run Date : January 4, 2006
Run Time: 8:08:18 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	8.893e-01	3.811e-93	4.282e-34	3.777e-95	4.244e-36
0.04	1.517e-02	6.491e-52	1.937e-35	2.871e-54	8.568e-38
0.06	2.911e-01	4.132e-28	1.210e-26	8.208e-31	2.404e-29
0.08	1.395e+00	1.522e-21	8.380e-20	2.408e-24	1.326e-22
TOTALS:	2.825e+00	1.522e-21	8.380e-20	2.408e-24	1.326e-22

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010405.MS5
Case Title: Line 1.26 H
This case was run on Wednesday, January 4, 2006 at 8:08:18 AM
Dose Point # 1 - (134.97,381,182.88) cm

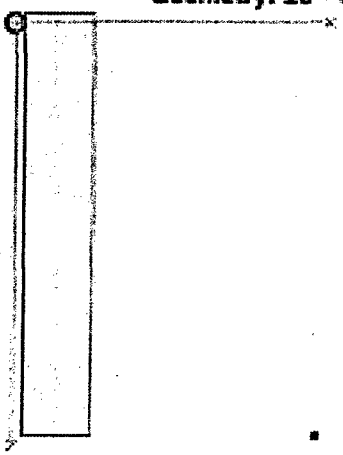
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.902e-020	1.048e-018
Photon Energy Fluence Rate	MeV/cm²/sec	1.522e-021	8.380e-020
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.408e-024	1.326e-022
Absorbed Dose Rate in Air	mGy/hr	2.102e-026	1.158e-024
"	mrad/hr	2.102e-024	1.158e-022
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.677e-026	2.025e-024
o Opposed	"	1.958e-026	1.079e-024
o Rotational	"	1.904e-026	1.048e-024
o Isotropic	"	1.890e-026	1.041e-024
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.643e-026	2.006e-024
o Opposed	"	2.677e-026	1.474e-024
o Rotational		2.677e-026	1.474e-024
o Isotropic		1.965e-026	1.082e-024
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.088e-026	1.701e-024
o Posterior/Anterior	"	2.356e-026	1.297e-024
o Lateral		1.452e-026	7.995e-025
o Rotational		2.006e-026	1.105e-024
o Isotropic		1.623e-026	8.937e-025

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122919.MS5
Run Date : December 29, 2005
Run Time: 3:09:53 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm 4 ft 5.1 in	381 cm 12 ft 6.0 in	182.88 cm 6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Zr-95	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	1.326e+00	8.182e-12	2.550e-10	1.573e-14	4.903e-13
0.7567	1.681e+00	1.347e-11	3.922e-10	2.578e-14	7.507e-13
TOTALS:	3.007e+00	2.165e-11	6.472e-10	4.152e-14	1.241e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122919.MS5
Case Title: Line 1.26 I
This case was run on Thursday, December 29, 2005 at 3:09:53 PM
Dose Point # 1 - (134.97,381,182.88) cm

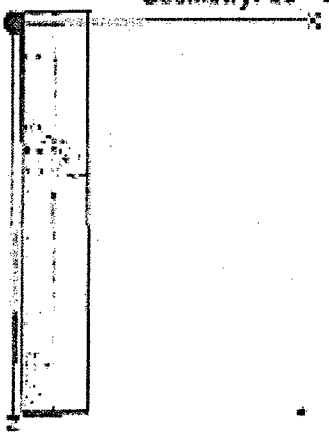
Results (Summed over energies)	Units	Without Buildup	Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.910e-011	8.704e-010
Photon Energy Fluence Rate	MeV/cm²/sec	2.165e-011	6.472e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.152e-014	1.241e-012
Absorbed Dose Rate in Air	mGy/hr	3.624e-016	1.083e-014
	mrad/hr	3.624e-014	1.083e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.248e-016	1.270e-014
o Opposed		3.455e-016	1.033e-014
o Rotational		3.455e-016	1.033e-014
o Isotropic		3.054e-016	9.128e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.536e-016	1.356e-014
o Opposed		4.322e-016	1.292e-014
o Rotational		4.322e-016	1.292e-014
o Isotropic		3.269e-016	9.770e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.773e-016	1.128e-014
o Posterior/Anterior		3.361e-016	1.005e-014
o Lateral		2.527e-016	7.554e-015
o Rotational		3.006e-016	8.986e-015
o Isotropic		2.575e-016	7.698e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122920.MS5
Run Date: December 29, 2005
Run Time: 3:11:41 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.26 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	182.88 cm
	4 ft 5.1 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.6
Shield 2	6.5 cm	Iron	7.86
Thin Void		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.001293
Wall Shld	0.762 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Eu-155	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.03	9.667e-03	4.142e-95	4.655e-35	4.105e-97	4.613e-38

Page : 2
DOS File : PB122920.MS5
Run Date : December 29, 2005
Run Time: 3:11:41 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	5.505e-01	2.356e-50	7.031e-34	1.042e-52	3.109e-36
0.05	1.791e-01	2.538e-35	9.522e-34	6.762e-38	2.537e-36
0.06	3.939e-02	5.593e-29	1.638e-27	1.111e-31	3.254e-30
0.08	9.431e-01	1.029e-21	5.667e-20	1.628e-24	8.968e-23
0.1	6.279e-01	1.711e-19	1.664e-17	2.618e-22	2.545e-20
TOTALS:	2.350e+00	1.721e-19	1.669e-17	2.634e-22	2.554e-20

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122920.MS5
Case Title: Line 1.26 J
This case was run on Thursday, December 29, 2005 at 3:11:41 PM
Dose Point # 1 - (134.97,381,182.88) cm

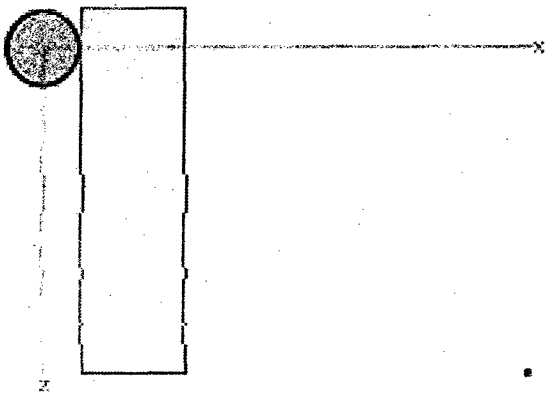
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.724e-018	1.671e-016
Photon Energy Fluence Rate	MeV/cm²/sec	1.721e-019	1.669e-017
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.634e-022	2.554e-020
Absorbed Dose Rate in Air	mGy/hr	2.299e-024	2.230e-022
"	mrad/hr	2.299e-022	2.230e-020
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.844e-024	3.727e-022
o Opposed	"	2.107e-024	2.044e-022
o Rotational	"	2.107e-024	2.044e-022
o Isotropic		2.039e-024	1.978e-022
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.819e-024	3.703e-022
o Opposed	"	2.962e-024	2.873e-022
o Rotational	"	2.962e-024	2.873e-022
o Isotropic	"	2.157e-024	2.092e-022
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.304e-024	3.204e-022
o Posterior/Anterior	"	2.591e-024	2.512e-022
o Lateral	"	1.599e-024	1.551e-022
o Rotational		2.213e-024	2.146e-022
o Isotropic		1.760e-024	1.707e-022

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB121915.MS5
Run Date : December 19, 2005
Run Time: 1:09:20 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.321e-03	1.085e-13	2.302e-12	2.095e-16	4.444e-15
1.1732	8.099e+00	7.292e-09	7.786e-08	1.303e-11	1.391e-10
1.3325	8.099e+00	1.258e-08	1.154e-07	2.182e-11	2.002e-10
TALS:	1.620e+01	1.987e-08	1.933e-07	3.485e-11	3.394e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121915.MS5
Case Title: Line 1.641 A2
This case was run on Monday, December 19, 2005 at 1:09:20 PM
Dose Point # 1 - (141.32,381,91.44) cm

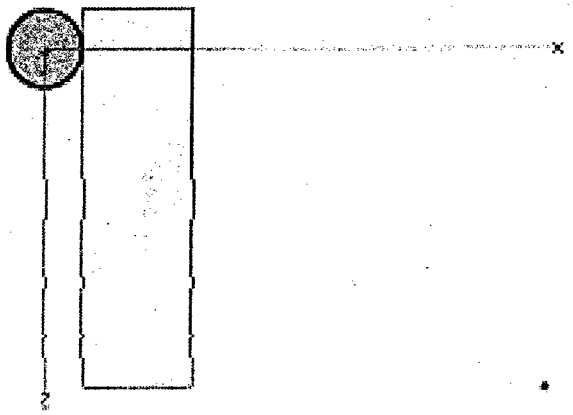
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.565e-008	1.530e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.987e-008	1.933e-007
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	3.485e-011	3.394e-010
Absorbed Dose Rate in Air	mGy/hr	3.043e-013	2.963e-012
"	mrad/hr	3.043e-011	2.963e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.454e-013	3.364e-012
o Opposed	"	2.975e-013	2.896e-012
o Rotational	"	2.975e-013	2.896e-012
o Isotropic	"	2.658e-013	2.587e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.677e-013	3.581e-012
o Opposed	"	3.540e-013	3.448e-012
o Rotational	"	3.540e-013	3.448e-012
o Isotropic	"	2.816e-013	2.741e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.110e-013	3.029e-012
o Posterior/Anterior	"	2.866e-013	2.790e-012
o Lateral	"	2.280e-013	2.218e-012
o Rotational	"	2.580e-013	2.512e-012
o Isotropic		2.284e-013	2.223e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122126.MS5
Run Date : December 21, 2005
Run Time: 5:32:49 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 B
Description: Revised Model Calc- Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ba-137m	2.0708e-010	7.6619e+000	4.2570e-009	1.5751e-004
Cs-137	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.586e-01	2.195e-65	1.383e-34	1.828e-67	1.152e-36
0.0322	2.927e-01	1.924e-63	2.652e-34	1.548e-65	2.134e-36
0.0364	1.065e-01	1.819e-49	1.478e-34	1.033e-51	8.396e-37
.516	6.894e+00	4.517e-10	1.021e-08	8.758e-13	1.979e-11

Page : 2
DOS File : PB122126.MS5
Run Date : December 21, 2005
Run Time: 5:32:49 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	7.452e+00	4.517e-10	1.021e-08	8.758e-13	1.979e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122126.MS5
Case Title: Line 1.641 B
This case was run on Wednesday, December 21, 2005 at 5:32:49 PM
Dose Point # 1 - (141.32,381,91.44) cm

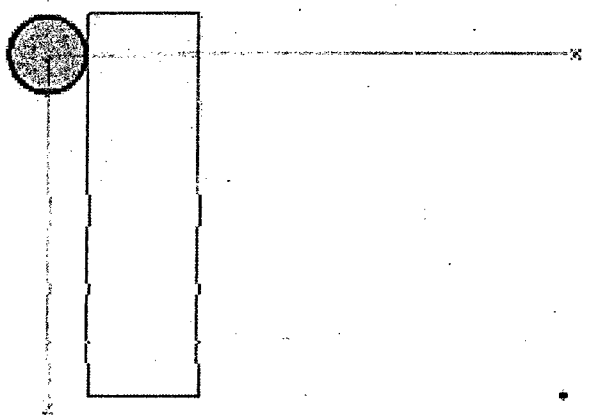
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.827e-010	1.543e-008
Photon Energy Fluence Rate	MeV/cm²/sec	4.517e-010	1.021e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.758e-013	1.979e-011
Absorbed Dose Rate in Air	mGy/hr	7.645e-015	1.728e-013
"	mrad/hr	7.645e-013	1.728e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.052e-015	2.046e-013
o Opposed	"	7.247e-015	1.638e-013
o Rotational	"	7.247e-015	1.638e-013
o Isotropic	"	6.409e-015	1.448e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.621e-015	2.174e-013
o Opposed	"	9.138e-015	2.065e-013
o Rotational	"	9.138e-015	2.065e-013
o Isotropic		6.851e-015	1.548e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	8.004e-015	1.809e-013
o Posterior/Anterior	"	7.065e-015	1.597e-013
o Lateral		5.239e-015	1.184e-013
o Rotational		6.313e-015	1.427e-013
o Isotropic		5.375e-015	1.215e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122127.MS5
Run Date : December 21, 2005
Run Time : 5:35:40 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 C
Description: Revised Model Calc- Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Eu-152	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.04	4.792e+00	8.694e-40	9.250e-33	3.845e-42	4.091e-35

Page : 2
DOS File : PB122127.MS5
Run Date : December 21, 2005
Run Time: 5:35:40 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.198e+00	2.782e-28	2.721e-27	7.410e-31	7.248e-30
0.1	2.303e+00	4.628e-16	2.759e-14	7.081e-19	4.221e-17
0.2	6.069e-01	6.825e-14	5.617e-12	1.204e-16	9.914e-15
0.3	2.190e+00	2.579e-12	1.571e-10	4.893e-15	2.979e-13
0.4	5.090e-01	2.747e-12	1.202e-10	5.352e-15	2.342e-13
0.5	4.569e-02	7.644e-13	2.507e-11	1.500e-15	4.921e-14
0.6	3.434e-01	1.406e-11	3.621e-10	2.744e-14	7.067e-13
0.8	1.442e+00	2.312e-10	4.055e-09	4.398e-13	7.713e-12
1.0	3.465e+00	1.539e-09	2.009e-08	2.837e-12	3.704e-11
1.5	1.879e+00	4.762e-09	3.822e-08	8.012e-12	6.430e-11
TOTALS:	1.877e+01	6.553e-09	6.303e-08	1.133e-11	1.103e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122127.MS5
Case Title: Line 1.641 C
This case was run on Wednesday, December 21, 2005 at 5:35:40 PM
Dose Point # 1 - (141.32,381,91.44) cm

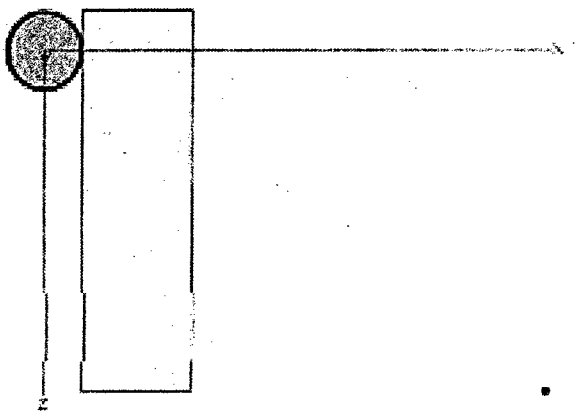
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	5.044e-009	5.215e-008
Photon Energy Fluence Rate	MeV/cm²/sec	6.553e-009	6.303e-008
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	1.133e-011	1.103e-010
Absorbed Dose Rate in Air	mGy/hr	9.890e-014	9.633e-013
	mrad/hr	9.890e-012	9.633e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.124e-013	1.098e-012
o Opposed		9.708e-014	9.424e-013
o Rotational		9.708e-014	9.424e-013
o Isotropic		8.681e-014	8.414e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.193e-013	1.167e-012
o Opposed		1.151e-013	1.124e-012
o Rotational		1.151e-013	1.124e-012
o Isotropic		9.170e-014	8.906e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.012e-013	9.872e-013
o Posterior/Anterior		9.334e-014	9.074e-013
o Lateral		7.460e-014	7.204e-013
o Rotational		8.414e-014	8.172e-013
o Isotropic		7.459e-014	7.218e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122128.MS5
Run Date : December 21, 2005
Run Time: 5:48:23 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 D
Description: Revised Model Calc- Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Eu-154	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	1.648e+00	2.991e-40	3.182e-33	1.323e-42	1.407e-35

Page : 2
DOS File : PB122128.MS5
Run Date : December 21, 2005
Run Time. 5:48:23 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	4.187e-01	9.719e-29	9.507e-28	2.589e-31	2.533e-30
0.1	3.277e+00	6.587e-16	3.927e-14	1.008e-18	6.008e-17
0.2	5.531e-01	6.220e-14	5.119e-12	1.098e-16	9.035e-15
0.4	5.778e-02	3.119e-13	1.365e-11	6.077e-16	2.659e-14
0.5	1.754e-02	2.934e-13	9.623e-12	5.760e-16	1.889e-14
0.6	6.533e-01	2.674e-11	6.887e-10	5.219e-14	1.344e-12
0.8	3.158e+00	5.064e-10	8.881e-09	9.633e-13	1.689e-11
1.0	2.492e+00	1.107e-09	1.445e-08	2.040e-12	2.663e-11
1.5	3.160e+00	8.010e-09	6.428e-08	1.348e-11	1.081e-10
TOTALS:	1.544e+01	9.650e-09	8.833e-08	1.653e-11	1.531e-10

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122128.MS5
Case Title: Line 1.641 D
This case was run on Wednesday, December 21, 2005 at 5:48:23 PM
Dose Point # 1 - (141.32,381,91.44) cm

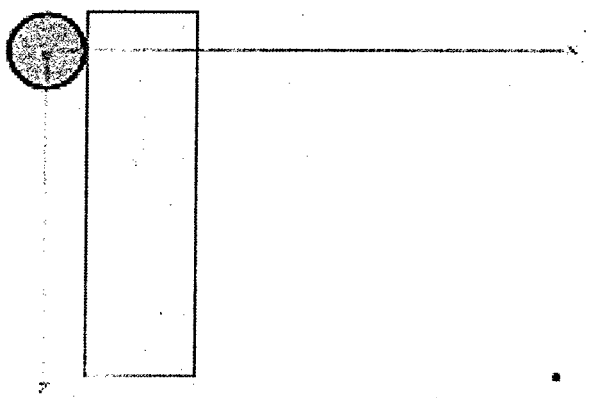
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.126e-009	6.963e-008
Photon Energy Fluence Rate	MeV/cm²/sec	9.650e-009	8.833e-008
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	1.653e-011	1.531e-010
Absorbed Dose Rate in Air	mGy/hr	1.443e-013	1.336e-012
"	mrad/hr	1.443e-011	1.336e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.638e-013	1.521e-012
o Opposed	"	1.420e-013	1.311e-012
o Rotational	"	1.420e-013	1.311e-012
o Isotropic		1.271e-013	1.172e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.737e-013	1.614e-012
o Opposed	"	1.678e-013	1.557e-012
o Rotational		1.678e-013	1.557e-012
o Isotropic		1.341e-013	1.238e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.475e-013	1.368e-012
o Posterior/Anterior	"	1.364e-013	1.261e-012
o Lateral		1.095e-013	1.006e-012
o Rotational		1.231e-013	1.136e-012
o Isotropic		1.093e-013	1.006e-012

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122129.MS5
Run Date : December 21, 2005
Run Time: 5:40:37 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 E
Description: Revised Model Calc- Ag108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Ag-108m	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	5.312e+00	1.878e-207	1.749e-33	6.504e-209	6.057e-35

Page : 2
DOS File : PB122129.MS5
Run Date : December 21, 2005
Run Time: 5:40:37 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.720e-06	1.197e-79	1.252e-39	1.186e-81	1.241e-41
0.08	5.740e-01	1.572e-18	5.952e-17	2.488e-21	9.419e-20
0.4	7.280e+00	3.929e-11	1.719e-09	7.655e-14	3.350e-12
0.6	7.321e+00	2.997e-10	7.718e-09	5.849e-13	1.506e-11
0.8	7.330e+00	1.175e-09	2.061e-08	2.235e-12	3.920e-11
TOTALS:	2.782e+01	1.514e-09	3.005e-08	2.897e-12	5.762e-11

MicroShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122129.MS5
Case Title: Line 1.641 E
This case was run on Wednesday, December 21, 2005 at 5:40:37 PM
Dose Point # 1 - (141.32,381,91.44) cm

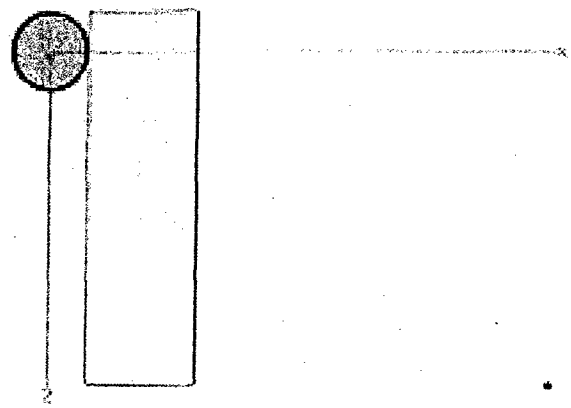
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.067e-009	4.292e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.514e-009	3.005e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.897e-012	5.762e-011
Absorbed Dose Rate in Air	mGy/hr	2.529e-014	5.030e-013
"	mrad/hr	2.529e-012	5.030e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.968e-014	5.926e-013
o Opposed	"	2.411e-014	4.787e-013
o Rotational		2.411e-014	4.787e-013
o Isotropic		2.131e-014	4.233e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.165e-014	6.309e-013
o Opposed	"	3.015e-014	6.005e-013
o Rotational	"	3.015e-014	6.005e-013
o Isotropic	"	2.280e-014	4.528e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.636e-014	5.256e-013
o Posterior/Anterior	"	2.347e-014	4.667e-013
o Lateral		1.764e-014	3.492e-013
o Rotational		2.099e-014	4.171e-013
o Isotropic		1.798e-014	3.567e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122130.MS5
Run Date : December 21, 2005
Run Time: 5:43:37 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Nb-94	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	2.864e-03	7.149e-309	7.568e-37	3.859e-310	4.085e-38
0.0175	5.487e-03	1.604e-303	1.464e-36	8.497e-305	7.752e-38
0.0196	1.612e-03	9.969e-223	5.142e-37	3.680e-224	1.898e-38
0.7026	8.099e+00	7.064e-10	1.473e-08	1.362e-12	2.841e-11
0.3711	8.099e+00	1.924e-09	3.011e-08	3.621e-12	5.667e-11

Page : 2
DOS File : PB122130.MS5
Run Date : December 21, 2005
Run Time: 5:43:37 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.621e+01	2.630e-09	4.484e-08	4.983e-12	8.508e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122130.MS5
Case Title: Line 1.641 F
This case was run on Wednesday, December 21, 2005 at 5:43:37 PM
Dose Point # 1 - (141.32,381,91.44) cm

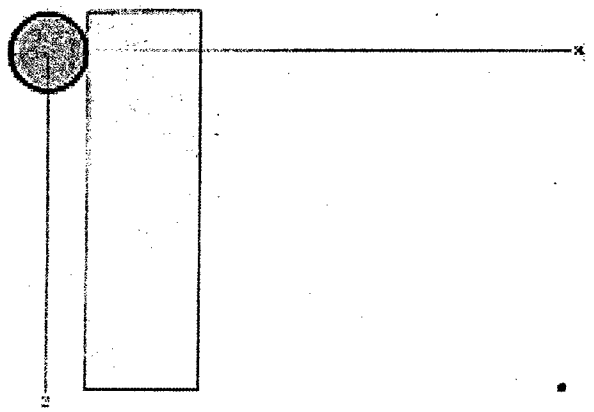
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.214e-009	5.553e-008
Photon Energy Fluence Rate	MeV/cm²/sec	2.630e-009	4.484e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.983e-012	8.508e-011
Absorbed Dose Rate in Air	mGy/hr	4.350e-014	7.427e-013
"	mrad/hr	4.350e-012	7.427e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.061e-014	8.650e-013
o Opposed	"	4.166e-014	7.109e-013
o Rotational	"	4.166e-014	7.109e-013
o Isotropic		3.684e-014	6.287e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.412e-014	9.247e-013
o Opposed	"	5.164e-014	8.821e-013
o Rotational		5.164e-014	8.821e-013
o Isotropic		3.942e-014	6.727e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.511e-014	7.706e-013
o Posterior/Anterior	"	4.046e-014	6.906e-013
o Lateral		3.074e-014	5.240e-013
o Rotational		3.622e-014	6.182e-013
o Isotropic		3.121e-014	5.322e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122921.MS5
Run Date : December 29, 2005
Run Time: 3:17:53 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	2.1690e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	1.616e+00	6.699e-77	1.117e-33	7.011e-79	1.169e-35
0.0298	2.999e+00	1.078e-74	2.137e-33	1.092e-76	2.165e-35
0.0336	1.066e+00	2.914e-57	1.116e-33	2.073e-59	7.936e-36
0.0396	6.091e-01	1.793e-41	1.134e-33	8.146e-44	5.154e-36

Page : 2
DOS File : PB122921.MS5
Run Date : December 29, 2005
Run Time: 3:17:53 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.290e+00	1.793e-41	5.504e-33	8.146e-44	4.644e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122921.MS5
Case Title: Line 1.641 G
This case was run on Thursday, December 29, 2005 at 3:17:53 PM
Dose Point # 1 - (141.32,381,91.44) cm

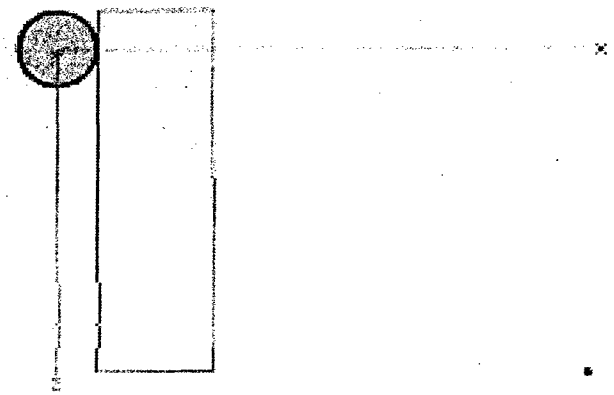
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.529e-040	1.716e-031
Photon Energy Fluence Rate	MeV/cm²/sec	1.793e-041	5.504e-033
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	8.146e-044	4.644e-035
Absorbed Dose Rate in Air	mGy/hr	7.111e-046	4.054e-037
"	mrad/hr	7.111e-044	4.054e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.018e-045	4.641e-037
o Opposed	"	5.127e-046	2.328e-037
o Rotational	"	4.642e-046	1.986e-037
o Isotropic	"	4.441e-046	1.844e-037
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.024e-045	5.058e-037
o Opposed	"	7.069e-046	3.478e-037
o Rotational	"	7.070e-046	3.478e-037
o Isotropic		5.188e-046	2.571e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.935e-046	2.081e-037
o Posterior/Anterior	"	3.588e-046	1.076e-037
o Lateral		1.982e-046	5.807e-038
o Rotational		3.226e-046	1.069e-037
o Isotropic		2.644e-046	8.856e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010406.MS5
Run Date : January 4, 2006
Run Time: 8:13:18 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 ; Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Sn-126	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.02	6.269e-01	2.216e-208	2.064e-34	7.676e-210	7.148e-36

Page : 2
DOS File : PB010406.MS5
Run Date : January 4, 2006
Run Time: 8:13:18 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	2.371e+00	1.651e-73	1.726e-33	1.636e-75	1.711e-35
0.04	4.046e-02	7.340e-42	7.809e-35	3.246e-44	3.454e-37
0.06	7.761e-01	5.345e-23	1.042e-21	1.062e-25	2.070e-24
0.08	3.719e+00	1.019e-17	3.857e-16	1.612e-20	6.103e-19
TOTALS:	7.534e+00	1.019e-17	3.857e-16	1.612e-20	6.103e-19

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010406.MS5
Case Title: Line 1.641 H
This case was run on Wednesday, January 4, 2006 at 8:13:18 AM
Dose Point # 1 - (141.32,381.91,44) cm

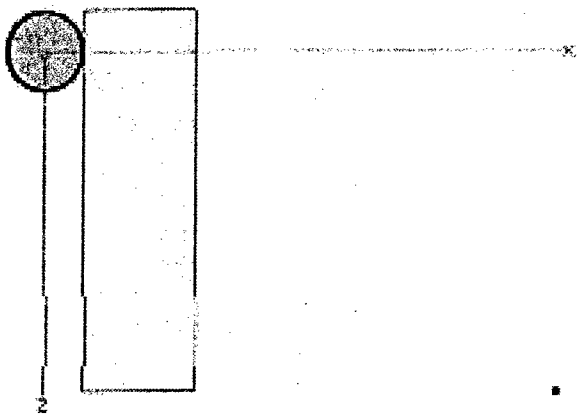
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.273e-016	4.821e-015
Photon Energy Fluence Rate	MeV/cm²/sec	1.019e-017	3.857e-016
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	1.612e-020	6.103e-019
Absorbed Dose Rate in Air	mGy/hr	1.407e-022	5.328e-021
"	mrad/hr	1.407e-020	5.328e-019
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.462e-022	9.320e-021
o Opposed	"	1.311e-022	4.964e-021
o Rotational	"	1.274e-022	4.825e-021
o Isotropic		1.265e-022	4.790e-021
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.439e-022	9.233e-021
o Opposed	"	1.793e-022	6.786e-021
o Rotational	"	1.793e-022	6.786e-021
o Isotropic	"	1.316e-022	4.981e-021
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.068e-022	7.827e-021
o Posterior/Anterior	"	1.577e-022	5.970e-021
o Lateral	"	9.719e-023	3.679e-021
o Rotational	"	1.343e-022	5.085e-021
o Isotropic	"	1.087e-022	4.113e-021

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122923.MS5
Run Date : December 29, 2005
Run Time: 3:21:15 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Zr-95	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	3.536e+00	3.557e-10	7.125e-09	6.840e-13	1.370e-11
0.7567	4.483e+00	5.544e-10	1.047e-08	1.061e-12	2.005e-11
TOTALS:	8.018e+00	9.101e-10	1.760e-08	1.745e-12	3.375e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\FB122923.MS5
Case Title: Line 1.641 I
This case was run on Thursday, December 29, 2005 at 3:21:15 PM
Dose Point # 1 - (141.32,381,91.44) cm

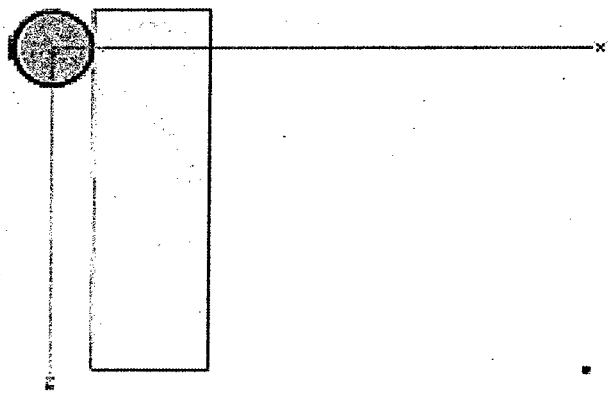
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.224e-009	2.368e-008
Photon Energy Fluence Rate	MeV/cm²/sec	9.101e-010	1.760e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.745e-012	3.375e-011
Absorbed Dose Rate in Air	mGy/hr	1.523e-014	2.946e-013
"	mrad/hr	1.523e-012	2.946e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.786e-014	3.454e-013
o Opposed	"	1.452e-014	2.808e-013
o Rotational	"	1.452e-014	2.808e-013
o Isotropic	"	1.284e-014	2.482e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.907e-014	3.687e-013
o Opposed	"	1.817e-014	3.513e-013
o Rotational		1.817e-014	3.513e-013
o Isotropic		1.374e-014	2.657e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.586e-014	3.067e-013
o Posterior/Anterior	"	1.413e-014	2.732e-013
o Lateral	"	1.062e-014	2.054e-013
o Rotational	"	1.264e-014	2.444e-013
o Isotropic	"	1.082e-014	2.093e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122924.MS5
Run Date: December 29, 2005
Run Time: 3:44:47 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	381 cm	91.44 cm
	4 ft 7.6 in	12 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-155	2.1890e-010	8.0992e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
	2.578e-02	1.794e-75	1.876e-35	1.778e-77	1.859e-37

Page : 2
DOS File : PB122924.MS5
Run Date : December 29, 2005
Run Time: 3:44:47 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.468e+00	2.664e-40	2.834e-33	1.178e-42	1.253e-35
0.05	4.775e-01	1.108e-28	1.084e-27	2.953e-31	2.888e-30
0.06	1.050e-01	7.234e-24	1.411e-22	1.437e-26	2.802e-25
0.08	2.515e+00	6.889e-18	2.608e-16	1.090e-20	4.127e-19
0.1	1.674e+00	3.365e-16	2.006e-14	5.148e-19	3.069e-17
TOTALS:	6.266e+00	3.434e-16	2.032e-14	5.257e-19	3.110e-17

MicroShield v5.04 (5.04-00362) **12/29/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122924.MS5
Case Title: Line 1.641 J
This case was run on Thursday, December 29, 2005 at 3:44:47 PM
Dose Point # 1 - (141.32,381.91,44) cm

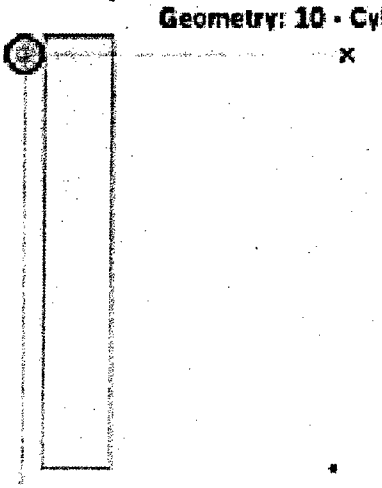
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.451e-015	2.039e-013
Photon Energy Fluence Rate	MeV/cm²/sec	3.434e-016	2.032e-014
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.257e-019	3.110e-017
Absorbed Dose Rate in Air	mGy/hr	4.589e-021	2.715e-019
"	mrad/hr	4.589e-019	2.715e-017
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.677e-021	4.541e-019
o Opposed	"	4.207e-021	2.489e-019
o Rotational	"	4.205e-021	2.488e-019
o Isotropic	"	4.071e-021	2.408e-019
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.627e-021	4.511e-019
o Opposed	"	5.912e-021	3.498e-019
o Rotational		5.912e-021	3.498e-019
o Isotropic		4.305e-021	2.547e-019
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.597e-021	3.902e-019
o Posterior/Anterior	"	5.170e-021	3.059e-019
o Lateral		3.191e-021	1.888e-019
o Rotational		4.416e-021	2.613e-019
o Isotropic		3.514e-021	2.079e-019

Page 1

Page : 1
DOS File : PB121917.MSS
Run Date : December 19, 2005
Run Time: 1:18:19 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	Ci/cm³	Bq/cm³
Co-60	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.909e-04	3.070e-15	1.040e-13	5.927e-18	2.008e-16
1.1732	6.074e+00	3.935e-10	6.080e-09	7.032e-13	1.086e-11
1.3325	6.074e+00	7.815e-10	1.013e-08	1.356e-12	1.758e-11
ALS:	1.215e+01	1.175e-09	1.621e-08	2.059e-12	2.845e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121917.MS5
Case Title: Line 1.81 A2
This case was run on Monday, December 19, 2005 at 1:18:19 PM
Dose Point # 1 - (138.78,381,182.88) cm

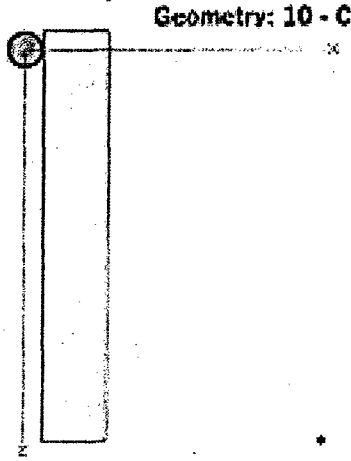
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.219e-010	1.279e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.175e-009	1.621e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.059e-012	2.845e-011
Absorbed Dose Rate in Air	mGy/hr	1.798e-014	2.483e-013
"	mrad/hr	1.798e-012	2.483e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.040e-014	2.819e-013
o Opposed	"	1.758e-014	2.428e-013
o Rotational		1.758e-014	2.428e-013
o Isotropic		1.571e-014	2.169e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.172e-014	3.001e-013
o Opposed	"	2.091e-014	2.890e-013
o Rotational	"	2.091e-014	2.890e-013
o Isotropic	"	1.664e-014	2.298e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.837e-014	2.539e-013
o Posterior/Anterior	"	1.693e-014	2.339e-013
o Lateral		1.348e-014	1.860e-013
o Rotational	"	1.525e-014	2.106e-013
o Isotropic		1.350e-014	1.864e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122131.MS5
Run Date: December 21, 2005
Run Time: 5:57:30 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 B
Description: Revised Model Calc- Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ba-137m	1.5531e-010	5.7464e+000	4.2570e-009	1.5751e-004
Cs-137	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	1.190e-01	8.090e-83	6.768e-35	6.739e-85	5.637e-37
0.0322	2.195e-01	2.278e-80	1.298e-34	1.834e-82	1.044e-36
0.0364	7.987e-02	4.644e-62	7.231e-35	2.638e-64	4.108e-37
.616	5.171e+00	1.200e-11	4.374e-10	2.326e-14	8.479e-13

Page : 2
DOS File : PB122131.MS5
Run Date : December 21, 2005
Run Time : 5:57:30 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	5.589e+00	1.200e-11	4.374e-10	2.326e-14	8.479e-13

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\FB122131.MS5
Case Title: Line 1.81 B
This case was run on Wednesday, December 21, 2005 at 5:57:30 PM
Dose Point # 1 - (138.78,381,182.88) cm

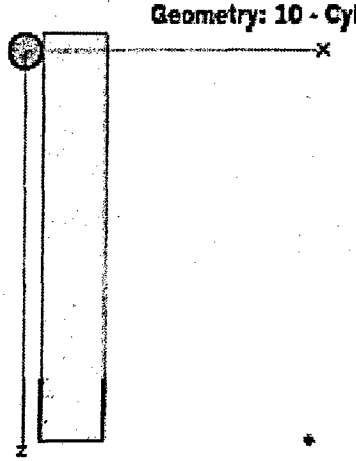
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.813e-011	6.611e-010
Photon Energy Fluence Rate	MeV/cm²/sec	1.200e-011	4.374e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.326e-014	8.479e-013
Absorbed Dose Rate in Air	mGy/hr	2.030e-016	7.403e-015
"	mrad/hr	2.030e-014	7.403e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.404e-016	8.764e-015
o Opposed	"	1.925e-016	7.017e-015
o Rotational	"	1.925e-016	7.017e-015
o Isotropic	"	1.702e-016	6.205e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.555e-016	9.315e-015
o Opposed	"	2.427e-016	8.847e-015
o Rotational		2.427e-016	8.847e-015
o Isotropic		1.819e-016	6.633e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.126e-016	7.750e-015
o Posterior/Anterior	"	1.876e-016	6.840e-015
o Lateral		1.391e-016	5.072e-015
o Rotational	"	1.677e-016	6.113e-015
o Isotropic	"	1.427e-016	5.204e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122132.MS5
Run Date : December 21, 2005
Run Time: 6:01:15 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 C
Description: Revised Model Calc- Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Eu-152	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)4	3.594e+00	5.464e-50	4.526e-33	2.416e-52	2.002e-35

Page : 2
DOS File . PB122132.MS5
Run Date : December 21, 2005
Run Time: 6:01:15 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	8.987e-01	6.428e-35	4.164e-33	1.712e-37	1.109e-35
0.1	1.727e+00	2.964e-19	2.871e-17	4.535e-22	4.392e-20
0.2	4.552e-01	2.821e-16	4.453e-14	4.979e-19	7.858e-17
0.3	1.642e+00	2.146e-14	2.443e-12	4.071e-17	4.634e-15
0.4	3.817e-01	3.575e-14	2.794e-12	6.965e-17	5.444e-15
0.5	3.426e-02	1.380e-14	7.755e-13	2.708e-17	1.522e-15
0.6	2.576e-01	3.272e-13	1.388e-11	6.386e-16	2.710e-14
0.8	1.082e+00	7.865e-12	2.141e-10	1.496e-14	4.073e-13
1.0	2.599e+00	6.895e-11	1.343e-09	1.271e-13	2.476e-12
1.5	1.409e+00	3.350e-10	3.726e-09	5.636e-13	6.268e-12
TOTALS:	1.408e+01	4.122e-10	5.303e-09	7.065e-13	9.190e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122132.MS5
Case Title: Line 1.81 C
This case was run on Wednesday, December 21, 2005 at 6:01:15 PM
Dose Point # 1 - (138.78,381,162.88) cm

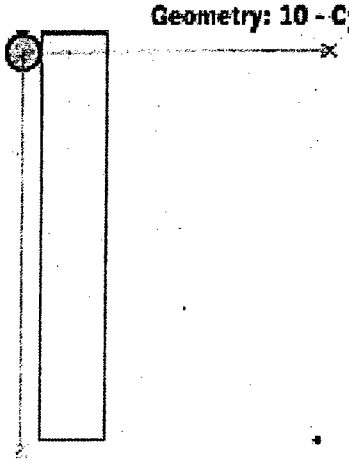
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.028e-010	4.135e-009
Photon Energy Fluence Rate	MeV/cm²/sec	4.122e-010	5.303e-009
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	7.065e-013	9.190e-012
Absorbed Dose Rate in Air	mGy/hr	6.167e-015	8.023e-014
"	mrad/hr	6.167e-013	8.023e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.997e-015	9.124e-014
o Opposed	"	6.068e-015	7.870e-014
o Rotational	"	6.068e-015	7.870e-014
o Isotropic	"	5.432e-015	7.036e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.419e-015	9.686e-014
o Opposed	"	7.167e-015	9.342e-014
o Rotational	"	7.167e-015	9.342e-014
o Isotropic	"	5.730e-015	7.435e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.301e-015	8.209e-014
o Posterior/Anterior	"	5.828e-015	7.569e-014
o Lateral	"	4.680e-015	6.042e-014
o Rotational		5.258e-015	6.822e-014
o Isotropic		4.673e-015	6.044e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122133.MS5
Run Date : December 21, 2005
Run Time: 6:08:42 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 D
Description: Revised Model Calc- Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm 4 ft 6.6 in	381 cm 12 ft 6.0 in	182.88 cm 6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Ro/cm²
Eu-154	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.04	1.236e+00	1.879e-50	1.557e-33	8.312e-53	6.886e-36

Page : 2
DOS File : PB122133.MS5
Run Date : December 21, 2005
Run Time: 6:08:42 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	3.140e-01	2.246e-35	1.455e-33	5.983e-38	3.876e-36
0.1	2.458e+00	4.219e-19	4.086e-17	6.455e-22	6.251e-20
0.2	4.148e-01	2.571e-16	4.058e-14	4.537e-19	7.162e-17
0.4	4.334e-02	4.059e-15	3.172e-13	7.908e-18	6.181e-16
0.5	1.315e-02	5.296e-15	2.977e-13	1.040e-17	5.843e-16
0.6	4.900e-01	6.223e-13	2.641e-11	1.215e-15	5.154e-14
0.8	2.369e+00	1.723e-11	4.690e-10	3.276e-14	8.920e-13
1.0	1.869e+00	4.957e-11	9.657e-10	9.138e-14	1.780e-12
1.5	2.370e+00	5.635e-10	6.267e-09	9.481e-13	1.054e-11
TOTALS:	1.158e+01	6.309e-10	7.728e-09	1.073e-12	1.327e-11

croShield v5.04 (5.04-00362) **12/21/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122133.MS5
Case Title: Line 1.81 D
This case was run on Wednesday, December 21, 2005 at 6:08:42 PM
Dose Point # 1 - (138.78,381,182.88) cm

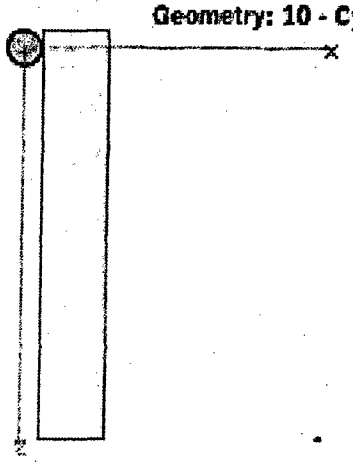
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.478e-010	5.775e-009
Photon Energy Fluence Rate	MeV/cm²/sec	6.309e-010	7.728e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.073e-012	1.327e-011
Absorbed Dose Rate in Air	mGy/hr	9.371e-015	1.158e-013
"	mrad/hr	9.371e-013	1.158e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.062e-014	1.315e-013
o Opposed	"	9.237e-015	1.139e-013
o Rotational	"	9.237e-015	1.139e-013
o Isotropic	"	8.278e-015	1.020e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.125e-014	1.395e-013
o Opposed	"	1.088e-014	1.347e-013
o Rotational	"	1.088e-014	1.347e-013
o Isotropic		8.720e-015	1.076e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	9.568e-015	1.184e-013
o Posterior/Anterior	"	8.866e-015	1.094e-013
o Lateral		7.143e-015	8.775e-014
o Rotational	"	8.002e-015	9.871e-014
o Isotropic	"	7.125e-015	8.765e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122134.MS5
Run Date: December 21, 2005
Run Time: 6:04:26 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ag-108m	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	3.984e+00	3.511e-269	8.557e-34	1.216e-270	2.964e-35

Page : 2
DOS File : PB122134.MS5
Run Date : December 21, 2005
Run Time: 6:04:26 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.290e-06	6.693e-100	6.125e-40	6.633e-102	6.070e-42
0.06	4.305e-01	2.930e-22	1.613e-20	4.637e-25	2.553e-23
0.4	5.460e+00	5.113e-13	3.996e-11	9.963e-16	7.787e-14
0.6	5.491e+00	6.975e-12	2.959e-10	1.361e-14	5.777e-13
0.8	5.497e+00	3.997e-11	1.088e-09	7.603e-14	2.070e-12
TOTALS:	2.086e+01	4.746e-11	1.424e-09	9.064e-14	2.726e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122134.MS5
Case Title: Line 1.61 E
This case was run on Wednesday, December 21, 2005 at 6:04:26 PM
Dose Point # 1 - (138.78,381,182.88) cm

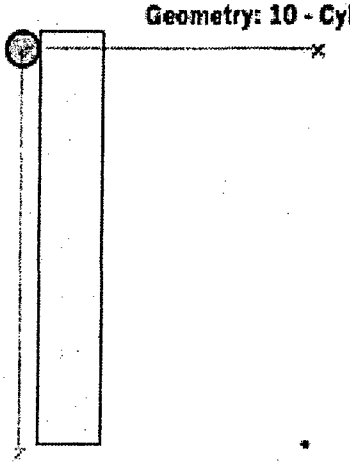
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.287e-011	1.954e-009
Photon Energy Fluence Rate	MeV/cm²/sec	4.746e-011	1.424e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	9.064e-014	2.726e-012
Absorbed Dose Rate in Air	mGy/hr	7.913e-016	2.380e-014
"	mrad/hr	7.913e-014	2.380e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.263e-016	2.794e-014
o Opposed	"	7.552e-016	2.268e-014
o Rotational	"	7.552e-016	2.268e-014
o Isotropic	"	6.676e-016	2.005e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.890e-016	2.979e-014
o Opposed	"	9.426e-016	2.837e-014
o Rotational	"	9.426e-016	2.837e-014
o Isotropic	"	7.144e-016	2.145e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	8.236e-016	2.481e-014
o Posterior/Anterior	"	7.347e-016	2.208e-014
o Lateral		5.537e-016	1.659e-014
o Rotational		6.573e-016	1.975e-014
o Isotropic		5.637e-016	1.691e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122135.MS5
Run Date : December 21, 2005
Run Time: 6:06:00 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.61 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Nb-94	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	2.148e-03	0.000e+00	3.704e-37	0.000e+00	1.999e-38
0.0175	4.115e-03	0.000e+00	7.163e-37	0.000e+00	3.793e-38
0.0196	1.209e-03	4.072e-288	2.516e-37	1.503e-289	9.289e-39
0.7026	6.074e+00	2.031e-11	6.748e-10	3.917e-14	1.301e-12
Σ11	6.074e+00	7.282e-11	1.743e-09	1.371e-13	3.281e-12

Page : 2
DOS File : PB122135.MSS
Run Date : December 21, 2005
Run Time: 6:06:00 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.215e+01	9.314e-11	2.418e-09	1.762e-13	4.582e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122135.MS5
Case Title: Line 1.81 F
This case was run on Wednesday, December 21, 2005 at 6:06:00 PM
Dose Point # 1 - (138.78,381,182.88) cm

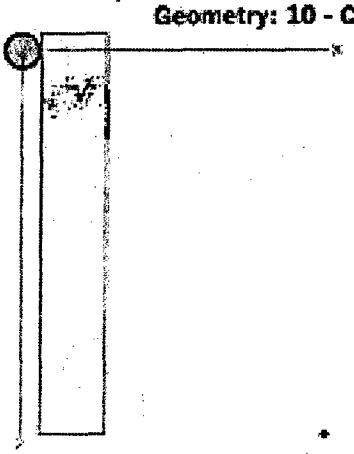
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.125e-010	2.962e-009
Photon Energy Fluence Rate	MeV/cm²/sec	9.314e-011	2.418e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.762e-013	4.582e-012
Absorbed Dose Rate in Air	mGy/hr	1.538e-015	4.000e-014
"	mrad/hr	1.538e-013	4.000e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.788e-015	4.655e-014
o Opposed	"	1.474e-015	3.831e-014
o Rotational	"	1.474e-015	3.831e-014
o Isotropic		1.304e-015	3.388e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.913e-015	4.977e-014
o Opposed	"	1.825e-015	4.749e-014
o Rotational		1.825e-015	4.749e-014
o Isotropic		1.395e-015	3.625e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.595e-015	4.149e-014
o Posterior/Anterior	"	1.431e-015	3.721e-014
o Lateral		1.089e-015	2.826e-014
o Rotational		1.282e-015	3.331e-014
o Isotropic		1.105e-015	2.869e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122925.MS5
Run Date : December 29, 2005
Run Time: 3:29:02 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
I-129	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	1.212e+00	3.914e-98	5.468e-34	4.096e-100	5.723e-36
0.0298	2.249e+00	2.447e-95	1.046e-33	2.479e-97	1.059e-35
0.0336	7.995e-01	1.708e-72	5.460e-34	1.215e-74	3.883e-36
0.0396	4.568e-01	6.565e-52	5.550e-34	2.983e-54	2.522e-36

Page : 2
DOS File : PB122925.MS5
Run Date : December 29, 2005
Run Time: 3:29:02 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.718e+00	6.565e-52	2.694e-33	2.983e-54	2.272e-35

MicroShield v5.04 (5.04-00362) **12/29/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122925.MS5
Case Title: Line 1.81 G
This case was run on Thursday, December 29, 2005 at 3:29:02 PM
Dose Point # 1 - (138.78,381,182.88) cm

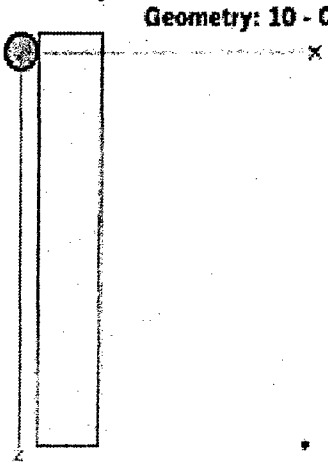
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.659e-050	8.395e-032
Photon Energy Fluence Rate	MeV/cm²/sec	6.565e-052	2.694e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.983e-054	2.272e-035
Absorbed Dose Rate in Air	mGy/hr	2.605e-056	1.984e-037
	mrad/hr	2.605e-054	1.984e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.728e-056	2.271e-037
o Opposed	"	1.878e-056	1.139e-037
o Rotational	"	1.700e-056	9.717e-038
o Isotropic	"	1.626e-056	9.025e-038
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.751e-056	2.475e-037
o Opposed	"	2.589e-056	1.702e-037
o Rotational	"	2.589e-056	1.702e-037
o Isotropic		1.900e-056	1.258e-037
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.174e-056	1.018e-037
o Posterior/Anterior	"	1.314e-056	5.264e-038
o Lateral	"	7.259e-057	2.841e-038
o Rotational		1.182e-056	5.231e-038
o Isotropic	"	9.685e-057	4.333e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010407.MS5
Run Date : January 4, 2006
Run Time: 8:18:21 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Sn-126	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.32	4.702e-01	4.143e-270	1.010e-34	1.435e-271	3.498e-36

Page : 2
DOS File : PB010407.MS5
Run Date : January 4, 2006
Run Time: 8:18:21 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.779e+00	9.229e-94	8.446e-34	9.147e-96	8.371e-36
0.04	3.034e-02	4.613e-52	3.821e-35	2.040e-54	1.690e-37
0.06	5.821e-01	4.779e-28	1.410e-26	9.492e-31	2.801e-29
0.08	2.789e+00	1.899e-21	1.045e-19	3.005e-24	1.654e-22
TOTALS:	5.650e+00	1.899e-21	1.045e-19	3.005e-24	1.654e-22

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010407.MS5
Case Title: Line 1.81 H
This case was run on Wednesday, January 4, 2006 at 8:18:21 AM
Dose Point # 1 - (138.78,381,182.88) cm

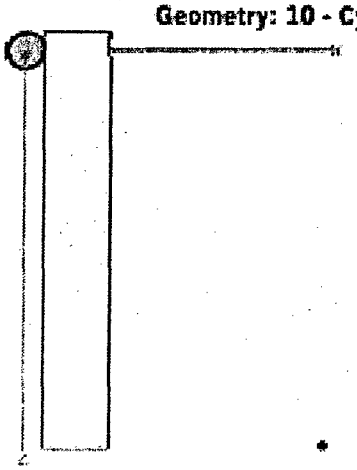
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.373e-020	1.307e-018
Photon Energy Fluence Rate	MeV/cm²/sec	1.899e-021	1.045e-019
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.005e-024	1.654e-022
Absorbed Dose Rate in Air	mGy/hr	2.623e-026	1.444e-024
"	mrad/hr	2.623e-024	1.444e-022
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.588e-026	2.526e-024
o Opposed	"	2.444e-026	1.345e-024
o Rotational		2.375e-026	1.308e-024
o Isotropic	"	2.358e-026	1.298e-024
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.545e-026	2.502e-024
o Opposed	"	3.341e-026	1.839e-024
o Rotational		3.341e-026	1.839e-024
o Isotropic		2.452e-026	1.350e-024
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.853e-026	2.121e-024
o Posterior/Anterior	"	2.939e-026	1.618e-024
o Lateral		1.811e-026	9.972e-025
o Rotational		2.503e-026	1.378e-024
o Isotropic		2.025e-026	1.115e-024

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122927.MS5
Run Date: December 29, 2005
Run Time: 3:33:53 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	381 cm	182.88 cm
	4 ft 6.6 in	12 ft 6.0 in	6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Zr-95	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	2.652e+00	1.064e-11	3.374e-10	2.046e-14	6.488e-13
0.7567	3.362e+00	1.756e-11	5.205e-10	3.361e-14	9.962e-13
TOTALS:	6.014e+00	2.820e-11	8.579e-10	5.407e-14	1.645e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122927.MS5
Case Title: Line 1.81 I
This case was run on Thursday, December 29, 2005 at 3:33:53 PM
Dose Point # 1 - (138.78,381,182.88) cm

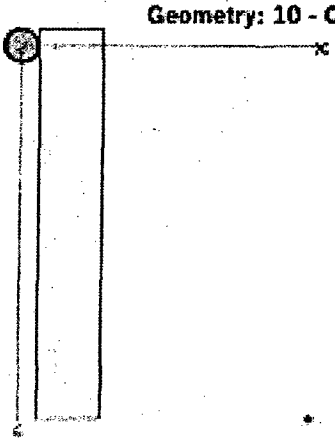
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.790e-011	1.154e-009
Photon Energy Fluence Rate	MeV/cm²/sec	2.820e-011	8.579e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.407e-014	1.645e-012
Absorbed Dose Rate in Air	mGy/hr	4.721e-016	1.436e-014
"	mrad/hr	4.721e-014	1.436e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.534e-016	1.683e-014
o Opposed	"	4.500e-016	1.369e-014
o Rotational	"	4.500e-016	1.369e-014
o Isotropic	"	3.978e-016	1.210e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.908e-016	1.797e-014
o Opposed	"	5.630e-016	1.713e-014
o Rotational	"	5.630e-016	1.713e-014
o Isotropic	"	4.257e-016	1.295e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.915e-016	1.495e-014
o Posterior/Anterior	"	4.378e-016	1.332e-014
o Lateral		3.292e-016	1.001e-014
o Rotational		3.916e-016	1.191e-014
o Isotropic		3.354e-016	1.020e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122928.MS5
Run Date : December 29, 2005
Run Time: 3:35:35 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.81 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm 4 ft 6.6 in	381 cm 12 ft 6.0 in	182.88 cm 6 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Eu-155	1.6417e-010	6.0744e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.03	1.933e-02	1.003e-05	9.181e-36	9.943e-08	9.099e-38

Page : 2
DOS File : PB122928.MS5
Run Date : December 29, 2005
Run Time: 3:35:35 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	1.101e+00	1.674e-50	1.387e-33	7.403e-53	6.133e-36
0.05	3.581e-01	2.561e-35	1.660e-33	6.824e-38	4.421e-36
0.06	7.878e-02	6.467e-29	1.909e-27	1.285e-31	3.791e-30
0.08	1.886e+00	1.284e-21	7.068e-20	2.032e-24	1.119e-22
0.1	1.256e+00	2.155e-19	2.087e-17	3.297e-22	3.193e-20
TOTALS:	4.699e+00	2.168e-19	2.094e-17	3.318e-22	3.204e-20

MicroShield v5.04 (5.04-00362) **12/29/05**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122928.MS5
Case Title: Line 1.81 J
This case was run on Thursday, December 29, 2005 at 3:35:35 PM
Dose Point # 1 - (138.78,381,182.88) cm

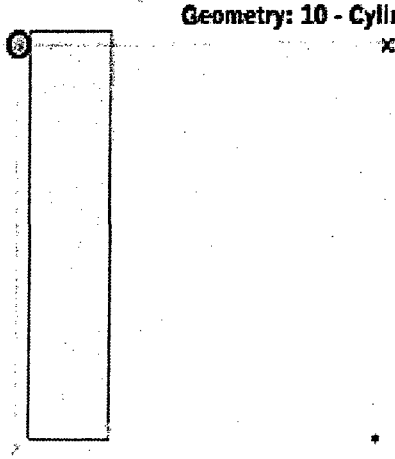
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.171e-018	2.096e-016
Photon Energy Fluence Rate	MeV/cm²/sec	2.168e-019	2.094e-017
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.318e-022	3.204e-020
Absorbed Dose Rate in Air	mGy/hr	2.896e-024	2.798e-022
"	mrad/hr	2.896e-022	2.798e-020
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.842e-024	4.676e-022
o Opposed	"	2.655e-024	2.564e-022
o Rotational	"	2.654e-024	2.564e-022
o Isotropic	"	2.569e-024	2.481e-022
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.810e-024	4.646e-022
o Opposed	"	3.731e-024	3.604e-022
o Rotational		3.731e-024	3.604e-022
o Isotropic		2.717e-024	2.624e-022
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.162e-024	4.019e-022
o Posterior/Anterior	"	3.263e-024	3.152e-022
o Lateral	"	2.014e-024	1.945e-022
o Rotational		2.787e-024	2.692e-022
o Isotropic		2.217e-024	2.142e-022

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB121919.MS5
Run Date : December 19, 2005
Run Time: 2:26:48 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	4.954e-04	1.479e-14	3.875e-13	2.856e-17	7.482e-16
1.1732	3.037e+00	1.293e-09	1.605e-08	2.310e-12	2.869e-11
1.3325	3.037e+00	2.353e-09	2.478e-08	4.082e-12	4.299e-11
TALS:	6.075e+00	3.646e-09	4.083e-08	6.393e-12	7.167e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121919.MS5
Case Title: Line 1.82 A2
This case was run on Monday, December 19, 2005 at 2:26:48 PM
Dose Point # 1 - (134.97,381,137.16) cm

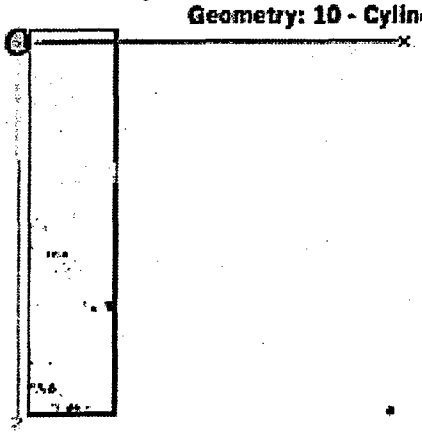
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.868e-009	3.228e-008
Photon Energy Fluence Rate	MeV/cm²/sec	3.646e-009	4.083e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.393e-012	7.167e-011
Absorbed Dose Rate in Air	mGy/hr	5.581e-014	6.257e-013
"	mrad/hr	5.581e-012	6.257e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.335e-014	7.104e-013
o Opposed	"	5.458e-014	6.118e-013
o Rotational	"	5.458e-014	6.118e-013
o Isotropic	"	4.876e-014	5.464e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.743e-014	7.563e-013
o Opposed	"	6.493e-014	7.281e-013
o Rotational		6.493e-014	7.281e-013
o Isotropic		5.165e-014	5.790e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.705e-014	6.397e-013
o Posterior/Anterior	"	5.256e-014	5.892e-013
o Lateral	"	4.182e-014	4.686e-013
o Rotational	"	4.733e-014	5.306e-013
o Isotropic	"	4.190e-014	4.695e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122136.MS5
Run Date : December 21, 2005
Run Time: 6:22:30 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 B
Description: Revised Model Calc- Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Ba-137m	7.7654e-011	2.8732e+000	4.2570e-009	1.5751e-004
Cs-137	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	5.948e-02	3.402e-73	4.329e-35	2.833e-75	3.606e-37
0.0322	1.097e-01	4.917e-71	8.299e-35	3.957e-73	6.679e-37
0.0364	3.994e-02	3.340e-55	4.625e-35	1.898e-57	2.628e-37
.516	2.585e+00	5.994e-11	1.683e-09	1.162e-13	3.262e-12

Page : 2
DOS File : PB122136.MS5
Run Date : December 21, 2005
Run Time: 6:22:30 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.794e+00	5.994e-11	1.683e-09	1.162e-13	3.262e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122136.MS5
Case Title: Line 1.82 B
This case was run on Wednesday, December 21, 2005 at 6:22:30 PM
Dose Point # 1 - (134.97,381,137.16) cm

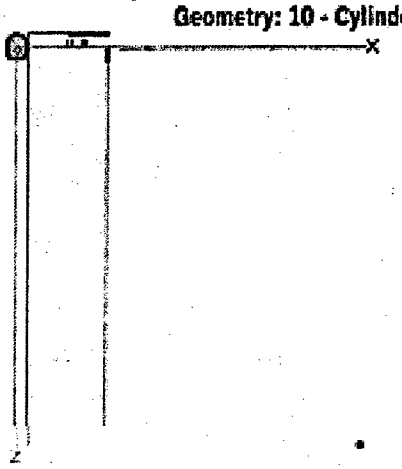
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.059e-011	2.543e-009
Photon Energy Fluence Rate	MeV/cm²/sec	5.994e-011	1.683e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.162e-013	3.262e-012
Absorbed Dose Rate in Air	mGy/hr	1.014e-015	2.848e-014
"	mrad/hr	1.014e-013	2.848e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.201e-015	3.372e-014
o Opposed	"	9.616e-016	2.699e-014
o Rotational		9.616e-016	2.699e-014
o Isotropic		8.503e-016	2.387e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.277e-015	3.583e-014
o Opposed	"	1.212e-015	3.404e-014
o Rotational	"	1.212e-015	3.404e-014
o Isotropic		9.090e-016	2.552e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.062e-015	2.981e-014
o Posterior/Anterior	"	9.374e-016	2.631e-014
o Lateral	"	6.951e-016	1.951e-014
o Rotational		8.377e-016	2.352e-014
o Isotropic		7.132e-016	2.002e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122137.MS5
Run Date: December 21, 2005
Run Time: 6:25:23 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 C
Description: Revised Model Calc- Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Eu-152	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	1.797e+00	1.690e-44	2.895e-33	7.474e-47	1.280e-35

Page : 2
DOS File : PB122137.MS5
Run Date : December 21, 2005
Run Time: 6:25:23 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	4.493e-01	1.845e-31	1.868e-30	4.916e-34	4.977e-33
0.1	8.635e-01	1.066e-17	8.150e-16	1.631e-20	1.247e-18
0.2	2.276e-01	3.876e-15	4.420e-13	6.842e-18	7.802e-16
0.3	8.212e-01	2.035e-13	1.683e-11	3.860e-16	3.192e-14
0.4	1.909e-01	2.661e-13	1.536e-11	5.184e-16	2.993e-14
0.5	1.713e-02	8.573e-14	3.617e-12	1.683e-16	7.100e-15
0.6	1.288e-01	1.762e-12	5.705e-11	3.440e-15	1.114e-13
0.8	5.408e-01	3.405e-11	7.258e-10	6.477e-14	1.380e-12
1.0	1.300e+00	2.536e-10	3.922e-09	4.675e-13	7.230e-12
1.5	7.046e-01	9.330e-10	8.500e-09	1.570e-12	1.430e-11
TOTALS:	7.040e+00	1.223e-09	1.324e-08	2.106e-12	2.309e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122137.MS5
Case Title: Line 1.82 C
This case was run on Wednesday, December 21, 2005 at 6:25:23 PM
Dose Point # 1 - (134.97,381,137.16) cm

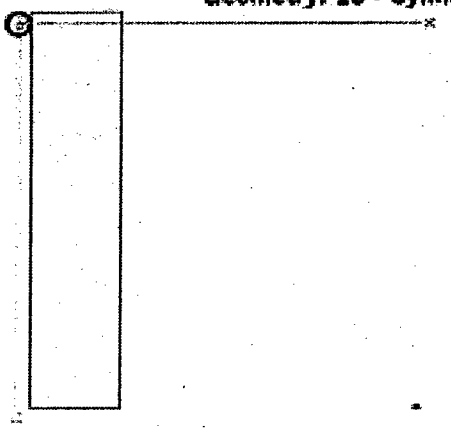
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.226e-010	1.070e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.223e-009	1.324e-008
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	2.106e-012	2.309e-011
Absorbed Dose Rate in Air	mGy/hr	1.839e-014	2.016e-013
	mrad/hr	1.839e-012	2.016e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.089e-014	2.296e-013
o Opposed	"	1.807e-014	1.974e-013
o Rotational		1.807e-014	1.974e-013
o Isotropic		1.617e-014	1.764e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.216e-014	2.439e-013
o Opposed	"	2.139e-014	2.350e-013
o Rotational		2.139e-014	2.350e-013
o Isotropic		1.707e-014	1.865e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.880e-014	2.065e-013
o Posterior/Anterior	"	1.737e-014	1.900e-013
o Lateral		1.391e-014	1.512e-013
o Rotational		1.566e-014	1.712e-013
o Isotropic		1.390e-014	1.514e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122138.MS5
Run Date : December 21, 2005
Run Time: 6:26:42 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 D
Description: Revised Model Calc- Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Eu-154	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.04	6.181e-01	5.813e-45	9.958e-34	2.571e-47	4.404e-36

Page 2
DOS File : PB122138.MS5
Run Date : December 21, 2005
Run Time : 6:26:42 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	1.570e-01	6.448e-32	6.527e-31	1.718e-34	1.739e-33
0.1	1.229e+00	1.518e-17	1.160e-15	2.322e-20	1.775e-18
0.2	2.074e-01	3.533e-15	4.029e-13	6.235e-18	7.110e-16
0.4	2.167e-02	3.021e-14	1.744e-12	5.886e-17	3.398e-15
0.5	6.576e-03	3.291e-14	1.388e-12	6.459e-17	2.725e-15
0.6	2.450e-01	3.352e-12	1.085e-10	6.543e-15	2.118e-13
0.8	1.184e+00	7.459e-11	1.590e-09	1.419e-13	3.023e-12
1.0	9.343e-01	1.824e-10	2.820e-09	3.361e-13	5.196e-12
1.5	1.185e+00	1.569e-09	1.430e-08	2.640e-12	2.405e-11
TOTALS:	5.789e+00	1.830e-09	1.882e-08	3.125e-12	3.249e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122138.MS5
Case Title: Line 1.82 D
This case was run on Wednesday, December 21, 2005 at 6:26:42 PM
Dose Point # 1 - (134.97,381,137.16) cm

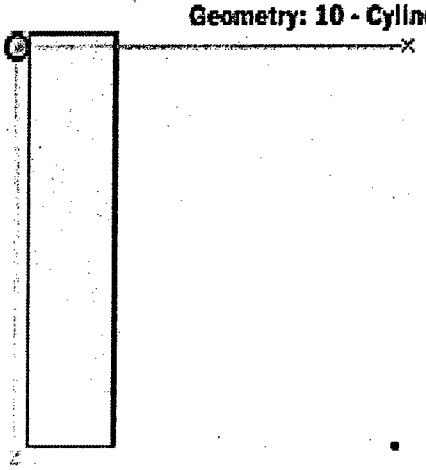
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.328e-009	1.453e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.830e-009	1.882e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.125e-012	3.249e-011
Absorbed Dose Rate in Air	mGy/hr	2.728e-014	2.837e-013
	mrad/hr	2.728e-012	2.837e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.094e-014	3.226e-013
o Opposed	"	2.686e-014	2.785e-013
o Rotational	"	2.686e-014	2.785e-013
o Isotropic	"	2.406e-014	2.491e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.279e-014	3.422e-013
o Opposed	"	3.169e-014	3.303e-013
o Rotational	"	3.169e-014	3.303e-013
o Isotropic	"	2.536e-014	2.630e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.787e-014	2.902e-013
o Posterior/Anterior	"	2.579e-014	2.677e-013
o Lateral	"	2.074e-014	2.141e-013
o Rotational	"	2.328e-014	2.414e-013
o Isotropic	"	2.070e-014	2.140e-013

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122139.MS5
Run Date : December 21, 2005
Run Time: 6:28:54 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Ag-108m	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.02	1.992e+00	2.769e-234	5.473e-34	9.593e-236	1.896e-35

Page : 2
DOS File : PB122139.MS5
Run Date : December 21, 2005
Run Time: 6:28:54 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	6.449e-07	1.149e-88	3.918e-40	1.138e-90	3.883e-42
0.08	2.152e-01	2.021e-20	9.243e-19	3.198e-23	1.463e-21
0.4	2.730e+00	3.806e-12	2.197e-10	7.415e-15	4.281e-13
0.6	2.745e+00	3.757e-11	1.216e-09	7.333e-14	2.374e-12
0.8	2.749e+00	1.731e-10	3.689e-09	3.292e-13	7.017e-12
TOTALS:	1.043e+01	2.145e-10	5.125e-09	4.100e-13	9.819e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122139.MS5
Case Title: Line 1.82 E
This case was run on Wednesday, December 21, 2005 at 6:28:54 PM
Dose Point # 1 - (134.97,381,137.16) cm

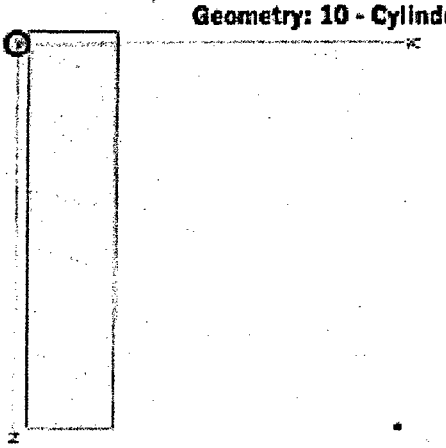
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.885e-010	7.187e-009
Photon Energy Fluence Rate	MeV/cm²/sec	2.145e-010	5.125e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.100e-013	9.819e-012
Absorbed Dose Rate in Air	mGy/hr	3.579e-015	8.572e-014
"	mrad/hr	3.579e-013	8.572e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.195e-015	1.008e-013
o Opposed	"	3.414e-015	8.164e-014
o Rotational		3.414e-015	8.164e-014
o Isotropic		3.018e-015	7.217e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.476e-015	1.074e-013
o Opposed	"	4.265e-015	1.023e-013
o Rotational	"	4.265e-015	1.023e-013
o Isotropic		3.229e-015	7.721e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.728e-015	8.947e-014
o Posterior/Anterior	"	3.322e-015	7.954e-014
o Lateral	"	2.500e-015	5.962e-014
o Rotational		2.972e-015	7.110e-014
o Isotropic		2.547e-015	6.084e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122140.MS5
Run Date : December 21, 2005
Run Time: 6:30:33 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Nb-94	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	1.074e-03	0.000e+00	2.369e-37	0.000e+00	1.279e-38
0.0175	2.057e-03	0.000e+00	4.581e-37	0.000e+00	2.426e-38
0.0196	6.044e-04	3.917e-251	1.609e-37	1.446e-252	5.941e-39
0.7026	3.037e+00	9.696e-11	2.494e-09	1.870e-13	4.809e-12
.711	3.037e+00	2.961e-10	5.580e-09	5.573e-13	1.050e-11

Page : 2
DOS File : PB122140.MS5
Run Date : December 21, 2005
Run Time: 6:30:33 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.078e+00	3.931e-10	8.074e-09	7.443e-13	1.531e-11

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122140.MS5
Case Title: Line 1.82 F
This case was run on Wednesday, December 21, 2005 at 6:30:33 PM
Dose Point # 1 - (134.97,381,137.16) cm

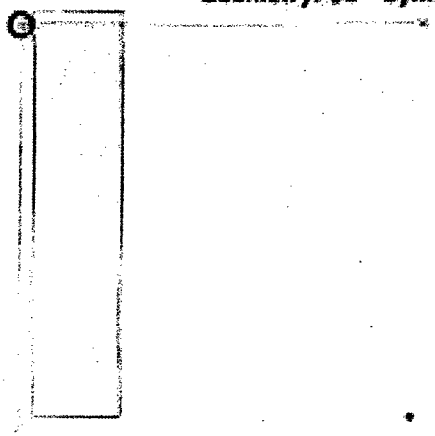
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.779e-010	9.955e-009
Photon Energy Fluence Rate	MeV/cm²/sec	3.931e-010	8.074e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.443e-013	1.531e-011
Absorbed Dose Rate in Air	mGy/hr	6.497e-015	1.337e-013
"	mrad/hr	6.497e-013	1.337e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.556e-015	1.556e-013
o Opposed	"	6.224e-015	1.280e-013
o Rotational		6.224e-015	1.280e-013
o Isotropic		5.504e-015	1.132e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.081e-015	1.664e-013
o Opposed	"	7.711e-015	1.587e-013
o Rotational		7.711e-015	1.587e-013
o Isotropic		5.890e-015	1.211e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.736e-015	1.387e-013
o Posterior/Anterior	"	6.044e-015	1.243e-013
o Lateral	"	4.595e-015	9.435e-014
o Rotational	"	5.412e-015	1.113e-013
o Isotropic	"	4.663e-015	9.581e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122929.MS5
Run Date : December 29, 2005
Run Time: 3:42:46 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
I-129	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	6.061e-01	2.441e-86	3.497e-34	2.554e-88	3.660e-36
0.0298	1.124e+00	7.026e-84	6.688e-34	7.119e-86	6.776e-36
0.0336	3.998e-01	3.963e-64	3.492e-34	2.818e-66	2.484e-36
0.0396	2.284e-01	2.764e-46	3.550e-34	1.256e-48	1.613e-36

Page : 2
DOS File : PB122929.MS5
Run Date : December 29, 2005
Run Time : 3:42:46 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS	2.359e+00	2.764e-46	1.723e-33	1.256e-48	1.453e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122929.MS5
Case Title: Line 1.82 G
This case was run on Thursday, December 29, 2005 at 3:42:46 PM
Dose Point # 1 - (134.97,381,137.16) cm

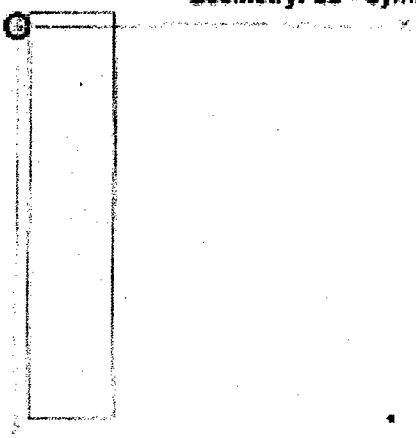
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	6.984e-045	5.369e-032
Photon Energy Fluence Rate	MeV/cm²/sec	2.764e-046	1.723e-033
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.256e-048	1.453e-035
Absorbed Dose Rate in Air	mGy/hr	1.097e-050	1.269e-037
	mrad/hr	1.097e-048	1.269e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.570e-050	1.453e-037
o Opposed	"	7.906e-051	7.286e-038
o Rotational	"	7.158e-051	6.215e-038
o Isotropic	"	6.848e-051	5.772e-038
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.579e-050	1.583e-037
o Opposed	"	1.090e-050	1.089e-037
o Rotational	"	1.090e-050	1.089e-037
o Isotropic	"	8.000e-051	8.046e-038
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	9.152e-051	6.512e-038
o Posterior/Anterior	"	5.532e-051	3.367e-038
o Lateral	"	3.056e-051	1.817e-038
o Rotational	"	4.975e-051	3.345e-038
o Isotropic	"	4.078e-051	2.772e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010408.MS5
Run Date : January 4, 2006
Run Time: 8:24:59 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Ba/cm³
Sn-126	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
)2	2.351e-01	3.268e-235	6.458e-35	1.132e-236	2.237e-36

Page : 2
DOS File : PB010408.MSS
Run Date : January 4, 2006
Run Time: 8:24:59 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	8.893e-01	1.584e-82	5.402e-34	1.570e-84	5.354e-36
0.04	1.517e-02	1.427e-46	2.444e-35	6.310e-49	1.081e-37
0.06	2.911e-01	1.747e-25	4.092e-24	3.470e-28	8.127e-27
0.08	1.395e+00	1.309e-19	5.989e-18	2.072e-22	9.478e-21
TOTALS:	2.825e+00	1.309e-19	5.989e-18	2.072e-22	9.478e-21

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010408.MS5
Case Title: Line 1.82 H
This case was run on Wednesday, January 4, 2006 at 8:24:59 AM
Dose Point # 1 - (134.97,381,187.16) cm

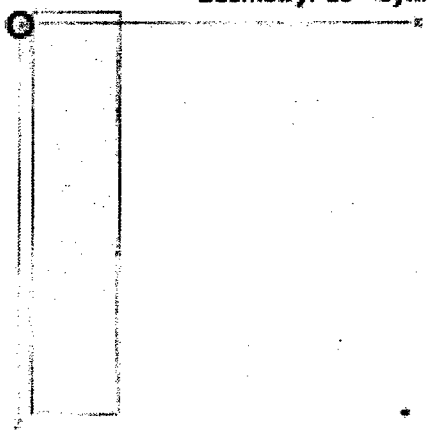
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.637e-018	7.486e-017
Photon Energy Fluence Rate	MeV/cm²/sec	1.309e-019	5.989e-018
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.072e-022	9.478e-021
Absorbed Dose Rate in Air	mGy/hr	1.809e-024	8.274e-023
	mrad/hr	1.809e-022	8.274e-021
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.164e-024	1.447e-022
o Opposed	"	1.685e-024	7.708e-023
o Rotational	"	1.638e-024	7.492e-023
o Isotropic	"	1.626e-024	7.438e-023
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.134e-024	1.434e-022
o Opposed	"	2.304e-024	1.054e-022
o Rotational	"	2.304e-024	1.054e-022
o Isotropic	"	1.691e-024	7.735e-023
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.657e-024	1.215e-022
o Posterior/Anterior	"	2.027e-024	9.271e-023
o Lateral	"	1.249e-024	5.714e-023
o Rotational	"	1.726e-024	7.897e-023
o Isotropic	"	1.396e-024	6.387e-023

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122931.MS5
Run Date : December 29, 2005
Run Time : 3:55:03 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Zr-95	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	1.326e+00	4.965e-11	1.222e-09	9.546e-14	2.350e-12
0.7567	1.681e+00	7.926e-11	1.831e-09	1.517e-13	3.504e-12
TOTALS:	3.007e+00	1.289e-10	3.053e-09	2.472e-13	5.854e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122931.MS5
Case Title: Line 1.82 I
This case was run on Thursday, December 29, 2005 at 3:55:03 PM
Dose Point # 1 - (134.97,381,137.16) cm

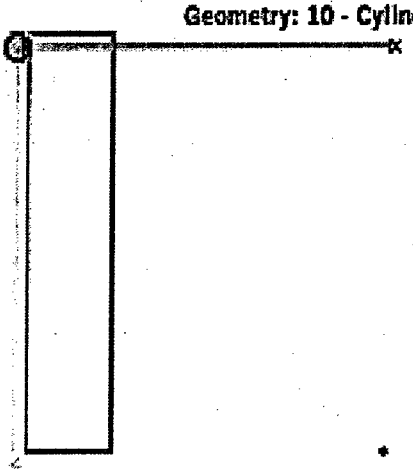
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.733e-010	4.107e-009
Photon Energy Fluence Rate	MeV/cm²/sec	1.289e-010	3.053e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.472e-013	5.854e-012
Absorbed Dose Rate in Air	mGy/hr	2.158e-015	5.111e-014
	mrad/hr	2.158e-013	5.111e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.529e-015	5.991e-014
o Opposed	"	2.057e-015	4.872e-014
o Rotational	"	2.057e-015	4.872e-014
o Isotropic	"	1.818e-015	4.306e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.700e-015	6.396e-014
o Opposed	"	2.573e-015	6.095e-014
o Rotational	"	2.573e-015	6.095e-014
o Isotropic	"	1.946e-015	4.609e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.247e-015	5.321e-014
o Posterior/Anterior	"	2.001e-015	4.739e-014
o Lateral	"	1.505e-015	3.563e-014
o Rotational	"	1.790e-015	4.239e-014
o Isotropic	"	1.533e-015	3.631e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122932.MS5
Run Date : December 29, 2005
Run Time: 3:57:38 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.82 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	381 cm	137.16 cm
	4 ft 5.1 in	12 ft 6.0 in	4 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Eu-155	8.2087e-011	3.0372e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
03	9.667e-03	1.722e-84	5.872e-36	1.706e-86	5.820e-38

Page : 2
DOS File : PB122932.MS5
Run Date : December 29, 2005
Run Time: 3:57:38 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	5.505e-01	5.177e-45	8.869e-34	2.290e-47	3.922e-36
0.05	1.791e-01	7.354e-32	7.445e-31	1.959e-34	1.983e-33
0.06	3.939e-02	2.364e-26	5.538e-25	4.696e-29	1.100e-27
0.08	9.431e-01	8.854e-20	4.050e-18	1.401e-22	6.409e-21
0.1	6.279e-01	7.753e-18	5.926e-16	1.186e-20	9.066e-19
TOTALS:	2.350e+00	7.841e-18	5.966e-16	1.200e-20	9.130e-19

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122932.MS5
Case Title: Line 1.82 J
This case was run on Thursday, December 29, 2005 at 3:57:38 PM
Dose Point # 1 - (134.97,381,137.16) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.863e-017	5.976e-015
Photon Energy Fluence Rate	MeV/cm²/sec	7.841e-018	5.965e-016
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.200e-020	9.130e-019
Absorbed Dose Rate in Air	mGy/hr	1.048e-022	7.970e-021
"	mrad/hr	1.048e-020	7.970e-019
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.752e-022	1.332e-020
o Opposed	"	9.603e-023	7.305e-021
o Rotational		9.600e-023	7.304e-021
o Isotropic		9.292e-023	7.069e-021
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.740e-022	1.324e-020
o Opposed	"	1.350e-022	1.027e-020
o Rotational		1.350e-022	1.027e-020
o Isotropic	"	9.827e-023	7.476e-021
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.506e-022	1.145e-020
o Posterior/Anterior	"	1.180e-022	8.980e-021
o Lateral	"	7.285e-023	5.542e-021
o Rotational		1.008e-022	7.669e-021
o Isotropic		8.021e-023	6.102e-021

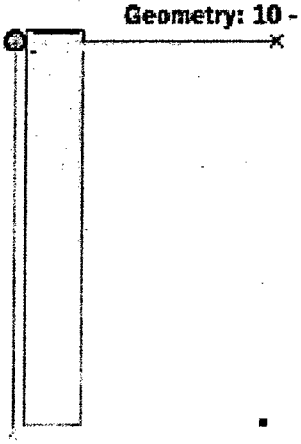
Page

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB121921.MS5
Ru ate: December 19, 2005
Run Time: 2:43:03 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 A2
Description: Revised Model Calc. - Co-60 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Co-60	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.606e-04	7.170e-16	2.821e-14	1.384e-18	5.447e-17
1.1732	4.050e+00	1.166e-10	2.020e-09	2.084e-13	3.609e-12
1.3325	4.050e+00	2.436e-10	3.513e-09	4.226e-13	6.095e-12
TALS:	8.100e+00	3.602e-10	5.533e-09	6.310e-13	9.705e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB121921.MS5
Case Title: Line 1.83 A2
This case was run on Monday, December 19, 2005 at 2:43:03 PM
Dose Point # 1 - (136.24,381,213.36) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.822e-010	4.358e-009
Photon Energy Fluence Rate	MeV/cm²/sec	3.602e-010	5.533e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.310e-013	9.705e-012
Absorbed Dose Rate in Air	mGy/hr	5.509e-015	8.472e-014
	mrad/hr	5.509e-013	8.472e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.252e-015	9.618e-014
o Opposed	"	5.388e-015	8.285e-014
o Rotational		5.388e-015	8.285e-014
o Isotropic		4.814e-015	7.401e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.654e-015	1.024e-013
o Opposed	"	6.409e-015	9.858e-014
o Rotational		6.409e-015	9.858e-014
o Isotropic	"	5.099e-015	7.841e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.631e-015	8.661e-014
o Posterior/Anterior	"	5.189e-015	7.979e-014
o Lateral	"	4.130e-015	6.348e-014
o Rotational	"	4.673e-015	7.185e-014
o Isotropic	"	4.138e-015	6.360e-014

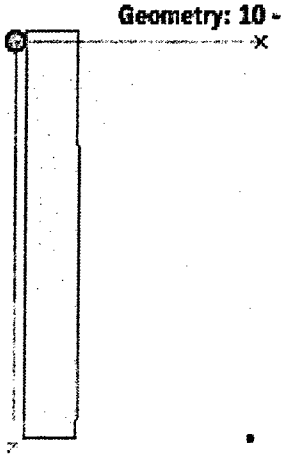
Page

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122141.MS5
Run Date : December 21, 2005
Run Time: 6:38:11 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 B
Description: Revised Model Calc- Cs-137 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Ba-137m	1.0354e-010	3.8309e+000	4.2570e-009	1.5751e-004
Cs-137	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	7.931e-02	3.620e-89	3.915e-35	3.015e-91	3.261e-37
0.0322	1.463e-01	1.539e-86	7.506e-35	1.239e-88	6.041e-37
0.0364	5.325e-02	1.078e-66	4.183e-35	6.124e-69	2.377e-37
.316	3.447e+00	2.737e-12	1.163e-10	5.306e-15	2.255e-13

Page : 2
DOS File : PB122141.MSS
Run Date : December 21, 2005
Run Time: 6:38:11 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	3.726e+00	2.737e-12	1.163e-10	5.306e-15	2.255e-13

MicroShield v5.04 (5.04-00362) **01/02/06**

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122141.MS5
Case Title: Line 1.83 B
This case was run on Wednesday, December 21, 2005 at 6:38:11 PM
Dose Point # 1 - (136.24,381,213.36) cm

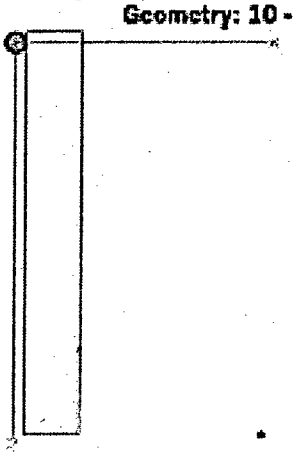
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	4.137e-012	1.758e-010
Photon Energy Fluence Rate	MeV/cm²/sec	2.737e-012	1.163e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	5.306e-015	2.255e-013
Absorbed Dose Rate in Air	mGy/hr	4.632e-017	1.969e-015
"	mrad/hr	4.632e-015	1.969e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.484e-017	2.331e-015
o Opposed	"	4.391e-017	1.866e-015
o Rotational		4.391e-017	1.866e-015
o Isotropic		3.883e-017	1.650e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.829e-017	2.477e-015
o Opposed	"	5.536e-017	2.353e-015
o Rotational	"	5.536e-017	2.353e-015
o Isotropic	"	4.151e-017	1.764e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.849e-017	2.061e-015
o Posterior/Anterior	"	4.280e-017	1.819e-015
o Lateral		3.174e-017	1.349e-015
o Rotational		3.825e-017	1.626e-015
o Isotropic		3.256e-017	1.384e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122142.MS5
Run Date: December 21, 2005
Run Time: 6:39:33 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 C
Description: Revised Model Calc- Eu-152 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Eu-152	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	2.396e+00	9.024e-54	2.618e-33	3.991e-56	1.158e-35

Page : 2
DOS File : PB122142.MS5
Run Date : December 21, 2005
Run Time: 6:39:33 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	5.991e-01	2.000e-37	2.140e-33	5.329e-40	5.702e-36
0.1	1.151e+00	1.651e-20	1.872e-18	2.525e-23	2.865e-21
0.2	3.035e-01	3.175e-17	6.224e-15	5.604e-20	1.098e-17
0.3	1.095e+00	3.152e-15	4.414e-13	5.980e-18	8.372e-16
0.4	2.545e-01	6.228e-15	5.881e-13	1.213e-17	1.146e-15
0.5	2.284e-02	2.722e-15	1.820e-13	5.342e-18	3.572e-16
0.6	1.717e-01	7.104e-14	3.539e-12	1.387e-16	6.907e-15
0.8	7.210e-01	1.967e-12	6.157e-11	3.742e-15	1.171e-13
1.0	1.733e+00	1.909e-11	4.213e-10	3.519e-14	7.766e-13
1.5	9.394e-01	1.091e-10	1.341e-09	1.836e-13	2.256e-12
TOTALS:	9.387e+00	1.303e-10	1.828e-09	2.227e-13	3.159e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122142.MS5
Case Title: Line 1.83 C
This case was run on Wednesday, December 21, 2005 at 6:39:33 PM
Dose Point # 1 - (136.24,381,213.36) cm

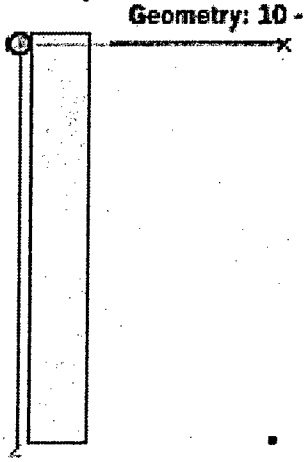
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.446e-011	1.401e-009
Photon Energy Fluence Rate	MeV/cm²/sec	1.303e-010	1.828e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.227e-013	3.159e-012
Absorbed Dose Rate in Air	mGy/hr	1.944e-015	2.758e-014
"	mrad/hr	1.944e-013	2.758e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.205e-015	3.134e-014
o Opposed	"	1.914e-015	2.707e-014
o Rotational	"	1.914e-015	2.707e-014
o Isotropic	"	1.714e-015	2.421e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.337e-015	3.326e-014
o Opposed	"	2.259e-015	3.209e-014
o Rotational	"	2.259e-015	3.209e-014
o Isotropic	"	1.808e-015	2.557e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.986e-015	2.820e-014
o Posterior/Anterior	"	1.838e-015	2.603e-014
o Lateral		1.478e-015	2.081e-014
o Rotational		1.659e-015	2.347e-014
o Isotropic		1.475e-015	2.081e-014

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122143.MS5
Run Date : December 21, 2005
Run Time: 6:40:51 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 D
Description: Revised Model Calc- Eu-154 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Eu-154	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
04	8.242e-01	3.104e-54	9.006e-34	1.373e-56	3.983e-36

Page : 2
DOS File : PB122143.MS5
Run Date : December 21, 2005
Run Time: 6:40:51 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.05	2.093e-01	6.989e-36	7.479e-34	1.862e-40	1.992e-36
0.1	1.639e+00	2.349e-20	2.665e-18	3.594e-23	4.077e-21
0.2	2.766e-01	2.894e-17	5.672e-15	5.107e-20	1.001e-17
0.4	2.889e-02	7.071e-16	6.676e-14	1.378e-18	1.301e-16
0.5	8.768e-03	1.045e-15	6.985e-14	2.051e-18	1.371e-16
0.6	3.266e-01	1.351e-13	6.731e-12	2.637e-16	1.314e-14
0.8	1.579e+00	4.309e-12	1.349e-10	8.196e-15	2.565e-13
1.0	1.246e+00	1.372e-11	3.029e-10	2.530e-14	5.584e-13
1.5	1.580e+00	1.836e-10	2.255e-09	3.089e-13	3.794e-12
TOTALS:	7.718e+00	2.018e-10	2.700e-09	3.427e-13	4.623e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122143.MS5
Case Title: Line 1.83 D
This case was run on Wednesday, December 21, 2005 at 6:40:51 PM
Dose Point # 1 - (136.24,381,213.36) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.417e-010	1.987e-009
Photon Energy Fluence Rate	MeV/cm²/sec	2.018e-010	2.700e-009
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.427e-013	4.623e-012
Absorbed Dose Rate in Air	mGy/hr	2.991e-015	4.036e-014
"	mrad/hr	2.991e-013	4.036e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.389e-015	4.580e-014
o Opposed	"	2.950e-015	3.971e-014
o Rotational		2.950e-015	3.971e-014
o Isotropic		2.644e-015	3.556e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.589e-015	4.855e-014
o Opposed	"	3.471e-015	4.690e-014
o Rotational		3.471e-015	4.690e-014
o Isotropic		2.785e-015	3.750e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.054e-015	4.124e-014
o Posterior/Anterior	"	2.831e-015	3.814e-014
o Lateral		2.283e-015	3.063e-014
o Rotational	"	2.556e-015	3.441e-014
o Isotropic	"	2.277e-015	3.058e-014

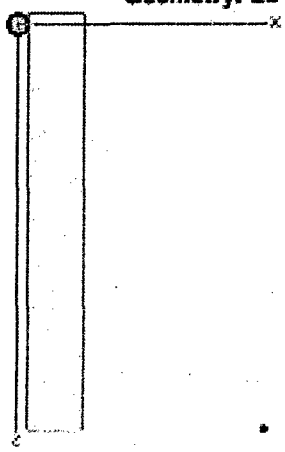
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MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122144.MS5
Run Date : January 2, 2006
Run Time: 8:09:57 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 E
Description: Revised Model Calc- Ag-108m Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	**30.48 cm**	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	**.025 cm**	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Ag-108m	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.02	2.656e+00	3.946e-291	4.950e-34	1.367e-292	1.715e-35

Page : 2
DOS File : PB122144.MS5
Run Date : January 2, 2006
Run Time: 8:09:57 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	8.599e-07	3.040e-107	3.543e-40	3.013e-109	3.512e-42
0.08	2.870e-01	1.029e-23	6.373e-22	1.628e-26	1.009e-24
0.4	3.640e+00	8.908e-14	8.411e-12	1.736e-16	1.639e-14
0.6	3.661e+00	1.514e-12	7.543e-11	2.956e-15	1.472e-13
0.8	3.665e+00	1.000e-11	3.130e-10	1.902e-14	5.953e-13
TOTALS:	1.391e+01	1.160e-11	3.968e-10	2.215e-14	7.589e-13

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122144.MS5
Case Title: Line 1.83 E
This case was run on Monday, January 2, 2006 at 8:09:57 AM
Dose Point # 1 - (136.24,381,213.36) cm

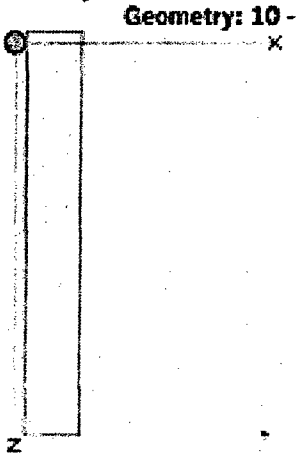
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.525e-011	5.380e-010
Photon Energy Fluence Rate	MeV/cm²/sec	1.160e-011	3.968e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.215e-014	7.589e-013
Absorbed Dose Rate in Air	mGy/hr	1.934e-016	6.625e-015
"	mrad/hr	1.934e-014	6.625e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.262e-016	7.770e-015
o Opposed	"	1.846e-016	6.318e-015
o Rotational		1.846e-016	6.318e-015
o Isotropic		1.632e-016	5.585e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.416e-016	8.289e-015
o Opposed	"	2.303e-016	7.897e-015
o Rotational	"	2.303e-016	7.897e-015
o Isotropic		1.746e-016	5.975e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.012e-016	6.903e-015
o Posterior/Anterior	"	1.796e-016	6.150e-015
o Lateral		1.354e-016	4.625e-015
o Rotational	"	1.607e-016	5.500e-015
o Isotropic	"	1.378e-016	4.713e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122145.MS5
Run Date: December 21, 2005
Run Time: 6:43:57 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 F
Description: Revised Model Calc- Nb-94 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm 4 ft 5.6 in	381 cm 12 ft 6.0 in	213.36 cm 7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Nb-94	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0174	1.432e-03	0.000e+00	2.142e-37	0.000e+00	1.156e-38
0.0175	2.743e-03	0.000e+00	4.143e-37	0.000e+00	2.194e-38
0.0196	8.058e-04	0.000e+00	1.456e-37	0.000e+00	5.374e-39
0.7026	4.050e+00	4.774e-12	1.841e-10	9.207e-15	3.550e-13
.711	4.050e+00	1.895e-11	5.185e-10	3.567e-14	9.758e-13

Page : 2
DOS File : PB122145.MS5
Run Date : December 21, 2005
Run Time: 6:43:57 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	8.104e+00	2.373e-11	7.026e-10	4.488e-14	1.331e-12

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122145.MS5
Case Title: Line 1.83 F
This case was run on Wednesday, December 21, 2005 at 6:43:57 PM
Dose Point # 1 - (136.24,381,213.36) cm

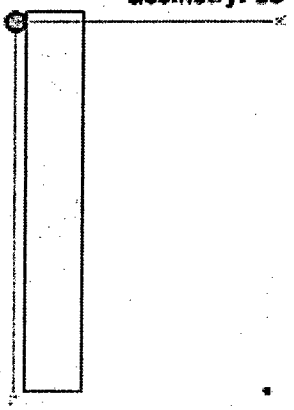
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.855e-011	8.572e-010
Photon Energy Fluence Rate	MeV/cm²/sec	2.373e-011	7.026e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.488e-014	1.331e-012
Absorbed Dose Rate in Air	mGy/hr	3.918e-016	1.162e-014
"	mrad/hr	3.918e-014	1.162e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.553e-016	1.351e-014
o Opposed	"	3.755e-016	1.113e-014
o Rotational	"	3.755e-016	1.113e-014
o Isotropic	"	3.321e-016	9.840e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.870e-016	1.445e-014
o Opposed	"	4.648e-016	1.379e-014
o Rotational		4.648e-016	1.379e-014
o Isotropic		3.553e-016	1.053e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	4.060e-016	1.205e-014
o Posterior/Anterior	"	3.646e-016	1.081e-014
o Lateral	"	2.774e-016	8.212e-015
o Rotational		3.264e-016	9.675e-015
o Isotropic		2.815e-016	8.336e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122933.MS5
Run Date : January 2, 2006
Run Time: 8:03:05 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 G
Description: Revised Model Calc- I-129 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 Cylinder Surface External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
I-129	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0295	8.081e-01	8.033e-106	3.163e-34	8.407e-108	3.310e-36
0.0298	1.499e+00	8.095e-103	6.049e-34	8.202e-105	6.129e-36
0.0336	5.330e-01	4.586e-78	3.158e-34	3.262e-80	2.245e-36
0.0396	3.045e-01	8.943e-56	3.211e-34	4.064e-58	1.459e-36

Page : 2
DOS File : PB122933.MS5
Run Date : January 2, 2006
Run Time: 8:03:05 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	3.145e+00	8.943e-56	1.558e-33	4.064e-58	1.314e-35

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122933.MS5
Case Title: Line 1.83 G
This case was run on Monday, January 2, 2006 at 8:03:05 AM
Dose Point # 1 - (136.24,381,213.36) cm

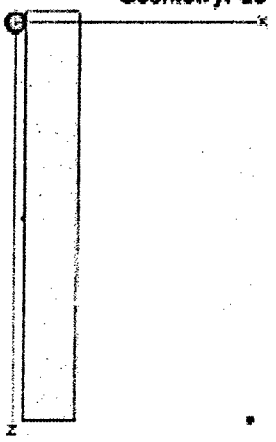
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.259e-054	4.856e-032
Photon Energy Fluence Rate	MeV/cm²/sec	8.943e-056	1.558e-033
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	4.064e-058	1.314e-035
Absorbed Dose Rate in Air	mGy/hr	3.548e-060	1.148e-037
	mrad/hr	3.548e-058	1.148e-035
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.078e-060	1.314e-037
o Opposed		2.558e-060	6.590e-038
o Rotational		2.316e-060	5.621e-038
o Isotropic		2.215e-060	5.221e-038
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	5.109e-060	1.432e-037
o Opposed		3.527e-060	9.846e-038
o Rotational		3.527e-060	9.846e-038
o Isotropic		2.588e-060	7.277e-038
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.961e-060	5.890e-038
o Posterior/Anterior		1.790e-060	3.045e-038
o Lateral		9.887e-061	1.644e-038
o Rotational		1.609e-060	3.026e-038
o Isotropic		1.319e-060	2.507e-038

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB010409.MS5
Run Date : January 4, 2006
Run Time: 8:29:50 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 H
Description: Revised Model Calc- Sn-126 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Sn-126	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.22	3.135e-01	4.657e-292	5.841e-35	1.613e-293	2.023e-36

Page : 2
DOS File : PB010409.MS5
Run Date : January 4, 2006
Run Time: 8:29:50 AM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.03	1.186e+00	4.192e-101	4.886e-34	4.155e-103	4.842e-36
0.04	2.023e-02	7.618e-56	2.210e-35	3.369e-58	9.776e-38
0.06	3.881e-01	5.534e-30	1.920e-28	1.099e-32	3.813e-31
0.08	1.859e+00	6.664e-23	4.129e-21	1.055e-25	6.535e-24
TOTALS:	3.767e+00	6.664e-23	4.129e-21	1.055e-25	6.535e-24

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB010409.MS5
Case Title: Line 1.83 H
This case was run on Wednesday, January 4, 2006 at 8:29:50 AM
Dose Point # 1 - (136.24,381,213.36) cm

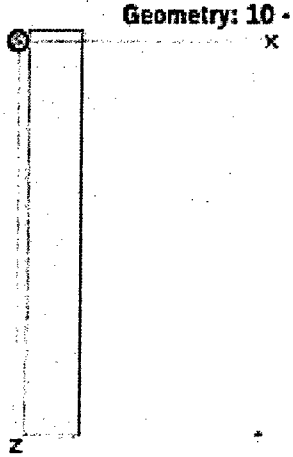
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	8.331e-022	5.162e-020
Photon Energy Fluence Rate	MeV/cm²/sec	6.664e-023	4.129e-021
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.055e-025	6.535e-024
Absorbed Dose Rate in Air	mGy/hr	9.207e-028	5.705e-026
"	mrad/hr	9.207e-026	5.705e-024
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.610e-027	9.979e-026
o Opposed	"	8.577e-028	5.315e-026
o Rotational	"	8.337e-028	5.166e-026
o Isotropic	"	8.277e-028	5.129e-026
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.595e-027	9.886e-026
o Opposed	"	1.173e-027	7.266e-026
o Rotational	"	1.173e-027	7.266e-026
o Isotropic		8.607e-028	5.333e-026
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.353e-027	8.381e-026
o Posterior/Anterior	"	1.032e-027	6.392e-026
o Lateral		6.358e-028	3.939e-026
o Rotational		8.787e-028	5.445e-026
o Isotropic		7.108e-028	4.404e-026

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122935.MS5
Run Date : December 29, 2005
Run Time: 4:09:22 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 I
Description: Revised Model Calc- Zr-95 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Zr-95	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.7242	1.768e+00	2.538e-12	9.320e-11	4.881e-15	1.792e-13
0.7567	2.241e+00	4.278e-12	1.464e-10	8.189e-15	2.801e-13
TOTALS:	4.009e+00	6.817e-12	2.396e-10	1.307e-14	4.593e-13

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122935.MS5
Case Title: Line 1.83 I
This case was run on Thursday, December 29, 2005 at 4:09:22 PM
Dose Point # 1 - (136.24,381,213.36) cm

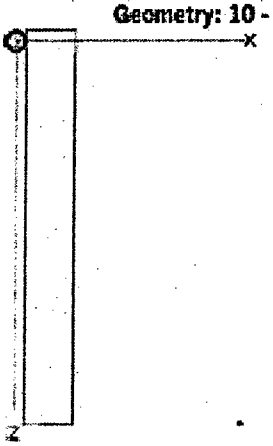
Results (Summed over energies)	Units	Without Buildup	Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.159e-012	3.221e-010
Photon Energy Fluence Rate	MeV/cm²/sec	6.817e-012	2.396e-010
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	1.307e-014	4.593e-013
Absorbed Dose Rate in Air	mGy/hr	1.141e-016	4.010e-015
	mrad/hr	1.141e-014	4.010e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.337e-016	4.701e-015
o Opposed		1.088e-016	3.823e-015
o Rotational		1.088e-016	3.823e-015
o Isotropic		9.614e-017	3.379e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.428e-016	5.018e-015
o Opposed		1.361e-016	4.782e-015
o Rotational		1.361e-016	4.782e-015
o Isotropic		1.029e-016	3.616e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.188e-016	4.175e-015
o Posterior/Anterior		1.058e-016	3.719e-015
o Lateral		7.957e-017	2.796e-015
o Rotational		9.464e-017	3.326e-015
o Isotropic		8.108e-017	2.849e-015

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB122936.MS5
R **Date: December 29, 2005**
Run Time: 4:10:54 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.83 J
Description: Revised Model Calc- Eu-155 Unit Act w Sched 40 & 12 in Shld
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	762.0 cm	25 ft
Radius	5.08 cm	2.0 in

Dose Points

	X	Y	Z
# 1	136.24 cm	381 cm	213.36 cm
	4 ft 5.6 in	12 ft 6.0 in	7 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	5.08 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Eu-155	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
.53	1.289e-02	4.557e-103	5.311e-36	4.516e-105	5.264e-38

Page : 2
DOS File : PB122936.MS5
Run Date : December 29, 2005
Run Time: 4:10:54 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.04	7.341e-01	2.765e-54	8.022e-34	1.223e-56	3.548e-36
0.05	2.388e-01	7.971e-38	8.529e-34	2.124e-40	2.272e-36
0.06	5.252e-02	7.489e-31	2.598e-29	1.488e-33	5.161e-32
0.08	1.257e+00	4.507e-23	2.793e-21	7.132e-26	4.419e-24
0.1	8.371e-01	1.200e-20	1.361e-18	1.836e-23	2.083e-21
TOTALS:	3.133e+00	1.205e-20	1.364e-18	1.843e-23	2.087e-21

MicroShield v5.04 (5.04-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB122936.MS5
Case Title: Line 1.83 J
This case was run on Thursday, December 29, 2005 at 4:10:54 PM
Dose Point # 1 - (136.24,381,213.36) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.206e-019	1.365e-017
Photon Energy Fluence Rate	MeV/cm²/sec	1.205e-020	1.364e-018
Exposure and Dose Rates			
Exposure Rate in Air	mR/hr	1.843e-023	2.087e-021
Absorbed Dose Rate in Air	mGy/hr	1.609e-025	1.822e-023
"	mrad/hr	1.609e-023	1.822e-021
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.689e-025	3.045e-023
o Opposed	"	1.475e-025	1.670e-023
o Rotational		1.475e-025	1.670e-023
o Isotropic		1.427e-025	1.616e-023
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.672e-025	3.026e-023
o Opposed	"	2.073e-025	2.348e-023
o Rotational	"	2.073e-025	2.348e-023
o Isotropic		1.509e-025	1.709e-023
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.312e-025	2.618e-023
o Posterior/Anterior	"	1.813e-025	2.053e-023
o Lateral	"	1.119e-025	1.267e-023
o Rotational		1.548e-025	1.753e-023
o Isotropic		1.232e-025	1.395e-023

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment C
Embedded Piping Dose Assessment & DCGL Calculation
Addendum 2
MicroShield Case Run Reports for
Pump Room Trench Pipe Cluster

MicroShield Case Run Reports for Pump Room Trench Pipe Cluster

Index

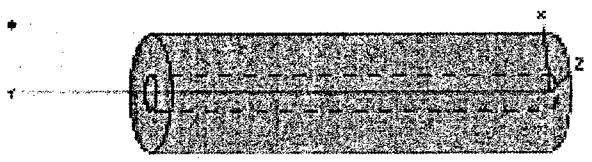
Run Date	Case Title	Description	File Name	Result (mrem/hr)
2/3/2006	Line 1.36 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020301	4.225E-13
2/3/2006	Line 1.35 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020302	1.305E-12
2/3/2006	Line 1.34 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020303	5.920E-15
2/3/2006	Line 1.33 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020304	8.646E-15
2/3/2006	Line 1.32 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020305	8.157E-19
2/3/2006	Line 1.31 A	PBRF Pump Room Trench with Co-60, 1 ft. concrete wall shield	PB020306	1.113E-17

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020301.MS5
Run Date : February 3, 2006
Run Time : 7:07:06 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.35 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	12.7 cm	5.0 in

Dose Points

	X	Y	Z
# 1	53.3 cm	404.8 cm	0 cm
	1 ft 9.0 in	13 ft 3.4 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	12.7 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.606e-04	8.759e-16	5.562e-16	1.691e-20	1.074e-16
1.1732	4.050e+00	3.552e-12	9.115e-11	6.347e-15	1.629e-13
1.3325	4.050e+00	9.129e-12	1.913e-10	1.584e-14	3.319e-13
TOTALS:	8.100e+00	1.268e-11	2.824e-10	2.218e-14	4.947e-13

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020301.MS5
Case Title: Line 1.35 A
This case was run on Friday, February 3, 2006 at 7:07:06 PM
Dose Point # 1 - (53.3,404.8,0) cm

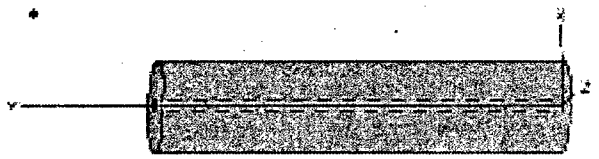
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.876e-012	2.212e-010
Photon Energy Fluence Rate	MeV/cm²/sec	1.268e-011	2.824e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.218e-014	4.947e-013
Absorbed Dose Rate in Air	mGy/hr	1.937e-016	4.319e-015
"	mrad/hr	1.937e-014	4.319e-013
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.198e-016	4.902e-015
o Opposed	"	1.895e-016	4.225e-015
o Rotational	"	1.895e-016	4.225e-015
o Isotropic	"	1.694e-016	3.775e-015
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.339e-016	5.217e-015
o Opposed	"	2.253e-016	5.025e-015
o Rotational		2.253e-016	5.025e-015
o Isotropic	"	1.793e-016	3.998e-015
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.979e-016	4.415e-015
o Posterior/Anterior	"	1.625e-016	4.069e-015
o Lateral	"	1.453e-016	3.239e-015
o Rotational	"	1.643e-016	3.664e-015
o Isotropic	"	1.456e-016	3.244e-015

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020302.MS5
Run Date : February 3, 2006
R Time: 7:33:25 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.35 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	3.81 cm	1.5 in

Dose Points

#	X	Y	Z
1	62.2 cm	404.8 cm	53.3 cm
	2 ft 0.5 in	13 ft 3.4 in	1 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.982e-04	7.447e-17	3.410e-15	1.438e-19	6.584e-18
1.1732	1.215e+00	1.672e-11	3.079e-10	2.810e-14	5.502e-13
1.3325	1.215e+00	3.485e-11	5.642e-10	6.047e-14	9.788e-13
TOTALS:	2.430e+00	5.058e-11	8.721e-10	8.857e-14	1.529e-12

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020302.MS5
Case Title: Line 1.35 A
This case was run on Friday, February 3, 2006 at 7:33:25 PM
Dose Point # 1 - (62.2,404.8,53.3) cm

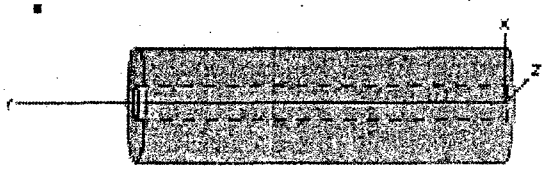
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.956e-011	6.858e-010
Photon Energy Fluence Rate	MeV/cm²/sec	5.056e-011	8.721e-010
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.857e-014	1.529e-012
Absorbed Dose Rate in Air	mGy/hr	7.732e-016	1.335e-014
"	mrad/hr	7.732e-014	1.335e-012
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.775e-016	1.515e-014
o Opposed	"	7.564e-016	1.305e-014
o Rotational	"	7.564e-016	1.305e-014
o Isotropic	"	6.759e-016	1.166e-014
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	9.339e-016	1.613e-014
o Opposed	"	8.995e-016	1.553e-014
o Rotational	"	8.995e-016	1.553e-014
o Isotropic	"	7.158e-016	1.235e-014
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.903e-016	1.365e-014
o Posterior/Anterior	"	7.284e-016	1.257e-014
o Lateral	"	5.799e-016	1.000e-014
o Rotational	"	6.560e-016	1.132e-014
o Isotropic	"	5.809e-016	1.002e-014

MicroShield v5.05 (5.05-00352)
Radiological Services, Inc.

Page : 1
DOS File : PB020303.MS5
Run Date: February 3, 2006
R Time: 7:21:18 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.34 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	12.7 cm	5.0 in

Dose Points

	X	Y	Z
# 1	53.3 cm	404.6 cm	106.6 cm
	1 ft 9.0 in	13 ft 3.4 in	3 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	12.7 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

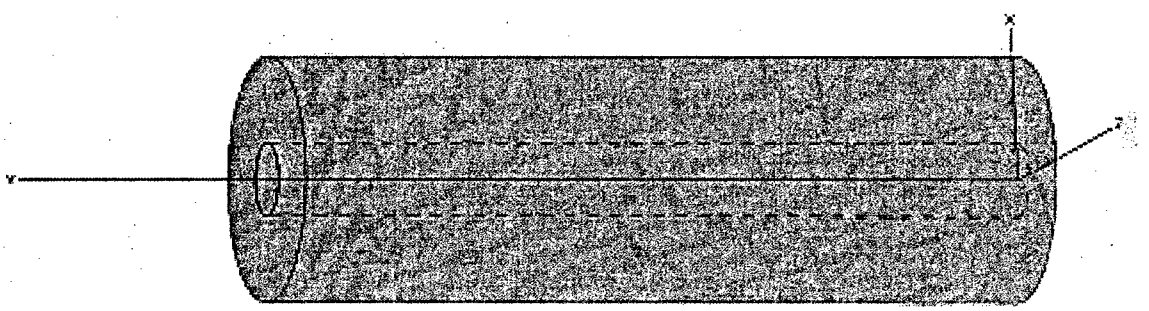
Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.606e-04	1.961e-20	2.080e-18	3.787e-23	4.016e-21
1.1732	4.050e+00	2.768e-14	1.070e-12	4.983e-17	1.912e-15
1.3325	4.050e+00	9.437e-14	2.893e-12	1.637e-16	5.019e-15
TOTALS:	8.100e+00	1.223e-13	3.963e-12	2.136e-16	6.930e-15



MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020303.MS5
Case Title: Line 1.34 A
This case was run on Friday, February 3, 2006 at 7:21:16 PM
Dose Point # 1 - (53.3,404.8,106.6) cm

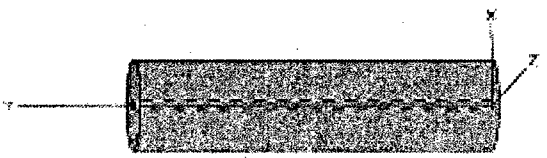
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.459e-014	3.083e-012
Photon Energy Fluence Rate	MeV/cm²/sec	1.223e-013	3.963e-012
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.136e-016	6.930e-015
Absorbed Dose Rate in Air	mGy/hr	1.864e-018	6.050e-017
"	mrad/hr	1.864e-016	6.050e-015
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.115e-018	6.865e-017
o Opposed	"	1.825e-018	5.920e-017
o Rotational	"	1.825e-018	5.920e-017
o Isotropic	"	1.631e-018	5.291e-017
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.250e-018	7.305e-017
o Opposed	"	2.168e-018	7.037e-017
o Rotational	"	2.168e-018	7.037e-017
o Isotropic	"	1.727e-018	5.603e-017
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.905e-018	6.183e-017
o Posterior/Anterior	"	1.757e-018	5.701e-017
o Lateral	"	1.400e-018	4.541e-017
o Rotational	"	1.583e-018	5.134e-017
o Isotropic	"	1.402e-018	4.548e-017

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020304.MS5
Run Date : February 3, 2006
Run Time : 7:34:46 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.33 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	62.2 cm	404.8 cm	160 cm
	2 ft 0.5 in	13 ft 3.4 in	5 ft 3.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.962e-04	5.287e-20	4.814e-18	1.021e-22	9.294e-21
1.1732	1.215e+00	4.940e-14	1.668e-12	8.826e-17	2.980e-15
1.3325	1.215e+00	1.519e-13	4.116e-12	2.635e-16	7.141e-15
TOTALS:	2.430e+00	2.013e-13	5.784e-12	3.518e-16	1.012e-14

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020304.MS5
Case Title: Line 1.33 A
This case was run on Friday, February 3, 2006 at 7:34:46 PM
Dose Point # 1 - (62.2,404.8,160) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.561e-013	4.511e-012
Photon Energy Fluence Rate	MeV/cm²/sec	2.013e-013	5.784e-012
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.518e-016	1.012e-014
Absorbed Dose Rate in Air	mGy/hr	3.071e-016	8.836e-017
"	mrad/hr	3.071e-016	8.836e-015
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.485e-018	1.003e-016
o Opposed	"	3.006e-018	8.646e-017
o Rotational	"	3.006e-018	8.646e-017
o Isotropic	"	2.687e-018	7.726e-017
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.707e-018	1.067e-016
o Opposed	"	3.572e-018	1.028e-016
o Rotational	"	3.572e-018	1.028e-016
o Isotropic	"	2.844e-018	8.182e-017
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.139e-018	9.031e-017
o Posterior/Anterior	"	2.894e-018	8.325e-017
o Lateral	"	2.306e-018	6.630e-017
o Rotational	"	2.607e-018	7.498e-017
o Isotropic	"	2.310e-018	6.641e-017

MicroShield v5.05 (5.05-00352)
Radiological Services, Inc.

Page : 1
DOS File : PB020305.MS5
Run Date : February 3, 2006
Run Time: 7:30:54 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.32 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	12.7 cm	5.0 in

Dose Points

	X	Y	Z
# 1	53.3 cm	404.8 cm	214 cm
	1 ft 9.0 in	13 ft 3.4 in	7 ft 0.3 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	12.7 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	1.0945e-010	4.0496e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.606e-04	6.803e-26	1.547e-23	1.314e-28	2.987e-26
1.1732	4.050e+00	1.368e-18	9.626e-17	2.444e-21	1.720e-19
1.3325	4.050e+00	8.273e-18	4.508e-16	1.435e-20	7.822e-19
TOTALS:	8.100e+00	9.641e-18	5.471e-16	1.680e-20	9.542e-19

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020305.MS5
Case Title: Line 1.32 A
This case was run on Friday, February 3, 2006 at 7:30:54 PM
Dose Point # 1 - (53.3,404.8,214) cm

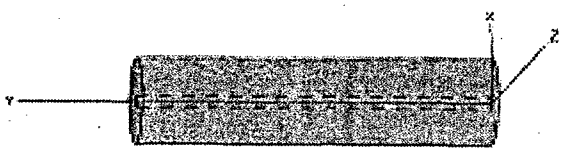
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.374e-018	4.204e-016
Photon Energy Fluence Rate	MeV/cm²/sec	9.641e-018	5.471e-016
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.680e-020	9.542e-019
Absorbed Dose Rate in Air	mGy/hr	1.466e-022	8.330e-021
"	mrad/hr	1.466e-020	8.330e-019
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.663e-022	9.448e-021
o Opposed	"	1.436e-022	8.157e-021
o Rotational	"	1.436e-022	8.157e-021
o Isotropic	"	1.284e-022	7.293e-021
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.769e-022	1.005e-020
o Opposed	"	1.705e-022	9.686e-021
o Rotational	"	1.705e-022	9.686e-021
o Isotropic	"	1.359e-022	7.718e-021
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.498e-022	8.511e-021
o Posterior/Anterior	"	1.382e-022	7.852e-021
o Lateral	"	1.103e-022	6.263e-021
o Rotational	"	1.245e-022	7.074e-021
o Isotropic	"	1.104e-022	6.270e-021

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020306.MS5
Run Date : February 3, 2006
R Time: 7:45:12 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.31 A
Description: PBRF Pmp Rm Trench Co-60 w 1 ft conc wall shield & conc core
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	62.2 cm	404.8 cm	266.5 cm
	2 ft 0.5 in	13 ft 3.4 in	8 ft 8.9 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Transition		Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	30.48 cm	Concrete	2.4
Immersion		Concrete	2.4

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm³	Bq/cm³
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.982e-04	4.193e-24	7.230e-22	8.095e-27	1.396e-24
1.1732	1.215e+00	2.817e-17	1.583e-15	5.034e-20	2.829e-18
1.3325	1.215e+00	1.336e-16	5.876e-15	2.318e-19	1.019e-17
TOTALS:	2.430e+00	1.618e-16	7.459e-15	2.822e-19	1.302e-17

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020306.MS5
Case Title: Line 1.31 A
This case was run on Friday, February 3, 2006 at 7:45:12 PM
Dose Point # 1 - (62.2,404.8,266.5) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.243e-016	5.759e-015
Photon Energy Fluence Rate	MeV/cm²/sec	1.618e-016	7.459e-015
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.822e-019	1.302e-017
Absorbed Dose Rate in Air	mGy/hr	2.463e-021	1.137e-019
"	mrad/hr	2.463e-019	1.137e-017
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.794e-021	1.290e-019
o Opposed	"	2.412e-021	1.113e-019
o Rotational	"	2.412e-021	1.113e-019
o Isotropic	"	2.157e-021	9.949e-020
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.972e-021	1.372e-019
o Opposed	"	2.864e-021	1.322e-019
o Rotational	"	2.864e-021	1.322e-019
o Isotropic	"	2.283e-021	1.053e-019
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.517e-021	1.162e-019
o Posterior/Anterior	"	2.322e-021	1.071e-019
o Lateral	"	1.852e-021	8.542e-020
o Rotational	"	2.092e-021	9.652e-020
o Isotropic	"	1.854e-021	8.554e-020

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment C
Embedded Piping Dose Assessment & DCGL Calculation
Addendum 3
MicroShield Case Run Reports for Area Factor Calculations

MicroShield Case Run Reports for Area Factor Calculations

Index

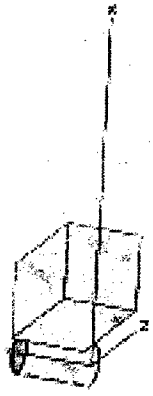
Run Date	Case Title	Description	MS5 File Name	Dose Rate (mrem/hr)
2/4/2006	Line 1.21 AF-A	PBRF Revised Model Co-60 Area Factor Calculation	PB020401	1.0810E-10
2/4/2006	Line 1.21 AF-B	PBRF Revised Model Co-60 Area Factor Calculation	PB020402	2.0910E-10
2/4/2006	Line 1.21 AF-C	PBRF Revised Model Co-60 Area Factor Calculation	PB020403	4.2570E-10
2/4/2006	Line 1.21 AF-D	PBRF Revised Model Co-60 Area Factor Calculation	PB020404	5.3940E-10
2/4/2006	Line 1.23 AF-A	PBRF Revised Model Co-60 Area Factor Calculation	PB020405	1.0820E-10
2/4/2006	Line 1.23 AF-B	PBRF Revised Model Co-60 Area Factor Calculation	PB020406	2.0910E-10
2/4/2006	Line 1.23 AF-C	PBRF Revised Model Co-60 Area Factor Calculation	PB020407	4.2580E-10
2/4/2006	Line 1.23 AF-D	PBRF Revised Model Co-60 Area Factor Calculation	PB020408	5.3950E-10
2/4/2006	Line 1.24 AF-A	PBRF Revised Model Co-60 Area Factor Calculation	PB020409	3.2270E-11
2/4/2006	Line 1.24 AF-B	PBRF Revised Model Co-60 Area Factor Calculation	PB020410	6.2720E-11
2/4/2006	Line 1.24 AF-C	PBRF Revised Model Co-60 Area Factor Calculation	PB020411	1.3130E-10
2/4/2006	Line 1.24 AF-D	PBRF Revised Model Co-60 Area Factor Calculation	PB020412	1.7250E-10
2/4/2006	Line 1.641 AF-A	PBRF Revised Model Co-60 Area Factor Calculation	PB020413	5.2760E-11
2/4/2006	Line 1.641 AF-B	PBRF Revised Model Co-60 Area Factor Calculation	PB020414	1.0250E-10
2/4/2006	Line 1.641 AF-C	PBRF Revised Model Co-60 Area Factor Calculation	PB020415	2.1390E-10
2/4/2006	Line 1.641 AF-D	PBRF Revised Model Co-60 Area Factor Calculation	PB020416	2.7950E-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020401.MS5
Run Date: February 4, 2006
R Time: 2:01:22 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 AF-A
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	30.48 cm	1 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	15.24 cm	45.72 cm
	4 ft 6.6 in	6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.6
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Co-60	6.5669e-012	2.4298e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	3.963e-05	7.261e-14	1.178e-12	1.402e-16	2.274e-15
1.1732	2.430e-01	3.571e-09	3.023e-08	6.381e-12	5.402e-11
1.3325	2.430e-01	5.722e-09	4.191e-08	9.926e-12	7.270e-11

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.860e-01	9.293e-09	7.213e-08	1.631e-11	1.267e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020401.MS5
Case Title: Line 1.21 AF-A
This case was run on Saturday, February 4, 2006 at 2:01:22 PM
Dose Point # 1 - (138.78,15.24,45.72) cm

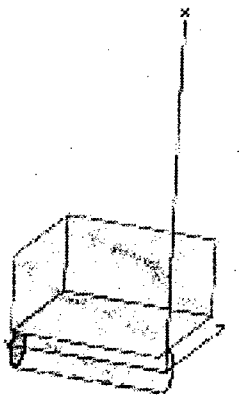
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.338e-009	5.721e-008
Photon Energy Fluence Rate	MeV/cm²/sec	9.293e-009	7.213e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.631e-011	1.267e-010
Absorbed Dose Rate in Air	mGy/hr	1.424e-013	1.106e-012
"	mrad/hr	1.424e-011	1.106e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.616e-013	1.256e-012
o Opposed	"	1.392e-013	1.081e-012
o Rotational	"	1.392e-013	1.081e-012
o Isotropic	"	1.244e-013	9.658e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.721e-013	1.337e-012
o Opposed	"	1.657e-013	1.287e-012
o Rotational	"	1.657e-013	1.287e-012
o Isotropic	"	1.317e-013	1.023e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.456e-013	1.131e-012
o Posterior/Anterior	"	1.341e-013	1.042e-012
o Lateral	"	1.066e-013	8.280e-013
o Rotational		1.207e-013	9.379e-013
o Isotropic		1.069e-013	8.299e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020402.MS5
Run Date : February 4, 2006
Run Time : 2:05:04 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 AF-B
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	60.96 cm	2 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	30.48 cm	45.72 cm
	4 ft 6.6 in	1 ft	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Co-60	1.3134e-011	4.8595e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	7.927e-05	1.383e-13	2.260e-12	2.669e-16	4.363e-15
1.1732	4.860e-01	6.655e-09	5.838e-08	1.225e-11	1.043e-10
1.3325	4.860e-01	1.101e-08	8.106e-08	1.909e-11	1.406e-10

DOS File : PB020402.MS5
Run Date: February 4, 2006
Run Time: 2:05:04 PM
Duration : 00:00:00

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	9.720e-01	1.786e-08	1.394e-07	3.134e-11	2.450e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020402.MS5
Case Title: Line 1.21 AF-B
This case was run on Saturday, February 4, 2006 at 2:06:04 PM
Dose Point # 1 - (138.78,30.48,45.72) cm

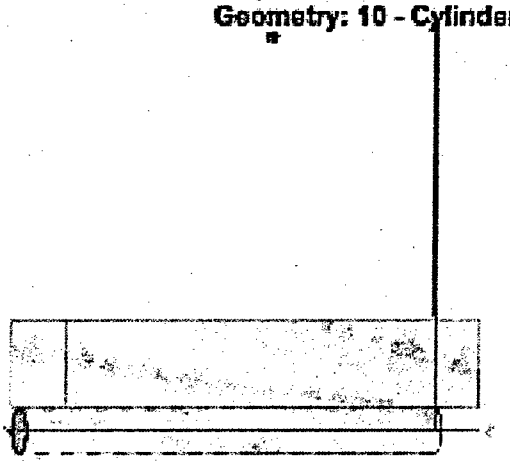
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.410e-008	1.106e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.786e-008	1.394e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.134e-011	2.450e-010
Absorbed Dose Rate in Air	mGy/hr	2.736e-013	2.139e-012
"	mrad/hr	2.736e-011	2.139e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.107e-013	2.428e-012
o Opposed	"	2.675e-013	2.091e-012
o Rotational	"	2.675e-013	2.091e-012
o Isotropic	"	2.390e-013	1.867e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.307e-013	2.585e-012
o Opposed	"	3.184e-013	2.489e-012
o Rotational	"	3.184e-013	2.489e-012
o Isotropic	"	2.532e-013	1.979e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.797e-013	2.187e-012
o Posterior/Anterior	"	2.577e-013	2.014e-012
o Lateral	"	2.049e-013	1.601e-012
o Rotational	"	2.320e-013	1.813e-012
o Isotropic	"	2.054e-013	1.604e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020403.MS5
Run Date: February 4, 2006
R Time: 2:06:55 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 AF-C
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions:

Height	152.4 cm	5 ft 0.0 in
Radius	7.62 cm	3.0 in

Dose Points:

	X	Y	Z
# 1	138.78 cm	76.2 cm	45.72 cm
	4 ft 6.6 in	2 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.6
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.982e-04	2.607e-13	4.424e-12	5.034e-16	8.542e-15
1.1732	1.215e+00	1.346e-06	1.163e-07	2.406e-11	2.115e-10
1.3325	1.215e+00	2.182e-06	1.656e-07	3.786e-11	2.874e-10

DOS File : PB020403.MS5
Run Date: February 4, 2006
Run Time: 2:06:55 PM
Duration : 00:00:00

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.430e+00	3.528e-08	2.840e-07	6.192e-11	4.988e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020403.MS5
Case Title: Line 1.21 AF-C
This case was run on Saturday, February 4, 2006 at 2:06:55 PM
Dose Point # 1 - (138.78,76.2,45.72) cm

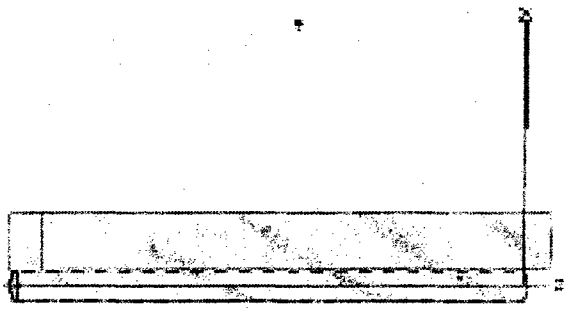
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.785e-008	2.252e-007
Photon Energy Fluence Rate	MeV/cm²/sec	3.528e-008	2.840e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.192e-011	4.988e-010
Absorbed Dose Rate in Air	mGy/hr	5.405e-013	4.355e-012
"	mrad/hr	5.405e-011	4.355e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.137e-013	4.945e-012
o Opposed	"	5.285e-013	4.257e-012
o Rotational	"	5.285e-013	4.257e-012
o Isotropic	"	4.721e-013	3.802e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.532e-013	5.265e-012
o Opposed	"	6.290e-013	5.068e-012
o Rotational	"	6.290e-013	5.068e-012
o Isotropic	"	5.002e-013	4.029e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.526e-013	4.453e-012
o Posterior/Anterior	"	5.091e-013	4.101e-012
o Lateral	"	4.049e-013	3.260e-012
o Rotational	"	4.584e-013	3.692e-012
o Isotropic		4.057e-013	3.267e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020404.MS5
Run Date : February 4, 2006
R Time: 2:11:09 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.21 AF-D
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	152.4 cm	45.72 cm
	4 ft 6.6 in	5 ft 0.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	2.3
Shield 1	.65 cm	Iron	7.85
Transition		Concrete	2.4
Shield 2	30.48 cm	Concrete	2.4
Air Gap		Air	0.001222
Wall Clad	.635 cm	Iron	7.85

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	6.5669e-011	2.4298e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	3.963e-04	3.019e-13	5.320e-12	5.830e-16	1.027e-14
1.1732	2.430e+00	1.630e-08	1.489e-07	2.914e-11	2.661e-10
1.3325	2.430e+00	2.673e-08	2.109e-07	4.638e-11	3.659e-10

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DOS File : PB020404.MS5
Run Date : February 4, 2006
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Duration : 00:00:00

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.860e+00	4.304e-08	3.598e-07	7.552e-11	6.321e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020404.MS5
Case Title: Line 1.21 AF-D
This case was run on Saturday, February 4, 2006 at 2:11:09 PM
Dose Point # 1 - (138.78,152.4,45.72) cm

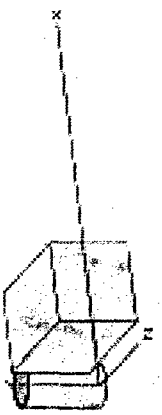
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.396e-006	2.852e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.304e-008	3.596e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.552e-011	6.321e-010
Absorbed Dose Rate in Air	mGy/hr	6.593e-013	5.518e-012
"	mrad/hr	6.593e-011	5.518e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.484e-013	6.265e-012
o Opposed	"	6.446e-013	5.394e-012
o Rotational	"	6.446e-013	5.394e-012
o Isotropic	"	5.758e-013	4.818e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.967e-013	6.670e-012
o Opposed	"	7.671e-013	6.422e-012
o Rotational	"	7.671e-013	6.422e-012
o Isotropic	"	6.101e-013	5.105e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.740e-013	5.641e-012
o Posterior/Anterior	"	6.209e-013	5.196e-012
o Lateral		4.938e-013	4.130e-012
o Rotational	"	5.591e-013	4.678e-012
o Isotropic	"	4.948e-013	4.140e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB030401.MS5
Run Date: March 4, 2006
Run Time: 3:58:06 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 AF-A
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	30.48 cm	1 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	136.78 cm	15.24 cm	45.7 cm
	4 ft 6.6 in	6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	6.5669e-012	2.4298e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	3.963e-05	7.263e-14	1.178e-12	1.402e-16	2.275e-15
1.1732	2.430e-01	3.572e-09	3.023e-08	6.383e-12	5.403e-11
1.3325	2.430e-01	5.724e-09	4.192e-08	9.931e-12	7.272e-11

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.660e-01	9.296e-09	7.215e-08	1.631e-11	1.266e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB030401.MS5
Case Title: Line 1.23 AF-A
This case was run on Saturday, March 4, 2006 at 3:56:06 PM
Dose Point # 1 - (138.78,15.24,45.7) cm

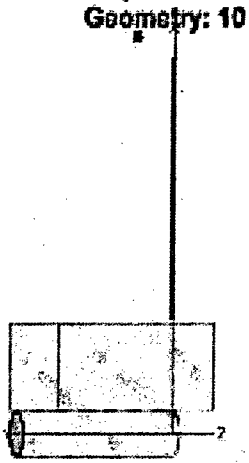
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.340e-009	5.723e-008
Photon Energy Fluence Rate	MeV/cm²/sec	9.296e-009	7.215e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.631e-011	1.268e-010
Absorbed Dose Rate in Air	mGy/hr	1.424e-013	1.107e-012
"	mrad/hr	1.424e-011	1.107e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.617e-013	1.256e-012
o Opposed	"	1.393e-013	1.082e-012
o Rotational	"	1.393e-013	1.082e-012
o Isotropic	"	1.244e-013	9.661e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.721e-013	1.338e-012
o Opposed	"	1.657e-013	1.288e-012
o Rotational	"	1.657e-013	1.288e-012
o Isotropic	"	1.318e-013	1.024e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.456e-013	1.131e-012
o Posterior/Anterior	"	1.341e-013	1.042e-012
o Lateral	"	1.067e-013	8.283e-013
o Rotational	"	1.206e-013	9.362e-013
o Isotropic	"	1.069e-013	8.301e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020406 MS5
Run Date: February 4, 2006
R Time: 2:25:44 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 AF-B
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	60.96 cm	2 ft
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	136.78 cm	30.48 cm	45.7 cm
	4 ft 6.6 in	1 ft	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.6
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	1.3134e-011	4.6595e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	7.927e-05	1.383e-13	2.261e-12	2.670e-16	4.365e-15
1.1732	4.860e-01	6.857e-09	5.840e-08	1.225e-11	1.044e-10
1.3325	4.860e-01	1.101e-08	8.106e-08	1.910e-11	1.407e-10

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	9.720e-01	1.787e-08	1.395e-07	3.135e-11	2.450e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020406.MS5
Case Title: Line 1.23 AF-B
This case was run on Saturday, February 4, 2006 at 2:25:44 PM
Dose Point # 1 - (138.78,30.48,45.7) cm

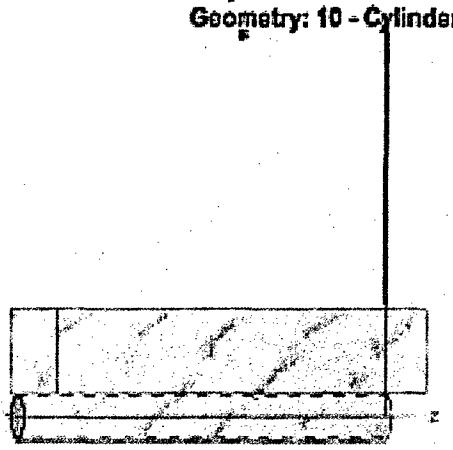
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.411e-008	1.106e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.787e-008	1.395e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.135e-011	2.450e-010
Absorbed Dose Rate in Air	mGy/hr	2.737e-013	2.139e-012
"	mrad/hr	2.737e-011	2.139e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.108e-013	2.429e-012
o Opposed	"	2.676e-013	2.091e-012
o Rotational		2.676e-013	2.091e-012
o Isotropic	"	2.391e-013	1.868e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.308e-013	2.586e-012
o Opposed	"	3.185e-013	2.490e-012
o Rotational	"	3.185e-013	2.490e-012
o Isotropic	"	2.533e-013	1.979e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.798e-013	2.187e-012
o Posterior/Anterior	"	2.578e-013	2.014e-012
o Lateral	"	2.050e-013	1.601e-012
o Rotational	"	2.321e-013	1.814e-012
o Isotropic	"	2.054e-013	1.605e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020407.MS5
Run Date: February 4, 2006
R Time: 2:24:25 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 AF-C
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	152.4 cm	5 ft 0.0 in
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	76.2 cm	45.7 cm
	4 ft 6.6 in	2 ft 6.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.982e-04	2.608e-13	4.426e-12	5.036e-16	8.545e-15
1.1732	1.215e+00	1.347e-08	1.184e-07	2.407e-11	2.115e-10
1.3325	1.215e+00	2.163e-08	1.657e-07	3.787e-11	2.875e-10

DOS File : PB020407.MS5
Run Date: February 4, 2006
Run Time: 2:24:25 PM
Duration : 00:00:00

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.430e+00	3.529e-08	2.841e-07	6.194e-11	4.990e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020407.MS5
Case Title: Line 1.23 AF-C
This case was run on Saturday, February 4, 2006 at 2:24:25 PM
Dose Point # 1 - (138.78,76.2,45.7) cm

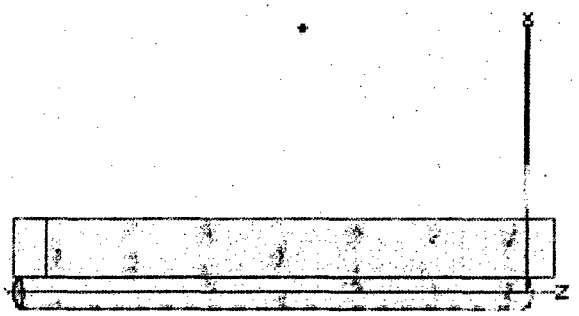
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	2.786e-008	2.252e-007
Photon Energy Fluence Rate	MeV/cm²/sec	3.529e-008	2.841e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.194e-011	4.980e-010
Absorbed Dose Rate in Air	mGy/hr	5.407e-013	4.356e-012
"	mrad/hr	5.407e-011	4.356e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.138e-013	4.946e-012
o Opposed	"	5.287e-013	4.258e-012
o Rotational	"	5.287e-013	4.258e-012
o Isotropic	"	4.723e-013	3.803e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.534e-013	5.266e-012
o Opposed	"	6.292e-013	5.070e-012
o Rotational	"	6.292e-013	5.070e-012
o Isotropic	"	5.003e-013	4.030e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	5.528e-013	4.454e-012
o Posterior/Anterior	"	5.092e-013	4.102e-012
o Lateral	"	4.050e-013	3.261e-012
o Rotational	"	4.585e-013	3.693e-012
o Isotropic	"	4.058e-013	3.268e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020408.MS5
Run Date : February 4, 2006
R Time: 2:23:00 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.23 AF-D
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	7.62 cm	3.0 in

Dose Points

	X	Y	Z
# 1	138.78 cm	152.4 cm	45.7 cm
	4 ft 6.6 in	5 ft 0.0 in	1 ft 6.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	7.62 cm²	Concrete	1.8
Shield 1	65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Co-60	6.5669e-011	2.4298e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6936	3.963e-04	3.021e-13	5.322e-12	5.832e-16	1.028e-14
1.1732	2.430e+00	1.631e-08	1.490e-07	2.914e-11	2.662e-10
1.3325	2.430e+00	2.674e-08	2.110e-07	4.639e-11	3.680e-10

DOS File : PB020408.MS5
Run Date: February 4, 2006
Run Time: 2:23:00 PM
Duration : 00:00:00

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.860e+00	4.305e-08	3.599e-07	7.554e-11	6.322e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020408.MS5
Case Title: Line 1.23 AF-D
This case was run on Saturday, February 4, 2006 at 2:23:00 PM
Dose Point # 1 - (138.78,152.4,45.7) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.397e-008	2.853e-007
Photon Energy Fluence Rate	MeV/cm²/sec	4.305e-008	3.599e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.554e-011	6.322e-010
Absorbed Dose Rate in Air	mGy/hr	6.595e-013	5.519e-012
"	mrad/hr	6.595e-011	5.519e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.467e-013	6.267e-012
o Opposed	"	6.448e-013	5.395e-012
o Rotational	"	6.448e-013	5.395e-012
o Isotropic	"	5.760e-013	4.819e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.969e-013	6.672e-012
o Opposed	"	7.674e-013	6.423e-012
o Rotational	"	7.674e-013	6.423e-012
o Isotropic	"	6.103e-013	5.106e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.742e-013	5.643e-012
o Posterior/Anterior	"	6.211e-013	5.197e-012
o Lateral	"	4.940e-013	4.131e-012
o Rotational	"	5.592e-013	4.679e-012
o Isotropic	"	4.950e-013	4.141e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020409.MS5
Run Date : February 4, 2006
R Time: 2:39:29 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 AF-A
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	30.48 cm	1 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	15.24 cm	91.44 cm
	4 ft 5.1 in	6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	3.2635e-012	1.2149e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.982e-05	1.605e-14	3.064e-13	3.099e-17	5.916e-16
1.1732	1.215e-01	9.367e-10	8.684e-09	1.674e-12	1.588e-11
1.3325	1.215e-01	1.555e-09	1.264e-08	2.697e-12	2.194e-11

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.430e-01	2.491e-09	2.153e-08	4.371e-12	3.781e-11

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020409.MS5
Case Title: Line 1.24 AF-A
This case was run on Saturday, February 4, 2006 at 2:39:29 PM
Dose Point # 1 - (134.97,15.24,91.44) cm

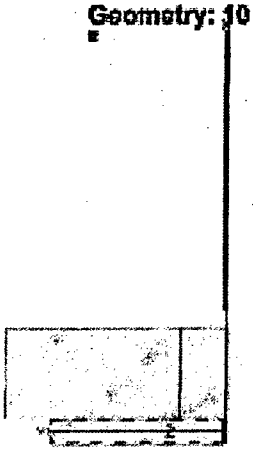
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.965e-009	1.706e-008
Photon Energy Fluence Rate	MeV/cm²/sec	2.491e-009	2.153e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	4.371e-012	3.781e-011
Absorbed Dose Rate in Air	mGy/hr	3.816e-014	3.301e-013
"	mrad/hr	3.816e-012	3.301e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.332e-014	3.748e-013
o Opposed	"	3.731e-014	3.227e-013
o Rotational	"	3.731e-014	3.227e-013
o Isotropic	"	3.333e-014	2.882e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	4.611e-014	3.991e-013
o Opposed	"	4.440e-014	3.842e-013
o Rotational		4.440e-014	3.842e-013
o Isotropic	"	3.531e-014	3.054e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.901e-014	3.375e-013
o Posterior/Anterior	"	3.594e-014	3.109e-013
o Lateral	"	2.856e-014	2.471e-013
o Rotational	"	3.236e-014	2.799e-013
o Isotropic	"	2.864e-014	2.477e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020410.MS5
Run Date: February 4, 2006
R Time: 2:40:59 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 AF-B
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	60.96 cm	2 ft
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	30.48 cm	91.44 cm
	4 ft 5.1 in	1 ft	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Co-60	6.5669e-012	2.4298e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

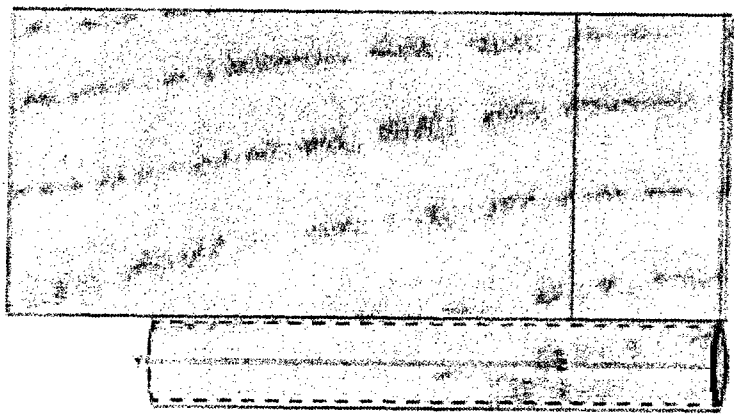
Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	3.963e-05	3.080e-14	5.916e-13	5.946e-17	1.142e-15
1.1732	2.430e-01	1.810e-09	1.725e-08	3.235e-12	3.083e-11
1.3325	2.430e-01	3.009e-09	2.469e-08	5.220e-12	4.266e-11

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	4.860e-01	4.819e-09	4.184e-08	8.455e-12	7.349e-11



MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020410.MS5
Case Title: Line 1.24 AF-B
This case was run on Saturday, February 4, 2006 at 2:40:59 PM
Dose Point # 1 - (134.97,30.48,91.44) cm

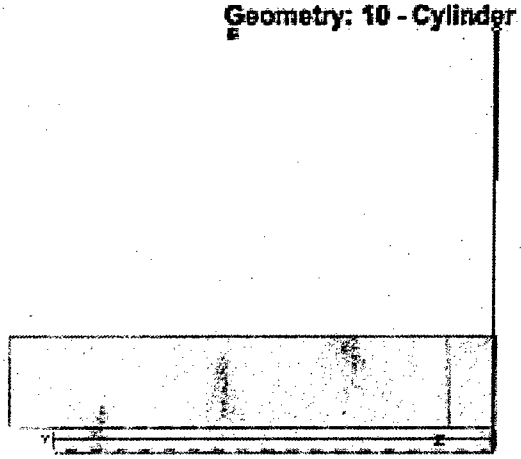
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.801e-009	3.316e-008
Photon Energy Fluence Rate	MeV/cm²/sec	4.619e-009	4.184e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.455e-012	7.349e-011
Absorbed Dose Rate in Air	mGy/hr	7.381e-014	6.416e-013
"	mrad/hr	7.381e-012	6.416e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.379e-014	7.285e-013
o Opposed	"	7.217e-014	6.272e-013
o Rotational	"	7.217e-014	6.272e-013
o Isotropic	"	6.447e-014	5.602e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.920e-014	7.756e-013
o Opposed	"	8.589e-014	7.467e-013
o Rotational	"	8.589e-014	7.467e-013
o Isotropic	"	6.830e-014	5.936e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.546e-014	6.559e-013
o Posterior/Anterior	"	6.951e-014	6.041e-013
o Lateral	"	5.529e-014	4.803e-013
o Rotational	"	6.259e-014	5.440e-013
o Isotropic	"	5.540e-014	4.813e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020411.MS5
Run Date : February 4, 2006
R Time: 2:43:21 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 AF-C
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	152.4 cm	5 ft 0.0 in
Radius	3.81 cm	1.5 in

Dose Points

	X	Y	Z
# 1	134.97 cm	76.2 cm	91.44 cm
	4 ft 5.1 in	2 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	1.6417e-011	6.0744e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

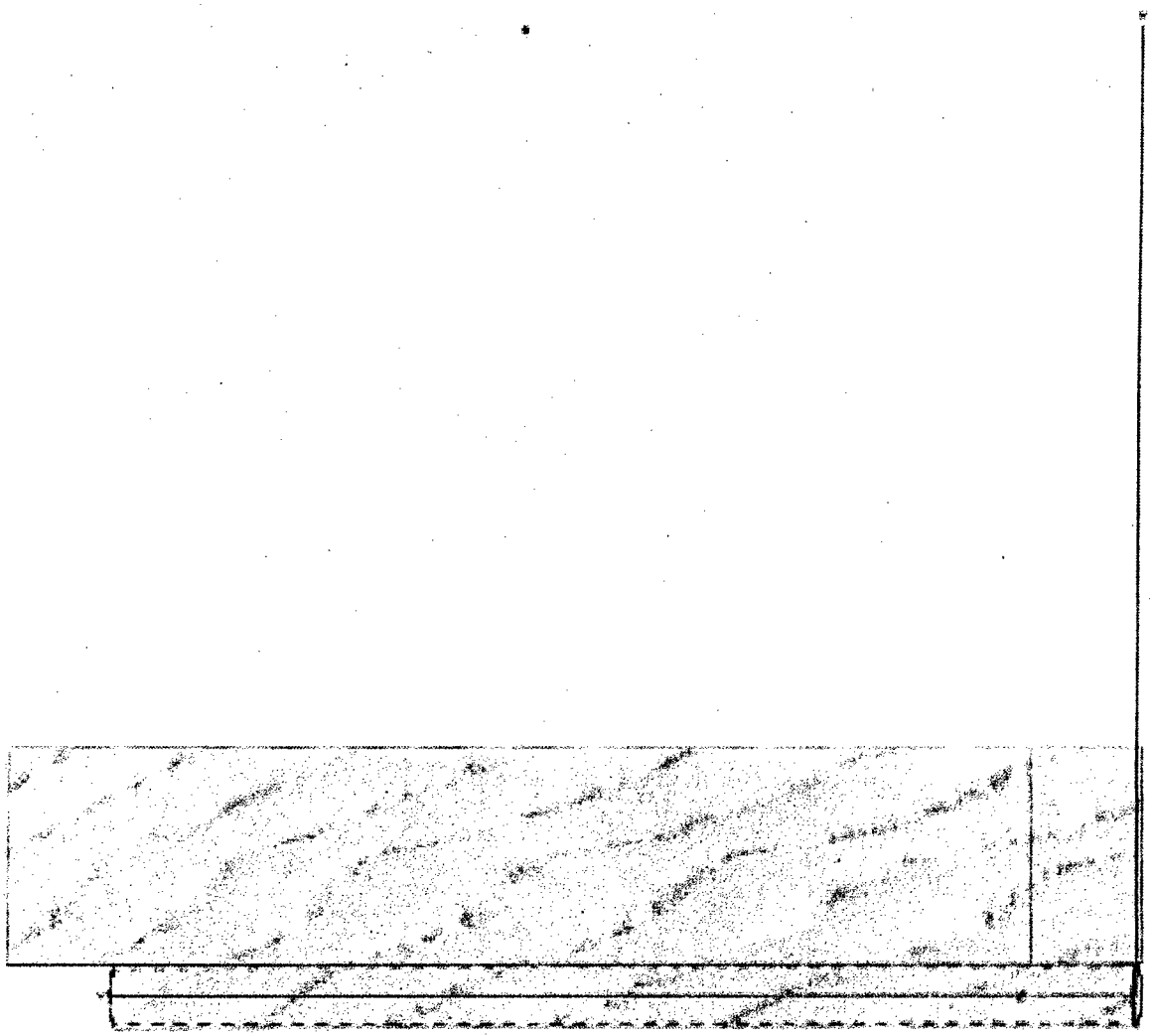
Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.909e-05	6.018e-14	1.194e-12	1.162e-16	2.305e-15
1.1732	6.074e-01	3.673e-09	3.596e-08	6.564e-12	6.427e-11
1.3325	6.074e-01	6.158e-09	5.164e-08	1.068e-11	8.959e-11

ıergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.215e+00	9.831e-09	6.760e-08	1.725e-11	1.539e-10

Page : 3
DOS File : PB020411.MS5
Run Date : February 4, 2006
Run Time : 2:43:21 PM
Duration : 00:00:00



MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020411.MS5
Case Title: Line 1.24 AF-C
This case was run on Saturday, February 4, 2006 at 2:43:21 PM
Dose Point # 1 - (134.97,76.2,91.44) cm

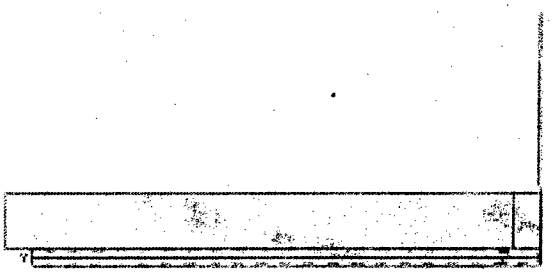
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	7.752e-009	6.941e-008
Photon Energy Fluence Rate	MeV/cm²/sec	9.831e-009	8.760e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.725e-011	1.539e-010
Absorbed Dose Rate in Air	mGy/hr	1.506e-013	1.343e-012
"	mrad/hr	1.506e-011	1.343e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.709e-013	1.525e-012
o Opposed	"	1.472e-013	1.313e-012
o Rotational	"	1.472e-013	1.313e-012
o Isotropic	"	1.315e-013	1.173e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.820e-013	1.624e-012
o Opposed	"	1.752e-013	1.563e-012
o Rotational	"	1.752e-013	1.563e-012
o Isotropic		1.393e-013	1.243e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.539e-013	1.373e-012
o Posterior/Anterior	"	1.418e-013	1.265e-012
o Lateral		1.128e-013	1.006e-012
o Rotational	"	1.277e-013	1.139e-012
o Isotropic	"	1.130e-013	1.008e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020412.MS5
Run Date: February 4, 2005
R Time: 2:44:33 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.24 AF-D
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

304.8 cm	10 ft 0.0 in
3.81 cm	1.5 in

Dose Points

X	Y	Z
134.97 cm	152.4 cm	91.44 cm
4 ft 5.1 in	5 ft 0.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	3.81 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Ba/cm²
Co-60	3.2835e-011	1.2149e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6936	1.982e-04	7.198e-14	1.483e-12	1.390e-16	2.863e-15
1.1732	1.215e+00	4.612e-09	4.692e-08	8.242e-12	8.384e-11
1.3325	1.215e+00	7.828e-09	6.818e-08	1.358e-11	1.183e-10

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.430e+00	1.244e-08	1.151e-07	2.182e-11	2.021e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020412.MS5
Case Title: Line 1.24 AF-D
This case was run on Saturday, February 4, 2006 at 2:44:33 PM
Dose Point # 1 - (134.97,152.4,91.44) cm

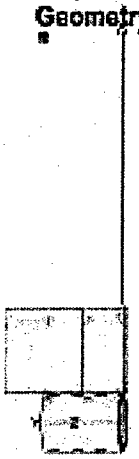
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	9.606e-009	9.116e-008
Photon Energy Fluence Rate	MeV/cm²/sec	1.244e-008	1.151e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.182e-011	2.021e-010
Absorbed Dose Rate in Air	mGy/hr	1.905e-013	1.765e-012
"	mrad/hr	1.905e-011	1.765e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.163e-013	2.004e-012
o Opposed	"	1.863e-013	1.725e-012
o Rotational	"	1.863e-013	1.725e-012
o Isotropic	"	1.664e-013	1.541e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.302e-013	2.133e-012
o Opposed	"	2.217e-013	2.054e-012
o Rotational	"	2.217e-013	2.054e-012
o Isotropic	"	1.763e-013	1.633e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.948e-013	1.804e-012
o Posterior/Anterior	"	1.794e-013	1.662e-012
o Lateral	"	1.427e-013	1.321e-012
o Rotational	"	1.616e-013	1.496e-012
o Isotropic	"	1.430e-013	1.324e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020413.MS5
Run Date: February 4, 2006
R Time: 2:58:20 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 AF-A
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	30.48 cm	1 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	15.24 cm	91.44 cm
	4 ft 7.6 in	6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.6
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	8.7559e-012	3.2397e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	5.285e-05	2.406e-14	4.708e-13	4.646e-17	9.090e-16
1.1732	3.240e-01	1.459e-09	1.440e-08	2.607e-12	2.573e-11
1.3325	3.240e-01	2.451e-09	2.080e-08	4.253e-12	3.609e-11

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.480e-01	3.910e-09	3.520e-08	6.860e-12	6.182e-11

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020413.MS5
Case Title: Line 1.641 AF-A
This case was run on Saturday, February 4, 2006 at 2:58:20 PM
Dose Point # 1 - (141.32,15.24,91.44) cm

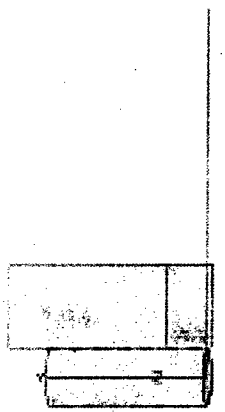
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	3.083e-009	2.789e-008
Photon Energy Fluence Rate	MeV/cm²/sec	3.910e-009	3.520e-008
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	6.860e-012	6.182e-011
Absorbed Dose Rate in Air	mGy/hr	5.989e-014	5.397e-013
"	mrad/hr	5.989e-012	5.397e-011
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	6.799e-014	6.126e-013
o Opposed	"	5.856e-014	5.276e-013
o Rotational	"	5.856e-014	5.276e-013
o Isotropic	"	5.231e-014	4.713e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.237e-014	6.524e-013
o Opposed	"	6.968e-014	6.281e-013
o Rotational	"	6.968e-014	6.281e-013
o Isotropic	"	5.542e-014	4.994e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.122e-014	5.518e-013
o Posterior/Anterior	"	5.640e-014	5.082e-013
o Lateral		4.486e-014	4.041e-013
o Rotational		5.079e-014	4.576e-013
o Isotropic		4.495e-014	4.049e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020414.MS5
Run Date: February 4, 2006
R Time: 3:00:06 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 AF-B
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	60.96 cm	2 ft
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	30.48 cm	91.44 cm
	4 ft 7.6 in	1 ft	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	1.7512e-011	6.4794e-001	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.057e-04	4.615e-14	9.085e-13	8.910e-17	1.754e-15
1.1732	6.479e-01	2.817e-09	2.795e-08	5.035e-12	4.994e-11
1.3325	6.479e-01	4.742e-09	4.043e-08	8.228e-12	7.014e-11

DOS File : PB020414.MS5
Run Date: February 4, 2006
Run Time: 3:00:06 PM
Duration : 00:00:00

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.296e+00	7.560e-09	6.838e-08	1.326e-11	1.201e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020414.MS5
Case Title: Line 1.641 AF-B
This case was run on Saturday, February 4, 2006 at 3:00:06 PM
Dose Point # 1 - (141.32,30.48,91.44) cm

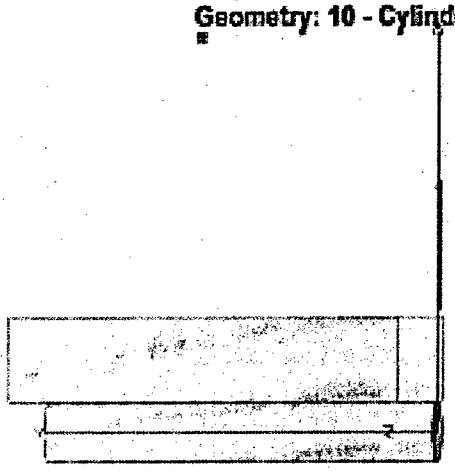
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	5.961e-009	5.416e-006
Photon Energy Fluence Rate	MeV/cm²/sec	7.560e-009	6.838e-006
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.326e-011	1.201e-010
Absorbed Dose Rate in Air	mGy/hr	1.158e-013	1.048e-012
"	mrad/hr	1.158e-011	1.048e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.314e-013	1.190e-012
o Opposed	"	1.132e-013	1.025e-012
o Rotational	"	1.132e-013	1.025e-012
o Isotropic	"	1.011e-013	9.154e-013
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.399e-013	1.267e-012
o Opposed	"	1.347e-013	1.220e-012
o Rotational	"	1.347e-013	1.220e-012
o Isotropic	"	1.071e-013	9.700e-013
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.184e-013	1.072e-012
o Posterior/Anterior	"	1.090e-013	9.872e-013
o Lateral	"	8.674e-014	7.848e-013
o Rotational	"	9.819e-014	8.889e-013
o Isotropic	"	8.691e-014	7.865e-013

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020415.MS5
Run Date: February 4, 2006
R Time: 3:01:23 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 AF-C
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	152.4 cm	5 ft 0.0 in
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	76.2 cm	91.44 cm
	4 ft 7.6 in	2 ft 6.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.6
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm²	Bq/cm²
Co-60	4.3760e-011	1.6198e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	2.642e-04	8.998e-14	1.828e-12	1.737e-16	3.529e-15
1.1732	1.620e+00	5.703e-09	5.807e-08	1.019e-11	1.038e-10
1.3325	1.620e+00	9.682e-09	8.463e-08	1.680e-11	1.468e-10

DOS File : PB020415.MS5
Run Date : February 4, 2006
Run Time : 3:01:23 PM
Duration : 00:00:00

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	3.240e+00	1.538e-08	1.427e-07	2.699e-11	2.506e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020415.MS5
Case Title: Line 1.641 AF-C
This case was run on Saturday, February 4, 2006 at 3:01:23 PM
Dose Point # 1 - (141.32,76.2,91.44) cm

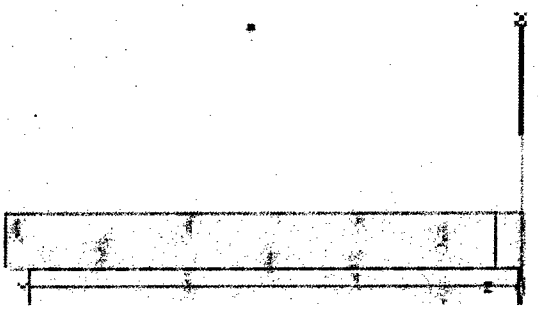
Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.213e-008	1.130e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.538e-008	1.427e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.699e-011	2.506e-010
Absorbed Dose Rate in Air	mGy/hr	2.356e-013	2.188e-012
"	mrad/hr	2.356e-011	2.188e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.675e-013	2.484e-012
o Opposed	"	2.304e-013	2.139e-012
o Rotational		2.304e-013	2.139e-012
o Isotropic	"	2.058e-013	1.910e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.847e-013	2.644e-012
o Opposed	"	2.742e-013	2.546e-012
o Rotational	"	2.742e-013	2.546e-012
o Isotropic	"	2.180e-013	2.024e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	2.409e-013	2.237e-012
o Posterior/Anterior	"	2.219e-013	2.060e-012
o Lateral	"	1.765e-013	1.638e-012
o Rotational		1.998e-013	1.855e-012
o Isotropic		1.769e-013	1.641e-012

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.

Page : 1
DOS File : PB020416.MS5
Run Date : February 4, 2006
R Time: 3:02:23 PM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Line 1.641 AF-D
Description: PBRF Rev Model Co-60 Area Factor Calculation
Geometry: 10 - Cylinder Surface - External Dose Point



Source Dimensions

Height	304.8 cm	10 ft 0.0 in
Radius	10.16 cm	4.0 in

Dose Points

	X	Y	Z
# 1	141.32 cm	152.4 cm	91.44 cm
	4 ft 7.6 in	5 ft 0.0 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	10.16 cm	Concrete	1.8
Shield 1	.65 cm	Iron	7.86
Transition		Concrete	2.4
Shield 3	30.48 cm	Concrete	2.4
Air Gap		Air	0.00122
Wall Clad	.025 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	uCi/cm²	Bq/cm²
Co-60	8.7559e-011	3.2397e+000	4.5000e-009	1.6650e-004

Buildup
The material reference is : Cyl. Core

Integration Parameters

Y Direction (axial)	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	5.285e-04	1.074e-13	2.262e-12	2.073e-16	4.368e-15
1.1732	3.240e+00	7.136e-09	7.536e-08	1.275e-11	1.347e-10
1.3325	3.240e+00	1.226e-08	1.111e-07	2.128e-11	1.928e-10

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.480e+00	1.940e-06	1.865e-07	3.403e-11	3.275e-10

MicroShield v5.05 (5.05-00362)
Radiological Services, Inc.
Conversion of calculated exposure in air to dose
FILE: C:\MS5\DATA\PB020416.MS5
Case Title: Line 1.641 AF-D
This case was run on Saturday, February 4, 2006 at 3:02:23 PM
Dose Point # 1 - (141.32,152.4,91.44) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Photon Fluence Rate (flux)	Photons/cm²/sec	1.529e-008	1.477e-007
Photon Energy Fluence Rate	MeV/cm²/sec	1.940e-008	1.865e-007
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	3.403e-011	3.275e-010
Absorbed Dose Rate in Air	mGy/hr	2.971e-013	2.859e-012
"	mrad/hr	2.971e-011	2.859e-010
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.372e-013	3.246e-012
o Opposed	"	2.905e-013	2.795e-012
o Rotational	"	2.905e-013	2.795e-012
o Isotropic	"	2.595e-013	2.497e-012
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	3.590e-013	3.456e-012
o Opposed	"	3.457e-013	3.327e-012
o Rotational	"	3.457e-013	3.327e-012
o Isotropic	"	2.749e-013	2.645e-012
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	3.037e-013	2.923e-012
o Posterior/Anterior	"	2.798e-013	2.692e-012
o Lateral	"	2.226e-013	2.141e-012
o Rotational	"	2.519e-013	2.424e-012
o Isotropic	"	2.230e-013	2.145e-012

Final Status Survey Plan
for the
Plum Brook Reactor Facility

Attachment D

Illustrations of Survey Area Classification

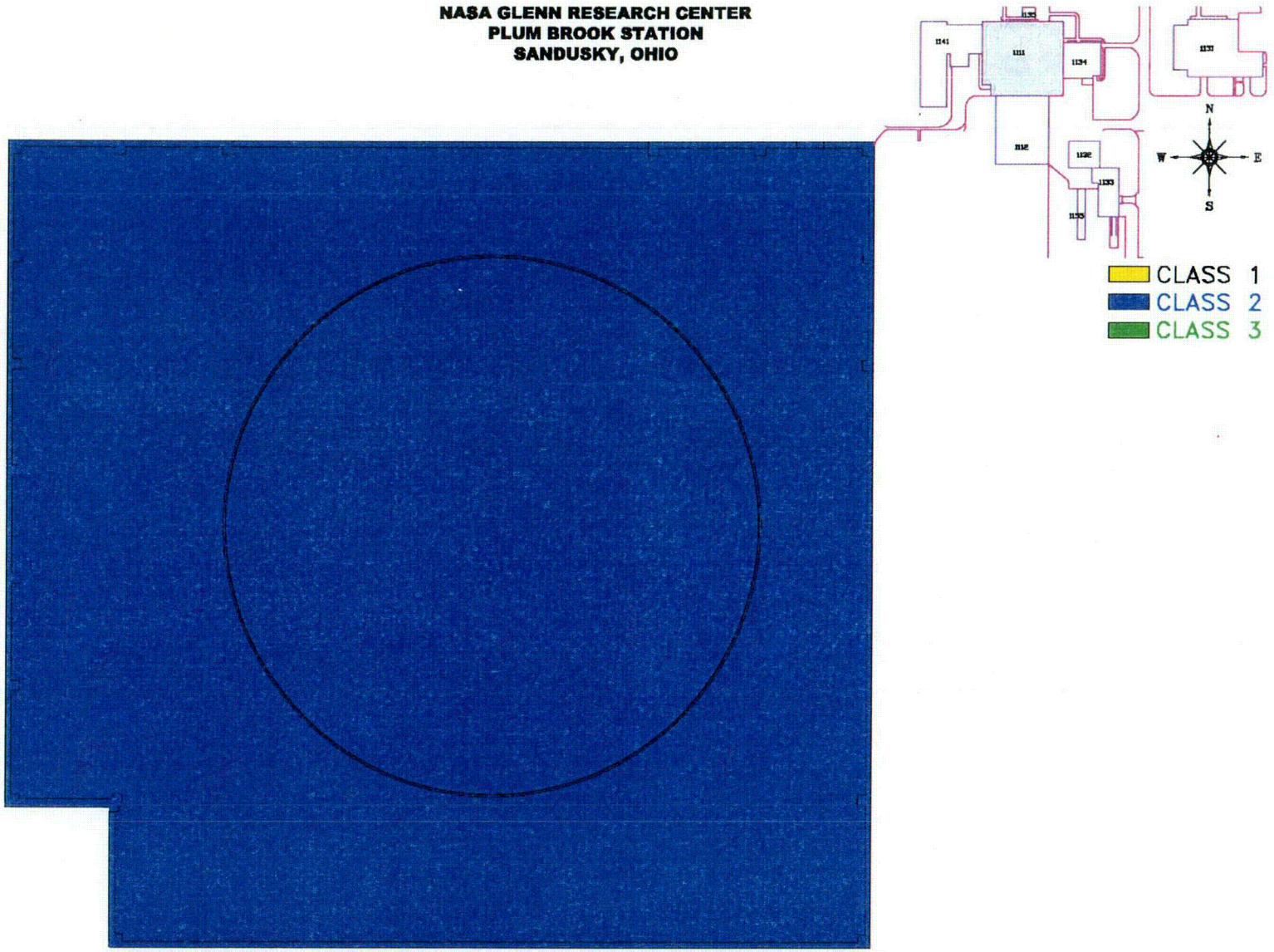


Figure D-1 – Reactor Building Roof Elevation

C10

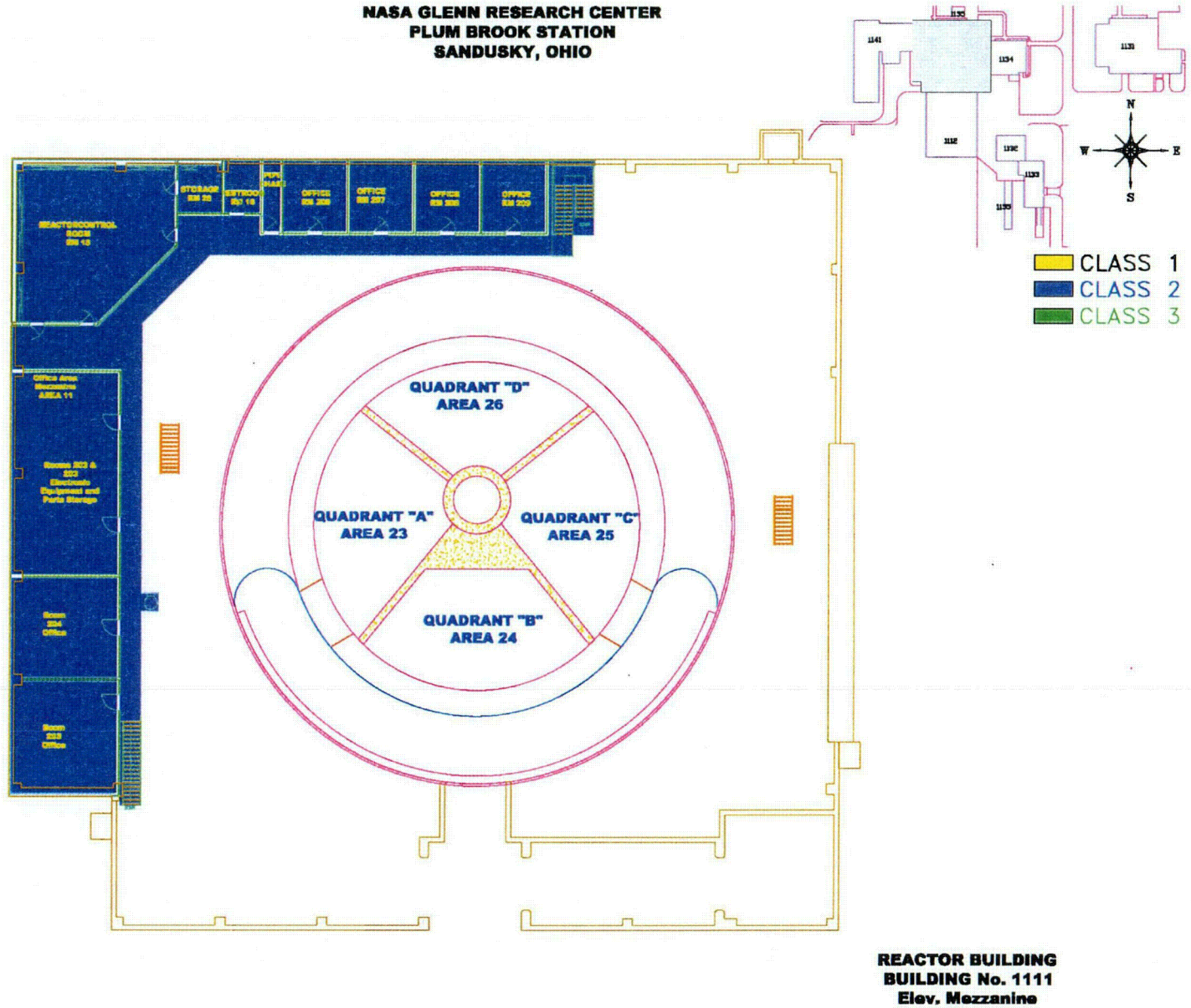


Figure D-2 – Reactor Building Mezzanine Elevation

C11

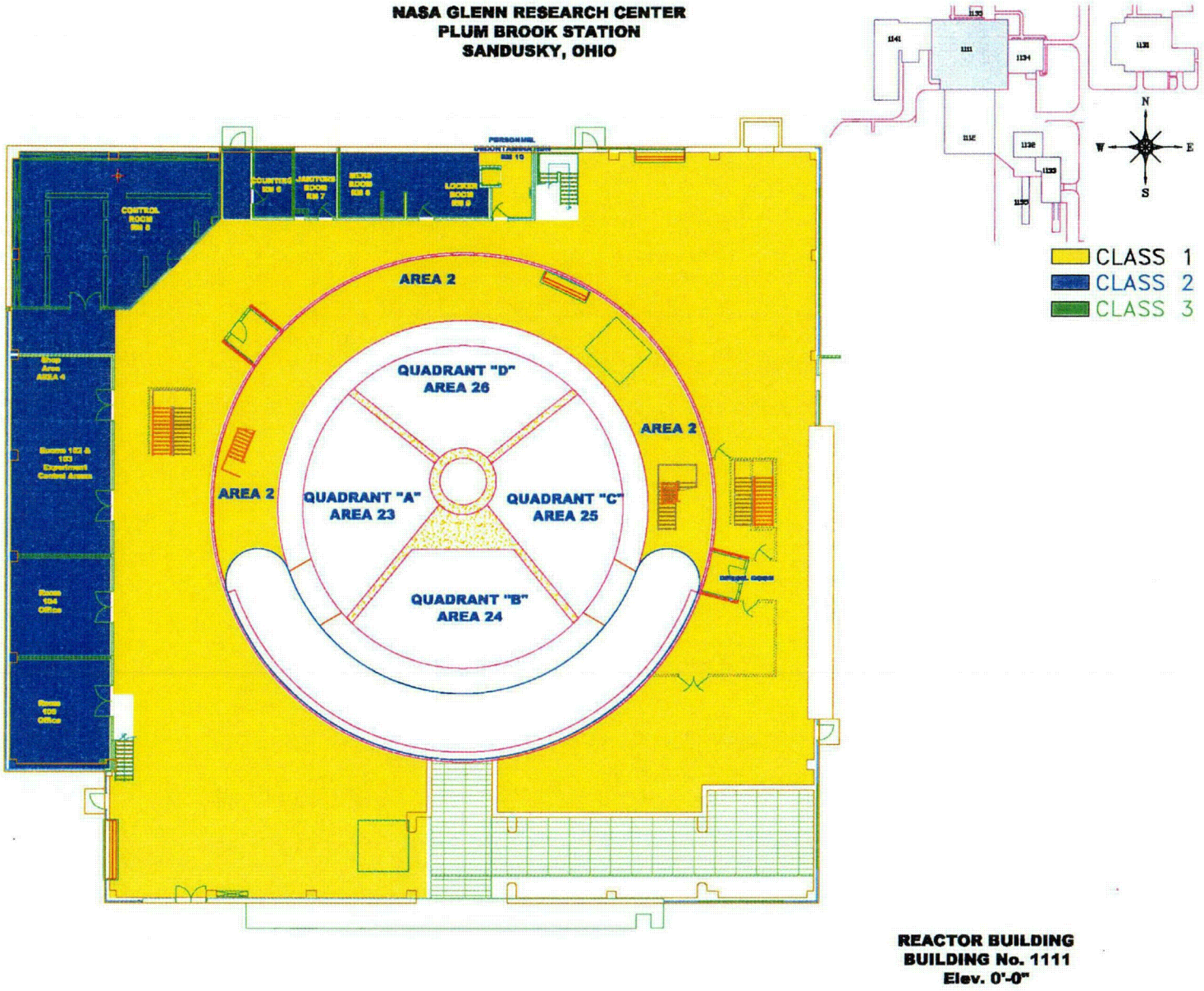


Figure D-3 – Reactor Building 0'-0" Elevation

C12

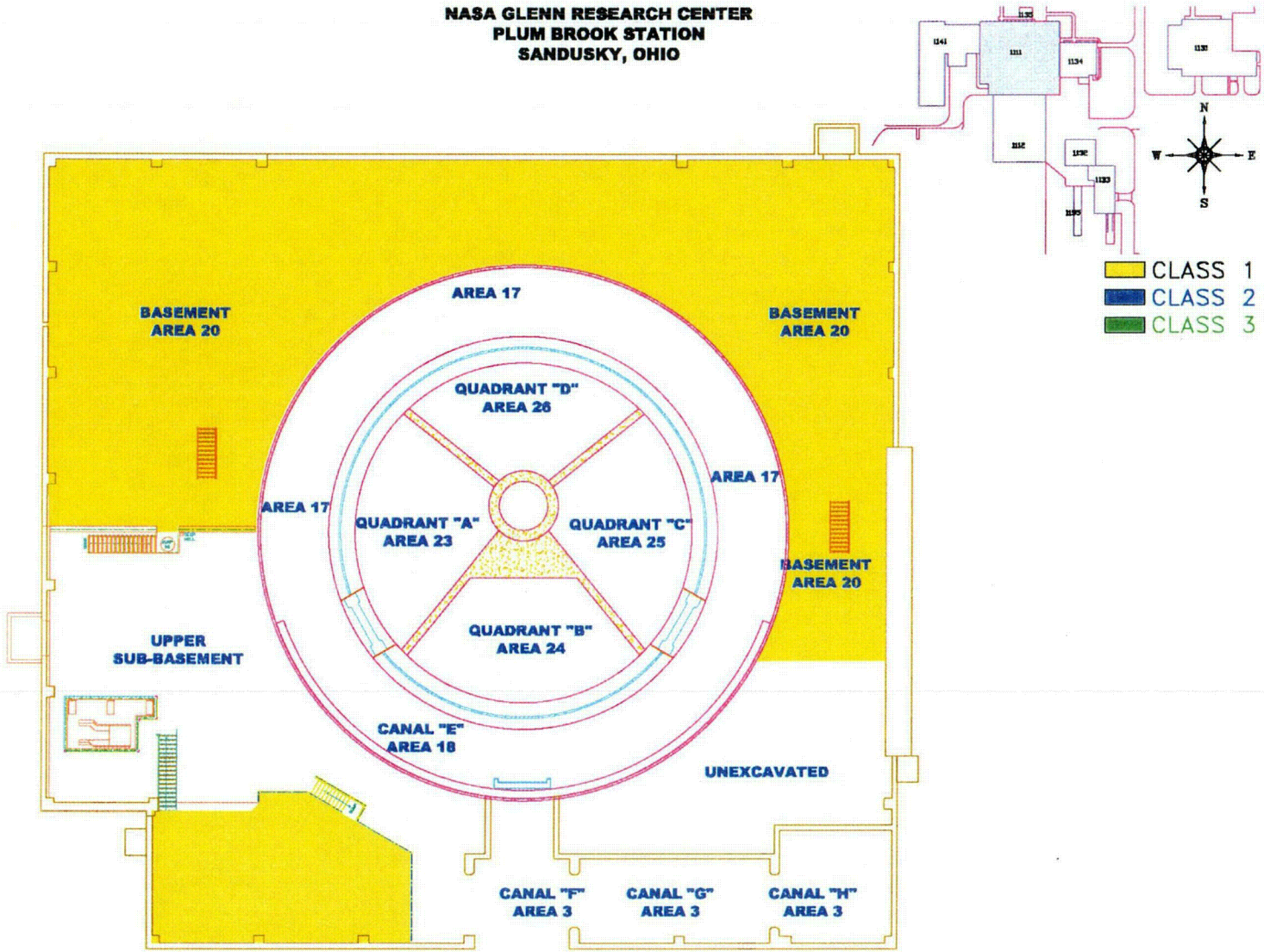


Figure D-4– Reactor Building -15'-0" Elevation

C13

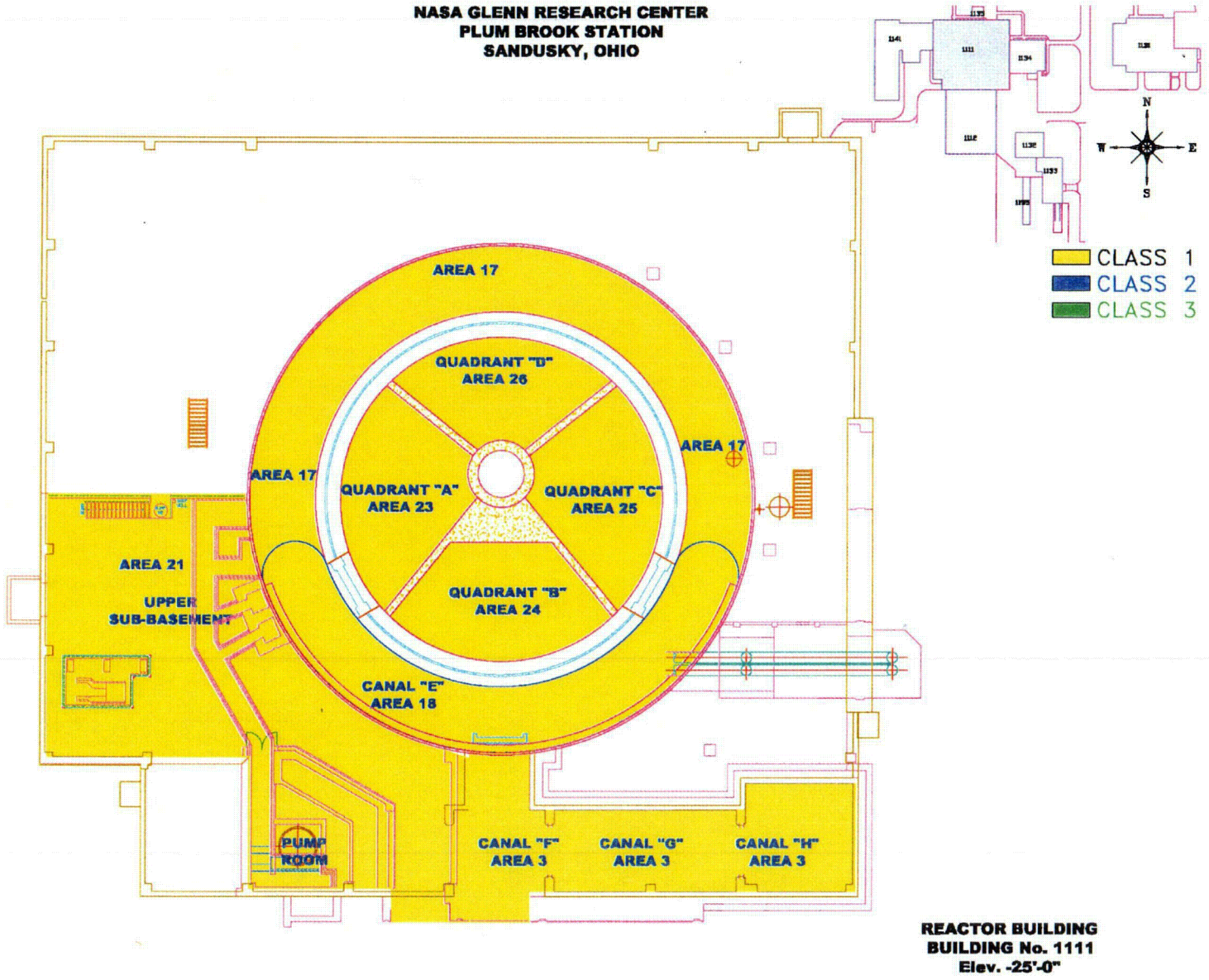
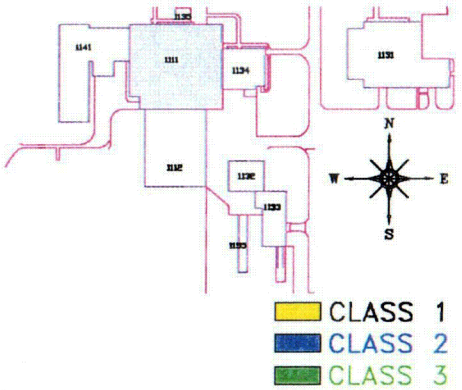
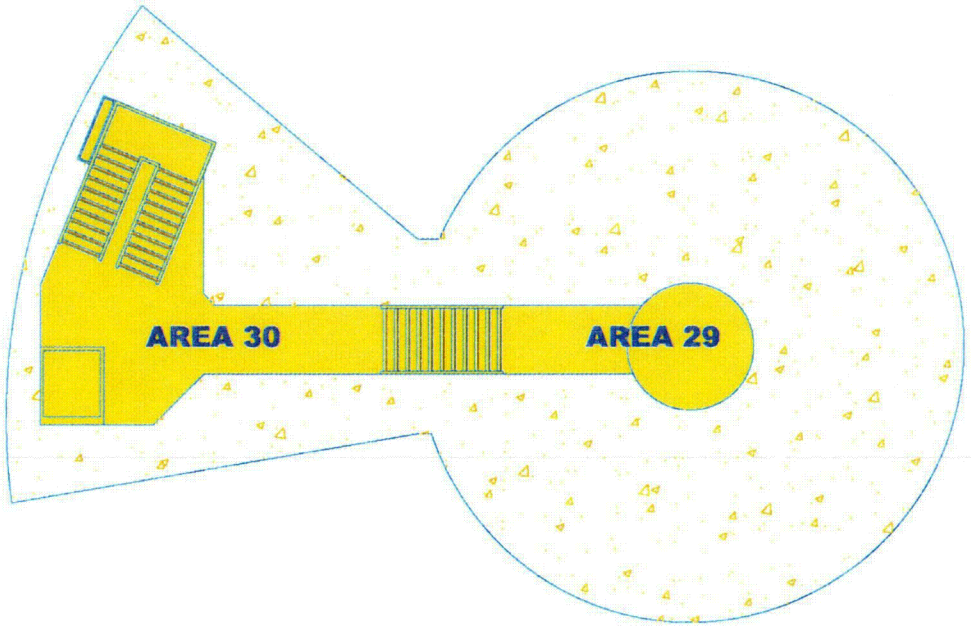


Figure D-5 – Reactor Building -25'-0" Elevation

C14

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REACTOR BUILDING
BUILDING No. 1111
Sub-Pile

Figure D-6 – Reactor Building Sub-Pile Elevation

C15

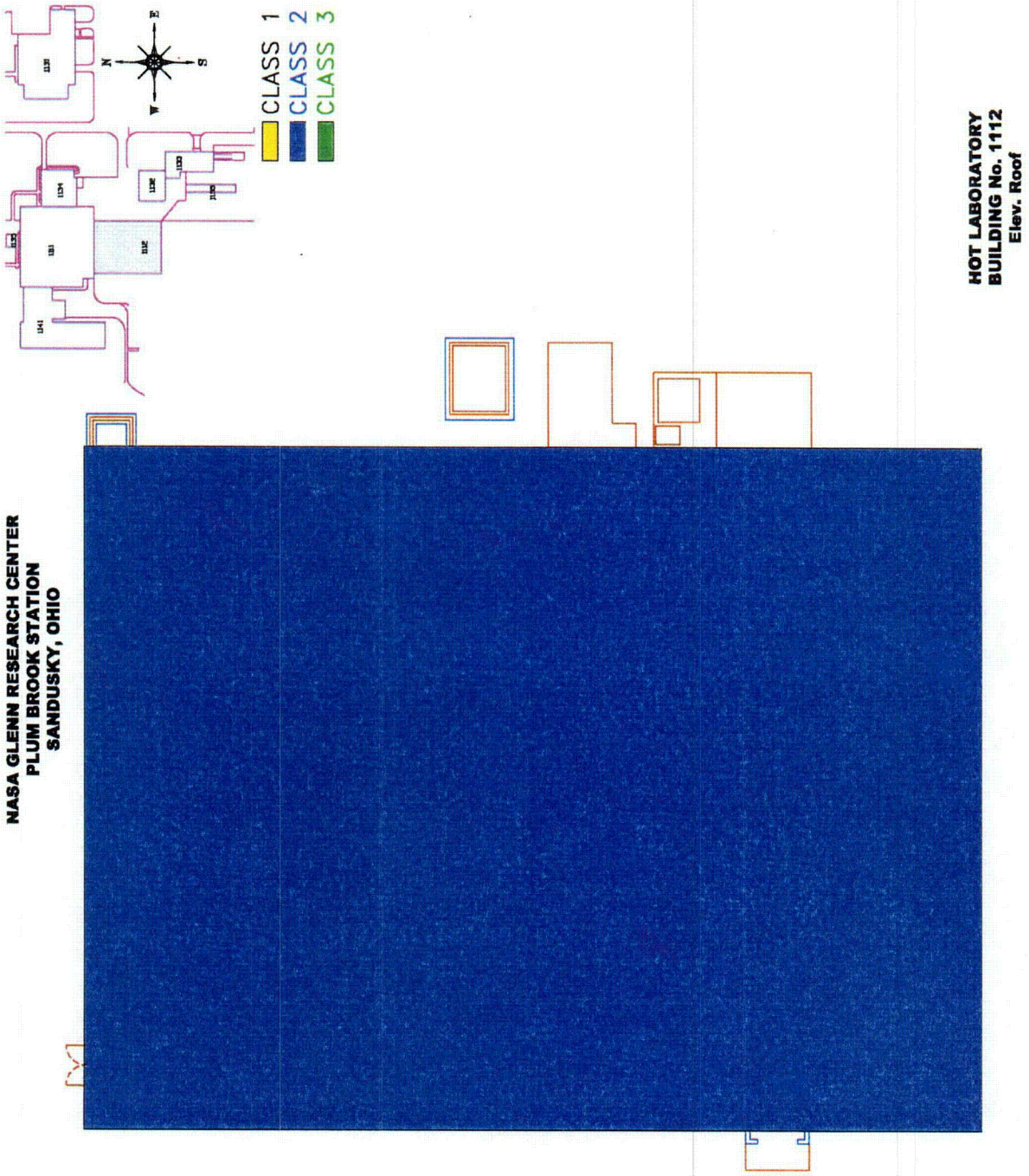


Figure D-7 – Hot Laboratory Building Roof Elevation

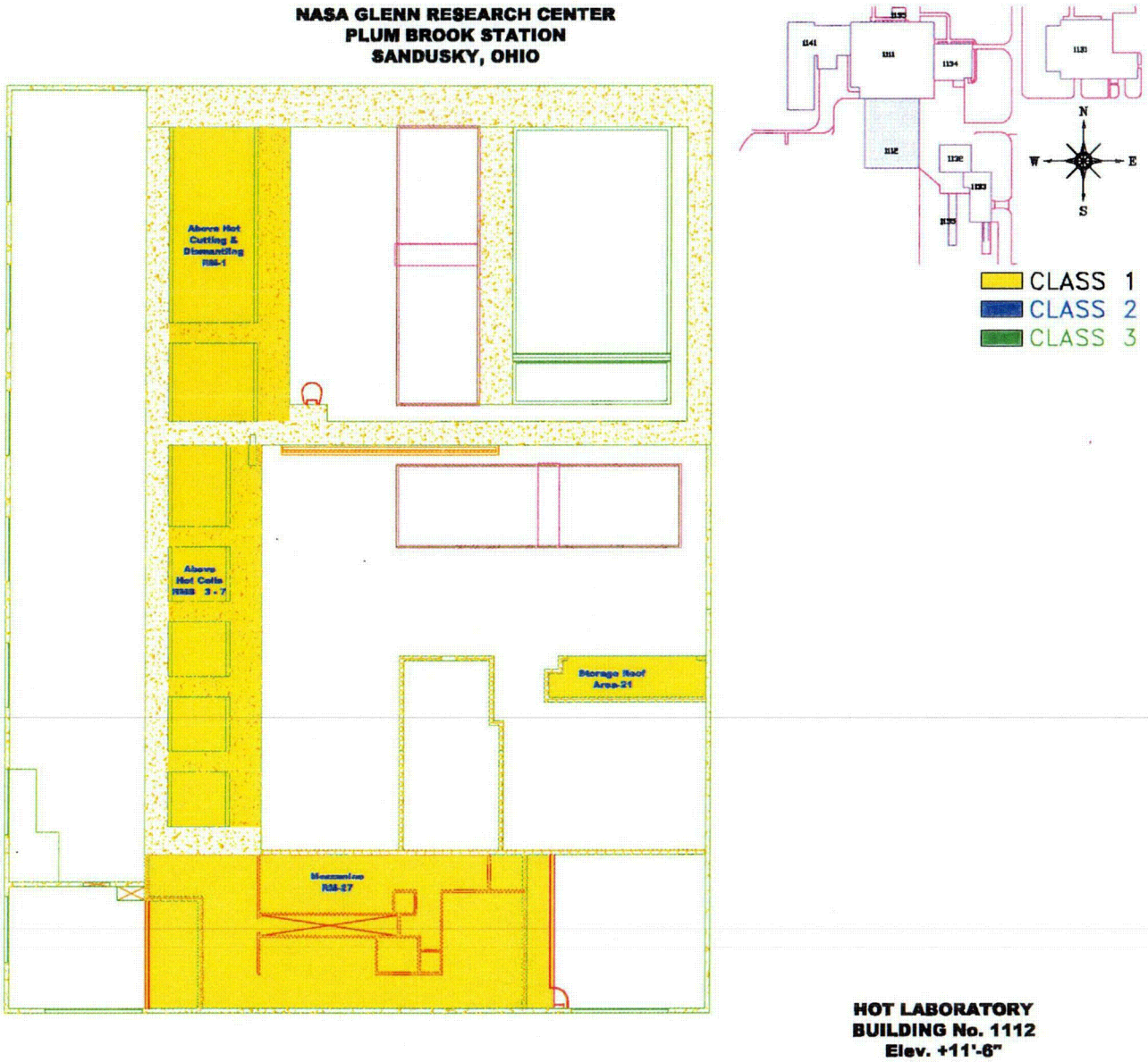


Figure D-8 – Hot Laboratory Building +11'-6" Elevation

C17

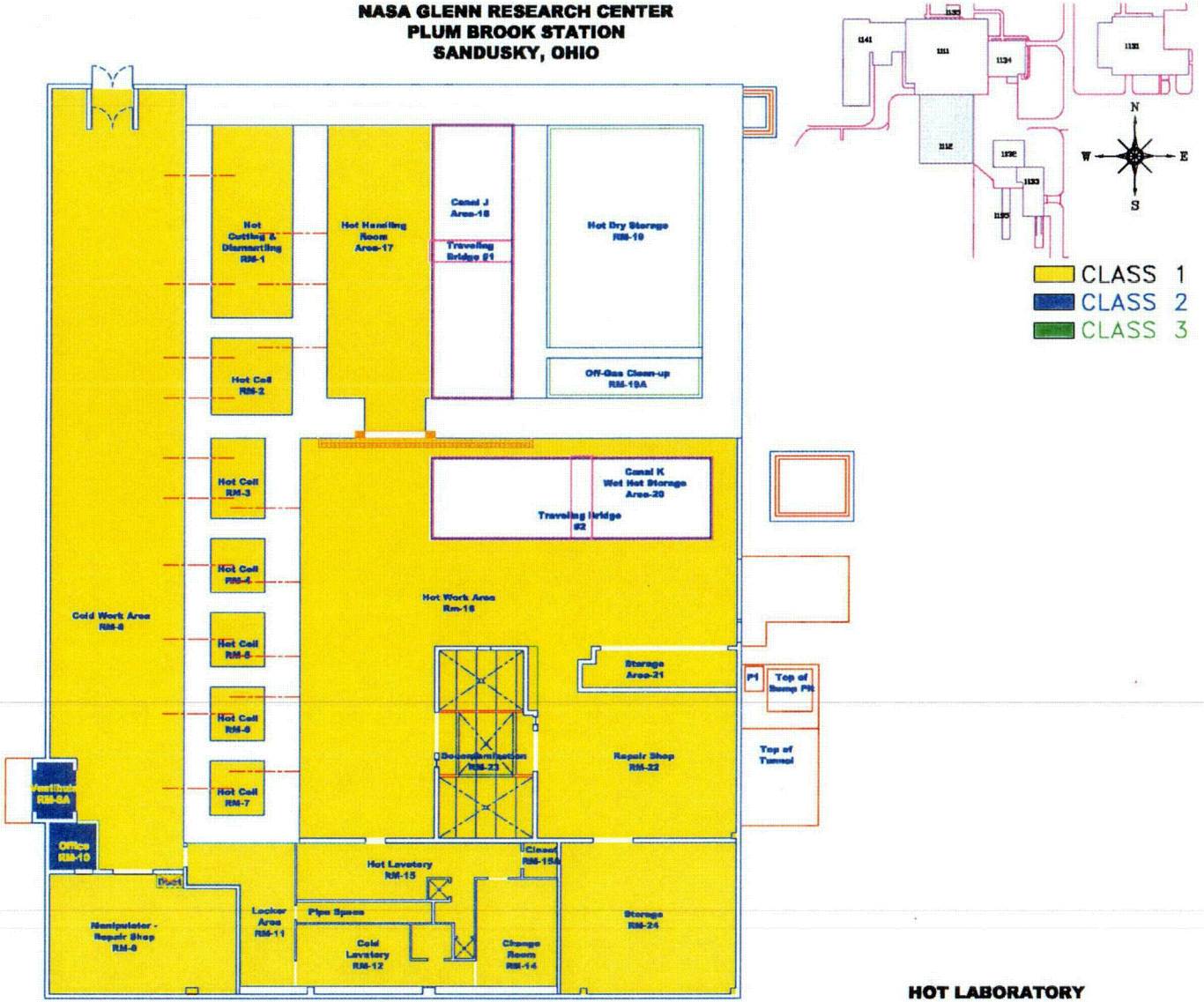


Figure D-9 – Hot Laboratory Building 0'-0" Elevation

C18

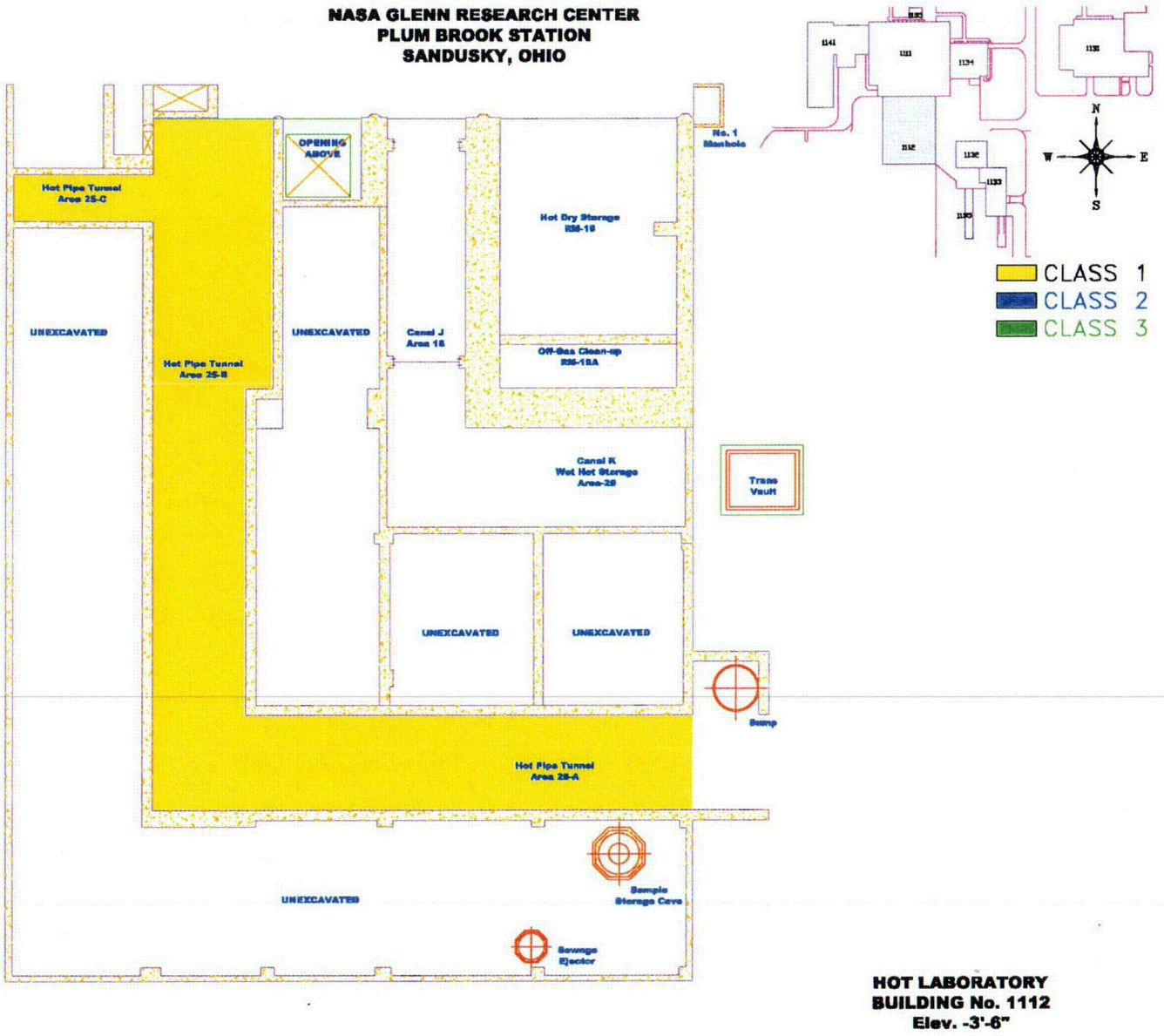


Figure D-10 – Hot Laboratory Building -3'-6" Elevation

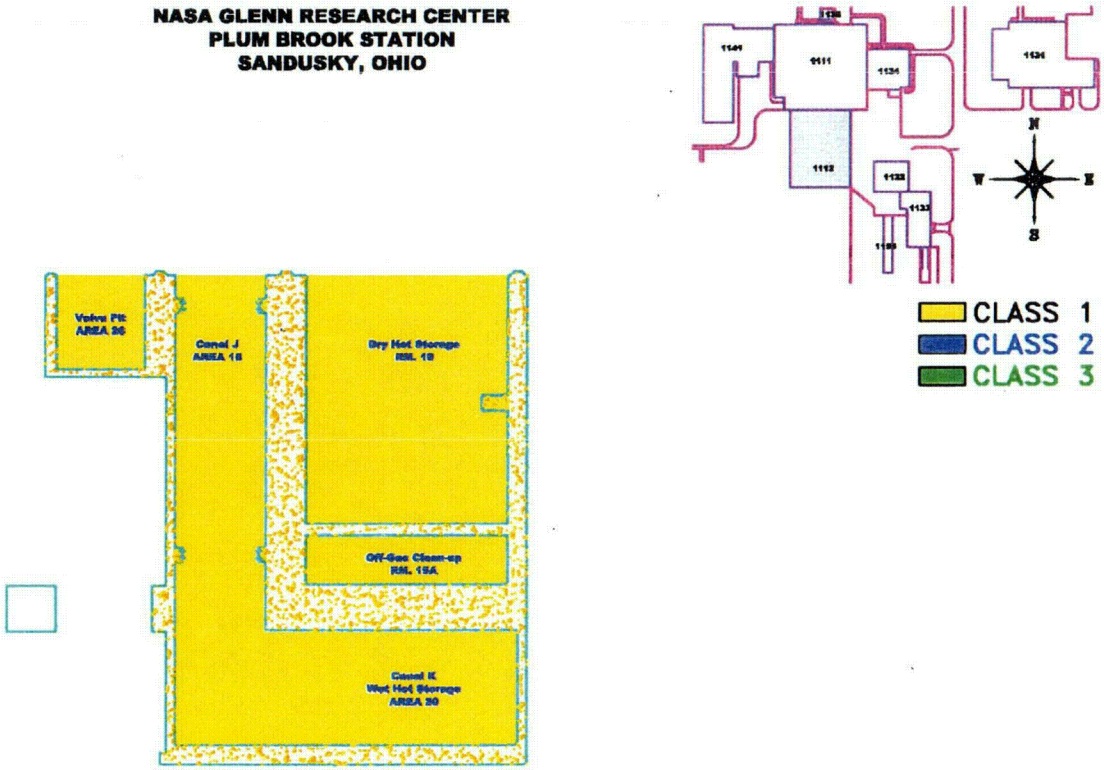


Figure D-11 – Hot Laboratory Building -25'-0" Elevation

C20

C21

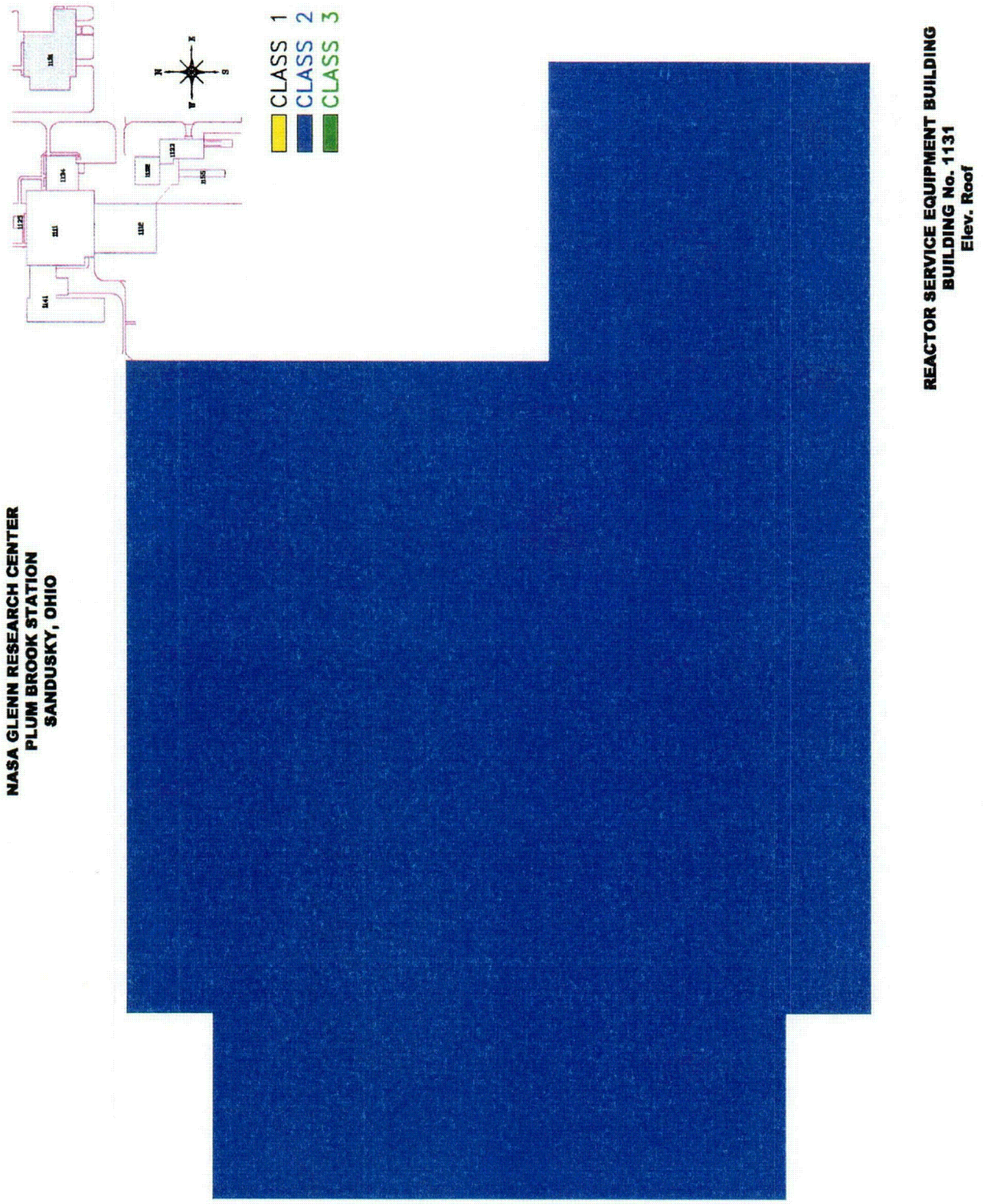
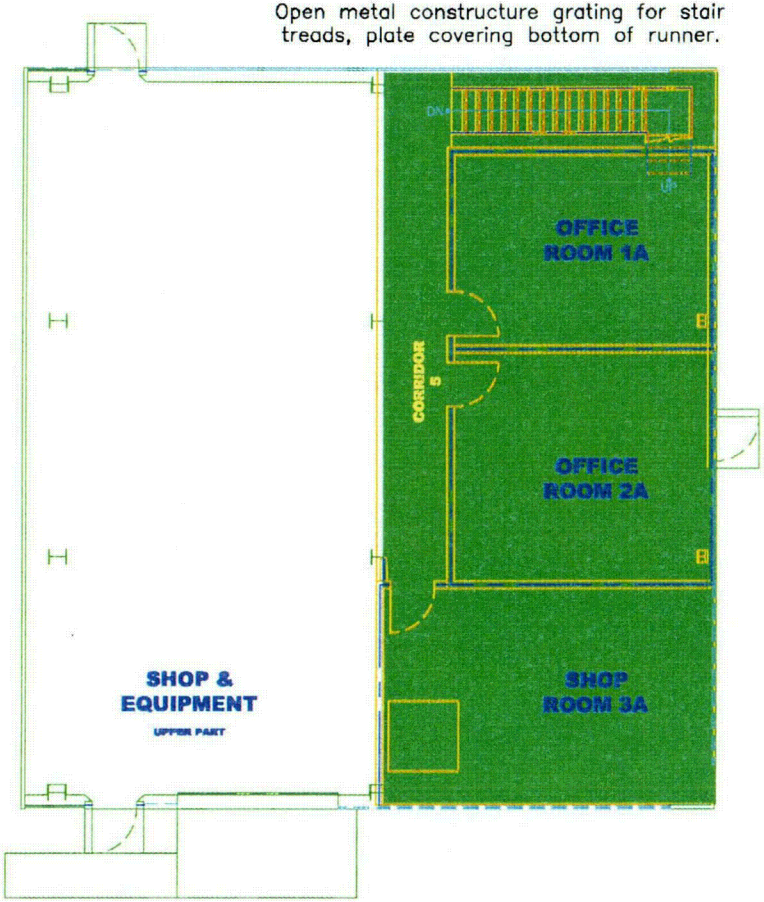
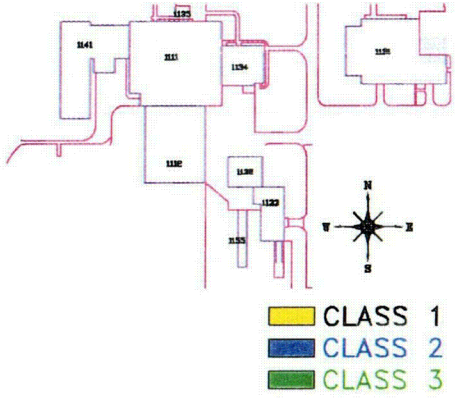


Figure D-12 – Service Equipment Building Roof Elevation

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REACTOR SERVICE EQUIPMENT BUILDING
BUILDING No. 1131
MEZZANINE FLOOR ADDITION

Figure D-13 – Service Equipment Building Mezzanine over Addition

C22

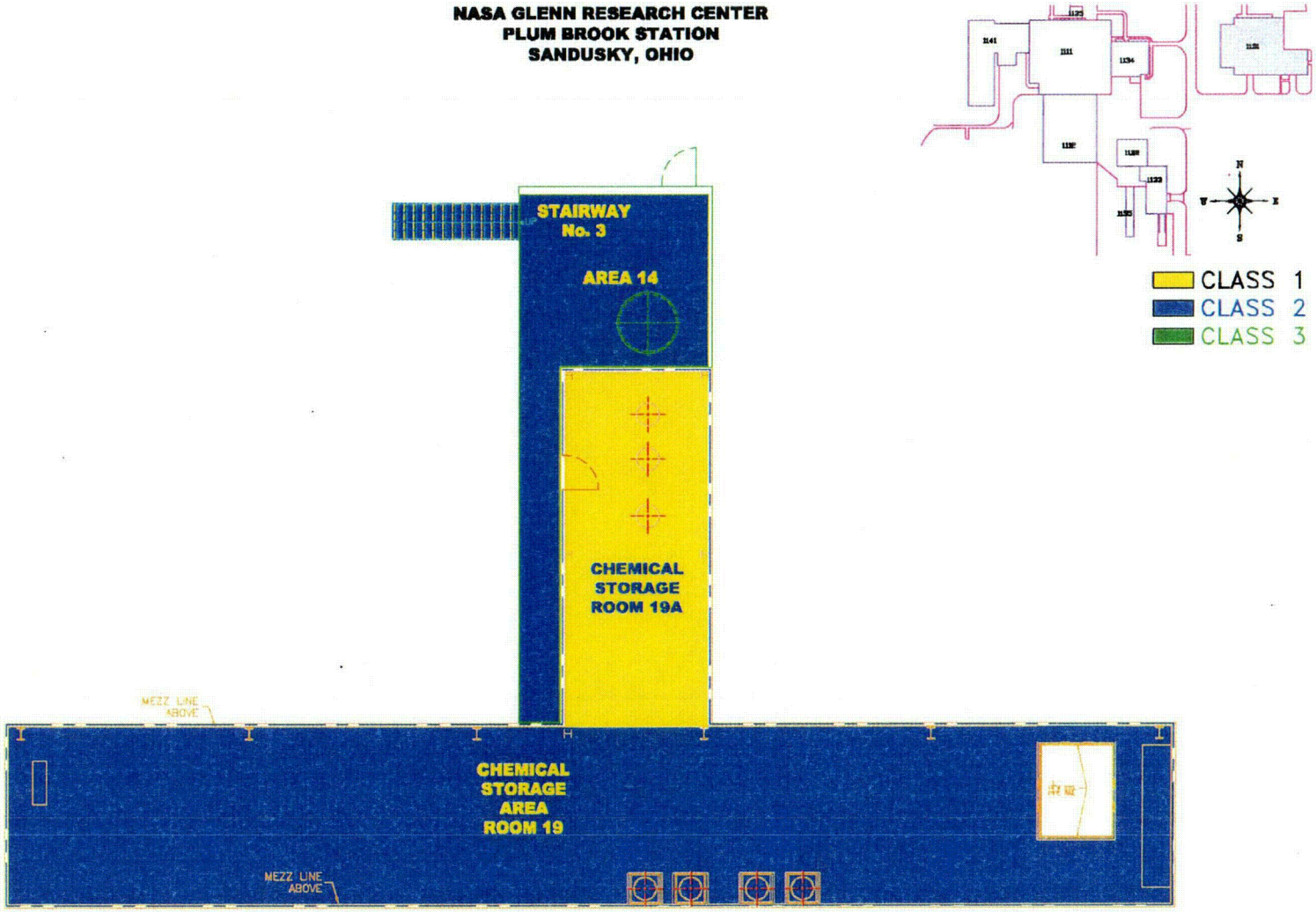


Figure D-14 – Service Equipment Building Mezzanine Elevation

C23

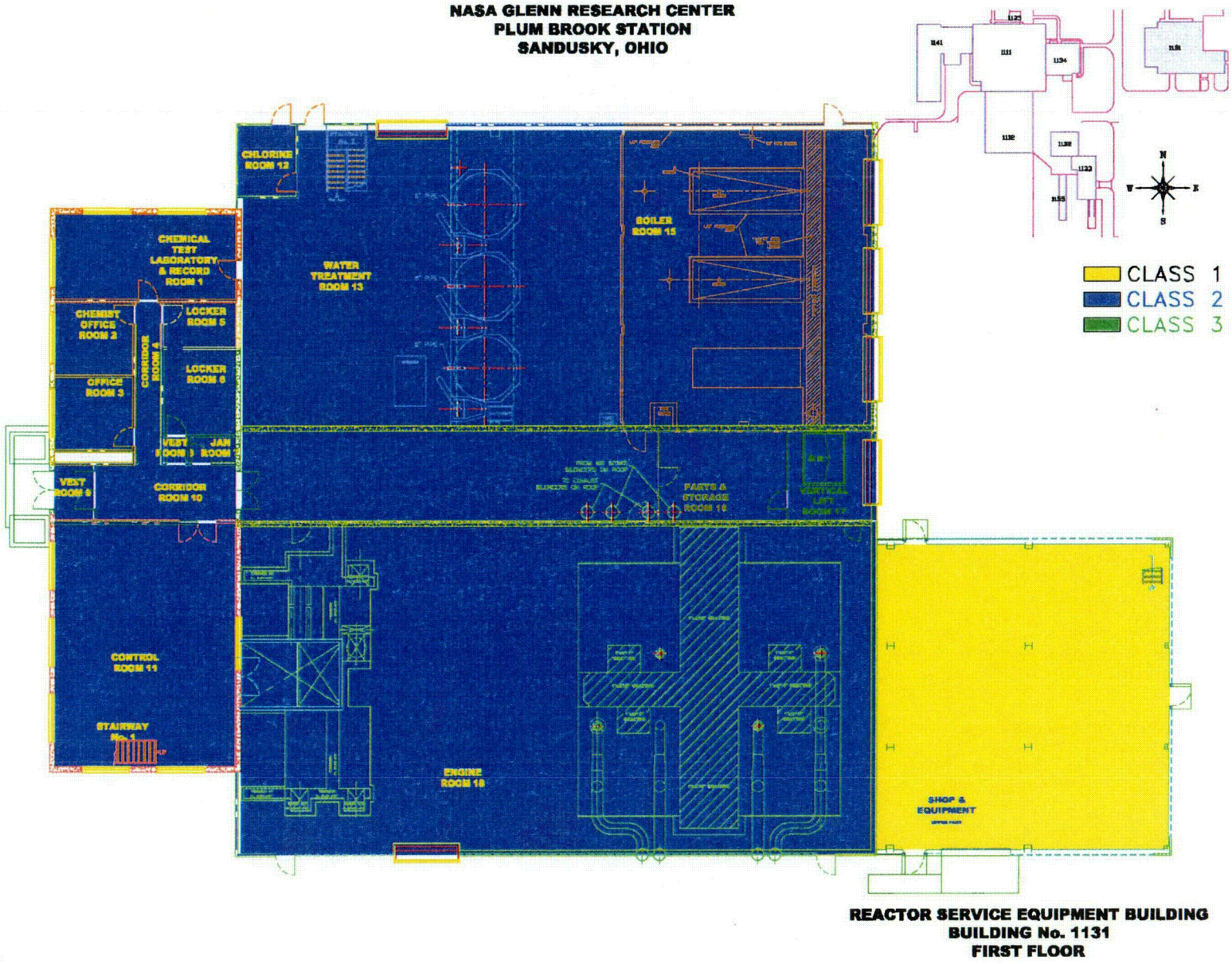


Figure D-15 – Service Equipment Building First Floor Elevation

C24

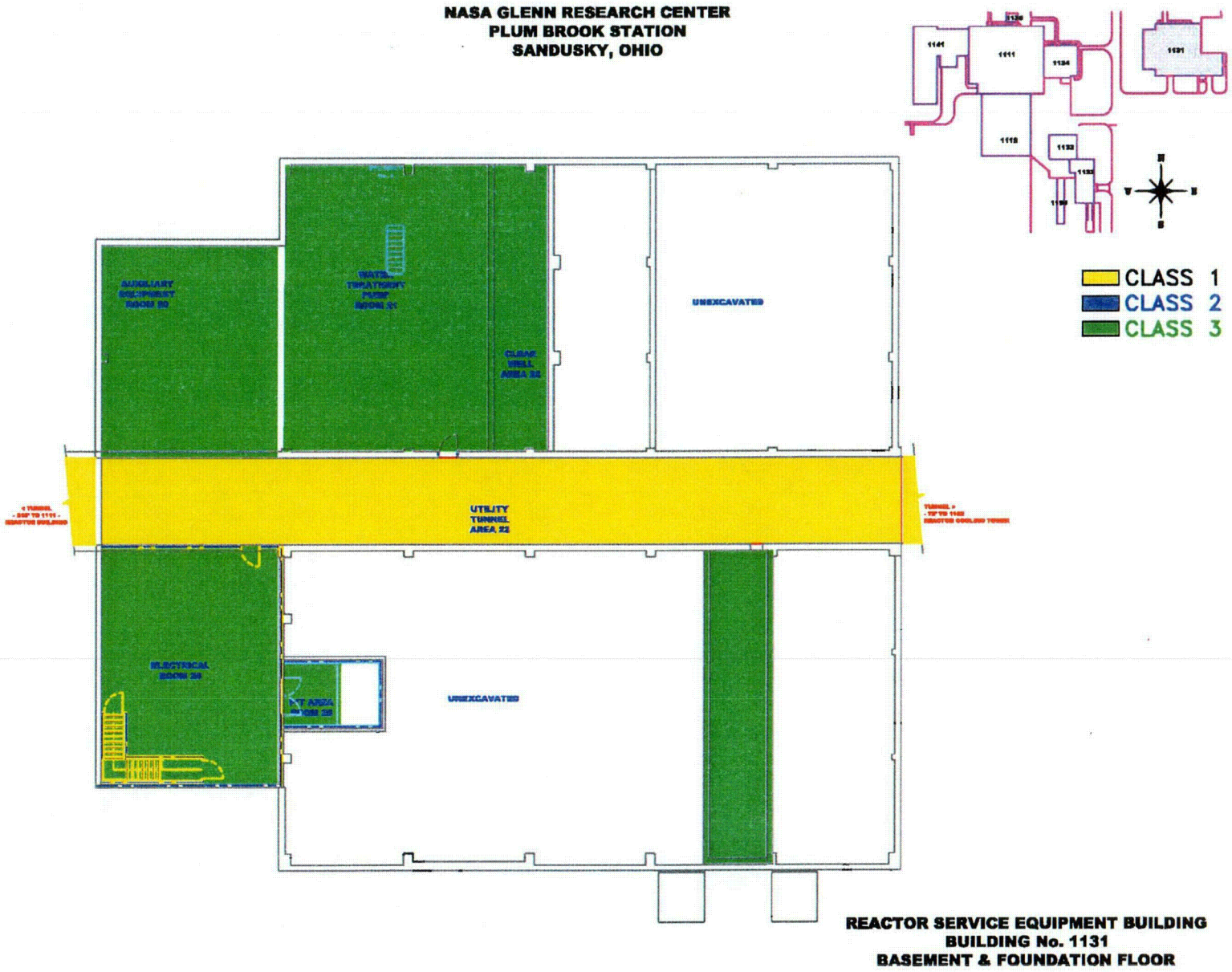


Figure D-16 – Service Equipment Building Basement Elevation

C25

C20

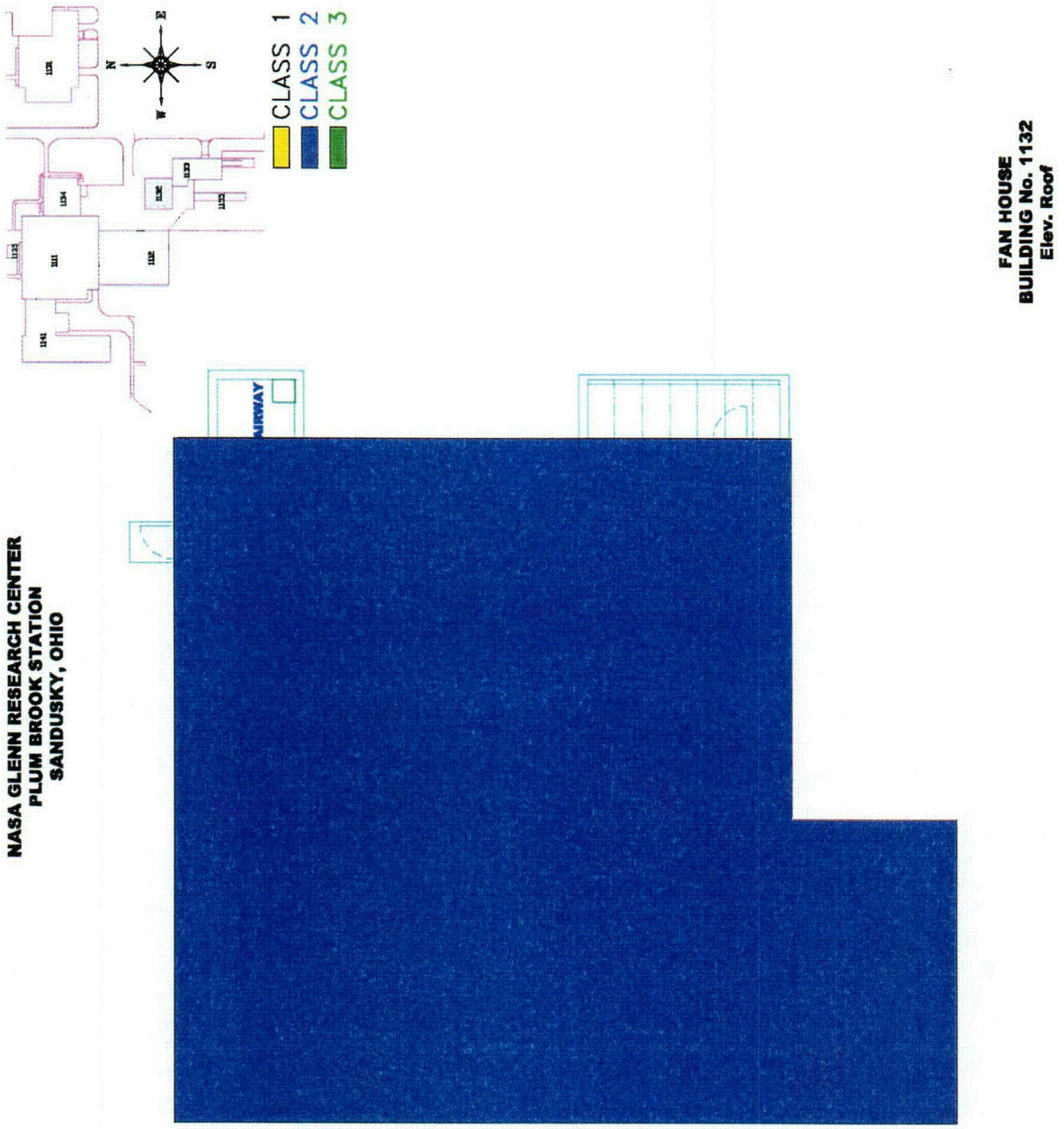


Figure D-17 – Fan House 0'-0" Elevation

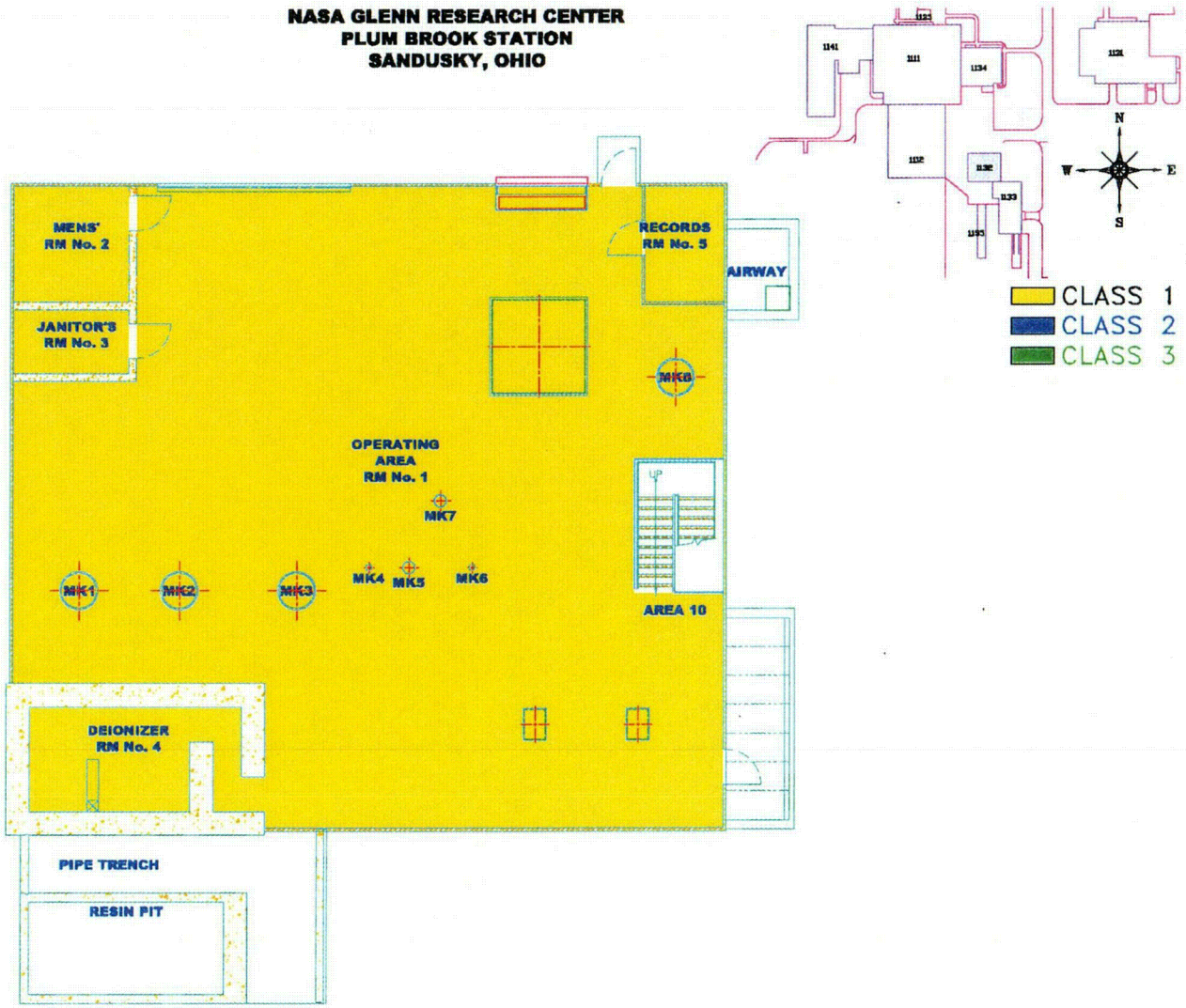


Figure D-18 – Fan House 0'-0" Elevation

C27

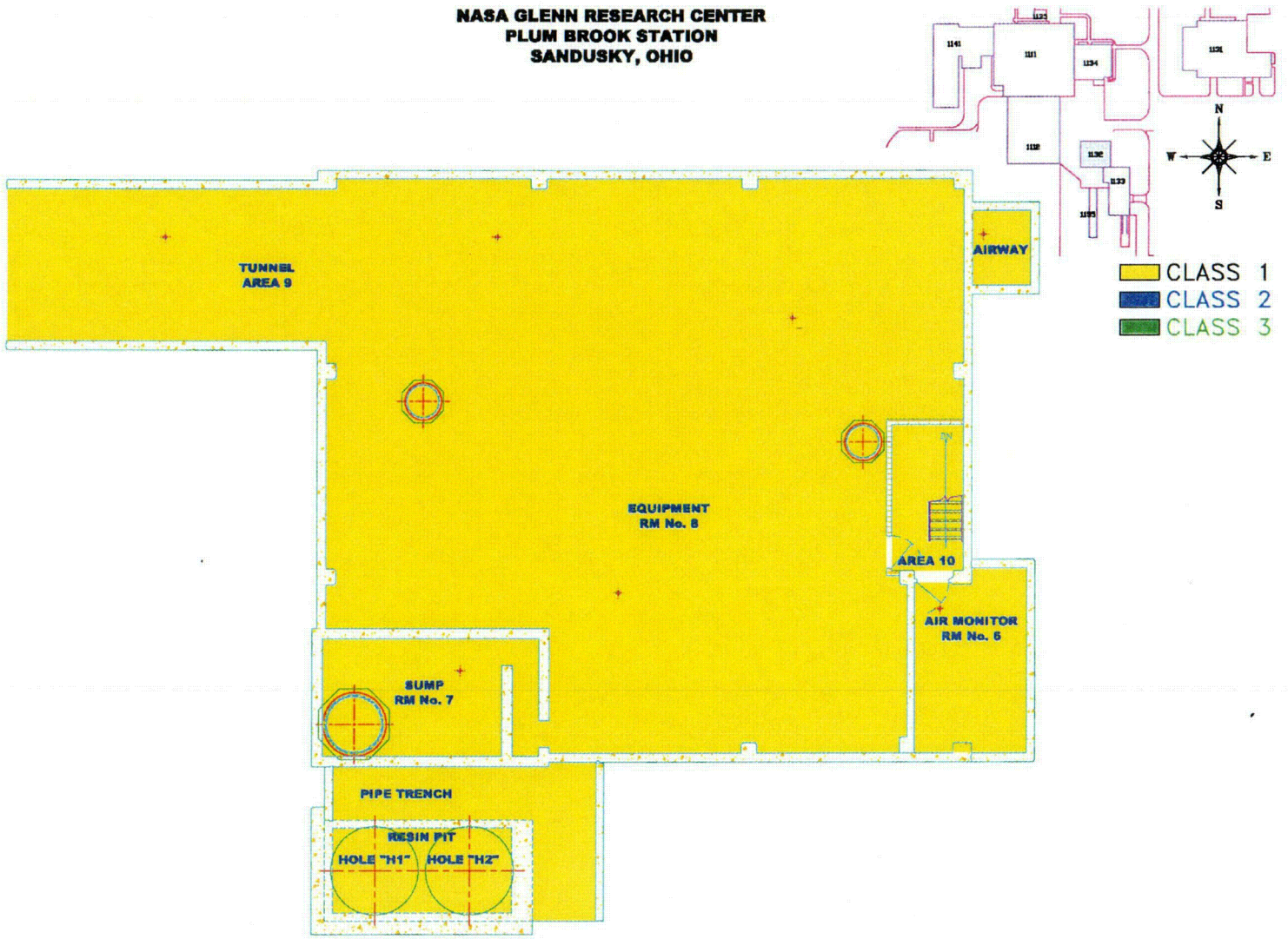


Figure D-19 – Fan House -12'-6" Elevation

C28

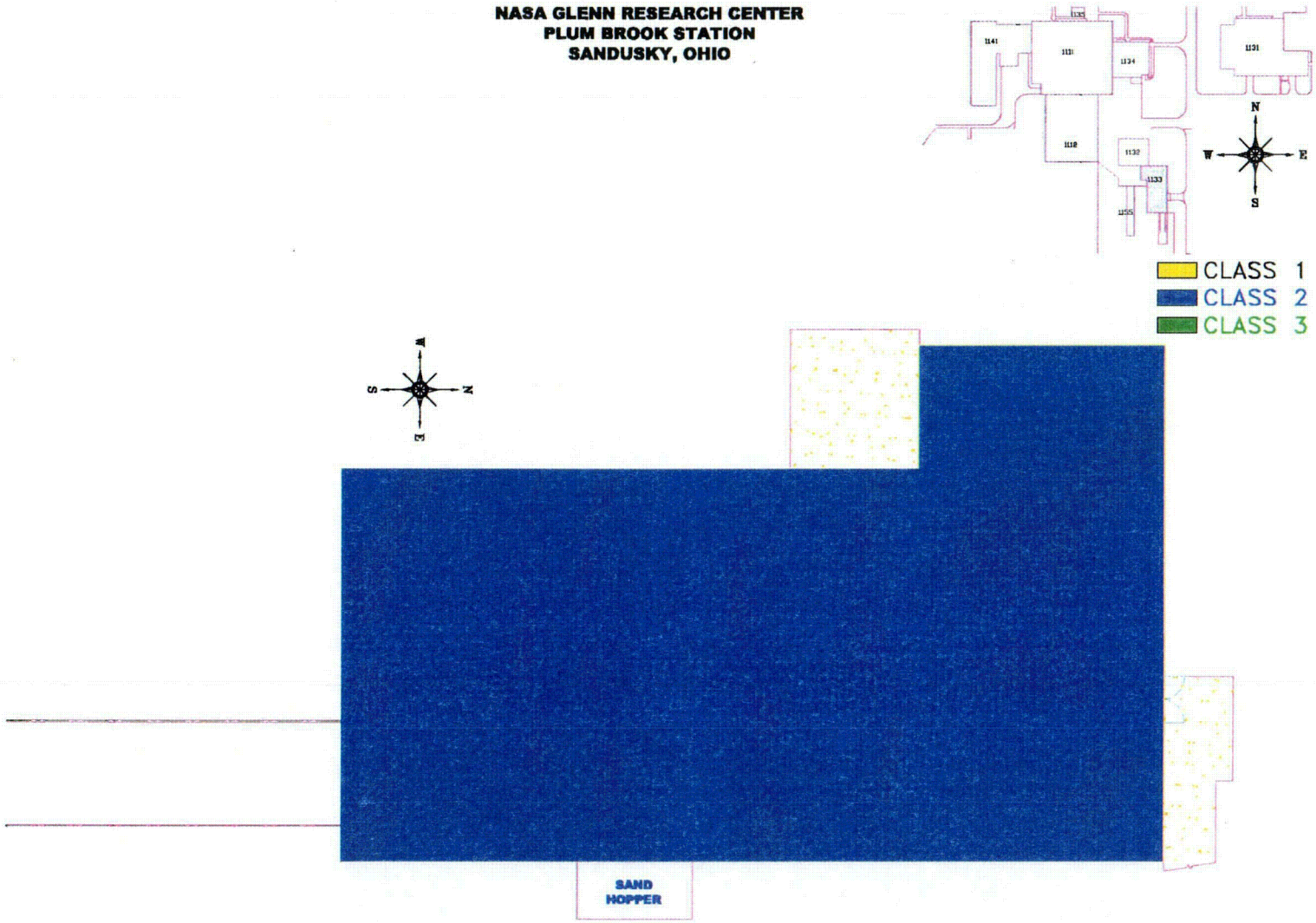


Figure D-20 – Waste Handling Building Roof Elevation

C29

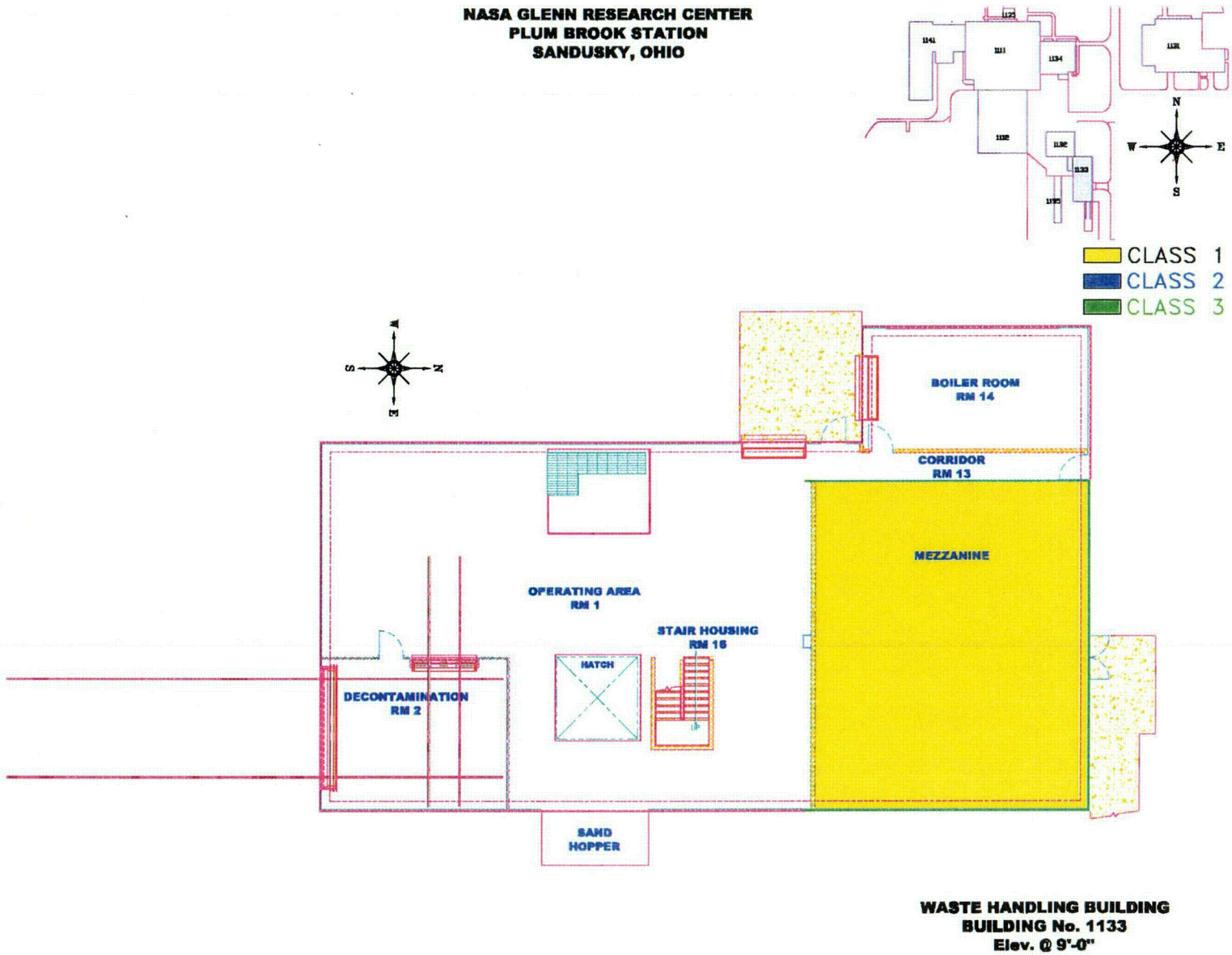


Figure D-21 – Waste Handling Building +9'-0" Elevation

C30

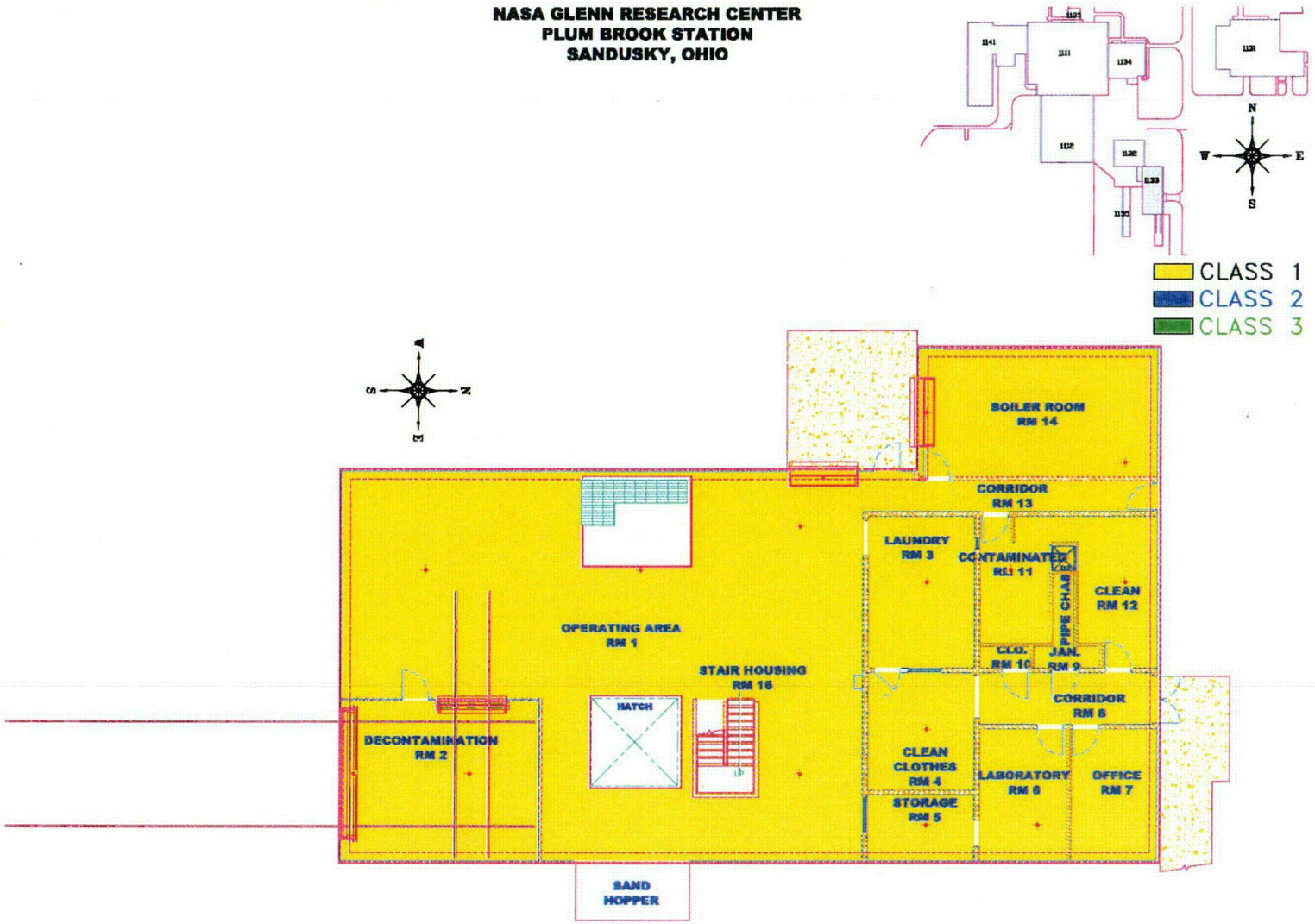


Figure D-22 – Waste Handling Building 0'-0" Elevation

C31

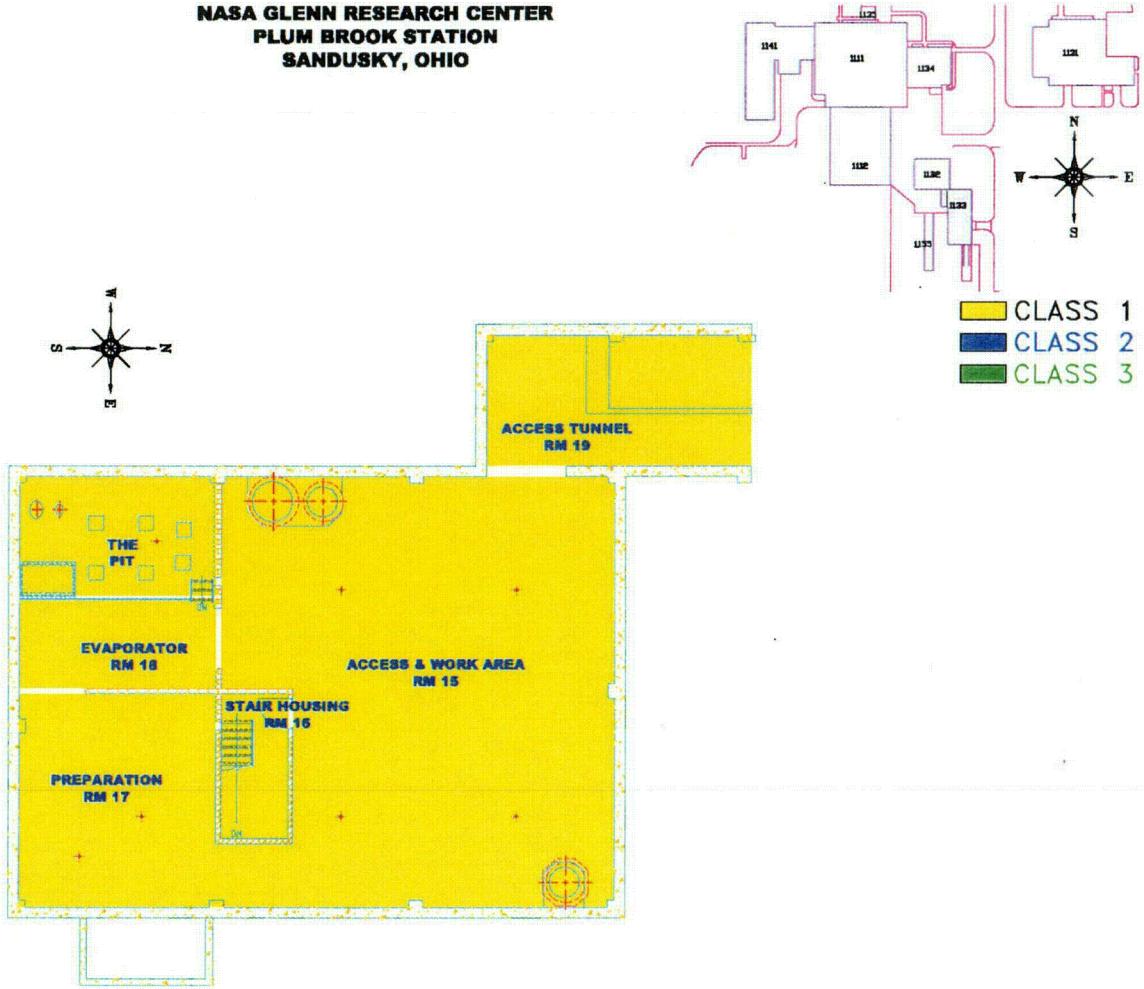


Figure D-23 – Waste Handling Building -13'-5" Elevation

C32

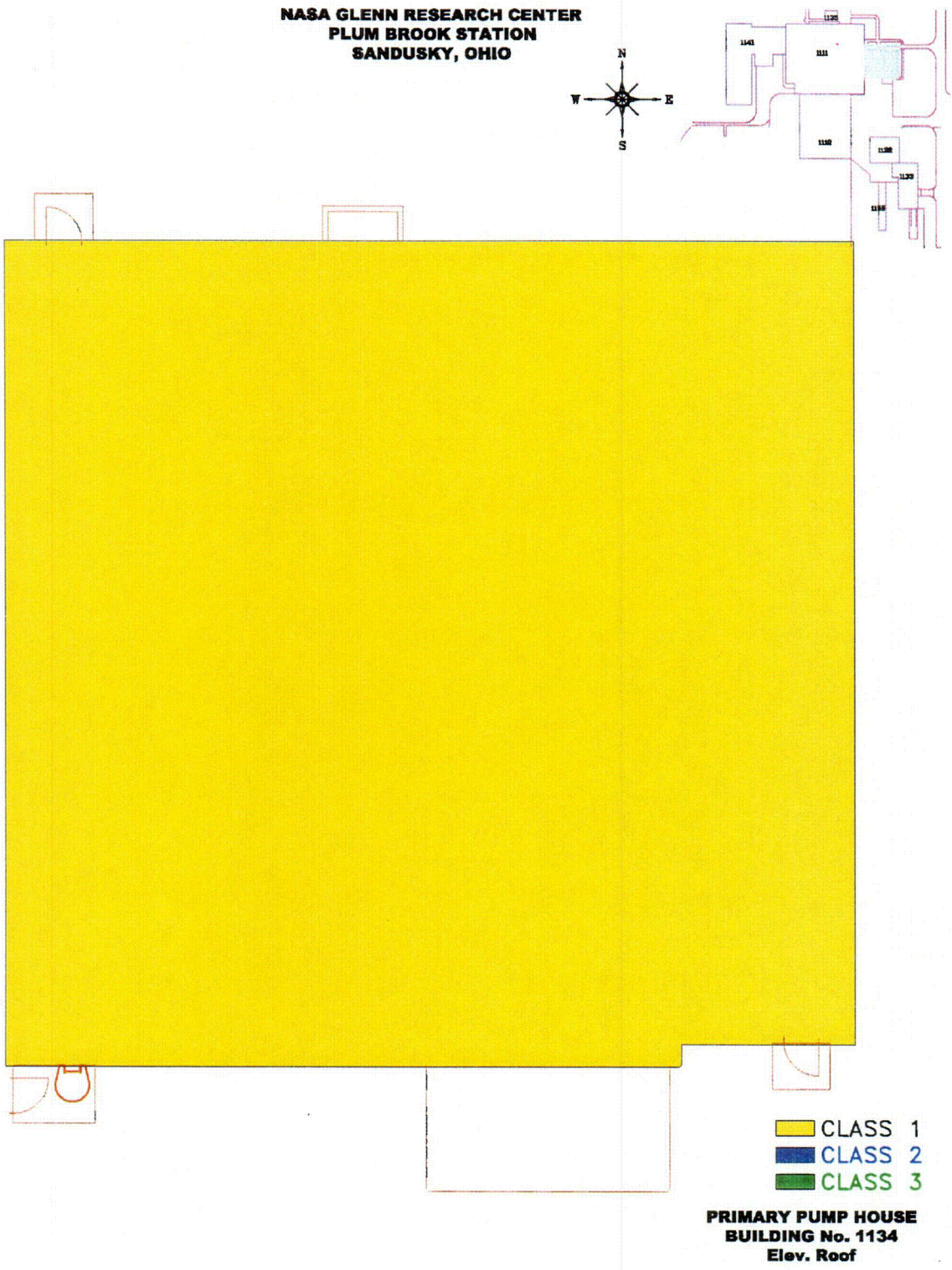


Figure D-24 – Primary Pump House Roof Elevation

C33

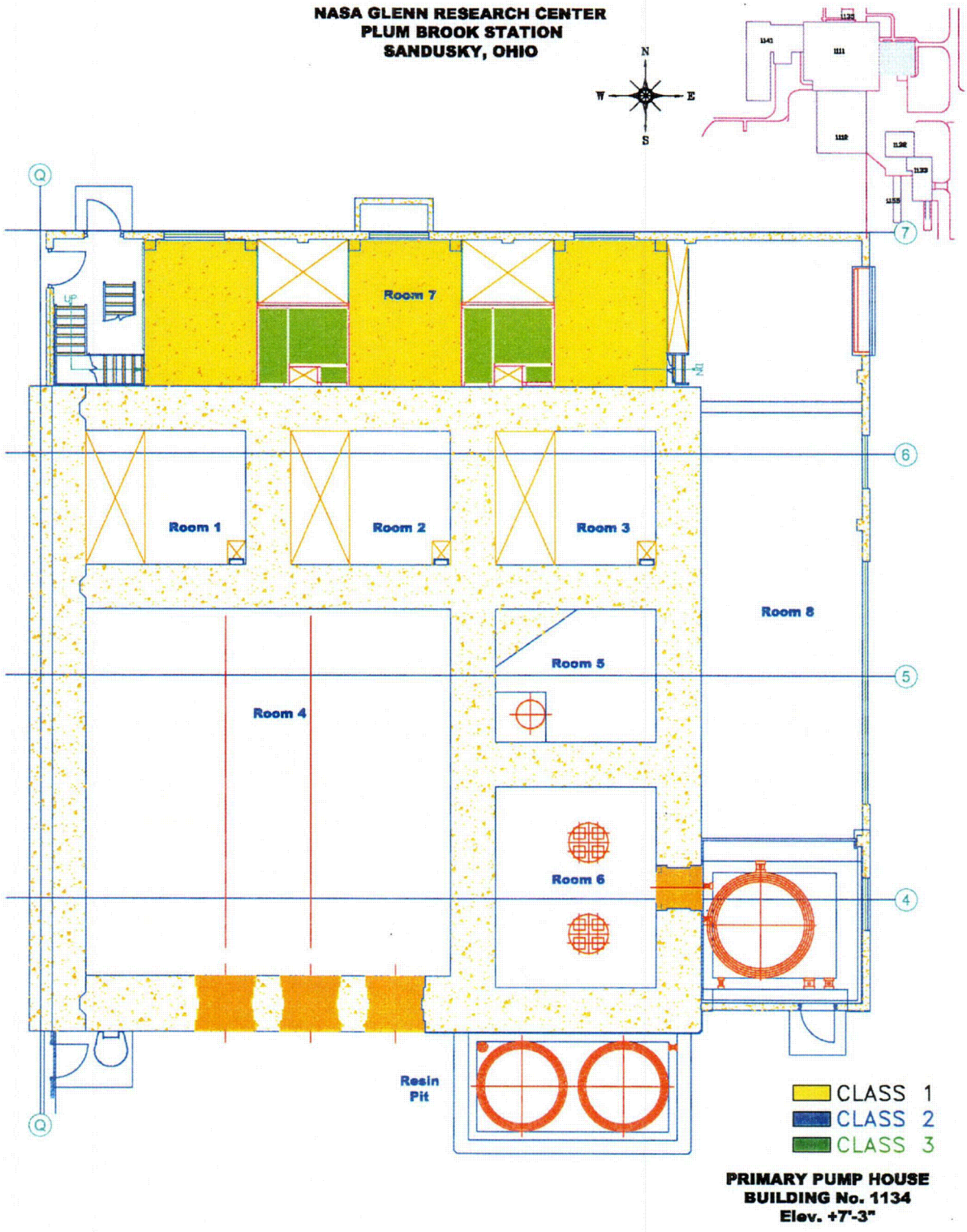


Figure D-25 – Primary Pump House +7'-3" Elevation

C34

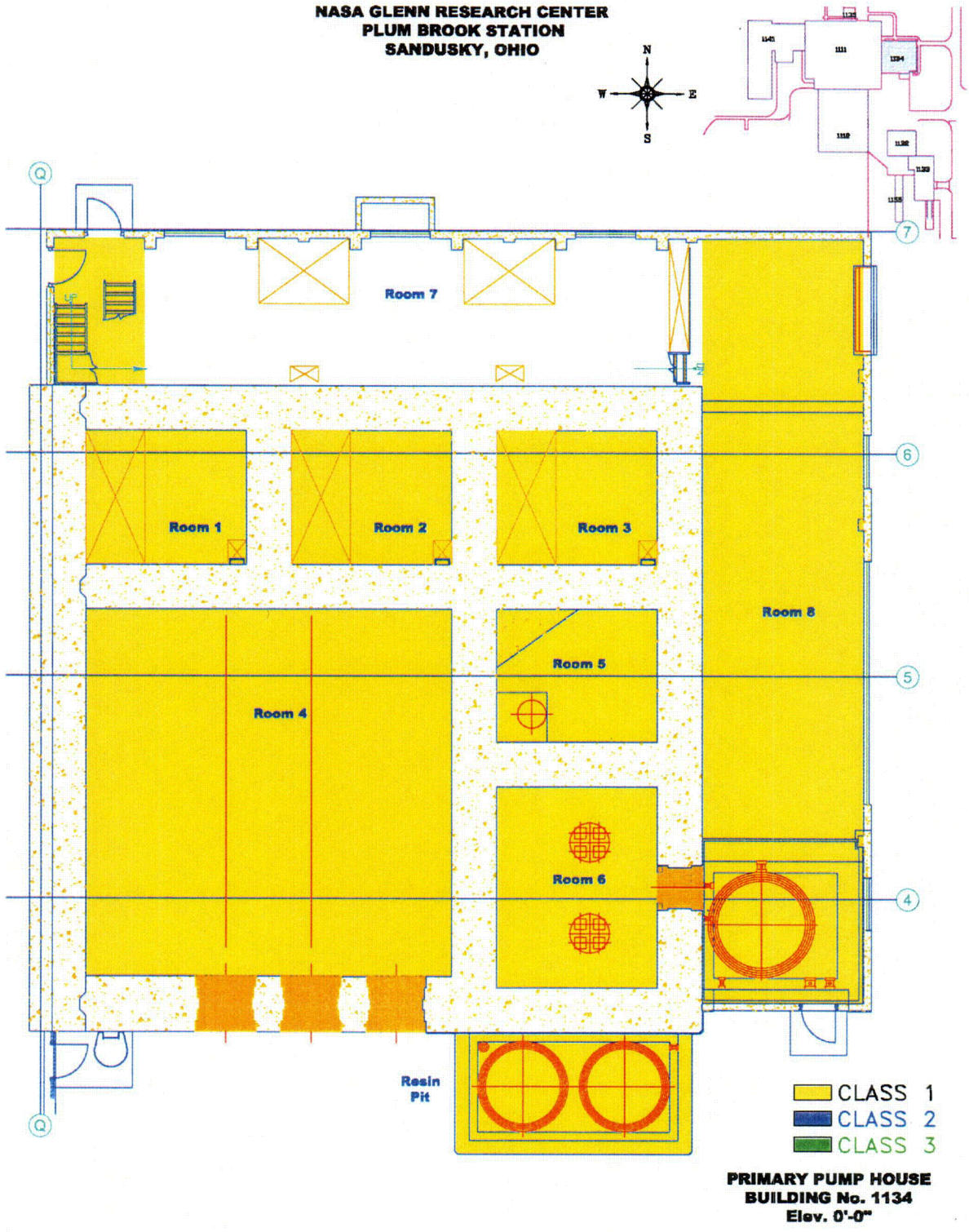


Figure D-26 – Primary Pump House 0'-0" Elevation

C35

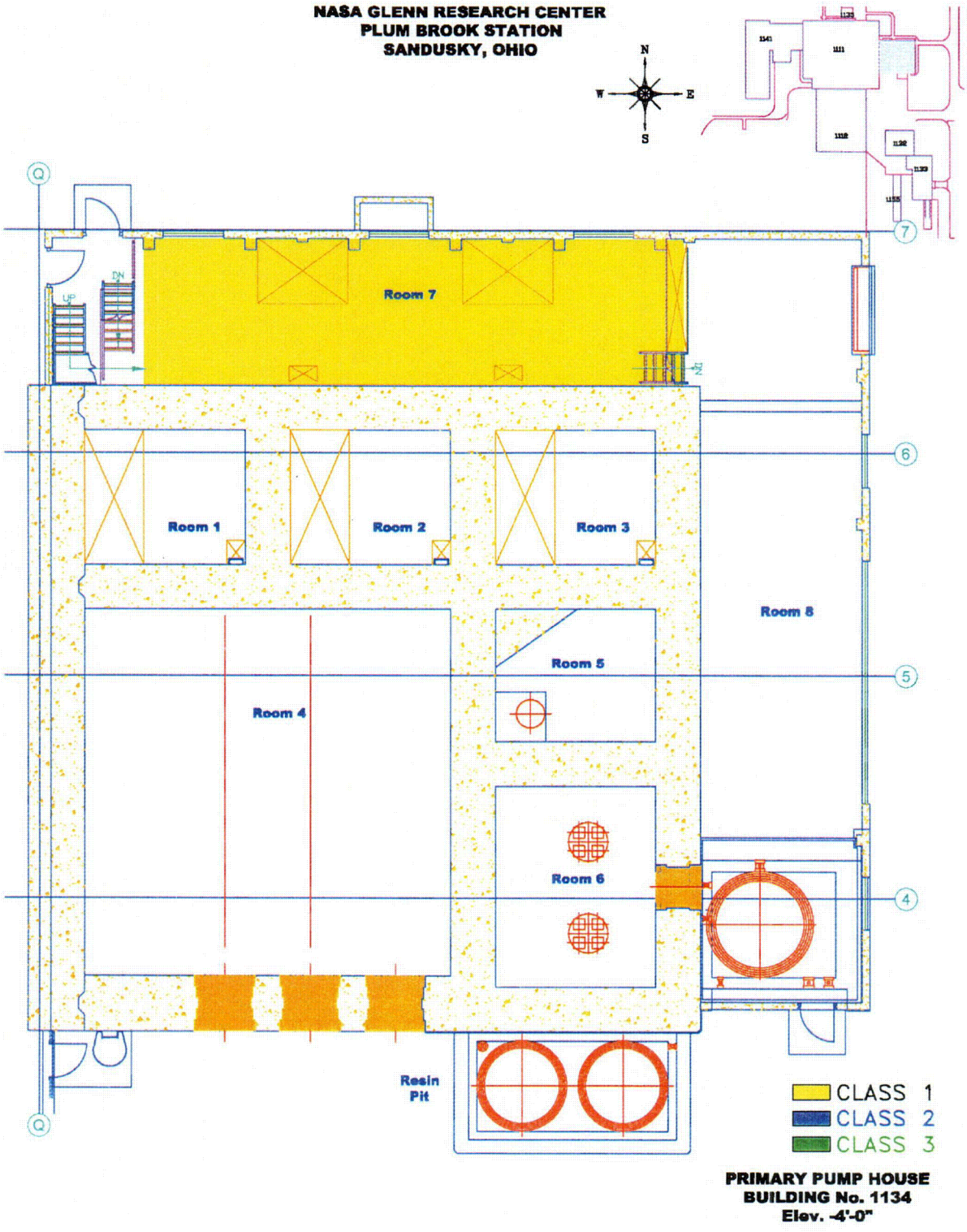


Figure D-27 – Primary Pump House -4'-0" Elevation

C36

C37

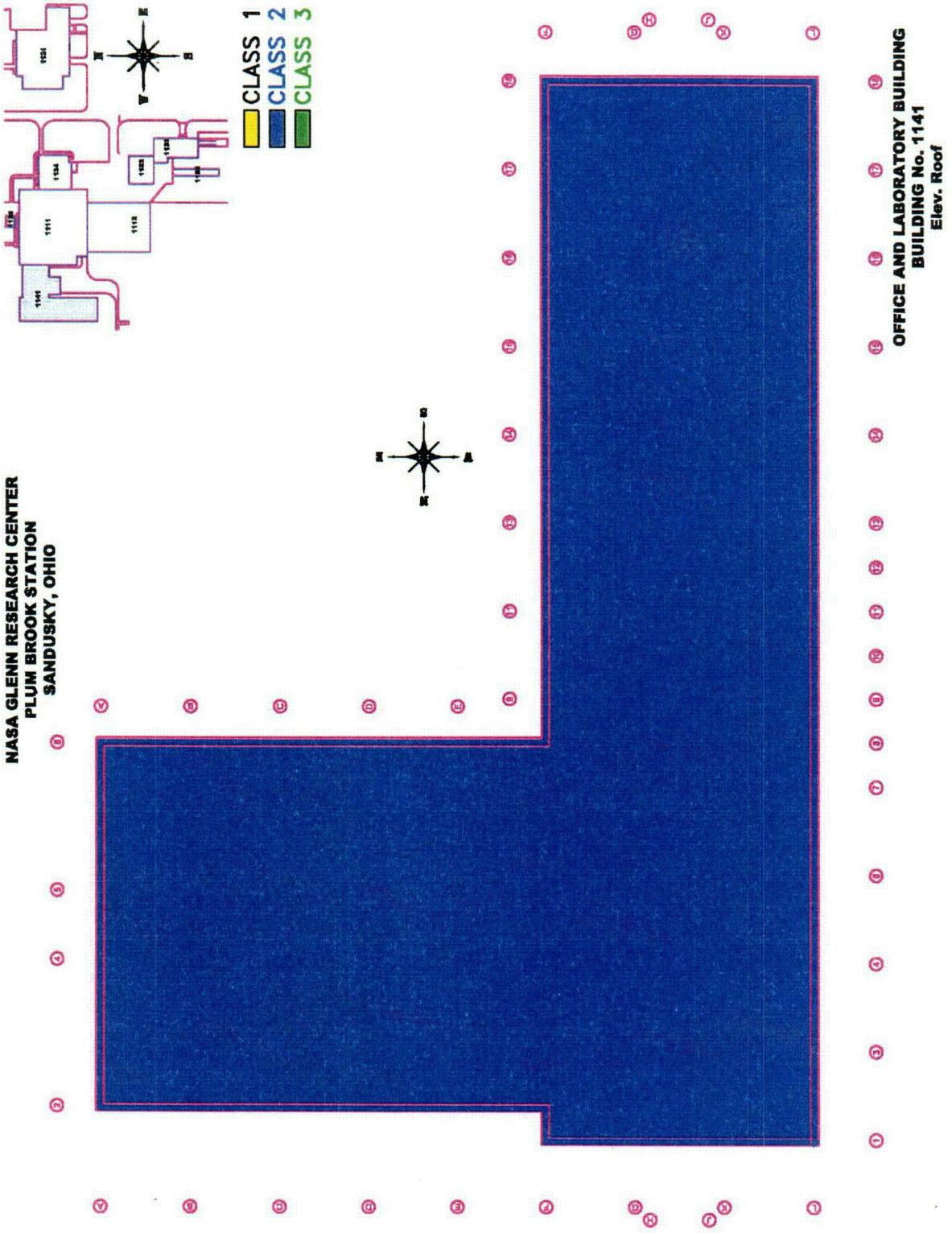


Figure D-28 – Reactor Office and Laboratory Building Roof Elevation

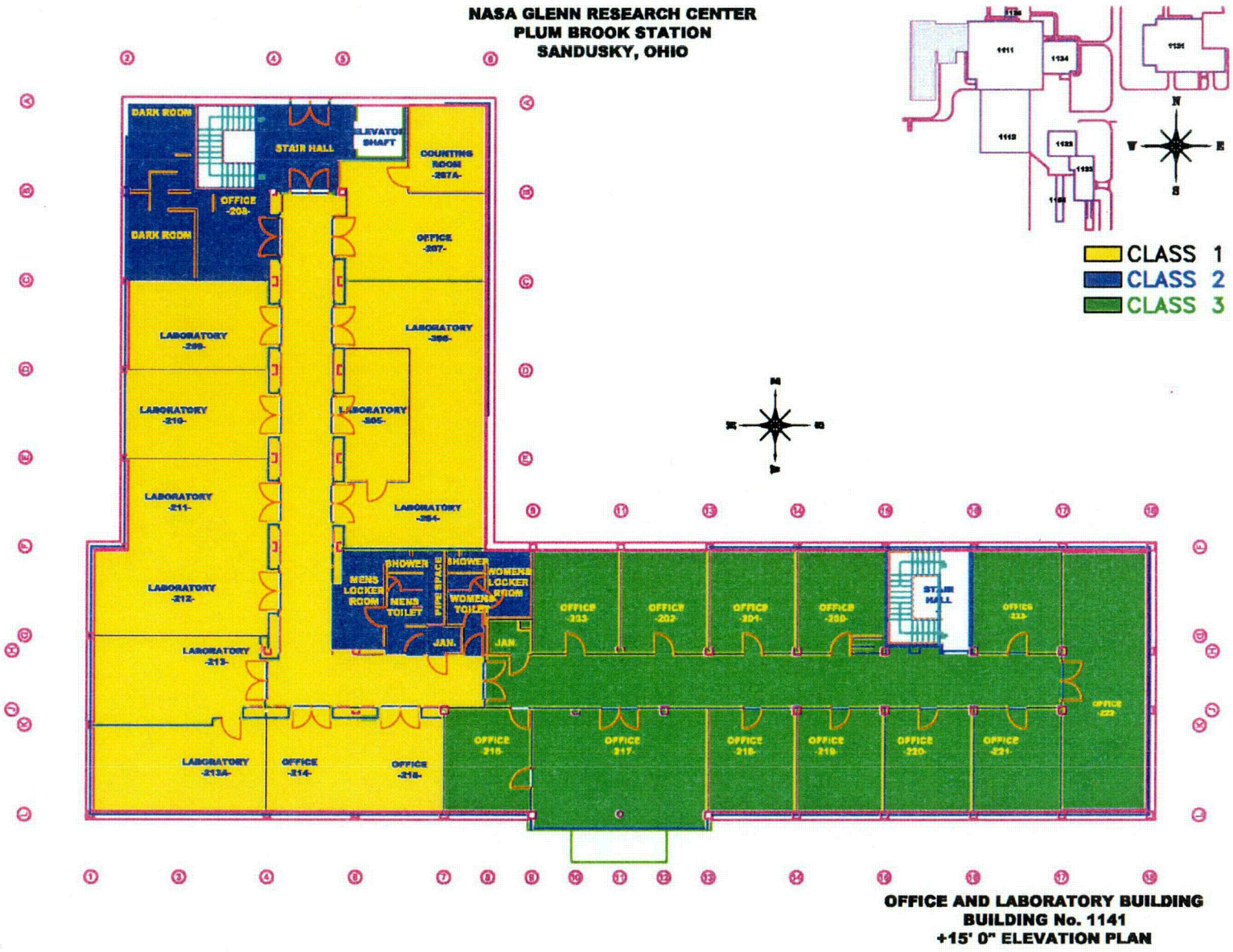


Figure D-29 – Reactor Office and Laboratory Building 2nd Floor Elevation

C38

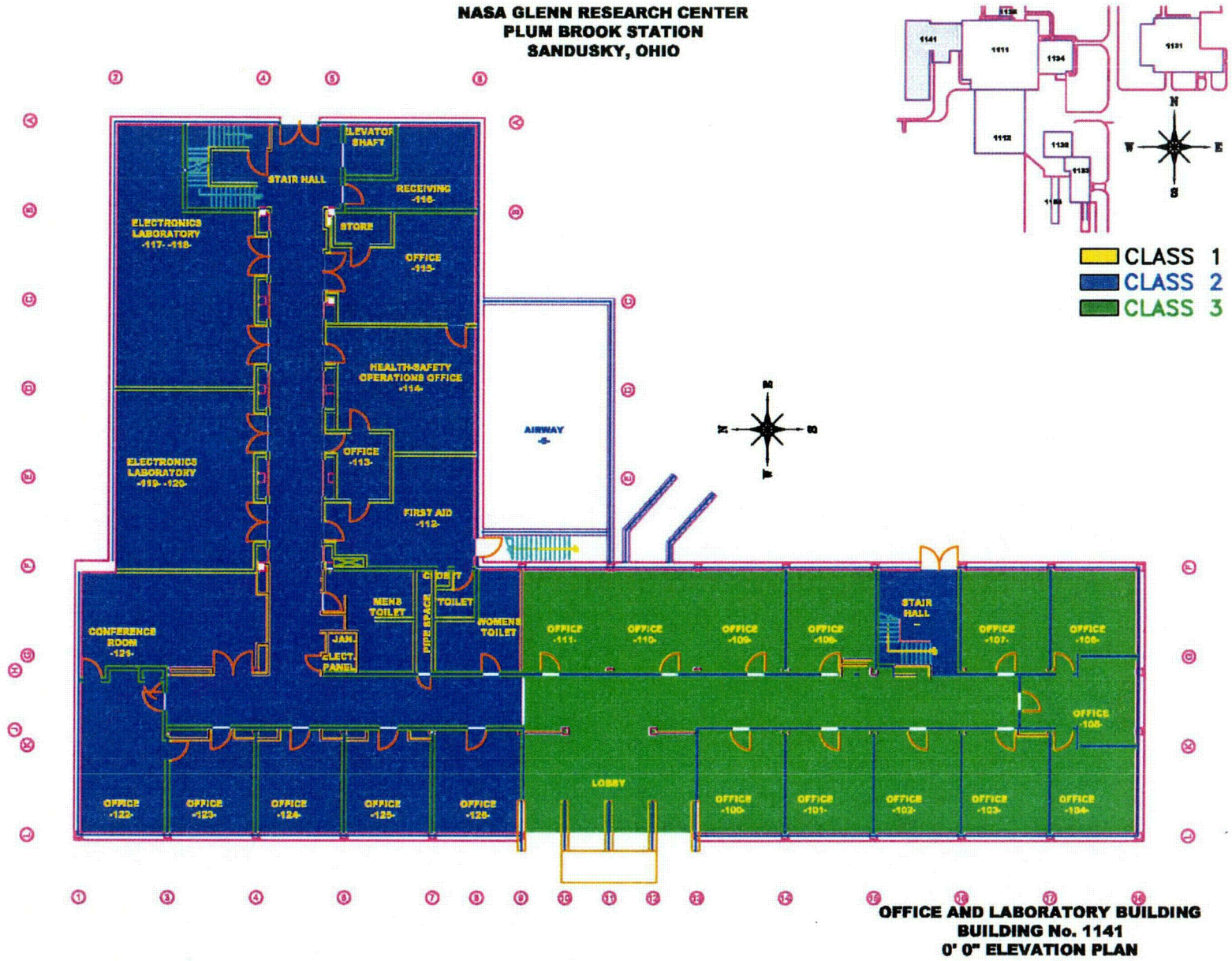


Figure D-30 – Reactor Office and Laboratory Building 1st Floor Elevation

C39

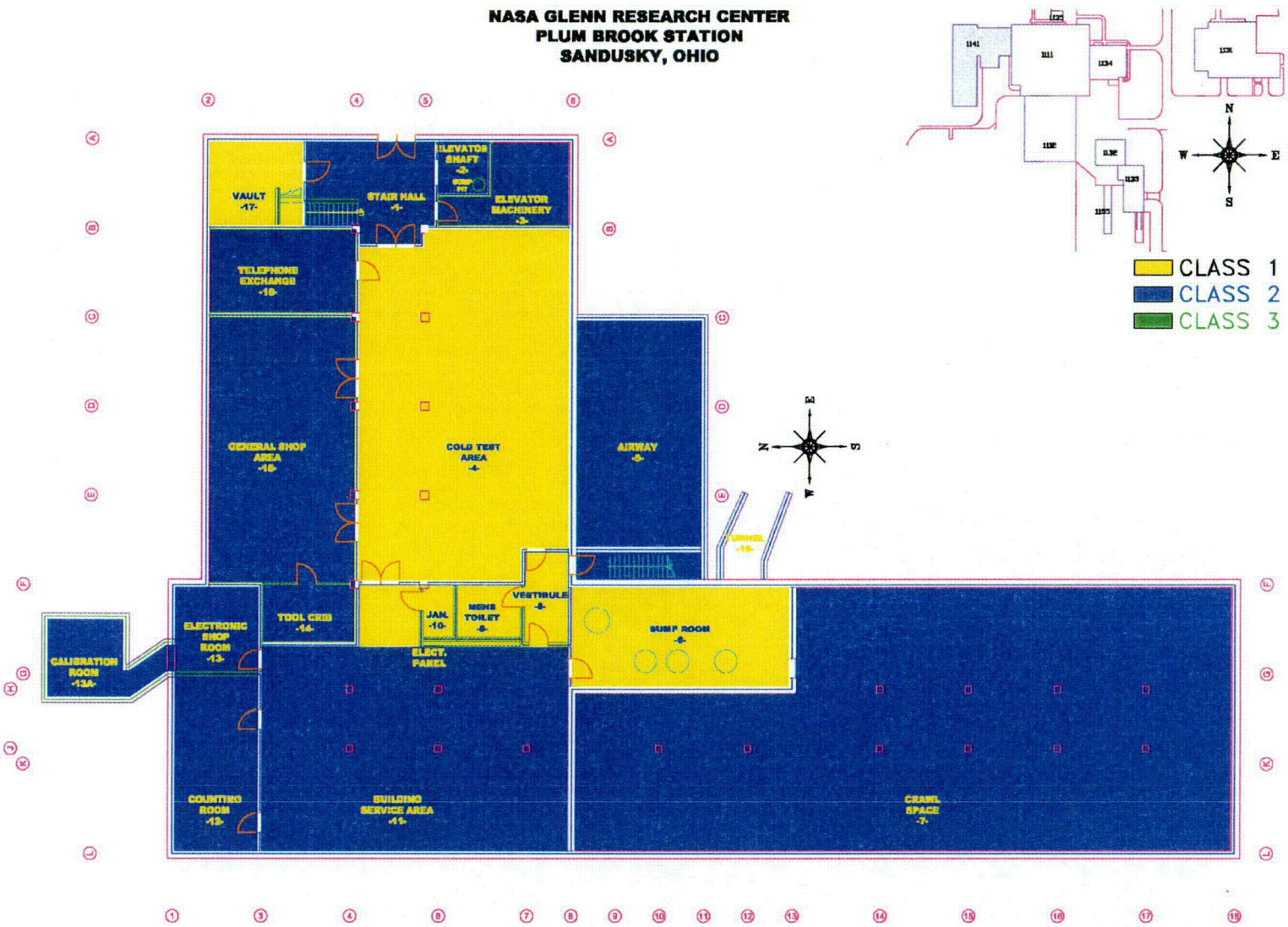
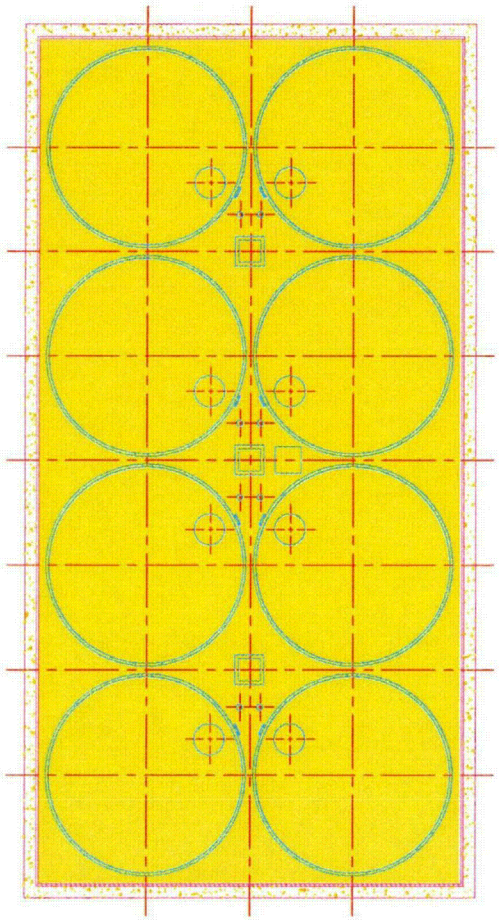
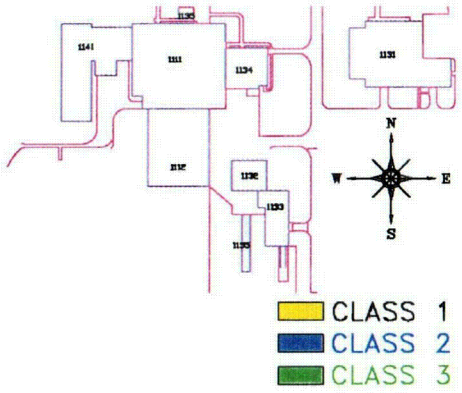


Figure D-31 – Reactor Office and Laboratory Building Basement Elevation

C40

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SANDUSKY, OHIO





HOT RETENTION TANKS
BUILDING No. 1155
Elev. @ -25'-0"

Figure D-32 – Hot Retention Area

C41

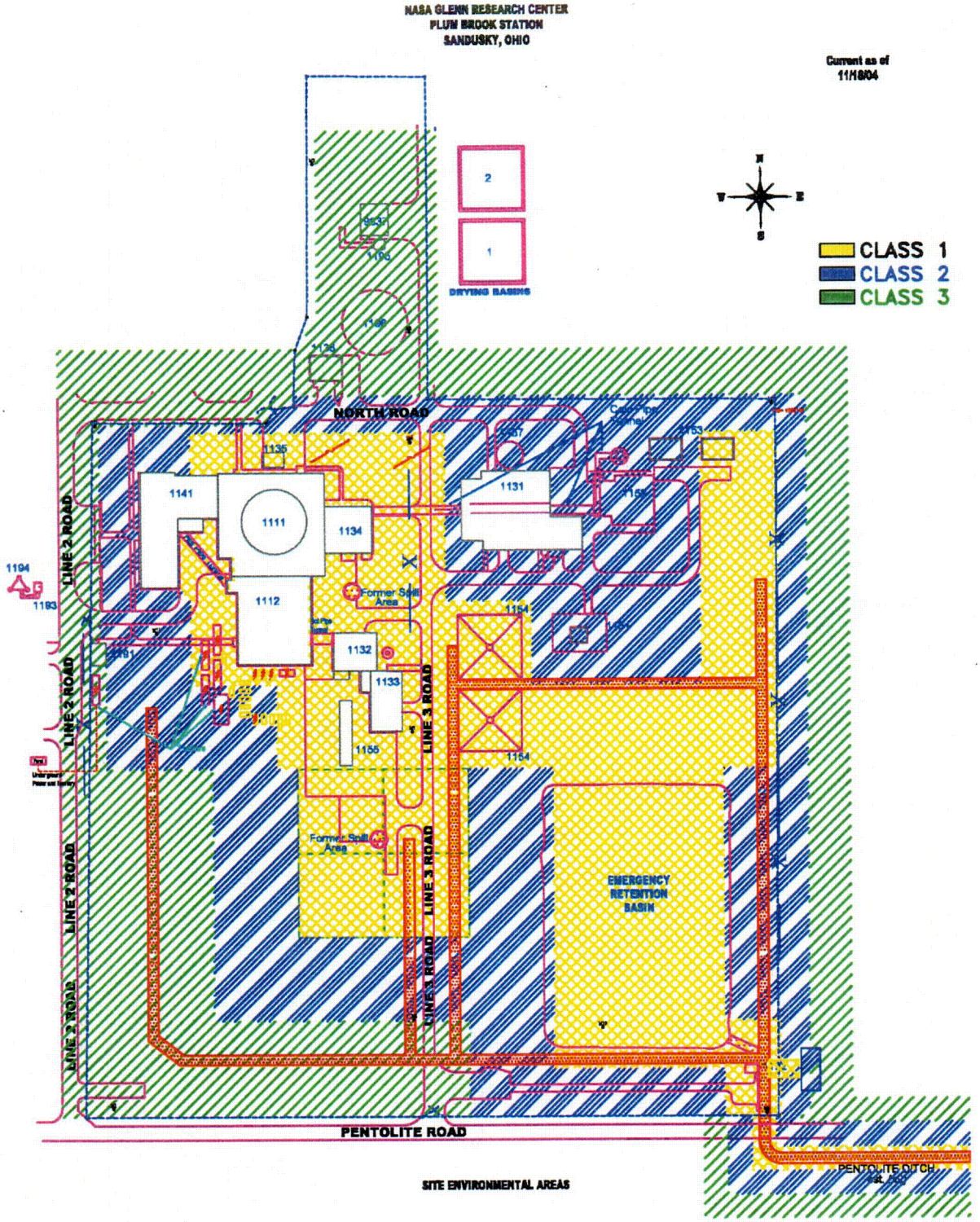


Figure D-33 – PBRF Environmental Areas

C42