ENGINEERING DATA TRANSMITTAL

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MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters

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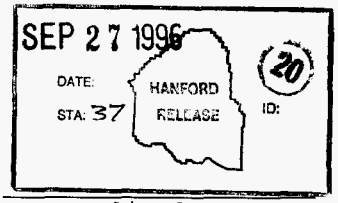

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1.0 MICROSHIELD[1] Dose Rate Calculations for HEPA Filters and Prefilters

One of the tank ventilation system accident scenarios identified in the FSAR is a filter blowout. In order to determine the accident consequences for filter blowout events, it is necessary to know the radioactive loading of the filters as a function of the filter contact dose rate. This calcnote documents the filter dose calculations which will be used in the Tank Farms FSAR. The calculations were done using the MICROSHIELD Version 4 computer code (Grove 1992). The BREMCALC computer code (Rittman 1992) was used to determine the bremsstrahlung radiation source term for the important beta emitters (^{90}Sr and ^{90}Y) as described in Section 1.1.

There are several HEPA filter and prefilter arrangements in the tank farms ventilation systems. The SX Tank Farm ventilation system consists of 3 x 3 arrays of 2 x 2 x 1 ft (0.61 x 0.61 x 0.3 m) filters in series. The passively ventilated SSTs contain either single 1 x 1 x 1 ft (0.3 x 0.3 x 0.3 m) or single 2 x 2 x 1 ft (0.61 x 0.61 x 0.3 m) breather filters in series. The DST ventilation system contains single 2 x 2 x 1 ft (0.61 x 0.61 x 0.61 m) filters in series. The DCRTs contain single 1 x 1 x 1 ft (0.3 x 0.3 x 0.3 m) filters in series. Each of the ventilation systems also contain prefilters, with the exception of the passively ventilated SSTs. The prefilters have the same cross sectional dimensions as the HEPA filters in the direction of airflow, however, the depth of the prefilters are 2.5 in (6.4 cm) versus 1 ft (0.3 m) for the HEPA filters.

Section 1.1 documents the contact dose rate calculation for a 3 x 3 array of 2 x 2 x 1 ft (0.61 x 0.61 x 0.3 m) filters loaded with 1 curie of radioactivity that originated from SST solid waste. Section 1.2 documents the contact dose rate calculation for a single 1 x 1 x 1 ft (0.3 x 0.3 x 0.3 m) breather filter loaded with 1 curie of SST solid waste. Section 1.3 documents the contact dose rate calculation for a single 2 x 2 x 2 ft (0.61 x 0.61 x 0.61 m) breather filter loaded with 1 curie of SST solid waste. Section 1.4 documents the contact dose rate calculation for a single 2 x 2 x 2 ft (0.61 x 0.61 x 0.61 m) filter loaded with 1 curie of DST liquid waste. Section 1.5 documents the contact dose rate calculation for a single 1 x 1 x 1 ft (0.3 x 0.3 x 0.3 m) DCRT filter loaded with 1 curie of SST liquid waste.

Section 1.6 documents the contact dose rate calculation for a 3 x 3 array of 2 ft x 2 ft x 2.5 in (0.61 x 0.61 x 0.064 m) prefilters loaded with 1 curie of SST solid waste. Section 1.7 documents the contact dose rate calculation for a single 2 ft x 2 ft x 2.5 in (0.61 x 0.61 x 0.064 m) prefilter loaded with 1 curie of DST liquid waste. Section 1.8 documents the contact dose rate calculation for a single 1 ft x 1 ft x 2.5 in (0.3 x 0.3 x 0.064 m) prefilter loaded with 1 curie of SST liquid waste.

The following assumptions were made for this analysis:

1) The waste material is assumed to be homogeneously distributed throughout the filter volume.

[1] MICROSHIELD is a registered trademark of Grove Engineering, Inc.

2) Contact dose rates correspond to the detector locations indicated on Figure 1 (page 8).

3) For the SX Tank Farm 3 by 3 filter configuration, a simplified geometry was used. The 9 filters which make up a 3 x 3 filter bank were modeled as a single rectangular parallelpiped with a height of 1.83 m (6 ft), a width of 1.83 m (6 ft), and a depth of 0.3 m (1 ft). From geometric considerations, on the average, gamma rays pass through about 5 thicknesses of the aluminum frame, or a total of 1.016 cm (0.4 in = 5 x 0.08 in) of aluminum (see Section 1.1).

4) The MICROSHIELD runs only included the radionuclides with major contributions to the dose rates. This decision was based on the waste type loaded on the HEPA filter (e.g. , SST Liquids, SST Solids, DST Liquids, etc.) and the radionuclide concentrations associated with that waste type (see Table 1).

1.1 SX Tank Farm Dose Rate Calculation for 3 x 3 HEPA Filter Arrangement (2 x 2 x 1 Filter)

The HEPA filters in the actively ventilated SSTs are 0.61 m (2 ft) long, by 0.61 m (2 ft) wide, and 0.3 m (1 ft) deep in the direction of airflow. The filter consists of a corrugated filter media of borosilicate glass microfibers with aluminum separators attached to the pleats. The filter media is housed in a 0.2 cm (0.08 in) thick aluminum frame. A filter bank in the SST ventilation system consists of an array of 3 x 3 filters. The following describes the MICROSHIELD model developed for a single filter.

The borosilicate glass microfibers have an areal density of about 9.7E-03 g/cm^2 (2.0E-02 lb/ft^2). The borosilicate glass material is distributed over an area of about 23.2 m^2 (250 ft^2), which results in about 2.27 kg (5 lb) of borosilicate glass microfibers on each filter. If this material is assumed to be homogeneously distributed throughout the entire filter volume, the density of borosilicate glass is 0.02 g/cc, as shown below.

$$\text{Density of Borosilicate Glass} = \frac{5 \text{ lb} \times 454 \text{ g/lb}}{(2\text{x}2\text{x}1) \text{ ft}^3 \times 28230 \text{ cc/ft}^3} = 0.02 \text{ g/cc}$$

The areal density of the corrugated aluminum separators is about 1.17E-02 g/cm^2 (2.39E-02 lb/ft^2). The total area of the aluminum separators is 29.8 m^2 (321 ft^2), which results in about 3.48 kg (7.66 lb) of aluminum on each filter. If this material is assumed to be homogeneously distributed throughout the entire filter volume, the density of aluminum is 0.03 g/cc, as shown below.

$$\text{Density of Aluminum} = \frac{7.66 \text{ lb} \times 454 \text{ g/lb}}{(2\text{x}2\text{x}1) \text{ ft}^3 \times 28230 \text{ cc/ft}^3} = 0.03 \text{ g/cc}$$

The following describes the simplified model developed for the 3 x 3 filter bank arrangement.

The 9 filters which make up a 3 x 3 filter bank were modeled as a single rectangular parallelpiped with a height of 1.83 m (6 ft), a width of 1.83 m (6 ft), and a depth of 0.3 m (1 ft). The radioactive source was assumed to be uniformly distributed throughout the entire volume (6 x 6 x 1 ft^3). From geometric considerations, on the average, gamma rays pass through about 5 thicknesses of the aluminum frame, or a total of 1.016 cm (0.4 in = 5 x 0.08 in) of aluminum. The "contact" dose rate was assumed to be measured at a location 1 ft from the bottom of the filter bank, 0.15 m (0.5 ft) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter. Figure 1 illustrates this location, which was identified by the requestor as the location where contact readings are made for a 3 x 3 filter configuration.

Two MICROSHIELD runs were made because the source term consisted of gamma emitters along with beta emitters which result in the production of bremsstrahlung radiation. The first run was made to calculate the dose contribution from ^{137m}Ba and ^{154}Eu, which are the major gamma emitters in the source term. The second run was made to calculate the dose contribution from bremsstrahlung radiation produced during the decay of $^{90}Sr/^{90}Y$. The second run was necessary because MICROSHIELD does not generate the bremsstrahlung source term internally. Therefore, the BREMCALC computer code was used to generate the bremsstrahlung source term which was then fed into MICROSHIELD to estimate the dose rate. Note that other beta and gamma emitters are present in the source term, however, the 3 radionuclides above are the major dose contributors.

The filter was assumed to be loaded with a total of 1 Ci of SST Solids, which has maximum sample activity concentrations of 1.0E+11 Bq/L of ^{137}Cs, 5.8E+09 Bq/L of ^{154}Eu, and 1.6E+12 Bq/L each of ^{90}Sr and ^{90}Y (see Table 1). The activity concentrations in Table 1 were taken from Van Keuren (1996). As mentioned above, other beta and gamma emitters present in the SST Solids composite have negligible dose contributions and were not included in the model. One curie of SST Solids would therefore contain about 0.4840 Ci each of ^{90}Sr and ^{90}Y, 0.0303 Ci of ^{137}Cs, and 0.0017 Ci of ^{154}Eu. Note that these numbers were slightly adjusted so that the sum for the mixture totalled 1 Ci.

The resulting contact dose rate from MICROSHIELD was 0.224 mSv/hr (22.4 mR/hr) from ^{137}Cs and ^{154}Eu, and 0.033 mSv/hr (3.3 mR/hr) from ^{90}Sr and ^{90}Y, or a total of 0.257 mSv/hr (25.7 mR/hr) per Ci of SST Solid waste accumulated on the 3 x 3 filter bank. These calculations assume the filters are uniformly loaded, which introduces some uncertainty in the results because the dose rate at the side of the filters is sensitive to the distribution of radioactive material on the filters contained in the 3 x 3 array. However, this was considered an acceptable approach and within the uncertainty of the overall calculations. The photon fluence-to-dose conversion factors used were the anterior-to-posterior irradiation pattern as outlined in ANSI standard

ANSI/ANS-6.1.1-1991 (ANS 1991). The ISO-PC input deck is included in Attachment 1. The MICROSHIELD output is included in the Appendix.

Note that although the filter media consists of borosilicate glass microfibers and aluminum separators, for simplicity the bremsstrahlung photon production rate used was for ^{90}Sr and ^{90}Y in water. This was done because the bremsstrahlung photon production rate for 1 Ci of ^{90}Sr and ^{90}Y in water was readily available (Savino 1995). The ISO-PC computer code (Rittman 1995) contains a model to approximate the bremsstrahlung radiation source term for a mixture. Using ISO-PC, the photon production rate from bremsstrahlung radiation was found to be slightly higher in the filter media than it was in water for 1 Ci of ^{90}Sr and ^{90}Y. Note that the dose contribution from ^{90}Sr and ^{90}Y is only 13% of the total, and since the end use of these dose rates is to back-calculate the activity on the filter given a contact dose rate, it is conservative to underestimate the bremsstrahlung contribution to the total dose. That is, the amount of material accumulated on the filter for a given contact dose rate will actually be lower than that predicted using the value calculated above (25.7 mR/hr/Ci). The photon production rate from BREMCALC is shown in Table 2 for 0.484 Ci of ^{90}Sr and ^{90}Y.

1.2 Single Breather Filter Dose Rate Calculation for Passively Ventilated SSTs (1 x 1 x 1 ft Filter)

Some of the HEPA filters in the passively ventilated SSTs are 0.3 m (1 ft) long, by 0.3 m (1 ft) wide, and 0.3 m (1 ft) deep in the direction of airflow. Calculations for a single breather filter loaded with 1 Ci of SST solids were performed similarly to those in Section 1.1. In this case the model geometry consisted of a 0.3 x 0.3 x 0.3 m (1 x 1 x 1 ft) filter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.15 m (0.5 ft) from the bottom of the filter bank, 0.15 m (0.5 ft) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter. Figure 1 illustrates this location for a single filter.

Once again, two MICROSHIELD runs were made because the source term consisted of gamma emitters and beta emitters which result in the production of bremsstrahlung radiation. The first run was made to calculate the dose contribution from ^{137m}Ba and ^{154}Eu, which are the major gamma emitters, and the second run was made to calculate the dose contribution from bremsstrahlung radiation produced during the decay of $^{90}Sr/^{90}Y$. The activities are the same as that described in Section 1.1. The photon production rate from BREMCALC is also the same as that described in Section 1.1 (see Table 2).

The resulting contact dose rate from MICROSHIELD was 4.05 mSv/hr (405 mR/hr) from ^{137}Cs and ^{154}Eu, and 0.694 mSv/hr (69.4 mR/hr) from ^{90}Sr and ^{90}Y, or a total of 4.75 mSv/hr (475 mR/hr) per Ci of SST Solid waste accumulated on the filter. The MICROSHIELD output is included in the Appendix.

1.3 Single Breather Filter Dose Rate Calculation for Passively Ventilated SSTs (2 x 2 x 1 ft Filter)

Some of the HEPA filters in the passively ventilated SSTs are 0.6 x 0.6 x 0.3 m (2 x 2 x 1 ft). Calculations for a single filter loaded with 1 Ci of SST solids were performed similarly to those in Section 1.1. In this case the model geometry consisted of a 0.61 x 0.61 x 0.3 m (2 x 2 x 1 ft) filter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.3 m (1 ft) from the bottom of the filter bank, 0.15 m (0.5 ft) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

Once again, two MICROSHIELD runs were made because the source term consisted of gamma emitters and beta emitters which result in the production of bremsstrahlung radiation. The activities are the same as that described in Section 1.1. The photon production rate from BREMCALC is also the same as that described in Section 1.1 (see Table 2).

The resulting contact dose rate from MICROSHIELD was 1.51 mSv/hr (151 mR/hr) from ^{137}Cs and ^{154}Eu, and 0.253 mSv/hr (25.3 mR/hr) from ^{90}Sr and ^{90}Y, or a total of 1.77 mSv/hr (177 mR/hr) per Ci of SST Solid waste accumulated on the filter. The MICROSHIELD output is included in the Appendix.

1.4 Dose Rate Calculation for DST Single (2 x 2 x 1 ft) Filter

A similar calculation was performed for a single filter loaded with 1 Ci of DST liquids. The model geometry consisted of a 0.61 x 0.61 x 0.3 m (2 x 2 x 1 ft) filter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.3 m (1 ft) from the bottom of the filter bank, 0.15 m (0.5 ft) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

By examining the maximum sample activity concentrations for DST liquids (see Table 1) it is evident that only ^{137}Cs needs to be accounted for because of the high activity concentration of ^{137}Cs relative to other gamma emitters. ^{90}Sr and ^{90}Y are in low enough concentrations that their contribution to the total dose is negligible. The source activity was then taken to be 1 Ci of ^{137}Cs which was distributed uniformly throughout the filter volume.

The resulting contact dose rate from MICROSHIELD was 44.7 mSv/hr (4,470 mR/hr). The MICROSHIELD output is included in the Appendix.

1.5 Single (1 x 1 x 1 ft) DCRT Filter Dose Rate Calculation

The DCRT filters are 0.3 m (1 ft) long, by 0.3 m (1 ft) wide, and 0.3 m (1 ft) deep in the direction of airflow. Calculations for a single filter loaded with 1 Ci of SST liquids were performed similarly to those above. The model geometry consisted of a 0.3 x 0.3 x 0.3 m (1 x 1 x 1 ft) filter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.15 m (0.5 ft) from the bottom of the filter bank, 0.15 m (0.5 ft)

from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

By examining the maximum sample activity concentrations for SST Liquids (see Table 1) it is evident that only ^{137}Cs and ^{154}Eu need to be accounted for because of the higher activity concentrations of these two nuclides relative to other gamma emitters. ^{90}Sr and ^{90}Y are in low enough concentrations that their contribution to the total dose is negligible. One curie of SST Liquids would therefore contain about 0.9016 Ci of ^{137}Cs and 0.0984 Ci of ^{154}Eu.

The resulting contact dose rate from MICROSHIELD was 130 mSv/hr (1.3 x 10^4 mR/hr). The MICROSHIELD output is included in the Appendix.

1.6 SX Tank Farm Dose Rate Calculation for 3 x 3 Prefilter Arrangement (2 ft x 2 ft x 2.5 in filter)

The prefilters in the actively ventilated SSTs are 0.61 m (2 ft) long, by 0.61 m (2 ft) wide, and 0.064 m (2.5 in) deep in the direction of airflow. The filter is similar to a common home furnace filter with light-weighted strands of fibrous material. The prefilters will be modeled using the same material constituents as that which was used for the HEPA filters. This is conservative since the prefilters actually have less shielding than the HEPA filters. This results in lower predicted dose rates for the prefilters, which results in a greater amount of radioactive material being predicted to have accumulated on the filter before a certain dose rate is reached.

A filter bank in the SST ventilation system consists of an array of 3 x 3 filters. The dose rate was assumed to be measured at a location 1 ft from the bottom of the filter bank, 0.032 m (1.25 in) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

Once again, two MICROSHIELD runs were made because the source term consisted of gamma emitters and beta emitters which result in the production of bremsstrahlung radiation. The activities are the same as that described in Section 1.1. The photon production rate from BREMCALC is also the same as that described in Section 1.1 (see Table 2).

The resulting contact dose rate from MICROSHIELD was 0.296 mSv/hr (29.6 mR/hr) from ^{137}Cs and ^{154}Eu, and 0.045 mSv/hr (4.5 mR/hr) from ^{90}Sr and ^{90}Y, or a total of 0.34 mSv/hr (34 mR/hr) per Ci of SST Solid waste accumulated on the filter. The MICROSHIELD output is included in the Appendix.

1.7 Dose Rate Calculation - Single DST (2 ft x 2 ft x 2.5 in) Prefilter

A similar calculation was performed for a single prefilter loaded with 1 Ci of DST liquids. The model geometry consisted of a 0.61 x 0.61 x 0.064 m (2 ft x 2 ft x 2.5 in) prefilter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.3 m (1 ft) from the bottom of the

filter bank, 0.064 m (1.25 in) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

By examining the maximum sample activity concentrations for DST liquids (see Table 1) it is evident that only ^{137}Cs needs to be accounted for because of the high activity concentration of ^{137}Cs relative to other gamma emitters. ^{90}Sr and ^{90}Y are in low enough concentrations that their contribution to the total dose is negligible. The source activity was then taken to be 1 Ci of ^{137}Cs which was distributed uniformly throughout the filter volume.

The resulting contact dose rate from MICROSHIELD was 61.0 mSv/hr (6.1 x 10^3 mR/hr). The MICROSHIELD output is included in the Appendix.

1.8 Single (1 ft x 1 ft x 2.5 in) DCRT Prefilter Dose Rate Calculation

The DCRT prefilters are 0.3 m (1 ft) long, by 0.3 m (1 ft) wide, and 0.064 m (2.5 in) deep in the direction of airflow. Calculations for a single prefilter loaded with 1 Ci of SST liquids were performed similarly to those above. The model geometry consisted of a 0.3 x 0.3 x 0.064 m (1 ft x 1 ft x 2.5 in) prefilter with a 0.2 cm (0.08 in) thick aluminum shield. Dose rates were calculated at a location 0.15 m (0.5 ft) from the bottom of the filter bank, 0.032 m (1.25 in) from the face of the filter in the direction of airflow, and 1.3 cm (0.5 in) off of the side of the filter.

By examining the maximum sample activity concentrations for SST liquids (see Table 1) it is evident that only ^{137}Cs and ^{154}Eu need to be accounted for because of the higher activity concentrations of these two nuclides relative to other gamma emitters. ^{90}Sr and ^{90}Y are in low enough concentrations that their contribution to the total dose is negligible. One curie of SST Liquids would therefore contain about 0.9016 Ci of ^{137}Cs and 0.0984 Ci of ^{154}Eu.

The resulting contact dose rate from MICROSHIELD was 2.2 x 10^2 mSv/hr (2.2 x 10^4 mR/hr). The MICROSHIELD output is included in the Appendix.

2.0 References

ANS, 1991, *Neutron and Gamma-Ray Fluence-to-Dose Factors*, ANSI/ANS-6.1.1-1991, American Nuclear Society, La Grange Park, Illinois.

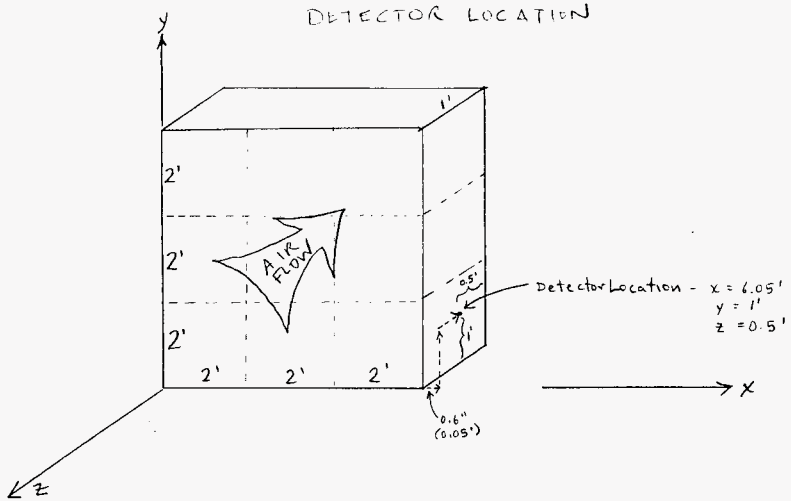
Grove 1992, *MICROSHIELD Version 4*, Grove Engineering, Inc. 15125 Shady Grove Road, Rockville, Maryland.

Rittman, P. D., 1992, *BREMCALC - A Computer Program for Calculating Electron and Positron Bremsstrahlung*, WHC-SA-1435-FP, Westinghouse Hanford Company, Richland, Washington.

Van Keuren, 1996, *Tank Waste Compositions and Atmospheric Dispersion Coefficients*, WHC-SD-WM-SARR-016 Rev. 2, Westinghouse Hanford Company, Richland, Washington.

FIGURE 1

3 x 3 FILTER CONFIGURATION
DETECTOR LOCATION



SINGLE FILTER
DETECTOR LOCATION

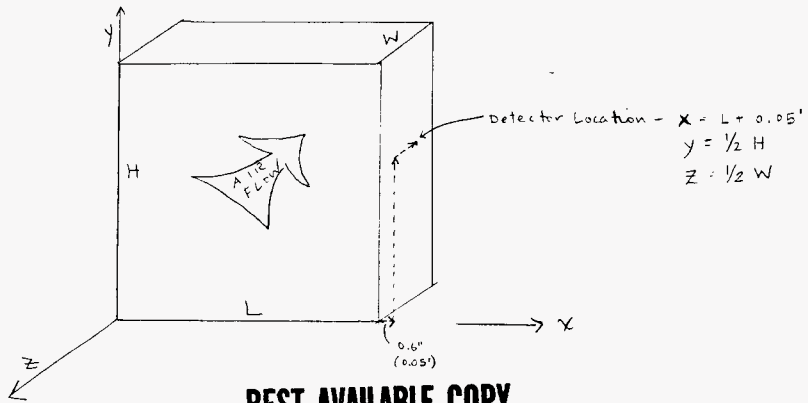


Table 1 - Tank Waste Maximum Sample Activity Concentrations[a]

ISOTOPE	Activity Concentrations, Bq/L			
	SST LIQUID	SST SOLID	DST LIQUID	DST SOLID
C 14	1.0E+05	1.2E+05	2.3E+05	1.6E+05
CO60	9.5E+06	4.2E+08	7.0E+06	1.5E+07
SE79	0.0E+00	1.7E+04	0.0E+00	0.0E+00
SR90	1.1E+10	1.6E+12	4.6E+09	5.2E+10
Y 90	1.1E+10	1.6E+12	4.6E+09	5.2E+10
TC99	1.7E+07	1.2E+10	1.1E+07	6.2E+07
RU106	9.9E+02	7.2E+04	0.0E+00	0.0E+00
SB125	3.4E+04	1.8E+08	0.0E+00	0.0E+00
I 129	1.0E+04	6.4E+06	2.0E+04	2.0E+04
CS134	1.2E+05	1.4E+06	6.1E+06	9.4E+06
CS137	2.2E+10	1.0E+11	5.9E+10	5.9E+10
CE144	9.1E+00	3.4E+02	0.0E+00	0.0E+00
PM147	0.0E+00	0.0E+00	3.6E+07	0.0E+00
EU154	2.4E+09	5.8E+09	4.2E+07	3.0E+08
EU155	5.9E+07	5.0E+06	0.0E+00	0.0E+00
NP237	0.0E+00	3.0E+07	2.3E+05	8.1E+05
PU238	9.2E+04	1.9E+08	1.8E+06	7.2E+07
PU239[b]	3.6E+07	4.4E+08	7.7E+06	1.6E+09
PU241	2.6E+08	3.2E+09	1.8E+07	3.8E+09
AM241	4.2E+07	2.3E+08	3.4E+07	2.7E+09
CM242	0.0E+00	0.0E+00	1.1E+01	0.0E+00
CM244	4.2E+05	2.3E+06	1.2E+05	1.6E+07
TOTALS	4.6E+10	3.4E+12	6.8E+10	1.7E+11

[a] From Van Keuren (1996).

[b] Includes ^{240}Pu.

Table 2 - Bremsstrahlung Photon Production Rates from ^{90}Sr and ^{90}Y in Water

Midpoint Energy, MeV	Photon Production Rates, photon/s	
	1 Ci of $^{90}Sr/^{90}Y$[a]	0.484 Ci of $^{90}Sr/^{90}Y$
0.015	7.8E+08	3.8E+08
0.025	4.0E+08	1.9E+08
0.035	2.6E+08	1.2E+08
0.045	1.8E+08	8.8E+07
0.055	1.4E+08	6.7E+07
0.065	1.1E+08	5.3E+07
0.075	8.9E+07	4.3E+07
0.085	7.4E+07	3.6E+07
0.095	6.3E+07	3.0E+07
0.150	3.3E+08	1.6E+08
0.250	1.3E+08	6.4E+07
0.350	6.9E+07	3.3E+07
0.475	5.5E+07	2.7E+07
0.650	3.5E+07	1.7E+07
0.825	1.4E+07	6.6E+06
1.000	9.8E+06	4.8E+06
1.225	5.5E+06	2.7E+06
1.475	2.1E+06	1.0E+06
1.700	5.3E+05	2.6E+05
1.900	1.4E+05	6.6E+04
2.100	1.5E+04	7.2E+03
2.300	8.3E+01	4.0E+01

1 Ci = 3.7 E+10 Bq

[a] From Savino (1995).

Appendix

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 3X3CSEU.MS4
Run Date: May 13, 1996
Run Time: 2:11 p.m. Monday
Duration: 0:00:50

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

Case Title: 3x3 HEPA - Simplified Model - 0.0303 Ci Cs/ 0.0017 Ci Eu154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	184.404	6.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	182.88	6.0	.0
Shield 1:	1.016	0.0	.4
Air Gap:	0.508	0.0	.2

Source Volume: 1.01941e+6 cm^3 36. cu ft. 62208 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	20
Y Direction	20
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	2.8660e-002	2.8114e-002	Eu-154	1.7000e-003	1.6676e-003

Page : 2
DOS File: 3X3CSEU.MS4
Run Date: May 13, 1996
Run Time: 2:11 p.m. Monday
Title : 3x3 HEPA - Simplified Model - 0.0303 Ci Cs/ 0.0017 Ci Eu154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1231	2.545e+007	2.169e+001	5.812e+001	3.406e-002	9.128e-002
0.246	4.296e+006	9.008e+000	1.900e+001	1.657e-002	3.496e-002
0.4426	5.850e+005	2.553e+000	4.393e+000	5.000e-003	8.602e-003
0.5907	3.920e+006	2.442e+001	3.832e+001	4.772e-002	7.486e-002
0.6628	9.715e+008	6.969e+003	1.058e+004	1.351e+001	2.050e+001
0.8723	8.825e+006	8.844e+001	1.253e+002	1.664e-001	2.358e-001
1.0024	1.788e+007	2.120e+002	2.914e+002	3.906e-001	5.369e-001
1.2719	2.328e+007	3.673e+002	4.810e+002	6.444e-001	8.440e-001
1.5767	2.217e+006	4.512e+001	5.693e+001	7.488e-002	9.449e-002
TOTAL:	1.058e+009	7.740e+003	1.165e+004	1.489e+001	2.242e+001

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 3X3SRY.MS4
Run Date: May 13, 1996
Run Time: 2:18 p.m. Monday
Duration: 0:02:04

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

Case Title: 3x3 HEPA - Simplified Model - 0.484 Ci Sr/Y

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	184.404	6.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	182.88	6.0	.0
Shield 1:	1.016	0.0	.4
Air Gap:	0.508	0.0	.2

Source Volume: 1.01941e+6 cm^3 36. cu ft. 62208 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	20
Y Direction	20
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
USER INPUT SOURCE TERM					

Page : 2
DOS File: 3X3SRY.MS4
Run Date: May 13, 1996
Run Time: 2:18 p.m. Monday
Title : 3x3 HEPA - Simplified Model - 0.484 Ci Sr/Y

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.790e+008	3.452e-011	3.803e-011	2.961e-012	3.262e-012
0.025	1.930e+008	3.502e-002	4.585e-002	6.040e-004	7.909e-004
0.035	1.240e+008	1.938e+000	3.164e+000	1.228e-002	2.005e-002
0.045	8.810e+007	7.021e+000	1.414e+001	2.335e-002	4.702e-002
0.055	6.680e+007	1.176e+001	2.785e+001	2.647e-002	6.269e-002
0.065	5.280e+007	1.480e+001	3.933e+001	2.687e-002	7.140e-002
0.075	4.310e+007	1.652e+001	4.560e+001	2.693e-002	7.432e-002
0.085	3.590e+007	1.736e+001	4.835e+001	2.697e-002	7.510e-002
0.095	3.040e+007	1.768e+001	4.929e+001	2.706e-002	7.544e-002
0.15	1.610e+008	1.791e+002	4.521e+002	2.949e-001	7.444e-001
0.25	6.390e+007	1.368e+002	2.868e+002	2.524e-001	5.291e-001
0.35	3.330e+007	1.086e+002	2.020e+002	2.095e-001	3.896e-001
0.475	2.660e+007	1.267e+002	2.130e+002	2.486e-001	4.179e-001
0.65	1.710e+007	1.198e+002	1.828e+002	2.325e-001	3.548e-001
0.825	6.580e+006	6.163e+001	8.847e+001	1.168e-001	1.677e-001
1.0	4.750e+006	5.615e+001	7.722e+001	1.035e-001	1.423e-001
1.225	2.680e+006	4.043e+001	5.333e+001	7.156e-002	9.440e-002
1.475	9.970e+005	1.876e+001	2.393e+001	3.170e-002	4.044e-002
1.7	2.580e+005	5.735e+000	7.155e+000	9.316e-003	1.162e-002
1.9	6.580e+004	1.665e+000	2.044e+000	2.616e-003	3.211e-003
2.1	7.210e+003	2.048e-001	2.479e-001	3.119e-004	3.775e-004
2.3	3.990e+001	1.259e-003	1.504e-003	1.861e-006	2.225e-006
TOTAL:	1.330e+009	9.427e+002	1.817e+003	1.744e+000	3.323e+000

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1 File Ref: _____
DOS File: 1X1BRSR.MS4 Date: __/__/__
Run Date: May 13, 1996 By: _____
Run Time: 2:20 p.m. Monday Checked: _____
Duration: 0:00:34

Case Title: 1 x 1 ft Breather Filter - 0.484 Ci Sr/Y90

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	32.004	1.0	.6
Dose point coordinate Y:	15.24	0.0	6.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	30.48	1.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 28316.8 cm^3 1 cu ft. 1728. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
USER INPUT SOURCE TERM					

Page : 2
DOS File: 1X1BRSR.MS4
Run Date: May 13, 1996
Run Time: 2:20 p.m. Monday
Title : 1 x 1 ft Breather Filter - 0.484 Ci Sr/Y90

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.790e+008	4.201e-001	4.483e-001	3.603e-002	3.845e-002
0.025	1.930e+008	1.457e+002	1.724e+002	2.514e+000	2.974e+000
0.035	1.240e+008	4.699e+002	6.282e+002	2.977e+000	3.980e+000
0.045	8.810e+007	6.472e+002	8.917e+002	2.152e+000	2.966e+000
0.055	6.680e+007	7.103e+002	1.032e+003	1.599e+000	2.324e+000
0.065	5.280e+007	7.207e+002	1.092e+003	1.308e+000	1.982e+000
0.075	4.310e+007	7.108e+002	1.046e+003	1.158e+000	1.705e+000
0.085	3.590e+007	6.905e+002	9.891e+002	1.073e+000	1.536e+000
0.095	3.040e+007	6.664e+002	9.383e+002	1.020e+000	1.436e+000
0.15	1.610e+008	5.859e+003	7.668e+003	9.648e+000	1.263e+001
0.25	6.390e+007	4.021e+003	4.894e+003	7.418e+000	9.030e+000
0.35	3.330e+007	2.997e+003	3.510e+003	5.780e+000	6.770e+000
0.475	2.660e+007	3.308e+003	3.762e+003	6.491e+000	7.381e+000
0.65	1.710e+007	2.962e+003	3.279e+003	5.750e+000	6.365e+000
0.825	6.580e+006	1.465e+003	1.596e+003	2.776e+000	3.024e+000
1.0	4.750e+006	1.294e+003	1.394e+003	2.385e+000	2.570e+000
1.225	2.680e+006	9.031e+002	9.628e+002	1.598e+000	1.704e+000
1.475	9.970e+005	4.078e+002	4.312e+002	6.893e-001	7.288e-001
1.7	2.580e+005	1.223e+002	1.286e+002	1.987e-001	2.090e-001
1.9	6.580e+004	3.502e+001	3.668e+001	5.502e-002	5.763e-002
2.1	7.210e+003	4.256e+000	4.443e+000	6.482e-003	6.765e-003
2.3	3.990e+001	2.588e-002	2.693e-002	3.827e-005	3.983e-005
TOTAL:	1.330e+009	2.814e+004	3.446e+004	5.663e+001	6.941e+001

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 1X1BRCS.MS4
Run Date: May 13, 1996
Run Time: 2:24 p.m. Monday
Duration: 0:00:14

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

Case Title: 1 x 1 ft Breather Filter - 0.0303 Ci Cs-137/0.0017 Ci Eu154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	32.004	1.0	.6
Dose point coordinate Y:	15.24	0.0	6.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	30.48	1.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 28316.8 cm^3 1 cu ft. 1728. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	2.8664e-002	1.0123e+000	Eu-154	1.7000e-003	6.0035e-002

Page : 2
DOS File: 1X1BRCS.MS4
Run Date: May 13, 1996
Run Time: 2:24 p.m. Monday
Title : 1 x 1 ft Breather Filter - 0.0303 Ci Cs-137/0.0017 Ci Eu154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0537	1.187e+008	1.214e+003	1.744e+003	2.841e+000	4.079e+000
0.246	4.296e+006	2.656e+002	3.240e+002	4.887e-001	5.961e-001
0.4426	5.850e+005	6.751e+001	7.728e+001	1.322e-001	1.513e-001
0.5907	3.920e+006	6.139e+002	6.847e+002	1.199e+000	1.338e+000
0.6628	9.717e+008	1.718e+005	1.899e+005	3.330e+002	3.681e+002
0.8723	8.825e+006	2.083e+003	2.261e+003	3.920e+000	4.255e+000
1.0024	1.788e+007	4.884e+003	5.261e+003	8.998e+000	9.693e+000
1.2719	2.328e+007	8.158e+003	8.682e+003	1.431e+001	1.523e+001
1.5767	2.217e+006	9.721e+002	1.025e+003	1.613e+000	1.701e+000
TOTAL:	1.151e+009	1.900e+005	2.099e+005	3.665e+002	4.051e+002

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 2X2BRSR.MS4
Run Date: May 13, 1996
Run Time: 2:27 p.m. Monday
Duration: 0:00:35

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

Case Title: 2 x 2 ft Breather Filter - 0.484 Ci Sr/Y90

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	62.484	2.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3

USER INPUT SOURCE TERM

Page : 2
DOS File: 2X2BRSR.MS4
Run Date: May 13, 1996
Run Time: 2:27 p.m. Monday
Title : 2 x 2 ft Breather Filter - 0.484 Ci Sr/Y90

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.790e+008	4.690e-002	5.027e-002	4.023e-003	4.312e-003
0.025	1.930e+008	3.510e+001	4.195e+001	6.053e-001	7.236e-001
0.035	1.240e+008	1.397e+002	1.914e+002	8.850e-001	1.212e+000
0.045	8.810e+007	2.091e+002	3.033e+002	6.953e-001	1.009e+000
0.055	6.680e+007	2.381e+002	3.708e+002	5.359e-001	8.346e-001
0.065	5.280e+007	2.462e+002	4.067e+002	4.469e-001	7.383e-001
0.075	4.310e+007	2.455e+002	3.960e+002	4.001e-001	6.454e-001
0.085	3.590e+007	2.401e+002	3.766e+002	3.730e-001	5.851e-001
0.095	3.040e+007	2.328e+002	3.585e+002	3.563e-001	5.487e-001
0.15	1.610e+008	2.073e+003	2.923e+003	3.414e+000	4.814e+000
0.25	6.390e+007	1.437e+003	1.848e+003	2.651e+000	3.410e+000
0.35	3.330e+007	1.077e+003	1.319e+003	2.078e+000	2.545e+000
0.475	2.660e+007	1.195e+003	1.409e+003	2.345e+000	2.765e+000
0.65	1.710e+007	1.075e+003	1.225e+003	2.087e+000	2.378e+000
0.825	6.580e+006	5.336e+002	5.956e+002	1.011e+000	1.129e+000
1.0	4.750e+006	4.727e+002	5.202e+002	8.713e-001	9.590e-001
1.225	2.680e+006	3.308e+002	3.592e+002	5.854e-001	6.358e-001
1.475	9.970e+005	1.497e+002	1.609e+002	2.531e-001	2.719e-001
1.7	2.580e+005	4.499e+001	4.799e+001	7.307e-002	7.796e-002
1.9	6.580e+004	1.289e+001	1.368e+001	2.026e-002	2.150e-002
2.1	7.210e+003	1.569e+000	1.658e+000	2.389e-003	2.524e-003
2.3	3.990e+001	9.546e-003	1.005e-002	1.412e-005	1.486e-005
TOTAL:	1.330e+009	9.990e+003	1.287e+004	1.969e+001	2.531e+001

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 2X2BRCS.MS4
Run Date: May 13, 1996
Run Time: 2:28 p.m. Monday
Duration: 0:00:14

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

Case Title: 2 x 2 ft Breather Filter - 0.0303 Ci Cs-137/0.0017 Ci Eu154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet	and inches
Dose point coordinate X:	62.484	2.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	2.8664e-002	2.5306e-001	Eu-154	1.7000e-003	1.5009e-002

Page : 2
DOS File: 2X2BRCS.MS4
Run Date: May 13, 1996
Run Time: 2:28 p.m. Monday
Title : 2 x 2 ft Breather Filter - 0.0303 Ci Cs-137/0.0017 Ci Eu154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0537	1.187e+008	4.057e+002	6.227e+002	9.492e-001	1.457e+000
0.246	4.296e+006	9.489e+001	1.224e+002	1.746e-001	2.252e-001
0.4426	5.850e+005	2.436e+001	2.898e+001	4.770e-002	5.674e-002
0.5907	3.920e+006	2.225e+002	2.560e+002	4.347e-001	5.002e-001
0.6628	9.717e+008	6.238e+004	7.095e+004	1.209e+002	1.375e+002
0.8723	8.825e+006	7.594e+002	8.441e+002	1.429e+000	1.588e+000
1.0024	1.788e+007	1.784e+003	1.963e+003	3.287e+000	3.617e+000
1.2719	2.328e+007	2.989e+003	3.239e+003	5.245e+000	5.683e+000
1.5767	2.217e+006	3.572e+002	3.824e+002	5.927e-001	6.346e-001
TOTAL:	1.151e+009	6.902e+004	7.841e+004	1.331e+002	1.513e+002

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 2X2DST.MS4
Run Date: May 13, 1996
Run Time: 2:48 p.m. Monday
Duration: 0:00:08

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

Case Title: DST HEPA Filter - Single 2 x 2 ft Filter - 1 Ci Cs-137

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	62.484	2.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 113267. cm^3 4 cu ft. 6912. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	9.4594e-001	8.3514e+000	Cs-137	9.9994e-001	8.8281e+000

Page : 2
DOS File: 2X2DST.MS4
Run Date: May 13, 1996
Run Time: 2:48 p.m. Monday
Title : DST HEPA Filter - Single 2 x 2 ft Filter - 1 Ci Cs-137

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0318	7.246e+008	5.512e+002	7.228e+002	4.591e+000	6.021e+000
0.0322	1.337e+009	1.072e+003	1.413e+003	8.628e+000	1.137e+001
0.0364	4.865e+008	6.310e+002	8.791e+002	3.585e+000	4.994e+000
0.6616	3.149e+010	2.018e+006	2.296e+006	3.912e+003	4.450e+003
TOTAL:	3.404e+010	2.020e+006	2.299e+006	3.929e+003	4.473e+003

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1 File Ref: _____
DOS File: 1X1DCRT.MS4 Date: __/__/__
Run Date: June 3, 1996 By: _____
Run Time: 9:51 a.m. Monday Checked: _____
Duration: 0:00:14

Case Title: DCRT HEPA Filter - 1 x 1 ft - 0.9016 Cs-137/0.0984 Ci Eu-154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	32.004	1.0	.6
Dose point coordinate Y:	15.24	0.0	6.0
Dose point coordinate Z:	15.24	0.0	6.0
Rectangular volume width :	30.48	1.0	.0
Rectangular volume length:	30.48	1.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 28316.8 cm^3 1 cu ft. 1728. cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	8.5290e-001	3.0120e+001	Eu-154	9.8400e-002	3.4750e+000

Page : 2
DOS File: 1X1DCRT.MS4
Run Date: June 3, 1996
Run Time: 9:51 a.m. Monday
Title : DCRT HEPA Filter - 1 x 1 ft - 0.9016 Cs-137/0.0984 Ci Eu-154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0684	4.046e+009	5.925e+004	8.911e+004	1.027e+002	1.545e+002
0.246	2.486e+008	1.538e+004	1.876e+004	2.829e+001	3.451e+001
0.4426	3.386e+007	3.908e+003	4.473e+003	7.653e+000	8.760e+000
0.5907	2.269e+008	3.553e+004	3.963e+004	6.942e+001	7.742e+001
0.6638	2.940e+010	5.207e+006	5.755e+006	1.009e+004	1.115e+004
0.8723	5.108e+008	1.206e+005	1.309e+005	2.269e+002	2.463e+002
1.0024	1.035e+009	2.827e+005	3.045e+005	5.208e+002	5.611e+002
1.2719	1.347e+009	4.722e+005	5.025e+005	8.285e+002	8.817e+002
1.5767	1.283e+008	5.627e+004	5.933e+004	9.338e+001	9.847e+001
TOTAL:	3.698e+010	6.252e+006	6.904e+006	1.197e+004	1.322e+004

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: PREFSRY.MS4
Run Date: May 22, 1996
Run Time: 10:26 a.m. Wednesday
Duration: 0:02:04

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

Case Title: 3x3 Prefilter - Simplified Model - 0.484 Ci Sr/Y

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	184.404	6.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	3.175	0.0	1.3
Rectangular volume width :	6.35	0.0	2.5
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	182.88	6.0	.0
Shield 1:	1.016	0.0	.4
Air Gap:	0.508	0.0	.2

Source Volume: 212376. cm^3 7.5 cu ft. 12960 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	20
Y Direction	20
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3

USER INPUT SOURCE TERM

Page : 2
DOS File: PREFSRY.MS4
Run Date: May 22, 1996
Run Time: 10:26 a.m. Wednesday
Title : 3x3 Prefilter - Simplified Model - 0.484 Ci Sr/Y

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	3.790e+008	1.852e-010	2.038e-010	1.588e-011	1.748e-011
0.025	1.930e+008	9.326e-002	1.213e-001	1.609e-003	2.092e-003
0.035	1.240e+008	3.771e+000	6.044e+000	2.389e-002	3.829e-002
0.045	8.810e+007	1.199e+001	2.327e+001	3.987e-002	7.738e-002
0.055	6.680e+007	1.889e+001	4.245e+001	4.252e-002	9.555e-002
0.065	5.280e+007	2.302e+001	5.756e+001	4.179e-002	1.045e-001
0.075	4.310e+007	2.521e+001	6.471e+001	4.109e-002	1.055e-001
0.085	3.590e+007	2.617e+001	6.722e+001	4.065e-002	1.044e-001
0.095	3.040e+007	2.642e+001	6.765e+001	4.044e-002	1.035e-001
0.15	1.610e+008	2.616e+002	6.031e+002	4.307e-001	9.931e-001
0.25	6.390e+007	1.962e+002	3.793e+002	3.620e-001	6.998e-001
0.35	3.330e+007	1.541e+002	2.668e+002	2.973e-001	5.146e-001
0.475	2.660e+007	1.781e+002	2.814e+002	3.495e-001	5.521e-001
0.65	1.710e+007	1.668e+002	2.416e+002	3.239e-001	4.690e-001
0.825	6.580e+006	8.527e+001	1.169e+002	1.616e-001	2.216e-001
1.0	4.750e+006	7.728e+001	1.021e+002	1.425e-001	1.881e-001
1.225	2.680e+006	5.535e+001	7.046e+001	9.796e-002	1.247e-001
1.475	9.970e+005	2.556e+001	3.159e+001	4.320e-002	5.340e-002
1.7	2.580e+005	7.789e+000	9.442e+000	1.265e-002	1.534e-002
1.9	6.580e+004	2.256e+000	2.696e+000	3.544e-003	4.236e-003
2.1	7.210e+003	2.770e-001	3.269e-001	4.217e-004	4.978e-004
2.3	3.990e+001	1.699e-003	1.983e-003	2.512e-006	2.933e-006
TOTAL:	1.330e+009	1.346e+003	2.435e+003	2.497e+000	4.468e+000

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: 3X3CSEU.MS4
Run Date: May 22, 1996
Run Time: 10:30 a.m. Wednesday
Duration: 0:00:50

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

Case Title: 3x3 Prefilter- Simplified Modl 0.0303 Ci Cs/0.0017 Ci Eu154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	184.404	6.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	3.175	0.0	1.3
Rectangular volume width :	6.35	0.0	2.5
Rectangular volume length:	182.88	6.0	.0
Rectangular volume height:	182.88	6.0	.0
Shield 1:	1.016	0.0	.4
Air Gap:	0.508	0.0	.2

Source Volume: 212376. cm^3 7.5 cu ft. 12960 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	20
Y Direction	20
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	2.8660e-002	1.3495e-001	Eu-154	1.7000e-003	8.0047e-003

Page : 2
DOS File: 3X3CSEU.MS4
Run Date: May 22, 1996
Run Time: 10:30 a.m. Wednesday
Title : 3x3 Prefilter- Simplified Modl 0.0303 Ci Cs/0.0017 Ci Eu154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1231	2.545e+007	3.194e+001	7.824e+001	5.016e-002	1.229e-001
0.246	4.296e+006	1.293e+001	2.513e+001	2.379e-002	4.624e-002
0.4426	5.850e+005	3.597e+000	5.803e+000	7.045e-003	1.136e-002
0.5907	3.920e+006	3.412e+001	5.064e+001	6.665e-002	9.893e-002
0.6628	9.715e+008	9.702e+003	1.398e+004	1.881e+001	2.710e+001
0.8723	8.825e+006	1.222e+002	1.657e+002	2.299e-001	3.117e-001
1.0024	1.788e+007	2.917e+002	3.851e+002	5.375e-001	7.095e-001
1.2719	2.328e+007	5.023e+002	6.355e+002	8.813e-001	1.115e+000
1.5767	2.217e+006	6.138e+001	7.516e+001	1.019e-001	1.247e-001
TOTAL:	1.058e+009	1.076e+004	1.540e+004	2.070e+001	2.964e+001

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1
DOS File: PREFDST.MS4
Run Date: May 22, 1996
Run Time: 9:46 a.m. Wednesday
Duration: 0:00:05

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

Case Title: DST Prefilter - 2 x 2 ft Filter - DST Liq - 1 Ci Cs-137

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	62.484	2.0	.6
Dose point coordinate Y:	30.48	1.0	.0
Dose point coordinate Z:	3.175	0.0	1.3
Rectangular volume width :	6.35	0.0	2.5
Rectangular volume length:	60.96	2.0	.0
Rectangular volume height:	60.96	2.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 23597.4 cm^3 .833333 cu ft. 1440 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	9.4594e-001	4.0087e+001	Cs-137	9.9994e-001	4.2375e+001

Page : 2
DOS File: PREFDST.MS4
Run Date: May 22, 1996
Run Time: 9:46 a.m. Wednesday
Title : DST Prefilter - 2 x 2 ft Filter - DST Liq - 1 Ci Cs-137

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0333	1.823e+009	2.871e+003	3.765e+003	2.092e+001	2.744e+001
0.6616	3.149e+010	2.825e+006	3.148e+006	5.477e+003	6.103e+003
TOTAL:	3.332e+010	2.828e+006	3.152e+006	5.498e+003	6.130e+003

MicroShield 4.00 - Serial #4.00-00386
Westinghouse Hanford Co.

Page : 1 File Ref: _____
DOS File: PREFDCRT.MS4 Date: __/__/__
Run Date: June 3, 1996 By: _____
Run Time: 9:52 a.m. Monday Checked: _____
Duration: 0:00:14

Case Title: DCRT Prefilter - 1 x 1 ft - 0.9016 Cs-137/ 0.0984 Ci Eu-154

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	32.004	1.0	.6
Dose point coordinate Y:	15.24	0.0	6.0
Dose point coordinate Z:	3.175	0.0	1.3
Rectangular volume width :	6.35	0.0	2.5
Rectangular volume length:	30.48	1.0	.0
Rectangular volume height:	30.48	1.0	.0
Shield 1:	0.2032	0.0	.1
Air Gap:	1.3208	0.0	.5

Source Volume: 5899.34 cm^3 .208333 cu ft. 360 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Aluminum	0.03	2.702	
Glass	0.02		

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES

Nuclide	curies	microCi/cm^3	Nuclide	curies	microCi/cm^3
Ba-137m	8.5290e-001	1.4458e+002	Eu-154	9.8400e-002	1.6680e+001

Page : 2
DOS File: PREFDCRT.MS4
Run Date: June 3, 1996
Run Time: 9:52 a.m. Monday
Title : DCRT Prefilter - 1 x 1 ft - 0.9016 Cs-137/ 0.0984 Ci Eu-154

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.0684	4.046e+009	1.036e+005	1.437e+005	1.795e+002	2.491e+002
0.246	2.486e+008	2.600e+004	3.041e+004	4.784e+001	5.595e+001
0.4426	3.386e+007	6.559e+003	7.295e+003	1.284e+001	1.429e+001
0.5907	2.269e+008	5.943e+004	6.476e+004	1.161e+002	1.265e+002
0.6638	2.940e+010	8.696e+006	9.409e+006	1.685e+004	1.824e+004
0.8723	5.108e+008	2.008e+005	2.142e+005	3.778e+002	4.030e+002
1.0024	1.035e+009	4.700e+005	4.983e+005	8.660e+002	9.182e+002
1.2719	1.347e+009	7.833e+005	8.226e+005	1.374e+003	1.443e+003
1.5767	1.283e+008	9.315e+004	9.712e+004	1.546e+002	1.612e+002
TOTAL:	3.698e+010	1.044e+007	1.129e+007	1.998e+004	2.161e+004

CHECKLIST FOR PEER REVIEW

Document Reviewed: "MICROSHIELD Dose Rate Calculation for HEPA Filters and Prefilters," WHC-SD-WM-CN-033 REV 0, by Anthony V. Savino, June 1996.

Scope of Review: Entire document

Yes	No	NA		
[ ]	[ ]	[X]	*	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]		Problem completely defined.
[ ]	[ ]	[X]		Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]		Necessary assumptions explicitly stated and supported.
[X]	[ ]	[ ]		Computer codes and data files documented.
[X]	[ ]	[ ]		Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]		Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]		Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]		Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[X]	[ ]	[ ]		Software input correct and consistent with document reviewed.
[X]	[ ]	[ ]		Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[X]		Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[X]		Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]		Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]		Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]		Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]		[X]	*	Review calculations, comments, and/or notes are attached.

[X] [ ] [ ] **Document approved.**

Dave Himes _____ 6/3/96
Reviewer (Printed Name and Signature) Date

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	A. V. Savino	Date 9/24/96
Project Title/Work Order		EDT No. 619404
MICROSHIELD Dose Rate Calculations for HEPA Filters and Prefilters		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
C. Carro	A2-34	X			
D. S. Leach	A3-34	X			
A. V. Savino (3)	G1-11	X			
TWRS S & L Project Files (6)	A2-26	X			
Central Files (Original + 1)	A3-88	X			