040-08868

II-VI
INCORPORATED

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November 16, 1999

Mr. John Kinneman
Chief, Nuclear Materials Safety Section
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, Pennsylvania 19406-1415

Re: Application to Amend Radioactive Material License No. STA-1455

Dear Mr. Kinneman:

II-VI Incorporated (II-VI) wishes to amend License No. STA-1455 to permit us to transfer solid materials (i.e., soils, filtercake) that contain less than 25 picocuries per gram (pCi/g) each of ^{232}Th and its progeny to an industrial landfill without regard for radiological constituents. The purpose for this request is to allow us to cost-effectively manage bulk solids that do not pose a radiological risk to members of the general population. This request is based upon the letter sent to the USNRC dated November 3, 1999 (See Attachment # 3). The following is our justification for this request.

Dose Basis

A critical step in assessing the concentration of radioactivity in solids that may be transferred to an industrial landfill is to determine a radiation dose to workers and members of the public that presents negligible radiological risk. This is the maximum dose, above background, that may be incurred by those impacted by the transfer such that radiation-induced health effects would not be detectable.

The U. S. Nuclear Regulatory Commission (USNRC) has promulgated a number of dose criteria that it considers to present negligible risk. For example, in Title 10, Code of Federal Regulations, Part 20 (10 CFR 20) Subpart D, a dose of 100 millirem per year to individual members of the public from licensed operations is deemed acceptable by this agency. Likewise, in 10 CFR 20 Subpart E, the USNRC considers a dose of 25 millirem per year to the maximally exposed individual from a decommissioned site to be acceptable. However, in preparing a Final Staff Technical Position on the release of a specific solid material, the

USNRC used a dose limit for members of the general public (above background) of one (1) millirem per year as its basis.[1]

To ensure consistency with generally accepted levels of dose that the USNRC considers to pose negligible radiological risk, and to ensure an element of conservatism in this analysis, the most limiting of the three levels acceptable to the USNRC was deemed applicable. Therefore, the dose basis used for this assessment is one (1) millirem total effective dose equivalent (TEDE) per year.[2]

Maximum Permissible Concentration in Landfill

To determine the maximum permissible concentration of solid materials that may be placed in any landfill, such that no member of the general public exceeds the dose basis of one(1) millirem per year after the landfill closes, the "agricultural farm family" scenario is deemed applicable. In this scenario, a hypothetical family is assumed to move onto the closed and capped landfill that contains bulk solids from licensable operations at II-VI. Because this fictitious family builds a home and raises all of the crops and livestock for family consumption directly on the property, they may incur a radiation dose by all of the following pathways:

Direct radiation exposure;

Inhalation of re-suspended radioactivity;

Ingestion of food from crops grown at the site;

Ingestion of milk from livestock that grazes at the site;

Ingestion of meat from livestock that grazes at the site;

Ingestion of fish from an on-site pond contaminated by water percolating through the materials in the capped landfill; and

Ingestion of water from a well on the property that is contaminated by waters percolating through the capped landfill.

The reason for selecting the agricultural farm family scenario for this dose assessment is that exposure of permanent residents is long-term in nature, generally involves a greater number of exposure pathways than for non-residents, and results in a high, or conservative, estimate of potential radiation dose. The non-resident group most likely to receive exposure from radioactivity at the capped and closed landfill is "scavengers". While scavenging can occur,

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[1]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997.

[2]This dose basis applies only to the assessment reported herein for the release of specified solid materials. It may or may not have applicability to other assessments and operating procedures.

this is not considered to be a likely scenario considering the lack of economic value of the materials in question, and the fact that the exposure of scavengers will be much smaller than that of a hypothetical permanent resident since the scavenger will spend less time at the site than the resident.

The computer code called RESRAD (Version 5.60) was used to model radionuclide fate and transport, and to assess the radiation dose incurred by the hypothetical family members from the radioactivity in the capped and closed landfill.[3] In addition, the USNRC's 1997 Final Staff Technical Position was used as guidance in developing the exposure scenario (i.e., certain input parameters for RESRAD were selected from this document).[4] The following are the assumptions used as input to the analysis:

> The landfill is capped and closed immediately after the 30-year period of material deposition ends.
>
> The hypothetical farm family moves onto the capped landfill immediately after closure (i.e., the 30+ years of continuing surveillance mandated by most closure plans is excluded from this assessment).
>
> For modeling purposes, the radionuclide concentration of the materials placed into the landfill was initially assumed to be one (1) pCi/g each of ^{232}Th plus its progeny (in equilibrium).[5]
>
> II-VI packages the bulk solid material in 30 cubic yard containers, each having approximate dimensions of 1.7 m x 2.1 m x 6.7 m.[6] Each container is completely full upon packaging.
>
> Each year for 30 years, a total of 10 containers are transferred to an industrial landfill, resulting in a total amount released of 6,881 m^3.[7]

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[3]Argonne National Laboratory Technical Report (Yu, C., et al.), "A Manual for Implementing Residential Radioactive Material Guidelines Using RESRAD", ANL/EAD/LD-2, September, 1993.

[4]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997.

[5]The results of this analysis on a " dose per unit concentration" basis were subsequently scaled to reflect the concentration associated with the one (1) millirem per year dose basis.

[6]Personal communication from M. Nanney (II-VI Incorporated) to C. Berger (Integrated Environmental Management, Inc.), November 8, 1999.

[7]Personal communication from M. Nanney (II-VI Incorporated) to C. Berger (Integrated Environmental Management, Inc.), November 8, 1999, wherein it was stated that the amount generated in a year is typically less than five (5) boxes.

All of the aforementioned material is transferred to a single industrial landfill, where it is disposed of in a single continuous volume measuring 1,146 m^2 by six (6) m deep.[8]
To maximize the hazard, the hydraulic gradient was considered to be parallel to more than the length of the disposed volume (i.e., 1000 meters).

Infiltration representative of a humid site was presumed and a minimal unsaturated zone thickness of one (1) meter between the contaminated zone and the saturated zone was assumed.[9]

At the time of landfill closure, there is a cover thickness of two (2) meters with an effective density of 1.5 grams/cm^3.[10]

The hypothetical agricultural farm family digs a three (3) meter foundation hole for the construction of their house. The top two (2) meters of the foundation were assumed to be cover material, and the bottom one (1) meter was assumed to be the material disposed of by II-VI.[11]

All other default-input parameters provided with the RESRAD code were deemed applicable.

Attachment 1 contains the summary report from the RESRAD analysis. The maximum possible dose rate for any member of the hypothetical family for a unit concentration of one (1) pCi/g of thorium and each progeny, using the aforementioned assumptions, is 7.914×10^{-5} mrem/yr. This occurs 1,000 years after the family takes up residence. The annual dose rates for all years prior to that time are less than this amount.

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[8]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 4, "Water Pathway Considerations".

[9]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 4, "Water Pathway Considerations".

[10]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 4, "Water Pathway Considerations".

[11]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 4, "Water Pathway Considerations".

The maximum soil concentration that would ensure the one (1) millirem dose basis is met, is derived as follows:

$$C_{max} = \frac{1\ \frac{mrem}{year}}{7.915 \times 10^{-5}\ \frac{\frac{mrem}{year}}{\frac{pCi}{gram}}} = 1.26 \times 10^{4}\ \frac{pCi}{gram}$$

Therefore, the one (1) millirem dose criterion would be met for this hypothetical family as long as the residual radioactivity in the bulk solids transferred by II-VI does not exceed 1.26×10^4 pCi of ^{232}Th (and of each progeny) per gram.

Maximum Permissible Concentration in Containers

From the aforementioned analysis, it is clear that significant concentrations of ^{232}Th (plus progeny) may be deposited in a capped and closed industrial landfill without resulting in radiological harm to members of the general public. However, a more limiting scenario is the direct radiation dose incurred by landfill workers who handle the containers of bulk solids transferred to them by II-VI.[12] To assess the magnitude of this exposure, the computer code Microshield was used.[13] Again using the USNRC's 1997 Final Staff Technical Position as guidance on developing the exposure scenario, the following are the assumptions used as input to this analysis:

> The dimensions of each container are 6.7 m x 2.1 m x 1.7 m, thus a rectangular volume was selected as the input geometry for the Microshield code.[14,15]
>
> Each container is completely full upon packaging.
>
> For modeling purposes, each container was assumed to hold 1.26×10^4 pCi/g each of ^{232}Th and its progeny in equilibrium.[16]
>
> The density of the material in each container is 1.5 g/cm^3, which is the density of typical soil.

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[12]Because the material in question is damp and of large particle sizes, inhalation doses were considered to be negligible.

[13]Grove Engineering, Inc. Microshield v. 5.01.

[14]Personal communication from M. Nanney (II-VI Incorporated) to C. Berger (Integrated Environmental Management, Inc.), November 8, 1999.

[15]The actual dimensions of the containers used by II-VI are approximately 6.7 m x 2.1 m x 1.7 m.

[16]The results of this analysis on a " dose per unit concentration" basis, as taken from the previous RESRAD analysis, were subsequently scaled to reflect the concentration associated with the one (1) millirem per year dose basis.

The shielding afforded by the container itself is excluded from this assessment.

Landfill workers spend their entire time at a distance of one (1) meter from the side of the container.[17]

Landfill workers handle containers from II-VI constantly and continuously for 32 hours of each 2,000 hour work year.[18]

Attachment 2 contains the Microshield summary report. The results of this analysis shows that a landfill worker incurs a radiation dose of 13.90 mrem/hr when handling containers bearing 1.26×10^4 pCi/g of thorium and each of its progeny.

Thus in order to ensure that the dose basis of one (1) millirem per year is met, the maximum concentration of ^{232}Th and of each of its progeny must be limited to 28.3 pCi/g. This is derived as follows:

$$C_{max} = 1 \frac{mrem}{year} \times \frac{1\ year}{32\ hours} \times \frac{1.26 \times 10^4 \frac{pCi}{gram}}{1.390 \times 10^1 \frac{mrem}{hour}} = 28.3 \frac{pCi}{gram}$$

Conclusions

It is clear that as long as the solid materials released by II-VI for disposal at a landfill do not exceed 25 pCi/g each of ^{232}Th and its progeny, no member of the general public will incur a radiation dose that can, in any way, be distinguished from the background radiation dose each individual incurs each day by virtue of being alive. Thus II-VI is justified in requesting an amendment to license No. STA-1455 to permit transfer of solid materials that contain less than 25 pCi/g each of ^{232}Th and progeny to be disposed of in a landfill without regard for radiological constituents.

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[17]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 3, "Direct Exposure".

[18]U. S. Nuclear Regulatory Commission, "Disposition of Cesium-137 Contaminated Emission Control Dust and Other Incident-related Materials: Final Staff Technical Position", 62 FR 13176, March 19, 1997, Section 3, "Direct Exposure".

A review of the USNRC Fee Schedule indicates there is no fee for this amendment. Please call me at (724) 352-4455 if I can answer any questions or assist you in any way in expediting your review of this important license amendment request.

Sincerely,

John A. Labrecque
Radiation Safety Director

cc: C. Johnson, Chief Executive Officer

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ATTACHMENT 1
RESRAD Summary Report

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: DOSFAC.BIN

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ra-228+D	5.080E-03	5.080E-03	DCF2(1)
B-1	Th-228+D	3.450E-01	3.450E-01	DCF2(2)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(3)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ra-228+D	1.440E-03	1.440E-03	DCF3(1)
D-1	Th-228+D	8.080E-04	8.080E-04	DCF3(2)
D-1	Th-232	2.730E-03	2.730E-03	DCF3(3)
D-34	Food transfer factors:			
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(1,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(1,3)
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(2,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(2,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(1,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(1,2)
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(2,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(2,2)
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.147E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	6.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+03	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ra-228	1.000E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Th-228	1.000E+00	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Th-232	1.000E+00	0.000E+00	---	S1(3)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(3)
R013	Cover depth (m)	2.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.000E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone effective porosity	2.000E-01	2.000E-01	---	EPCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Humidity in air (g/cm**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	1.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.185E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	2.000E-04	2.000E-04	---	MLINH
R017	Dilution length for airborne dust, inhalation (m)	3.000E+00	3.000E+00	---	LM
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	1.000E+00	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.573E-01	FMEAT
R018	Contamination fraction of milk	-1	-1	0.573E-01	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	1.000E+00	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	3.000E+00	1.500E-01	---	FLOOR
R021	Bulk density of building foundation (g/cm**3)	2.400E+00	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	4.000E-01	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	1.000E-01	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	5.000E-02	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	3.000E-02	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	2.000E-06	2.000E-06	---	DIFCV
R021	in foundation material	3.000E-07	3.000E-07	---	DIFFL
R021	in contaminated zone soil	2.000E-06	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	2.000E+00	2.000E+00	---	HMIX
R021	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R021	Average building air exchange rate (1/hr)	5.000E-01	5.000E-01	---	REXG
R021	Height of the building (room) (m)	2.500E+00	2.500E+00	---	HRM
R021	Building interior area factor	0.000E+00	0.000E+00	code computed (time dependent)	FAI
R021	Building depth below ground surface (m)	-1.000E+00	-1.000E+00	code computed (time dependent)	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	1.500E-01	1.500E-01	---	EMANA(2)

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	1147.00 square meters	Ra-228	1.000E+00
Thickness:	6.00 meters	Th-228	1.000E+00
Cover Depth:	2.00 meters	Th-232	1.000E+00

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 25 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	9.723E-10	9.831E-10	1.004E-09	1.082E-09	1.351E-09	2.973E-09	2.897E-08	7.914E-05
M(t):	3.889E-11	3.932E-11	4.018E-11	4.329E-11	5.403E-11	1.189E-10	1.159E-09	3.166E-06

Maximum TDOSE(t): 7.914E-05 mrem/yr at t = 1.000E+03 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	1.139E-11	0.0117	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	9.609E-10	0.9883	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.723E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.139E-11	0.0117
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.609E-10	0.9883
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.723E-10	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.873E-10	0.2923	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	6.764E-10	0.6880	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	1.939E-11	0.0197	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	9.831E-10	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.873E-10	0.2923
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.764E-10	0.6880
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.939E-11	0.0197
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.831E-10	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	5.425E-10	0.5401	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	3.352E-10	0.3337	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	1.268E-10	0.1262	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.004E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.425E-10	0.5401
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.352E-10	0.3337
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.268E-10	0.1262
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.004E-09	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	4.406E-10	0.4071	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	2.871E-11	0.0265	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	6.129E-10	0.5663	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.082E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.406E-10	0.4071
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.871E-11	0.0265
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.129E-10	0.5663
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.082E-09	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	5.329E-11	0.0395	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	2.563E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	1.297E-09	0.9605	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	1.351E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.329E-11	0.0395
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.563E-14	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.297E-09	0.9605
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.351E-09	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.372E-14	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	5.445E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	2.973E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.973E-09	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.372E-14	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.445E-25	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.973E-09	1.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.973E-09	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	6.294E-24	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	2.839E-08	0.9799	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.839E-08	0.9799	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.828E-17	0.0000	1.714E-19	0.0000	4.102E-23	0.0000	2.188E-18	0.0000	3.414E-20	0.0000	7.550E-20	0.0000	3.075E-17	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	5.368E-10	0.0185	3.252E-12	0.0001	5.158E-16	0.0000	4.153E-11	0.0014	6.483E-13	0.0000	1.434E-12	0.0000	2.897E-08	1.0000
Total	5.368E-10	0.0185	3.252E-12	0.0001	5.158E-16	0.0000	4.153E-11	0.0014	6.483E-13	0.0000	1.434E-12	0.0000	2.897E-08	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	7.914E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	7.914E-05	1.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Radio-														
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	8.285E-14	0.0000	5.019E-16	0.0000	7.168E-20	0.0000	6.410E-15	0.0000	1.000E-16	0.0000	2.213E-16	0.0000	7.914E-05	1.0000
Total	8.285E-14	0.0000	5.019E-16	0.0000	7.168E-20	0.0000	6.410E-15	0.0000	1.000E-16	0.0000	2.213E-16	0.0000	7.914E-05	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	Ra-228	1.000E+00	1.139E-11	1.022E-11	8.230E-12	3.856E-12	4.418E-13	2.250E-16	3.072E-17	0.000E+00
Ra-228	Th-228	1.000E+00	0.000E+00	2.771E-10	5.343E-10	4.368E-10	5.285E-11	2.350E-14	2.954E-20	0.000E+00
Ra-228	ðDSR(j)		1.139E-11	2.873E-10	5.425E-10	4.406E-10	5.329E-11	2.372E-14	3.075E-17	0.000E+00
Th-228	Th-228	1.000E+00	9.609E-10	6.764E-10	3.352E-10	2.871E-11	2.563E-14	5.445E-25	0.000E+00	0.000E+00
Th-232	Th-232	1.000E+00	2.024E-31	2.088E-31	2.222E-31	2.765E-31	5.160E-31	4.583E-30	2.350E-27	7.171E-18
Th-232	Ra-228	1.000E+00	0.000E+00	1.308E-12	3.585E-12	9.053E-12	1.632E-11	4.222E-11	1.175E-09	6.087E-06
Th-232	Th-228	1.000E+00	0.000E+00	1.808E-11	1.232E-10	6.039E-10	1.281E-09	2.930E-09	2.780E-08	7.305E-05
Th-232	ðDSR(j)		2.024E-31	1.939E-11	1.268E-10	6.129E-10	1.297E-09	2.973E-09	2.897E-08	7.914E-05

Branch Fraction is the cumulative factor for the j'th principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life μ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 25 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	2.195E+12	8.701E+10	4.608E+10	5.674E+10	4.691E+11	*2.721E+14	*2.721E+14	*2.721E+14
Th-228	2.602E+10	3.696E+10	7.459E+10	8.708E+11	*8.192E+14	*8.192E+14	*8.192E+14	*8.192E+14
Th-232	*1.092E+05	*1.092E+05	*1.092E+05	*1.092E+05	*1.092E+05	*1.092E+05	*1.092E+05	*1.092E+05

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 1.000E+03 years

Nuclide (i)	Initial pCi/g	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ra-228	1.000E+00	126.1 þ 0.1	1.898E-09	1.317E+10	0.000E+00	*2.721E+14
Th-228	1.000E+00	0.000E+00	9.609E-10	2.602E+10	0.000E+00	*8.192E+14
Th-232	1.000E+00	1.000E+03	7.914E-05	*1.092E+05	7.914E-05	*1.092E+05

*At specific activity limit

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr							
		t=	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	Ra-228	1.000E+00	1.139E-11	1.022E-11	8.230E-12	3.856E-12	4.418E-13	2.250E-16	3.072E-17	0.000E+00
Ra-228	Th-232	1.000E+00	0.000E+00	1.308E-12	3.585E-12	9.053E-12	1.632E-11	4.222E-11	1.175E-09	6.087E-06
Ra-228	ðDOSE(j):		1.139E-11	1.153E-11	1.182E-11	1.291E-11	1.676E-11	4.222E-11	1.175E-09	6.087E-06
Th-228	Ra-228	1.000E+00	0.000E+00	2.771E-10	5.343E-10	4.368E-10	5.285E-11	2.350E-14	2.954E-20	0.000E+00
Th-228	Th-228	1.000E+00	9.609E-10	6.764E-10	3.352E-10	2.871E-11	2.563E-14	5.445E-25	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.808E-11	1.232E-10	6.039E-10	1.281E-09	2.930E-09	2.780E-08	7.305E-05
Th-228	ðDOSE(j):		9.609E-10	9.716E-10	9.927E-10	1.069E-09	1.334E-09	2.931E-09	2.780E-08	7.305E-05
Th-232	Th-232	1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.583E-30	2.350E-27	7.171E-18

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g							
		t=	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	Ra-228	1.000E+00	1.000E+00	8.856E-01	6.945E-01	2.966E-01	2.610E-02	5.276E-06	1.469E-16	0.000E+00
Ra-228	Th-232	1.000E+00	0.000E+00	1.133E-01	3.025E-01	6.965E-01	9.644E-01	9.901E-01	9.898E-01	9.889E-01
Ra-228	ðS(j):		1.000E+00	9.989E-01	9.970E-01	9.931E-01	9.905E-01	9.901E-01	9.898E-01	9.889E-01
Th-228	Ra-228	1.000E+00	0.000E+00	2.851E-01	5.375E-01	4.062E-01	3.925E-02	7.939E-06	2.210E-16	0.000E+00
Th-228	Th-228	1.000E+00	1.000E+00	6.961E-01	3.372E-01	2.670E-02	1.903E-05	1.840E-16	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.861E-02	1.240E-01	5.616E-01	9.513E-01	9.901E-01	9.898E-01	9.889E-01
Th-228	ðS(j):		1.000E+00	9.998E-01	9.988E-01	9.945E-01	9.906E-01	9.901E-01	9.898E-01	9.889E-01
Th-232	Th-232	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	9.999E-01	9.996E-01	9.986E-01

BRF(i) is the branch fraction of the parent nuclide.

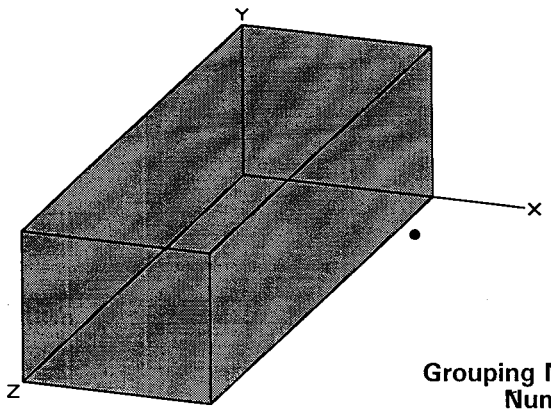
ATTACHMENT 2
Microshield Summary Report

MicroShield v5.01 (5.01-00996)
Integrated Environmental Management, Inc.

Page : 1
DOS File : Case1
Run Date: November 9, 1999
Run Time: 8:43:32 AM
Duration : 00:00:33

File Ref: 97012.06
Date: 4-8-99
By: [illegible]
Checked: _____

Case Title: II-VI Solids
Description: 30 cubic yard container - dose rate at one meter
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	206.0 cm	6 ft 9.1 in
Width	671.0 cm	22 ft 0.2 in
Height	168.0 cm	5 ft 6.1 in

Dose Points

	X	Y	Z
# 1	306 cm	84 cm	330 cm
	10 ft 0.5 in	2 ft 9.1 in	10 ft 9.9 in

Shields

Shield Name	Dimension	Material	Density
Source	2.32e+07 cm³	Concrete	1.5
Air Gap		Air	0.00122

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
Ac-228	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Bi-212	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Pb-212	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Po-212	2.8563e-001	1.0568e+010	1.2300e-002	4.5510e+002
Po-216	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Ra-224	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Ra-228	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Rn-220	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Th-228	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Th-232	4.3890e-001	1.6239e+010	1.8900e-002	6.9930e+002
Tl-208	1.5675e-001	5.7997e+009	6.7500e-003	2.4975e+002

Buildup
The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	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
0.04	1.660e+08	2.487e-02	4.580e-02	1.100e-04	2.026e-04
0.06	1.123e+08	1.166e-01	3.005e-01	2.316e-04	5.969e-04
0.08	7.006e+09	1.500e+01	4.423e+01	2.374e-02	6.999e-02
0.1	1.152e+09	3.745e+00	1.170e+01	5.730e-03	1.791e-02
0.15	6.826e+08	4.149e+00	1.319e+01	6.832e-03	2.173e-02
0.2	8.821e+09	8.058e+01	2.482e+02	1.422e-01	4.380e-01
0.3	4.231e+09	6.795e+01	1.921e+02	1.289e-01	3.645e-01
0.4	3.842e+08	9.230e+00	2.420e+01	1.799e-02	4.715e-02
0.5	2.245e+09	7.394e+01	1.827e+02	1.451e-01	3.586e-01
0.6	5.134e+09	2.193e+02	5.142e+02	4.281e-01	1.004e+00
0.8	5.169e+09	3.346e+02	7.261e+02	6.364e-01	1.381e+00
1.0	9.456e+09	8.486e+02	1.741e+03	1.564e+00	3.210e+00
1.5	2.178e+09	3.570e+02	6.649e+02	6.007e-01	1.119e+00
2.0	4.928e+07	1.240e+01	2.180e+01	1.917e-02	3.371e-02

DOS File : Case1
Run Date: November 9, 1999
Run Time: 8:43:32 AM
Duration : 00:00:33

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
3.0	5.788e+09	2.643e+03	4.301e+03	3.586e+00	5.836e+00
TOTALS:	5.257e+10	4.670e+03	8.686e+03	7.305e+00	1.390e+01

ATTACHEMENT 3
USNRC Letter – November 3, 1999

II-VI
INCORPORATED

II-VI INCORPORATED, 375 Saxonburg Boulevard, Saxonburg, PA 16056

General Offices: 724-352-4455 Sales: 724-352-1504 FAX:724-352-5284

November 3, 1999

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C 20555

Docket No.: 040-08868
License No.: STA-1455

RE: Reply to Notice of Violation – Dated September 23, 1999

Dear Sirs:

A Notice of Violation was issued to II-VI Incorporated referencing the manner in which we dispose of solid residual material (filtercake) from our facility. The basis of the Notice of Violation is that II-VI Incorporated did not receive authorization to release our filtercake. Although we do not believe II-VI Incorporated is being handled consistently under the regulations as compared with other licensees, we are not contesting this Notice of Violation. The following is our response.

Reason for the Violation
It should be noted for the record that this concern was initially identified during a USNRC Audit July 8-9, 1998. At that time, the inspectors asked us if we met the 10 pCi/g release criteria (based upon the USNRC Branch Technical Position) for release of our filtercake for conventional disposal. We commenced testing, and discovered some samples over the identified release criteria. II-VI Incorporated immediately undertook very costly facility modifications and engineering changes to meet the stated release criteria, and ensure all samples are kept ALARA. The USNRC was made aware of these actives in a letter sent January 15, 1999. With the implemented engineering changes, all subsequent samples were well below the USNRC recommended release criteria.

During a NRC Inspection conducted August 18-20, 1999, we were informed our efforts were not adequate, and we were to be cited under 10 CFR 20.2001(a). In addition, we understand that this interpretation of the regulations is not being consistently applied to other licensees both in Region I and other USNRC regions. While we recognize and acknowledge a violation of the letter of 10 CFR 20.2001(a), II-VI Incorporated believes this deficiency in and inconsistent application of the regulations could result in an unfair business advantage for our competitors.

Corrective Steps Taken and Results Achieved
II-VI Incorporated is committed to meeting the intent of all regulations, and protecting our employees, communities and the environment. As such, our immediate corrective action is to cease releasing our residual filtercake material until site specific release criteria for solids could be secured from the USNRC.

Corrective Steps Taken to Avoid Further Violations
A formal application requesting release criteria for this material, with dose assessments will be submitted to the USNRC, Region I, as an amendment to our license. This request for authorization will be submitted by November 19, 1999.

Date When Full Compliance Will Be Achieved
Because full compliance can only be achieved when II-VI Incorporated receives an amendment to our license, we are dependent upon timely review and approval of our amendment application by the USNRC. And, because continued storage of our solid material while awaiting USNRC approval will be costly and detrimental to our operation, we urge the USNRC to give immediate attention to our request.

If you have any questions, please contact our Radiation Safety Director, John Labrecque, at (724) 352-4455.

Regards,

Carl J. Johnson
CEO, II-VI Incorporated

Cc: Regional Administrator, Region I, USNRC
John D. Kinneman, Chief, Nuclear Materials Safety Branch 2, USNRC
Elizabeth Ullrich, Senior Health Physicist, Region I, USNRC
John A. Labrecque – Radiation Safety Director, II-VI Incorporated