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NSTC GREAT LAKES, IL
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AMENDMENT TO SOURCE MATERIAL LICENSE STC-133-REQUEST TO USE COMMODITY SPECIFICS DCGLS WITH TRANSMITTAL NSTC GREAT LAKES IL
2/7/2006
DEFENSE LOGISTICS AGENCY

104

DEFENSE LOGISTICS AGENCY
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IN REPLY REFER TO

FEB 0 7 2006

DNSC-E

U.S. Nuclear Regulatory Commission
Region 1, Nuclear Materials Safety Branch
Division of Nuclear Materials Safety
ATTN: Ms Betsy Ullrich
475 Allendale Road
King of Prussia, PA 19406-1415

SUBJECT: Amendment to Source Material License STC-133 - Request to Use Commodity Specific DCGLs at Binghamton and Somerville Depots

Docket No. 04000341
Control No. 137882

Dear Ms. Ullrich:

Review following our submittal request dated January 11, 2006, indicates that our DCGL estimates based upon DandD runs for natural uranium are not conservative. For this work, we have opted to select U-238+C and U-235+C as the radionuclides of choice versus natural uranium. The use of U-238+C and U-235+C shows more in-growth of daughter products and therefore the results are more conservative. The DandD results for natural thorium versus Th-233+C are consistent and no change in approach for natural thorium is made.

This letter request is a replacement of our request dated January 11, 2006, and is in reference to your letter dated December 21, 2005 requesting additional information to continue your review of our request to use site-specific DCGLs at the Binghamton and Somerville Depots. There are only two radionuclides of concern, natural thorium and natural uranium. Our intent is to be consistent for both radionuclides in the selection of the dosimetry method. The attached information is provided in support of this request for radionuclide-specific DCGLs for natural thorium as 37.3 dpm/100 cm^2 and natural uranium as 110 dpm/100 cm^2. The activity abundance of the natural uranium is U-238, U-234, and U-235 at 48.83%, 48.83%, and 2.34%, respectively.

Federal Recycling Program Printed on Recycled Paper

Application of the number of alpha emissions per decay through each decay chain yields DCGL values for natural thorium and natural uranium in terms of alpha emissions at 224 αpm/100 cm^2 and 448 αpm/100 cm^2, respectively.

The following table provides a cross reference to the information requests of your referenced letter:

NRC Letter	Response
3rd para: identity of radionuclides	Attachment A, Section a. Radionuclides of Concern
Paragraph a.	Attachment A, Section b. Scenario for the scenario assumptions
	Attachment A, Section c. Critical Group for the critical group assumptions
Paragraph b.	Attachment A, Section d. Selection of Program Code and Model, *Application of Federal Guidance Report No. 13*
Paragraph c.	Attachment B.
Paragraph d.	Attachment A, Section d. Selection of Program Code and Model
Paragraph e.	Attachment A, Section e. Uncertainty/Sensitivity Analysis

The scenarios, models and parameters in DandD were defined to be "reasonably conservative" such that they would not be "bounding" or unrealistic, while still generally overestimating rather than underestimating potential dose. Our approach of applying the latest dosimetry models and dose conversion factors contained in Federal Guidance Report No. 13 does not negate that dose is still conservatively overestimated as the remaining default parameter values of DandD were used. However, the developed DCGLs better represent the hazards associated with the radionuclides than those which would be applied under existing Part 20 criteria.

Our forthcoming final status survey plans (one for each Depot) will delineate the application of a gross activity DCGL per survey unit based upon approval of the request for the radionuclide-specific DCGLs described above. The concept of gross activity DCGLs must be applied, as our commodities were a mixture of varying concentrations of both radionuclides.

Should you have any questions regarding this letter, please contact me or Mr. Mike Pecullan of our office. You may also call Mr. Claude Wiblin, CHP, at (410) 923-4653. Mr. Wiblin is a representative of our contracted decommissioning firm, Chesapeake Nuclear Services, Inc.

Sincerely,

Stephen W Smith

for K. KEVIN REILLY
Director,
Directorate of Environmental
Management

Attachments

Attachment A

Information for Site-Specific DCGLs at Binghamton and Somerville Depots

Information for Site-Specific DCGLs at Binghamton and Somerville Depots

a. Radionuclides of Concern: natural thorium and natural uranium

b. Scenario:

The Building Occupancy scenario model is selected as defined in Volume 1 and implemented in Version 2.1 of DandD.

This selection is based on the following assumptions which parallel those of DandD:

Radioactive dose results from exposure via three major exposure pathways:

- External exposure to penetrating radiation from surface sources,
- Inhalation of resuspended surface contamination, and
- Inadvertent ingestion of surface contamination

Other scenario assumptions from DandD which meet our situation include:

- The building will be commercially used after decommissioning.
- The occupancy of the building will occur immediately after its release.
- The residual contamination will be represented by a thin surface layer left on the inner building surfaces.
- The exposure type will be a long-term chronic exposure to low level radioactive contamination since major contamination will be cleaned up prior to decommissioning.

c. Critical Group:

The screening group is a site-independent population, appropriate for use at both sites, which is reasonably expected to receive the greatest exposure given the scenario definition. The result of a screening group review is consistent with the DandD building occupancy scenario; the screening group is expected to consist of full-time adult male workers in light industry.

d. Selection of Program Code and Model

Application of the DandD Code:

The simplest method to select initial screening DandD DCGLs is from Table 5.19, Concentration (dpm/100cm^2) equivalent to 25 mrem/y for the specified value of P_{crit} from Vol. 3 of NUREG/CR-5512. However, selections for natural thorium and natural uranium were not available when Table 5.19 was published and only recently has the DandD code included them. The NRC has also published a Notice in the Federal Register, June 13, 2000, stating that for radionuclides not listed, the latest version of the DandD code may be used. Our purpose in running the DandD code is to obtain these missing P_{crit} values of 0.90 for natural thorium and natural uranium.

For this evaluation, reverse engineering was applied and 10,000 simulations were run to assure that estimated DCGLs would not exceed 25.0 mrem per year. Only default parameters were used. The estimated DCGL for the Building Occupancy Scenario was 5.9 dpm/100cm^2 for natural thorium. To determine the estimated DCGL for natural uranium, a mixture of U-238+C and U-235+C was used as 11.6 dpm/100cm^2 and 0.556 dpm/100cm^2, respectively. Copies of the DandD computer runs are attached.

Application of Federal Guidance Report No. 13:

The Federal Guidance Report No. 13 (FG Report-13) provides methods and data for estimating risks due to both internal and external radionuclide exposures. It is an update of Federal Guidance Report No. 11 based on current ICRP lung models and it includes coefficients for assessing cancer risks from environmental exposure to about 800 radionuclides. 10 CFR Part 20 is based in part on Federal Guidance Report No. 11 and requires specific approval by the NRC to use the new updated coefficients FG Report-13.

The FG Report-13 risk coefficients and dose conversion factors are based on state-of-the-art methods that take into account age and gender dependence of intake, metabolism, dosimetry, radiogenic risk and competing causes of death in estimating the risks to health from internal or external exposure to radionuclides. Although the dose per unit intake calculated using the new models does not differ by more than a factor of about two from the values in part 20 for most radionuclides, the differences are substantial for some, particularly for the isotopes of thorium, uranium, and some of the transuranic radionuclides. There is precedence for this request, for example[1], for inhalation of insoluble thorium-232, the dose per unit intake calculated using the revised ICRP lung model is a factor of about 15 times lower than that in part 20. Because release criteria and protective measures are based on the hazard, and since the hazard is proportional to dose, part 20 requires significantly more protective measures when using natural thorium and natural uranium than would be warranted based on the revised models.

The chemical form of the material is an oxide as that found in nature; the material was either part of a metal or ores. Both uranium and thorium oxides are given a lung clearance classification of "Y" in Part 20 and to be as consistent as possible with Part 20, the most similar lung clearance definition found in FG Report -13 was selected for these calculations which is slow, "S". To conform with the critical group defined above, the dose conversion factors were selected as those for adults for the effective dose for the 50-year period following intake.

Tables 1 through 4 compare the inhalation and ingestion CEDE factors for both DandD and FG Report-13 for both radionuclides of concern. These tables list the CEDE conversion factors for both models and a ratio multiple from DandD to FG Report-13 for each radionuclide in the decay chains.

Tables 5 and 6 show the annual dose rate by the external, inhalation and ingestion pathways by each radionuclide in the decay chains from the DandD

[1] Nuclear Fuel Services, Inc.; Environmental Assessment and Finding of No Significant Impact, FR 7/16/03, pages 42139-42140.

code runs. The inputs for these runs are for a surface concentration of 5.85 dpm/100cm^2 for natural thorium and for natural uranium a concentration of 11.6 dpm/100cm^2 as U-238+C and 0.556 dpm/100cm^2 as U-235+C.

Application of FG Report -13 dose conversion factors in Tables 7 and 8 show dose reductions from 25 mrem to 3.9 and 5.4 mrem for natural thorium and natural uranium, respectively. These reductions establish alternate values for P_{crit} values of 0.90 for natural thorium and natural uranium as 37.3 dpm/100 cm^2 and 110 dpm/100 cm^2, respectively. The activity abundance of the natural uranium is U-238, U-234, and U-235 at 48.83%, 48.83%, and 2.34%, respectively. These are the radionuclide specific DCGLs requested to be applied at the Binghamton and Somerville Depots.

These DCGL values are developed into DCGLs based on alpha emissions as follows. Data from *The Health Physics and Radiological Handbook*[2] was used to establish the number of alpha emissions per parent decay in each chain.

- As Th-232 is in equilibrium with its progeny, there are six alpha emissions for each decay of a Th-232 atom. The alpha emissions are one each from Th-232, Th-228, Ra-224, Rn-220, Po-216 while Bi-212 and Po-212 combined emissions yield one from both. The alpha based DCGL for 37.3 dpm/100cm^2 is then six times that or ~224 αpm/100cm^2.

- As natural uranium consists of U-238, U-234 and U-235, the number of alphas emitted per decay of a U-238 atom requires consideration of the activity abundance of each found in nature, 48.83%, 48.83%, and 2.34%.

  U-238 and U-234 are considered in the same decay chain with a total of eight alpha emissions for each decay of a U-238 atom. The alpha emissions are counted as one each from U-238, U-234, Th-230, Ra-226, Rn-222, Po-218, Po-214, and Po-210. Credit was not taken for the insignificant alpha emission fractions of At-218, Pb-210, and Bi-210. The contribution to the natural uranium alpha based DCGL from U-238+C at 53.7 dpm/100cm^2 is eight times that or 430 αpm/100cm^2.

  For the U-235 series, the alpha emissions total seven for each decay of a U-235 atom with one each from U-235, Pa-231, Th-227, Ra-223, Rn-219, Po-215, and Bi-211. Credit was not taken for the insignificant alpha emission fractions of Ac-227, Fr-223, At-215, and Po-211. The contribution to the natural uranium alpha based DCGL from U-235+C at 2.57 dpm/100cm^2 is seven times that or 18 αpm/100cm^2.

  The combined alpha DCGL from U-238+C and U-235+C at 53.7 and 2.57 dpm/100cm^2, respectively, is 448 αpm/100cm^2.

e. Uncertainty/Sensitivity Analyses

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[2] *The Health Physics and Radiological Handbook,* Revised Edition, Scinta, Inc. Silver Spring, MD 20902, 1992.

The NRC has provided justification for the DandD conservative parameters and the probability distribution functions (PDFs) in Volume 3 of the NUREG/CR-5512. There are no parameters used in the analysis which were changed from the default values.

Copies of the available sensitivity analyses for both radionuclides are provided as Figures 1 and 2. The resuspension factor is the only available parameter. For the indicated performance objective value of 25 mrem and since only default parameter values were used, the ranges of these default parameters should be acceptable for this decommissioning activity.

Table 1. Comparison of Natural Thorium Inhalation CEDE Factors			
Nuclide	DandD CEDE Factor (Sv/Bq)	FGR-13 CEDE Factor (Sv/Bq)	Multiple
232Th	4.43E-04	2.48E-05	0.06
228Ra	1.29E-06	1.60E-05	12.40
228Th	9.23E-05	3.97E-05	0.43
224Ra	8.53E-07	3.36E-06	3.94
212Pb	4.56E-08	1.90E-07	4.17
Ac-228	8.33E-08	1.46E-08	0.18
Bi-212	5.83E-09	3.32E-08	5.69

Table 2. Comparison of Natural Thorium Ingestion CEDE Factors			
Nuclide	DandD CEDE Factor (Sv/Bq)	FGR-13 CEDE Factor (Sv/Bq)	Multiple
232Th	7.38E-07	2.31E-07	0.31
228Ra	3.88E-07	6.97E-07	1.80
228Th	1.07E-07	7.20E-08	0.67
224Ra	9.89E-08	6.45E-08	0.65
212Pb	1.23E-08	5.98E-09	0.49
Ac-228	5.85E-10	4.01E-10	0.69
Bi-212	2.87E-10	2.59E-10	0.90

Table 3. Comparison of Natural Uranium Inhalation CEDE Factors			
Nuclide	DandD CEDE Factor (Sv/Bq)	FGR-13 CEDE Factor (Sv/Bq)	Multiple
238U	3.20E-05	8.04E-06	0.25
234Th	9.47E-09	7.69E-09	0.81
234U	3.58E-05	9.40E-06	0.26
230Th	8.80E-05	1.40E-05	0.16
226Ra	2.32E-06	9.51E-06	4.10
222Rn	0.00E+00		
210Pb	3.67E-06	5.61E-06	1.53
210Bi	5.29E-08	1.33E-07	2.51
210Po	2.54E-06	4.27E-06	1.68
235U	3.32E-05	8.47E-06	0.26
231Th	2.37E-10	3.34E-10	1.41
231Pa	3.47E-04	2.89E-05	0.08
227Ac	1.81E-03	5.53E-05	0.03
227Th	4.37E-06	1.04E-05	2.38
223Ra	2.12E-06	8.68E-06	4.09
234Pa	2.20E-10	4.10E-10	1.86
214Pb	2.11E-09	1.47E-08	6.97
214Bi	1.78E-09	1.54E-08	8.65
223Fr	1.68E-09	1.21E-08	7.20
211Pb	2.35E-09	1.20E-08	5.11

Table 4. Comparison of Natural Uranium Ingestion CEDE Factors			
Nuclide	DandD CEDE Factor (Sv/Bq)	FGR-13 CEDE Factor (Sv/Bq)	Multiple
238U	6.88E-08	4.45E-08	0.65
234Th	3.69E-09	3.40E-09	0.92
234U	7.66E-08	4.95E-08	0.65
230Th	1.48E-07	2.14E-07	1.45
226Ra	3.58E-07	2.80E-07	0.78
222Rn	0.00E+00		
210Pb	1.45E-06	6.96E-07	0.48
210Bi	1.73E-09	1.31E-09	0.76
210Po	5.14E-07	1.21E-06	2.35
235U	7.19E-08	4.67E-08	0.65
231Th	3.65E-10	3.36E-10	0.92
231Pa	2.86E-06	4.79E-07	0.17
227Ac	3.80E-06	3.23E-07	0.09
227Th	1.03E-08	9.09E-09	0.88
223Ra	1.78E-07	1.04E-07	0.58
234Pa	5.84E-10	5.24E-10	0.90
214Pb	1.69E-10	1.39E-10	0.82
214Bi	7.64E-11	1.12E-10	1.47
223Fr	2.33E-09	2.36E-09	1.01
211Pb	1.42E-10	1.78E-10	1.25

Table 5. DandD Dose from Natural Thorium Surface Concentration of 5.85 dpm/100cm^2			
Nuclide	**External**	**Inhalation**	**Secondary Ingestion**
232Th	4.52E-06	2.05E+01	1.85E-02
228Ra	0.00E+00	5.98E-02	9.74E-03
228Ac	7.61E-03	3.86E-03	1.47E-05
228Th	1.93E-05	4.28E+00	2.69E-03
224Ra	7.85E-05	3.95E-02	2.48E-03
220Rn	3.13E-06	0.00E+00	0.00E+00
216Po	1.36E-07	0.00E+00	0.00E+00
212Pb	1.17E-03	2.11E-03	3.09E-04
212Bi	1.46E-03	2.70E-04	7.20E-06
212Po	0.00E+00	0.00E+00	0.00E+00
208Tl	8.81E-03	0.00E+00	0.00E+00
Sum of All Pathways			25

Table 7. FGR-13 Dose from Natural Thorium Surface Concentration of 5.85 dpm/100cm^2			
Nuclide	**External**	**Inhalation**	**Secondary Ingestion**
232Th	4.52E-06	1.15E+00	5.79E-03
228Ra	0.00E+00	7.42E-01	1.75E-02
228Ac	7.61E-03	6.77E-04	1.01E-05
228Th	1.93E-05	1.84E+00	1.81E-03
224Ra	7.85E-05	1.56E-01	1.62E-03
220Rn	3.13E-06	0.00E+00	0.00E+00
216Po	1.36E-07	0.00E+00	0.00E+00
212Pb	1.17E-03	8.79E-03	1.50E-04
212Bi	1.46E-03	1.54E-03	6.50E-06
212Po	0.00E+00	0.00E+00	0.00E+00
208Tl	8.81E-03	0.00E+00	0.00E+00
Sum of All Pathways			3.92

Table 6. DandD Dose from U-238 +C & U-235+C Initial Surface Concentration of 11.6 and 0.556 dpm/100cm^2

Nuclide	External	Inhalation	Secondary Ingestion
238U	8.97E-06	2.94E+00	3.42E-03
234Th	1.35E-04	8.70E-04	1.84E-04
234U	1.22E-05	3.29E+00	3.81E-03
230Th	1.22E-05	8.09E+00	7.37E-03
226Ra	1.05E-04	2.13E-01	1.78E-02
222Rn	6.43E-06	0.00E+00	0.00E+00
210Pb	4.03E-05	3.37E-01	7.22E-02
210Bi	1.71E-05	4.86E-03	8.61E-05
210Po	1.35E-07	2.33E-01	2.56E-02
235U	1.16E-04	1.46E-01	1.72E-04
231Th	1.45E-05	1.04E-06	8.71E-07
231Pa	3.18E-05	1.53E+00	6.82E-03
227Ac	1.23E-07	7.97E+00	9.07E-03
227Th	6.08E-07	1.02E-07	7.67E-08
223Ra	7.97E-05	1.90E-02	2.42E-05
223Fr	1.00E-04	9.34E-03	4.25E-04
219Rn	4.28E-05	0.00E+00	0.00E+00
215Po	1.36E-07	0.00E+00	0.00E+00
211Pb	3.96E-05	1.04E-05	3.39E-07
211Bi	3.58E-05	0.00E+00	0.00E+00
211Po	1.66E-08	0.00E+00	0.00E+00
207Tl	2.93E-06	0.00E+00	0.00E+00
234mPa	2.48E-04	0.00E+00	0.00E+00
234Pa	5.99E-05	4.04E-08	5.81E-08
218Po	1.45E-07	0.00E+00	0.00E+00
214Pb	3.96E-03	1.94E-04	8.41E-06
218At	0.00E+00	0.00E+00	0.00E+00
214Bi	2.30E-02	1.64E-04	3.80E-06
214Po	1.32E-06	0.00E+00	0.00E+00
Sum of All Pathways			2.50E+01

Table 8. FGR-13 Dose from U-238+C and U-235+C Initial Surface Concentration of 11.6 and 0.556 dpm/100cm^2

Nuclide	External	Inhalation	Secondary Ingestion
238U	8.97E-06	7.39E-01	2.21E-03
234Th	1.35E-04	7.06E-04	1.70E-04
234U	1.22E-05	8.64E-01	2.46E-03
230Th	1.22E-05	1.29E+00	1.07E-02
226Ra	1.05E-04	8.73E-01	1.39E-02
222Rn	6.43E-06	0.00E+00	0.00E+00
210Pb	4.03E-05	5.15E-01	3.47E-02
210Bi	1.71E-05	1.22E-02	6.52E-05
210Po	1.35E-07	3.92E-01	6.03E-02
235U	1.16E-04	3.72E-02	1.12E-04
231Th	1.45E-05	1.47E-06	8.02E-07
231Pa	3.18E-05	1.27E-01	1.14E-03
227Ac	1.23E-07	2.44E-01	7.71E-04
227Th	6.08E-07	2.43E-07	6.77E-08
223Ra	7.97E-05	7.78E-02	1.41E-05
223Fr	1.00E-04	6.73E-02	4.30E-04
219Rn	4.28E-05	0.00E+00	0.00E+00
215Po	1.36E-07	0.00E+00	0.00E+00
211Pb	3.96E-05	5.31E-05	4.25E-07
211Bi	3.58E-05	0.00E+00	0.00E+00
211Po	1.66E-08	0.00E+00	0.00E+00
207Tl	2.93E-06	0.00E+00	0.00E+00
234mPa	2.48E-04	0.00E+00	0.00E+00
234Pa	5.99E-05	7.53E-08	5.21E-08
218Po	1.45E-07	0.00E+00	0.00E+00
214Pb	3.96E-03	1.35E-03	6.92E-06
218At	0.00E+00	0.00E+00	0.00E+00
214Bi	2.30E-02	1.42E-03	5.57E-06
214Po	1.32E-06	0.00E+00	0.00E+00
Sum of All Pathways			5.39E+00

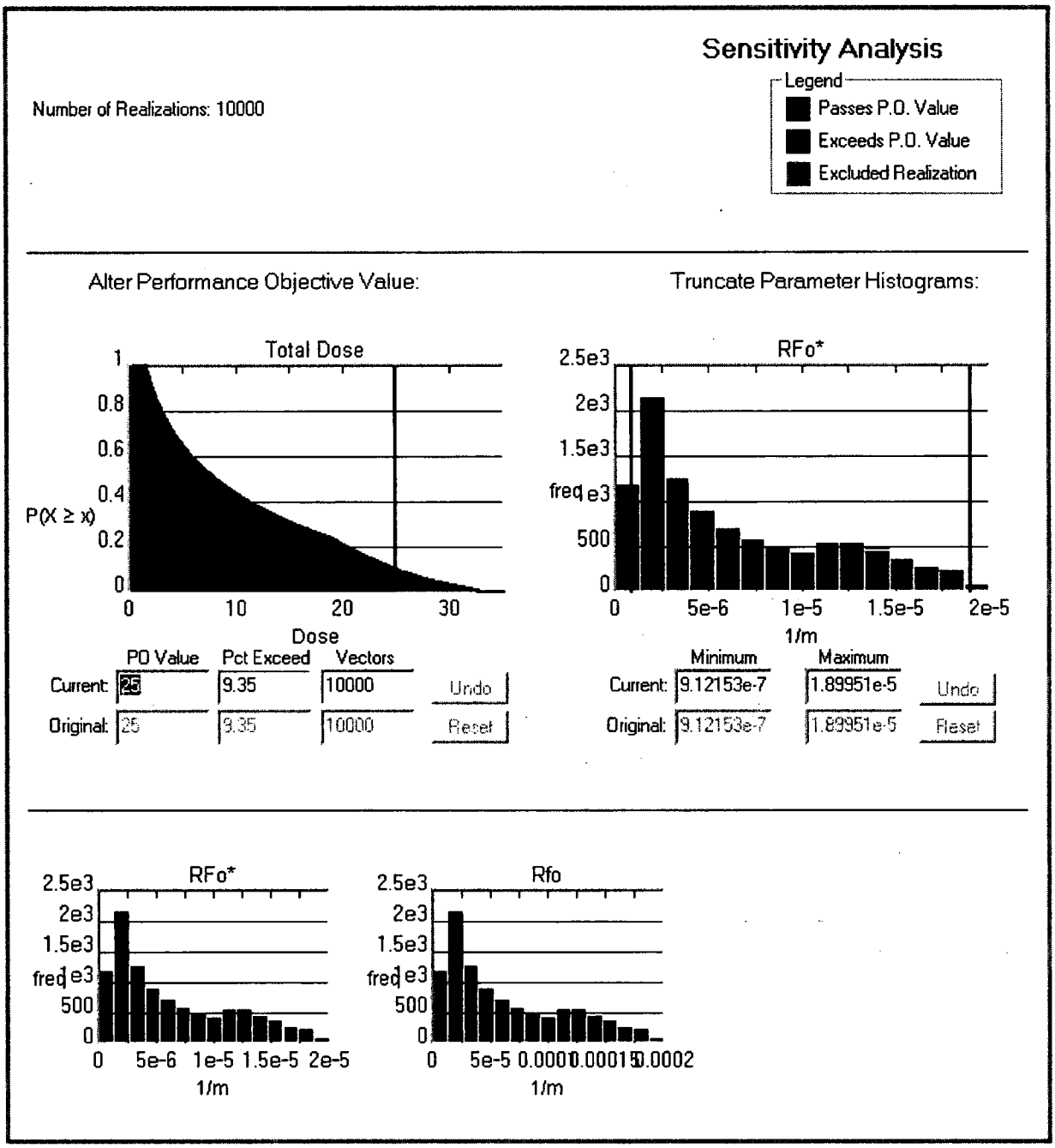

Figure 1. Sensitivity of the Resuspension Factor for Natural Thorium

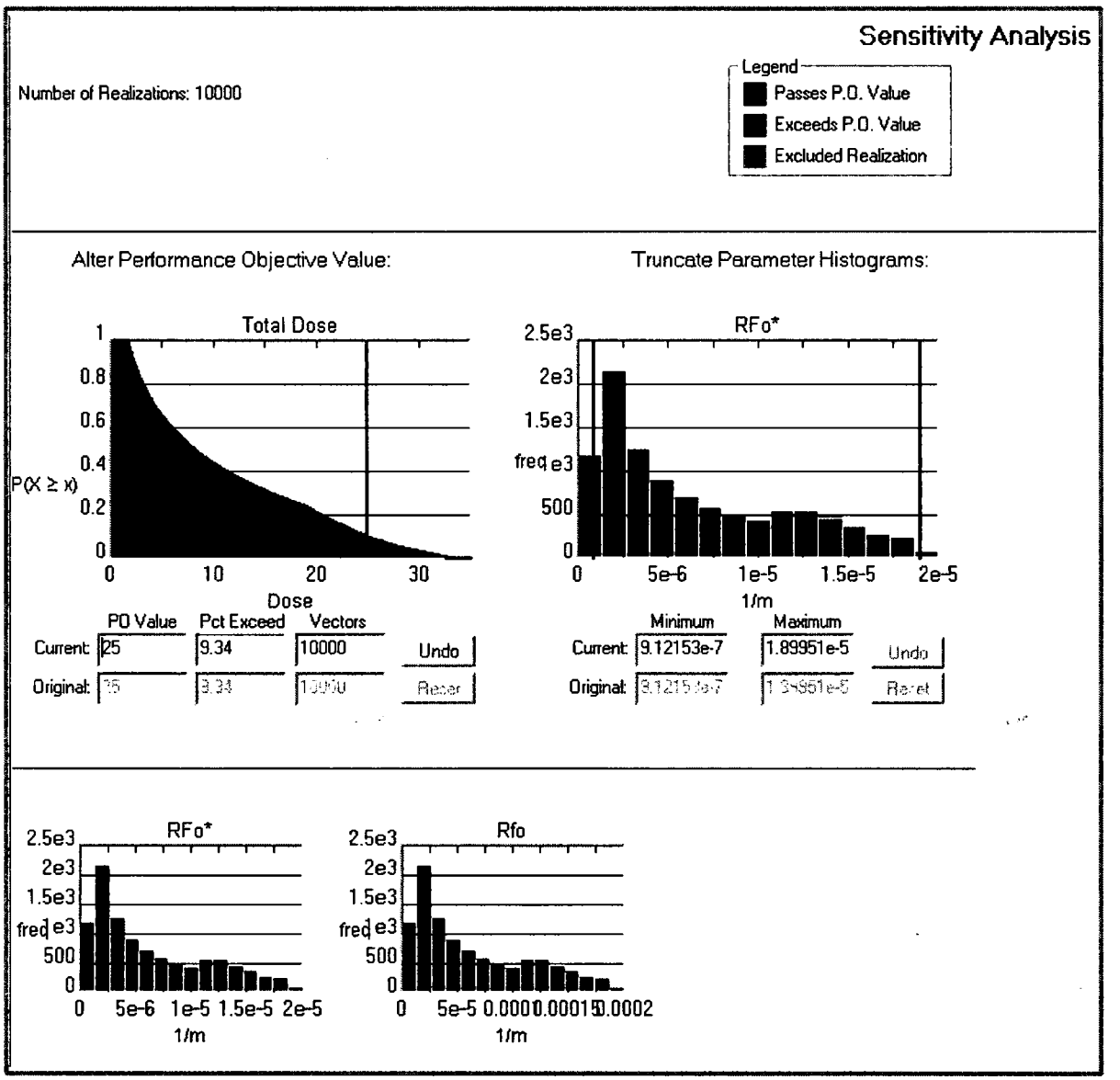

Figure 2. Sensitivity of the Resuspension Factor for Natural Uranium

Appendix B - DandD Computer Run Printouts

Natural Thorium B-2
Natural Uranium B-10

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 8/19/2005 12:48:52 PM
Site Name: Binghamton and Somerville
Description: Reverse Engineering to document 25 mrem /year from estimated DCGL
FileName:C:\DLA-Proposal\DandD Runs\Th Natural 25 mrem.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 10000
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution

Th_Nat	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Estimated value for 25 mrem/year		Value 5.85E+00

Chain Data:

Number of chains: **1**

Chain No. 1: **Th_Nat**
Nuclides in chain: **12**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m^3))
232Th	1	5.13E+12					7.38E-07	4.43E-04	4.76E-14	2.40E-16
228Ra	2	2.10E+03	1	1	0	0	3.88E-07	1.29E-06	0.00E+00	0.00E+00
228Ac	Implicit		2	1			5.85E-10	8.33E-08	8.01E-11	2.38E-12
228Th	3	6.99E+02	2	1	0	0	1.07E-07	9.23E-05	2.03E-13	3.60E-15
224Ra	4	3.66E+00	3	1	0	0	9.89E-08	8.53E-07	8.26E-13	2.26E-14
220Rn	Implicit		4	1			0.00E+00	0.00E+00	3.29E-14	9.52E-16
216Po	Implicit		4	1			0.00E+00	0.00E+00	1.43E-15	4.21E-17
212Pb	5	4.43E-01	4	1	0	0	1.23E-08	4.56E-08	1.23E-11	3.13E-13
212Bi	Implicit		5	1			2.87E-10	5.83E-09	1.54E-11	4.63E-13
212Po	Implicit		5	0.6407			0.00E+00	0.00E+00	0.00E+00	0.00E+00
208Tl	Implicit		5	0.3593			0.00E+00	0.00E+00	2.58E-10	8.36E-12

Th_Nat	1	0.00E+00					0.00E+00	0.00E+00	2.58E-10	8.36E-12

Initial Concentrations:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value

Nuclide	Surface Concentration (dpm/100 cm**2)
232Th	5.85E+00
228Ra	5.85E+00
228Ac	5.85E+00
228Th	5.85E+00
224Ra	5.85E+00
220Rn	5.85E+00
216Po	5.85E+00
212Pb	5.85E+00
212Bi	5.85E+00
212Po	3.75E+00
208Tl	2.10E+00

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution

To:Time In Building	The time in the building during the occupancy period	CONSTANT(hr/week)
Default value used		Value 4.50E+01
Tto:Occupancy Period	The duration of the occupancy exposure period	CONSTANT(days)
Default value used		Value 3.65E+02
Vo:Breathing Rate	The average volumetric breathing rate during building occupancy for an 8-hour work day	CONSTANT(m**3/hr)
Default value used		Value 1.40E+00
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * FI	DERIVED(1/m)
Default value used		
GO*:Ingestion Rate	Effective secondary ingestion transfer rate of removable surface activity from building surfaces to the mouth during building occupancy = GO * FI	DERIVED(m**2/hr)
Default value used		
Tstart:Start Time	The start time of the scenario in days	CONSTANT(days)
Default value used		Value 0.00E+00
Tend:End Time	The ending time of the scenario in days	CONSTANT(days)
Default value used		Value 3.65E+02
dt:Time Step Size	The time step size	CONSTANT(days)
Default value used		Value 3.65E+02
Pstep:Print Step Size	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)

Default value used		Value 1.00E+00
AOExt:External Exposure Area	Minimum surface area to which occupant is exposed via external radiation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOInh:Inhalation Exposure Area	Minimum surface area to which occupant is exposed via inhalation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOIng:Secondary Ingestion Exposure Area	Minimum surface area to which occupant is exposed via secondary ingestion during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AO:Exposure Area	Minimum surface area to which occupant is exposed during the occupancy period	DERIVED(m**2)
Default value used		
Fl:Loose Fraction	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
Default value used		Value 1.00E-01
Rfo:Loose Resuspension Factor	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
Default value used		Value / Probability 9.12E-06 / 0.00E+00 1.10E-04 / 7.67E-01 1.46E-04 / 9.09E-01 1.62E-04 / 9.50E-01 1.85E-04 / 9.90E-01 1.90E-04 / 1.00E+00

GO:Loose Ingestion Rate	The secondary ingestion transfer rate of loose removable surface activity from building surfaces to the mouth during building occupancy	CONSTANT(m**2/hr)
Default value used		Value 1.10E-04

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 10000 **calculated TEDE values are <** 2.47E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.44E+01 **to** 2.50E+01 **mrem/year**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

Concentration at Time of Peak Dose:

Nuclide	Surface Concentration (dpm/100 cm**2)
232Th	5.85E+00
228Ra	5.85E+00
228Ac	5.85E+00
228Th	5.85E+00
224Ra	5.85E+00

220Rn	5.85E+00
216Po	5.85E+00
212Pb	5.85E+00
212Bi	5.85E+00
212Po	3.75E+00
208Tl	2.10E+00

Pathway Dose from All Nuclides (mrem)

All Pathways Dose	External	Inhalation	Secondary Ingestion
2.50E+01	1.92E-02	2.49E+01	3.38E-02

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
232Th	2.06E+01
228Ra	6.95E-02
228Ac	1.15E-02
228Th	4.28E+00
224Ra	4.21E-02
220Rn	3.13E-06
216Po	1.36E-07
212Pb	3.59E-03
212Bi	1.74E-03

212Po	0.00E+00
208Tl	8.81E-03
All Nuclides	2.50E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	External	Inhalation	Secondary Ingestion
232Th	4.52E-06	2.05E+01	1.85E-02
228Ra	0.00E+00	5.98E-02	9.74E-03
228Ac	7.61E-03	3.86E-03	1.47E-05
228Th	1.93E-05	4.28E+00	2.69E-03
224Ra	7.85E-05	3.95E-02	2.48E-03
220Rn	3.13E-06	0.00E+00	0.00E+00
216Po	1.36E-07	0.00E+00	0.00E+00
212Pb	1.17E-03	2.11E-03	3.09E-04
212Bi	1.46E-03	2.70E-04	7.20E-06
212Po	0.00E+00	0.00E+00	0.00E+00
208Tl	8.81E-03	0.00E+00	0.00E+00

DandD Building Occupancy Scenario

DandD Version: 2.1.0
Run Date/Time: 1/31/2006 1:28:45 PM
Site Name: Binghamton and Somerville Depots
Description: Combination of U-235+C and U-238+C at natural uranium concentration ratios.

Demonstration of DCGL for 25 mrem/y
FileName:C:\DLA\Revision\DCGLs\U-235+C and U-238+C.mcd

Options:

Implicit progeny doses NOT included with explicit parent doses
Nuclide concentrations are NOT distributed among all progeny
Number of simulations: 10000
Seed for Random Generation: 8718721
Averages used for behavioral type parameters

External Pathway is ON
Inhalation Pathway is ON
Secondary Ingestion Pathway is ON

Initial Activities:

Nuclide	Area of Contamination (m^2)	Distribution
235U+C	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Fraction of activity at natural value of 0.0234 fraction of total.		Value 5.56E-01
238U+C	UNLIMITED	CONSTANT(dpm/100 cm**2)
Justification for concentration: Value set per natural radioactivity ratio of 0.4883 fraction of total activity.		Value 1.16E+01

Chain Data:

Number of chains: **2**

Chain No. 1: **235U+C**
Nuclides in chain: **13**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m^3))
235U+C	1	2.57E+11								
231Th	2	1.06E+00	1	1	0	0	3.65E-10	2.37E-10	1.60E-12	1.68E-14
231Pa	3	1.20E+07	2	1	0	0	2.86E-06	3.47E-04	3.52E-12	8.30E-14
227Ac	4	7.95E+03	3	1	0	0	3.80E-06	1.81E-03	1.36E-14	2.26E-16
223Fr	Implicit		4	0.0138			2.33E-09	1.68E-09	4.88E-12	8.74E-14
227Th	5	1.87E+01	4	0.9862	0	0	1.03E-08	4.37E-06	8.94E-12	2.29E-13

223Ra	6	1.14E+01	5	1	4	0.0138	1.78E-07	2.12E-06	1.11E-11	2.67E-13
219Rn	Implicit		6	1			0.00E+00	0.00E+00	4.74E-12	1.33E-13
215Po	Implicit		6	1			0.00E+00	0.00E+00	1.51E-14	4.30E-16
211Pb	Implicit		6	1			1.42E-10	2.35E-09	4.38E-12	1.26E-13
211Bi	Implicit		6	1			0.00E+00	0.00E+00	3.96E-12	1.10E-13
211Po	Implicit		6	0.0028			0.00E+00	0.00E+00	6.57E-13	1.94E-14
207Tl	Implicit		6	0.9972			0.00E+00	0.00E+00	3.25E-13	8.19E-15

Chain No. 2: **238U+C**
Nuclides in chain: **16**

Nuclide	Chain Position	Half Life	First Parent	Fractional Yield	Second Parent	Fractional Yield	Ingestion CEDE Factor (Sv/Bq)	Inhalation CEDE Factor (Sv/Bq)	Surface Dose Rate Factor ((Sv/d)/(Bq/m^2))	15 cm Dose Rate Factor ((Sv/d)/(Bq/m^3))
238U+C	1	1.63E+12								
234Th	2	2.41E+01	1	1	0	0	3.69E-09	9.47E-09	7.18E-13	1.12E-14
234mPa	Implicit		2	0.998			0.00E+00	0.00E+00	1.32E-12	3.62E-14
234Pa	Implicit		2	0.002	0	0.0013	5.84E-10	2.20E-10	1.59E-10	4.65E-12
234U	3	8.93E+07	2	1	0	0	7.66E-08	3.58E-05	6.46E-14	1.85E-16
230Th	4	2.81E+07	3	1	0	0	1.48E-07	8.80E-05	6.48E-14	5.52E-16
226Ra	5	5.84E+05	4	1	0	0	3.58E-07	2.32E-06	5.56E-13	1.42E-14
222Rn	6	3.82E+00	5	1	0	0	0.00E+00	0.00E+00	3.41E-14	9.81E-16
218Po	Implicit		6	1			0.00E+00	0.00E+00	7.67E-16	2.27E-17
214Pb	Implicit		6	0.9998			1.69E-10	2.11E-09	2.10E-11	5.78E-13

218At	Implicit		6	0.0002			0.00E+00	0.00E+00	0.00E+00	0.00E+00
214Bi	Implicit		6	1			7.64E-11	1.78E-09	1.22E-10	3.77E-12
214Po	Implicit		6	0.9998			0.00E+00	0.00E+00	7.02E-15	2.07E-16
210Pb	7	8.15E+03	6	1	0	0	1.45E-06	3.67E-06	2.14E-13	1.13E-15
210Bi	8	5.01E+00	7	1	0	0	1.73E-09	5.29E-08	9.06E-14	1.61E-15
210Po	9	1.38E+02	8	1	0	0	5.14E-07	2.54E-06	7.16E-16	2.11E-17

Initial Concentrations:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value

Nuclide	Surface Concentration (dpm/100 cm**2)
235U	5.56E-01
231Th	5.56E-01
231Pa	5.56E-01
227Ac	5.56E-01
223Fr	7.67E-03
227Th	5.48E-01
223Ra	5.56E-01
219Rn	5.56E-01
215Po	5.56E-01
211Pb	5.56E-01
211Bi	5.56E-01
211Po	1.56E-03

207Tl	5.54E-01
238U	1.16E+01
234Th	1.16E+01
234mPa	1.16E+01
234Pa	2.32E-02
234U	1.16E+01
230Th	1.16E+01
226Ra	1.16E+01
222Rn	1.16E+01
218Po	1.16E+01
214Pb	1.16E+01
218At	2.32E-03
214Bi	1.16E+01
214Po	1.16E+01
210Pb	1.16E+01
210Bi	1.16E+01
210Po	1.16E+01

Model Parameters:

General Parameters:

Parameter Name	Description	Distribution

To:Time In Building	The time in the building during the occupancy period	CONSTANT(hr/week)
Default value used		Value 4.50E+01
Tto:Occupancy Period	The duration of the occupancy exposure period	CONSTANT(days)
Default value used		Value 3.65E+02
Vo:Breathing Rate	The average volumetric breathing rate during building occupancy for an 8-hour work day	CONSTANT(m**3/hr)
Default value used		Value 1.40E+00
RFo*:Resuspension Factor	Effective resuspension factor during the occupancy period = RFo * Fl	DERIVED(1/m)
Default value used		
GO*:Ingestion Rate	Effective secondary ingestion transfer rate of removable surface activity from building surfaces to the mouth during building occupancy = GO * Fl	DERIVED(m**2/hr)
Default value used		
Tstart:Start Time	The start time of the scenario in days	CONSTANT(days)
Default value used		Value 0.00E+00
Tend:End Time	The ending time of the scenario in days	CONSTANT(days)
Default value used		Value 3.65E+02
dt:Time Step Size	The time step size	CONSTANT(days)
Default value used		Value 3.65E+02
Pstep:Print Step Size	The time steps for the history file. Doses will be written to the history file every n time steps	CONSTANT(none)

Default value used		Value 1.00E+00
AOExt:External Exposure Area	Minimum surface area to which occupant is exposed via external radiation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOInh:Inhalation Exposure Area	Minimum surface area to which occupant is exposed via inhalation during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AOIng:Secondary Ingestion Exposure Area	Minimum surface area to which occupant is exposed via secondary ingestion during occupancy period	CONSTANT(m**2)
Default value used		Value 1.00E+01
AO:Exposure Area	Minimum surface area to which occupant is exposed during the occupancy period	DERIVED(m**2)
Default value used		
Fl:Loose Fraction	Fraction of surface contamination available for resuspension and ingestion	CONSTANT(none)
Default value used		Value 1.00E-01
Rfo:Loose Resuspension Factor	Resuspension factor for loose contamination	CONTINUOUS LOGARITHMIC(1/m)
Default value used		Value / Probability 9.12E-06 / 0.00E+00 1.10E-04 / 7.67E-01 1.46E-04 / 9.09E-01 1.62E-04 / 9.50E-01 1.85E-04 / 9.90E-01

		1.90E-04 1.00E+00
GO:Loose Ingestion Rate	The secondary ingestion transfer rate of loose removable surface activity from building surfaces to the mouth during building occupancy	CONSTANT(m**2/hr)
Default value used		Value 1.10E-04

Correlation Coefficients:

None

Summary Results:

90.00% **of the** 10000 **calculated TEDE values are** < 2.47E+01 **mrem/year .**
The 95 % Confidence Interval for the 0.9 **quantile value of TEDE is** 2.44E+01 **to** 2.50E+01 **mrem/year**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 quantile value

Concentration at Time of Peak Dose:

Nuclide	Surface Concentration (dpm/100 cm**2)
235U	5.56E-01
231Th	5.56E-01
231Pa	5.56E-01

227Ac	5.56E-01
223Fr	7.67E-03
227Th	5.48E-01
223Ra	5.56E-01
219Rn	5.56E-01
215Po	5.56E-01
211Pb	5.56E-01
211Bi	5.56E-01
211Po	1.56E-03
207Tl	5.54E-01
238U	1.16E+01
234Th	1.16E+01
234mPa	1.16E+01
234Pa	2.32E-02
234U	1.16E+01
230Th	1.16E+01
226Ra	1.16E+01
222Rn	1.16E+01
218Po	1.16E+01
214Pb	1.16E+01
218At	2.32E-03
214Bi	1.16E+01
214Po	1.16E+01

210Pb	1.16E+01
210Bi	1.16E+01
210Po	1.16E+01

Pathway Dose from All Nuclides (mrem)

All Pathways Dose	External	Inhalation	Secondary Ingestion
2.50E+01	2.81E-02	2.48E+01	1.47E-01

Radionuclide Dose through All Active Pathways (mrem)

Nuclide	All Pathways Dose
235U	1.47E-01
231Th	1.64E-05
231Pa	1.54E+00
227Ac	7.98E+00
223Fr	7.87E-07
227Th	1.91E-02
223Ra	9.86E-03
219Rn	4.28E-05
215Po	1.36E-07
211Pb	5.03E-05
211Bi	3.58E-05

211Po	1.66E-08
207Tl	2.93E-06
238U	2.94E+00
234Th	1.19E-03
234mPa	2.48E-04
234Pa	6.00E-05
234U	3.29E+00
230Th	8.10E+00
226Ra	2.31E-01
222Rn	6.43E-06
218Po	1.45E-07
214Pb	4.16E-03
218At	0.00E+00
214Bi	2.32E-02
214Po	1.32E-06
210Pb	4.10E-01
210Bi	4.97E-03
210Po	2.59E-01
All Nuclides	2.50E+01

Dose from Each Nuclide through Each Active Pathway (mrem)

Nuclide	External	Inhalation	Secondary Ingestion

235U	1.16E-04	1.46E-01	1.72E-04
231Th	1.45E-05	1.04E-06	8.71E-07
231Pa	3.18E-05	1.53E+00	6.82E-03
227Ac	1.23E-07	7.97E+00	9.07E-03
223Fr	6.08E-07	1.02E-07	7.67E-08
227Th	7.97E-05	1.90E-02	2.42E-05
223Ra	1.00E-04	9.34E-03	4.25E-04
219Rn	4.28E-05	0.00E+00	0.00E+00
215Po	1.36E-07	0.00E+00	0.00E+00
211Pb	3.96E-05	1.04E-05	3.39E-07
211Bi	3.58E-05	0.00E+00	0.00E+00
211Po	1.66E-08	0.00E+00	0.00E+00
207Tl	2.93E-06	0.00E+00	0.00E+00
238U	8.97E-06	2.94E+00	3.42E-03
234Th	1.35E-04	8.70E-04	1.84E-04
234mPa	2.48E-04	0.00E+00	0.00E+00
234Pa	5.99E-05	4.04E-08	5.81E-08
234U	1.22E-05	3.29E+00	3.81E-03
230Th	1.22E-05	8.09E+00	7.37E-03
226Ra	1.05E-04	2.13E-01	1.78E-02
222Rn	6.43E-06	0.00E+00	0.00E+00
218Po	1.45E-07	0.00E+00	0.00E+00
214Pb	3.96E-03	1.94E-04	8.41E-06

218At	0.00E+00	0.00E+00	0.00E+00
214Bi	2.30E-02	1.64E-04	3.80E-06
214Po	1.32E-06	0.00E+00	0.00E+00
210Pb	4.03E-05	3.37E-01	7.22E-02
210Bi	1.71E-05	4.86E-03	8.61E-05
210Po	1.35E-07	2.33E-01	2.56E-02