**Analysis of Criticality Alarm System Response to an
Accidental Criticality Outside the Cascade Process
Buildings at the Portsmouth Gaseous Diffusion Plant**

July 1994

by

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Under Contract 400183

to

MARTIN MARIETTA UTILITY SERVICES, INC.

**PORTSMOUTH GASEOUS DIFFUSION PLANT
P.O. Box 628 Piketon, Ohio 45661**

Under Contract USECHQ-93-C-001

to the

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ABSTRACT

Neutron dose rates at detector positions within the X-326, X-330, and X-333 buildings were evaluated for an accidental criticality outside of each building. As fissile material bearing equipment and containers are moved to and from each building, the possibility exists for a criticality accident to occur. This analysis demonstrates that a criticality accident which occurs at any position on the access roads alongside a process building can be detected. The detectable area includes all points within the access road boundary along each face of each building.

This analysis also demonstrates that the criticality alarm systems of the process buildings will respond to criticality events occurring within the tie lines connecting the process buildings.

This analysis was performed using the MCNP monte carlo neutron-proton transport code.^[Ref. 1] The radiation source is the neutron leakage spectrum of a critical solution of 4.95 percent enriched $\text{UO}_2\text{F}_2\text{-H}_2\text{O}$ at a power level corresponding to the ANSI ANS 8.3^[Ref. 2] Standard minimum accident of concern. The evaluated neutron fluxes were converted to neutron dose rates by use of the Henderson^[Ref. 3] free-in-air response functions. Critical source positions correspond to the farthest source to detector distances on the access roads along each face of the three buildings, and the centerpoint of the building tie lines.

This report contains the methodology used for this study, a background on the data used, and a section about the assumptions and limits to all conclusions.

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1.0 CONCLUSIONS

Results of the dose rate computations show that for all three process buildings, the criticality alarm system will respond to the ANSI ANS 8.3^[Ref. 2] Standard minimum accident of concern occurring at any position along the building access roads. Dose rates at the detector position closest to the source range from 14.0 to 57.6 mrad h⁻¹ at locations on the access roads on all four faces of all three buildings. These dose rates are greater than the 5 mrad h⁻¹ setpoint for the criticality alarm detector. Actual dose rates are undoubtedly much higher due to the very conservative approach followed throughout this analysis.

Dose rates at the nearest detector positions assuming a critical source at the center of each inter building tie line range from 43 to 93 mrad h⁻¹. However, the potential for a criticality to occur within a tie line is virtually impossible due to the geometry of the system. The tie lines are smaller in size than the 10.25 inch "safe" pipe diameter ^[Ref. 4] for uranium enriched to 5 percent U²³⁵.

Atmospheric precipitation has been shown to have a negligible effect on the alarm system response. The amount of moderating material in the air was calculated using a rainfall rate of 4 inches per hour with the average drop falling at 10 mph. These assumptions are conservative because they correspond to a maximum believable amount of moderating material in the air.

The greatest factors affecting the dose rates at the detector locations are the drop off of flux as a function of the square of distance, and intervening shielding material. The calculational model includes all significant structural and fixed shielding between the detector and potential critical source. Unsurprisingly, the lowest recorded dose rates pertain to detector positions farthest from the building face and having the greatest amount of attenuating material between the source and detector. The effect of scattering of particles

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from areas adjacent to and beyond the detectors has been shown to have little effect on the dose rates. One can conclude, therefore, that the major contribution to dose rate at the detector positions is from epithermal to fast neutrons which leave the source in nearly the line of sight direction to the detector position.

The criticality alarm system is expected to detect and respond to a minimum accident of concern occurring along the access roads adjacent to the process buildings.

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2.0 INTRODUCTION

Uranium bearing equipment (e.g. compressors) and containers are periodically moved to and from each of the three process buildings at the Portsmouth Gaseous Diffusion Plant. Previous analyses ^[Ref. 5] have shown that the criticality alarm systems present in each of the buildings will respond to the ANSI ANS 8.3 Standard minimum accident of concern occurring anywhere within the buildings. This analysis examines the detector response to an accidental criticality which may occur outside the process buildings.

Neutron detectors are present on the ground and cell floors of each of the three process buildings to cover all areas within the building. Due to their positioning, these detectors vary in their sensitivity to radiation outside of the building. Position within the building dictates not only the distance to an outside position but also the amount of intervening shielding from structures within the building.

Neutron detectors present on the cell level of each building are spaced equidistant from each other and the adjacent side of the building. These detectors were recently relocated to a position 1 meter above the cell floor to ease maintenance and reduce battery failure rates as a result of elevated temperatures above the cell building. Since the access road parallels the building faces, the point on the road farthest from a detector is the point perpendicular to the midpoint between any two detectors.

Detectors present on the ground floor of the process buildings are not uniformly positioned. They are, however, subject to far less shielding from interstitial material as are the cell level detectors.

The criticality alarm system must be able to respond to the ANSI minimum accident of concern. ANSI Standard ANS-8.3-1986, "Criticality Accident Alarm System," provides

guidance for the establishment and maintenance of systems in facilities engaged in the processing of fissionable materials. Section 5.6 of the standard addresses the question of the minimum accident of concern.

5.6. Detection Criterion. Criticality alarm systems shall be designed to detect immediately the minimum accident of concern. For this purpose, in areas where material is handled or processed with only nominal shielding, the minimum accident may be assumed to deliver the equivalent of an absorbed dose in free air of 20 rad at a distance of 2 meters from the reaction material in 60 s. The alarm signal shall activate promptly when the dose rate at the detectors equals or exceeds a value equivalent to 20 rad min⁻¹ at 2 meters from the reacting material.

This detection criterion establishes the reference criticality incident used for this study. In terms of average dose rate, the criticality event generates 1,200 rad h⁻¹ of combined neutron and photon absorbed dose at positions 2 meters from the surface of the critical volume.

A second important consideration addressed by the standard is the ability of the detection system to avoid false alarms from background radiation through the use of appropriate discriminator trip point settings.

5.7.2. To minimize false alarms, the trip point may be set in the rad h⁻¹ range as long as the criterion of 5.6 is met. The alarm trip point of the rate sensing device should be more than 10 mrad h⁻¹ above normal or operational background at the monitoring point.

The neutron background radiation levels within the cascade process buildings are less than 0.1 mrad h⁻¹. An alarm set point of 5 mrad h⁻¹ is used at the Portsmouth facility. [Ref. 6]

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There have not been any false criticality alarms at the Portsmouth facility as a result of high background radiation.

Another factor in the evaluation of the criticality alarm system is the shielding effect of process equipment located between the radiation source and the detectors. The location and spacing are addressed in Section 5.8 of the ANSI standard.

5.8. Spacing. The location and spacing of detectors should be chosen to avoid the effect of shielding by massive equipment or materials. Low density materials of construction such as wood framing, thin interior walls, hollow brick tiles, etc., consistent with the selected alarm point and with the detection criterion.

3.0 PROBLEM SPECIFICATIONS

The question of concern in this analysis is whether or not the criticality alarm systems present in the X-326, X-330 and X-333 process buildings will respond to the ANSI Standard minimum accident of concern occurring at locations outside of the buildings. These locations are all points along the access roads, and the tie lines connecting building X-330 with X-333 and X-326.

Enriched uranium material present in equipment and containers in these cascade buildings may be in the form of UF_6 , UO_2F_2 , UF_4 , or other fluorinated compounds. These compounds may be in various hydrated or solution states. For the purposes of this analysis, it is assumed that a uranyl fluoride solution critical event is representative of the credible situation which may occur. Currently, the Portsmouth Gaseous Diffusion Plant enriches UF_6 to five weight percent U-235. Previous analysis of the criticality alarm detectors has shown that a higher enrichment criticality produces a weaker fission spectrum for the ANSI Standard minimum accident. Lower enrichment criticalities will produce a higher dose rate at the evaluated detector positions. For this reason, an experimentally derived neutron leakage spectrum from a critical uranyl fluoride solution of 4.95 weight percent U-235 enrichment was chosen to describe the source term.^[Ref. 7] This source term from the SHEBA critical experiments^[Ref. 8] will produce the lowest detector dose rate for the enrichment limit corresponding to the minimum accident of concern. The energy spectrum for the 4.95 percent SHEBA source is listed in Table 1.

Dimensions for each of the three building models were obtained from facility blueprints listed in References 9 through 16. Current detector positions for the ground and cell floors were obtained from facility drawings listed in References 17 through 21. It was assumed that the cell floor detectors have been relocated to a height 1 meter from the cell floor as described elsewhere^[Ref. 5]

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Number densities used in the models are listed in Table 2. These were obtained from a previous analysis performed by Westfall et al [Ref. 22], with the exception of materials six through eight, which were mixed in order to account for homogenization of the cell floor, structural material present in the ground floor level, and atmospheric precipitation. Ground floor homogenized number densities are for air containing 2 percent steel to approximate the many vertical support beams present. Atmospheric precipitation number densities include water equivalent to 4 inches of rainfall per hour. The homogenized cell level material is a combination of the homocell and air number densities volume weighted by the corresponding amounts of cell and aisle present on the cell floor of the process buildings.

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Table 1.
Neutron Leakage Spectrum of 4.95% Enriched $\text{UO}_2\text{F}_2\text{-H}_2\text{O}$ Optimum H/U

Group Number	Upper Energy (eV)	Normalized Group Strength
1	2.00e+7	1.99e-2
2	6.43e+6	1.11e-1
3	3.00e+6	1.21e-1
4	1.85e+6	6.45e-2
5	1.40e+6	7.98e-2
6	9.00e+5	1.14e-1
7	4.00e+5	9.77e-2
8	1.00e+5	6.51e-2
9	1.70e+4	4.66e-2
10	3.00e+3	4.08e-2
11	5.50e+2	3.77e-2
12	1.00e+2	2.46e-2
13	3.00e+1	2.14e-2
14	1.00e+1	2.10e-2
15	3.05	1.02e-2
16	1.77	5.93e-3
17	1.30	2.69e-3
18	1.13	2.34e-3
19	1.00	4.33e-3
20	0.8	1.38e-2
21	0.4	4.00e-3
22	0.325	7.25e-3
23	0.225	2.30e-2
24	0.1	2.92e-2
25	0.05	1.70e-2
26	0.03	1.32e-1
27	0.001	2.36e-3
	1.00e-5*	1.00

* Represents lower limit of energy group

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Table 2.
Material Compositions

Material	Element	Number Density (Atom barn ⁻¹ cm ⁻¹)	Element	Number Density (Atom barn ⁻¹ cm ⁻¹)
Air (Zone 1)	Nitrogen	3.570E-5	Oxygen	7.840E-6
Concrete (Zone 2)	Hydrogen	1.487E-2	Aluminum	7.350E-4
	Carbon	3.814E-3	Silicon	6.037E-3
	Oxygen	4.152E-2	Calcium	1.159E-2
	Sodium	3.040E-4	Iron	1.968E-4
	Magnesium	5.870E-4		
Steel (Zone 3)	Carbon	3.921E-3	Iron	8.349E-2
Homogenized Cell (Zone 4)	Carbon	6.230E-5	Chromium	1.619E-4
	Fluorine	8.880E-5	Manganese	1.703E-5
	Aluminum	8.420E-5	Iron	5.934E-4
	Silicon	1.666E-5	Nickel	4.563E-4
	Chlorine	8.800E-5	Copper	3.273E-5
Roof (Zone 5)	Hydrogen	4.288E-2	Oxygen	1.896E-3
	Carbon	1.812E-2	Iron	2.783E-2
Homogenized X-333 Process Area (Zone 6)	Nitrogen	1.37E-2	Chlorine	5.451E-5
	Oxygen	3.027E-6	Chromium	9.934E-5
	Carbon	3.824E-5	Manganese	1.045E-5
	Fluorine	5.451E-5	Iron	3.643E-4
	Aluminum	5.169E-5	Nickel	2.801E-4
	Silicon	1.023E-5	Copper	2.009E-5
Homogenized Ground Level (Zone 7)	Nitrogen	3.570E-5	Iron	1.669E-3
	Oxygen	7.840E-6	Carbon	7.842E-5
Air with Rain (Zone 8)	Nitrogen	3.570E-5	Hydrogen	4.2242E-7
	Oxygen	8.0512E-6		

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4.0 METHODOLOGY

The entire analysis was performed with monte carlo neutron/photon transport code MCNP run in the neutron mode. MCNP uses combinatorial geometry for constructing detailed three dimensional models.

In order to assess dose rate response, a separate MCNP model was constructed of each process building. Each model is a three dimensional representation of the building with a ground level, concrete floor, a cell level consisting of homogenized cells separated by open aisles and a large open bay area above, covered with the building roof. Figures 1 through 4 show the top and side elevation views of the models. Each building is modeled on a concrete ground extending out to the access road location in each direction. Air is used to fill the empty space within the model. All significant fixed shielding is incorporated into the model. It was assumed that there are no other significant radiation shielding materials or objects between potential critical sources and the detectors.

Cell detail was modeled only within one corner of the building. Within the cell region of the model, a detector was modeled corresponding to the corner detector position. In this manner, minimum dose rates could be evaluated along each building face. Regions beyond the detector were modeled as homogenized boxes to give proper backscattering without making the model overly complex.

Figure 5 shows the model geometry of the MCNP input for the X-330 building as interpreted by the SABRINA computer code. The figure shows the cell detail present on the second floor of the model, the building roof (cut away), the concrete floor (magenta), the ground floor (blue), all atop the outside pavement (white). SABRINA allows for visual inspection of MCNP model geometry, aiding in de-bugging, and in no way affects calculational results.

Figure 1. X-326 Building Model - Top View

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Figure 3. X-333 Building Model - Top View

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Figure 4. X-326, X-330, X-333 Building Model — Side Elevation

Legend

Roof		Cells		Access Road
Homogenized Process Bldg.		Concrete Floor		Universe
Ground Floor		

Figure 5. SABRINA Image of MCNP Model

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A simplified two dimensional R-Z model was constructed to evaluate the dose rates for the ground floor detectors. This was done to increase computational efficiency over the large distances dictated by the detector positions. The two dimensional R-Z model is identical to the side view shown in Figure 4 with the source located on the model centerline (Z axis) and all cells modeled as coaxial rings extending radially outward from the source.

Spherical cells of 1.5 meter radius were used to evaluate dose rates at the cell level detector locations. A 1 meter by 1 meter ring shaped box was used in the two dimensional model to represent the ground floor detector locations. Appendix A details the MCNP models used.

Due to the nature of the problem at hand, every effort was made to ensure that the results are conservative and underestimate the detector response. These conservative approaches include source positioning, homogenization of materials, tallying options, and the model geometry itself. No factors used in any of the models could result in an overestimation of dose.

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5.0 RESULTS

Table 3 lists the dose rates at the nearest cell floor detector due to a criticality on the access roads. The results are the of the lowest dose rate due to a source on the access road along the building side listed. The opposite side (listed in parenthesis) will have the results due to the symmetry of the detector layout on the cell floor. For all cases, the minimum of 5 mrad h⁻¹ in air is easily met. Actual dose rates will be much greater than those listed in Table 3 due to the conservative nature of the analysis. Appendix A lists the MCNP input files used to generate all results of this analysis.

Table 3.
Dose Rates at Nearest Detector Positions From Access Road Sources

Building	Face	Distance to Face (meters)	Distance to Detector (meters)	Dose Rate $\pm 1\sigma$ (mrad h ⁻¹)
X-326	East (West)	40	95	38 $\pm$ 1.5
X-326	South (North)	40	86	57 $\pm$ 1.9
X-330	East (West)	40	92	34 $\pm$ 2.3
X-330	South (North)	37	103	38 $\pm$ 2.4
X-333	South (North)	33	110	24 $\pm$ 1.3
X-333	West (East)	51	144	14 $\pm$ 1.3

Table 4 lists the dose rates at the nearest detector due to sources located midway within the inter building tie lines. Each is well above the required 5 mrad h⁻¹. The dose rates are higher from a tie line source due to the elevation of the source. This results in less shielding (primarily from the concrete floor between floors) and the closer proximity to the detectors.

Table 4.
Dose Rates at Nearest Detector From Tie Line Sources

Building	Tie Line Source Position	Dose rate (mrad h⁻¹)
X-326	Northern Face	81 ± 3.6
X-330	Southern Face	93 ± 4.5
X-330	Eastern Face	85 ± 3.7
X-333	Western Face	43 ± 1.9

Table 5 shows the results of the ground floor dose rate calculations. Neutron radiation from the critical source drops off sharply after traveling through more than 40 meters of outside air and 30 meters of the ground floor interior.

Table 5.
Ground Floor Detector Dose Rates

Distance From Source to Detector* (meters)	Dose Rate ±1σ (mrad h⁻¹)
41	2532 ± 40
45	1480 ± 30
49	717 ± 14
53	341 ± 10
57	150 ± 7
61	72 ± 4
65	34 ± 2.4
69	16.7 ± 1.8

* Includes 40 meters of outside air

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The effect of atmospheric precipitation was analyzed due to the additional moderating material introduced between the source and detector during a rain shower. The effect of introducing a moderator to the outside air can impact the dose rate at a detector by softening the neutron spectrum. Softening of the spectrum could result in a lower dose rate due to the behavior of the response function at lower energies. Identical runs were made with and without the rain with the results showing no difference within the 1σ confidence interval.

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APPENDIX A. MCNP INPUTS

The following three MCNP input files were used to generate the dose rate values in this report. A full description of the model is given in the main body of this report. This Appendix explains the technical description of the input files.

Each of the input files contains the same cell cards and surface cards that describe the basic model. Cell dimensions were changed for each model to reflect the different dimensions of each building. The material cards are common to all models. All models are set to run in the neutron mode with the source definition (*sdef*). The energy distribution (*d1*) is listed in the *si1* card as a histogram distribution (h) corresponding to the 27-group structure listed in Table 3. The *sp1* card contains the source probability distribution for the corresponding enrichment, listed in Table 3. The *cut:n* card was used to decrease run times by transporting only particles born above 17 KeV. This was done because the response functions used are of zero value below 17 KeV.

The *f4:n* card indicates cell average flux tally on the cells listed. A brief description of each of the edit cells is given as a comment on the corresponding cell card. The *e4* card modifies the *f4* tally by editing only over the group structure specified by the *e4* entries.

The *em4* card contains the group-wise flux to dose response functions for the energy group structure of the *e4* card. These values are the response functions (listed in Appendix B), multiplied by the source strength (listed in Table 2), multiplied by the conversion factors of 3,600 sec h⁻¹, and 10³ mrad rad⁻¹. The *fc4* tally comment card was used to indicate in the output file that the *f4* tallies were modified by a response function, and the units of mrad h⁻¹ are printed with the results.

Of particular importance to this analysis is the neutron importance card (*imp:n*). These entries assign weight windows to the surfaces of each cell in order to balance the neutron

population between the source and the detector positions. This must be achieved to ensure accuracy of the solution, for information once lost in transport cannot be regained. The importances listed in the *imp:n* card balance the neutron population throughout the problem ensuring adequate detector statistics.

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Table A-1.
X-326 Building Model with Eastern Face Source

x-326 building		+py	-py	+px	-px	+pz	-pz		
c	x326e								
c	eastern face source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-112	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5	\$ j7

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```

51 4 1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1 4.354e-5 -301
200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 1800
103 py 2800
104 py 3200
105 py 4200
106 py 4600
107 py 5600
108 py 6000
109 py 7000
110 py 7400
111 py 8400
112 py 16800
113 py 8800
114 py 9800
200 px -4000.1 $ southern source surface
201 px 0
202 px 2000
203 px 3400
204 px 4100
205 px 6900
206 px 76000
207 px 7600
208 px 10400
301 s 4250 2500 881 150
mode n
imp:n 1 1 0 1 4 0 0 1 1 4 1 1 1 4 1 1 1 1 0
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 1 1 0 0
      0 0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0
sdef erg=d1 pos= 10950 -4000 100 $ eastern source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
sp1 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
      7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)
m1 7014.50c 3.570e-5 $ air
      8016.50c 7.840e-6

```

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m2	1001.50c	1.487e-2	\$ concrete
	6012.50c	3.814e-2	
	8016.50c	4.152e-2	
	11023.50c	3.040e-4	
	12000.51c	5.870e-4	
	13027.50c	7.350e-4	
	14000.50c	6.037e-3	
	20000.51c	1.159e-2	
	26000.50c	1.968e-4	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area
	8016.50c	3.027e-6	
	6012.50c	3.824e-5	
	9019.50c	5.451e-5	
	13027.50c	5.169e-5	
	14000.50c	1.023e-5	
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	\$ homogenized ground level
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
nps	50000000		
print			
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	\$ homogenized ground level
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
nps	50000000		
print			

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Table A-2.
X-326 Building with Northern Face Source

x-326 building		+py	-py	+px	-px	+pz	-pz	
c	x326s							
c	southern face source							
c	4.95% enriched optimum							h/u source
1	2	7.9654e-2	100	-112	200	-206	1	-2 \$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7 \$ ae air (east)
3	1	4.354e-5	101	-114	200	-201	2	-7 \$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3 \$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4 \$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5 \$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5 \$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6 \$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7 \$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5 \$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5 \$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5 \$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5 \$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5 301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5 \$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5 \$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5 \$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5 \$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5 \$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5 \$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5 \$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5 \$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5 \$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5 \$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5 \$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5 \$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5 \$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5 \$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5 \$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5 \$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5 \$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5 \$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5 \$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5 \$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5 \$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5 \$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5 \$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5 \$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5 \$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5 \$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5 \$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5 \$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5 \$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5 \$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5 \$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5 \$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5 \$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5 \$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5 \$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5 \$ j7
51	4	1.6021e-3	113	-114	207	-208	4	-5 \$ c18
101	1	4.354e-5	-301					

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```

200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 114 -112 200 -201 2 -7 $ asw
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 1800
103 py 2800
104 py 3200
105 py 4200
106 py 4600
107 py 5600
108 py 6000
109 py 7000
110 py 7400
111 py 8400
112 py 16800
113 py 8800
114 py 9800
200 px -4000.1 $ southern source surface
201 px 0
202 px 2000
203 px 3400
204 px 4100
205 px 6900
206 px 76000
207 px 7600
208 px 10400
301 s 4250 2500 881 150
mode n
imp:n 1 0 1 1 1 0 0 1 1 1 3 4 4 4 4 3 3 3 3 3
      3 3 2 2 2 2 2 1 1 1 1 1 1 1 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0
sdef erg=d1 pos= -4000 6900 100 $ southern source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
si1 h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
sp1 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
      7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)

```

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m1	7014.50c	3.570e-5	\$ air		
	8016.50c	7.840e-6			
m2	1001.50c	1.487e-2	\$ concrete	8016.50c	4.152e-2
	11023.50c	3.040e-4			
	12000.51c	5.870e-4			
	13027.50c	7.350e-4			
	14000.50c	6.037e-3			
	20000.51c	1.159e-2			
	26000.50c	1.968e-4			
m3	6012.50c	3.921e-3	\$ steel		
	26000.50c	8.349e-2			
m4	6012.50c	6.230e-5	\$ homogenized cell material		
	9019.50c	8.880e-5			
	13027.50c	8.420e-5			
	14000.50c	1.666e-5			
	17000.50c	8.880e-5			
	24000.50c	1.619e-4			
	25055.51c	1.703e-5			
	26000.50c	5.934e-4			
	28000.50c	4.563e-4			
	29000.50c	3.273e-5			
m5	1001.50c	4.288e-2	\$ roof		
	6012.50c	1.812e-2			
	8016.50c	1.896e-3			
	26000.50c	2.783e-2			
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area		
	8016.50c	3.027e-6			
	6012.50c	3.824e-5			
	9019.50c	5.451e-5			
	13027.50c	5.169e-5			
	14000.50c	1.023e-5			
	17000.50c	5.451e-5			
	24000.50c	9.934e-5			
	25055.51c	1.045e-5			
	26000.50c	3.643e-4			
	28000.50c	2.801e-4			
	29000.50c	2.009e-5			
m7	7014.50c	3.570e-5			
	8016.50c	7.840e-6			
	26000.50c	1.669e-3			
	6012.50c	7.842e-5			
nps	50000000				
print					

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Table A-3.
X-330 Building Model with Eastern Face Source

x-330 building			+py	-py	+px	-px	+pz	-pz	
c	x330e								
c	eastern face source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	400	-209	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-112	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	\$ 301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17

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```

50 1 4.354e-5 113 -114 205 -207 4 -5 $ j7
51 4 1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1 4.354e-5 -301 $ cell level det
200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 100 -101 209 -206 2 -7 $ aee
204 1 4.354e-5 -400 100 201 2 -7 $ ae lower
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 2000
103 py 3300
104 py 3700
105 py 5000
106 py 5400
107 py 6700
108 py 7100
109 py 8400
110 py 8800
111 py 10100
112 py 19400
113 py 10500
114 py 11800
200 px -3700.1 $ southern source surface
201 px 0
202 px 600
203 px 2900
204 px 3700
205 px 6000
206 px 66300
207 px 6800
208 px 9100
209 px 9751 $ aee plane
301 s 3860 3000 881 100
400 p 1 2.425 0 0 $ cutoff plane
mode n
imp:n 1 1 0 1 4 0 0 1 1 4 1 1 1 4 1 1 1 1 0
      0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 1 1 0 0
      0 0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0
sdef erg=d1 pos= 9750 -4000 100 $ eastern source position in cm
cut:n le50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199

```

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```

f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)
m1 7014.50c 3.570e-5 $ air
8016.50c 7.840e-6
m2 1001.50c 1.487e-2 $ concrete
6012.50c 3.814e-2
8016.50c 4.152e-2
11023.50c 3.040e-4
12000.51c 5.870e-4
13027.50c 7.350e-4
14000.50c 6.037e-3
20000.51c 1.159e-2
26000.50c 1.968e-4
m3 6012.50c 3.921e-3 $ steel
26000.50c 8.349e-2
m4 6012.50c 6.230e-5 $ homogenized cell material
9019.50c 8.880e-5
13027.50c 8.420e-5
14000.50c 1.666e-5
17000.50c 8.880e-5
24000.50c 1.619e-4
25055.51c 1.703e-5
26000.50c 5.934e-4
28000.50c 4.563e-4
29000.50c 3.273e-5
m5 1001.50c 4.288e-2 $ roof
6012.50c 1.812e-2
8016.50c 1.896e-3
26000.50c 2.783e-2
m6 7014.50c 1.378e-5 $ homogenized x-333 process area
8016.50c 3.027e-6
6012.50c 3.824e-5
9019.50c 5.451e-5
13027.50c 5.169e-5
14000.50c 1.023e-5
17000.50c 5.451e-5
24000.50c 9.934e-5
25055.51c 1.045e-5
26000.50c 3.643e-4
28000.50c 2.801e-4
29000.50c 2.009e-5
m7 7014.50c 3.570e-5 $ homogenized ground level
8016.50c 7.840e-6
26000.50c 1.669e-3
6012.50c 7.842e-5
nps 36000000
print

```

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Table A-4.
X-330 Building Model with Southern Face Source

x-330 building		+py	-py	+px	-px	+pz	-pz		
c	x330s								
c	southern face source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-114	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17

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```

50 1 4.354e-5 113 -114 205 -207 4 -5 $ j7
51 4 1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1 4.354e-5 -301
200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 114 -112 200 -201 2 -7 $ asw
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 2000
103 py 3300
104 py 3700
105 py 5000
106 py 5400
107 py 6700
108 py 7100
109 py 8400
110 py 8800
111 py 10100
112 py 19400
113 py 10500
114 py 11800
200 px -3700.1 $ southern source surface
201 px 0
202 px 600
203 px 2900
204 px 3700
205 px 6000
206 px 66300
207 px 6800
208 px 9100
301 s 3860 3000 881 100
mode n
imp:n 1 0 1 1 1 0 0 1 1 1 3 4 4 4 4 3 3 3 3 3
      3 3 2 2 2 2 2 1 1 1 1 1 1 1 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0
sdef erg=d1 pos= -3700 9700 100 $ southern source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
      7.488e11 8.975e11

```

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```

fc4  cell average dose rate (mrad/h)
m1   7014.50c  3.570e-5  $ air
      8016.50c  7.840e-6
m2   1001.50c  1.487e-2  $ concrete
      6012.50c  3.814e-2
      8016.50c  4.152e-2
      11023.50c 3.040e-4
      12000.51c 5.870e-4
      13027.50c 7.350e-4
      14000.50c 6.037e-3
      20000.51c 1.159e-2
      26000.50c 1.968e-4

m3   6012.50c  3.921e-3  $ steel
      26000.50c 8.349e-2
m4   6012.50c  6.230e-5  $ homogenized cell material
      9019.50c  8.880e-5
      13027.50c 8.420e-5
      14000.50c 1.666e-5
      17000.50c 8.880e-5
      24000.50c 1.619e-4
      25055.51c 1.703e-5
      26000.50c 5.934e-4
      28000.50c 4.563e-4
      29000.50c 3.273e-5
m5   1001.50c  4.288e-2  $ roof
      6012.50c  1.812e-2
      8016.50c  1.896e-3
      26000.50c 2.783e-2
m6   7014.50c  1.378e-5  $ homogenized x-333 process area
      8016.50c  3.027e-6
      6012.50c  3.824e-5
      9019.50c  5.451e-5
      13027.50c 5.169e-5
      14000.50c 1.023e-5
      17000.50c 5.451e-5
      24000.50c 9.934e-5
      25055.51c 1.045e-5
      26000.50c 3.643e-4
      28000.50c 2.801e-4
      29000.50c 2.009e-5
m7   7014.50c  3.570e-5  $ homogenized ground level
      8016.50c  7.840e-6
      26000.50c 1.669e-3
      6012.50c  7.842e-5
nps  40000000
print

```

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Table A-5.
X-333 Building Model with Southern Face Source

x-333 building		+py	-py	+px	-px	+pz	-pz	
c	x333s							
c	southern face source							
c	4.95% enriched optimum h/u source							
1	2	7.9654e-2	100	-112	200	-206	1	-2 \$ concrete ground
2	1	4.354e-5	100	-101	201	-209	2	-7 \$ as air (south)
3	1	4.354e-5	101	-112	200	-201	2	-7 \$ aw air (west)
4	7	1.791e-3	101	-114	201	-208	2	-3 \$ 1st level under cell
5	2	7.9654e-2	101	-112	201	-206	3	-4 \$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5 \$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5 \$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6 \$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7 \$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5 \$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5 \$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5 \$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5 \$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5 \$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5 \$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5 \$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5 \$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5 \$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5 301 \$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5 \$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5 \$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5 \$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5 \$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5 \$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5 \$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5 \$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5 \$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5 \$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5 \$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5 \$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5 \$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5 \$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5 \$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5 \$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5 \$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5 \$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5 \$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5 \$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5 \$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5 \$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5 \$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5 \$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5 \$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5 \$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5 \$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5 \$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5 \$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5 \$ c17

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```

50 1 4.354e-5 113 -114 205 -207 4 -5 $ j7
51 4 1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1 4.354e-5 -301 $ cell level detector
200 1 4.354e-5 100 -101 200 -201 2 -7 $ asw air (southwest)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 100 -101 209 -206 2 -7 $ ase
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -3300.1 $ southern source surface
101 py 0
102 py 1250
103 py 3140
104 py 3780
105 py 5670
106 py 6310
107 py 8200
108 py 8840
109 py 10730
110 py 11370
111 py 13260
112 py 29500
113 py 13900
114 py 15790
200 px -5100.1 $ western source surface
201 px 0
202 px 730
203 px 5380
204 px 6290
205 px 10940
206 px 44400
207 px 11670
208 px 16320
209 px 11760
301 s 6300 6150 871 150
mode n
imp:n 1 1 0 1 4 0 0 1 1 4 1 3 4 4 4 1 4 4 4 4
      1 1 1 4 1 0 0 0 0 0 0 0 0 0 4 4 3 3 2 2
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0
sdef erg=d1 pos= 11750 -3300 100 $ southern source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101

```

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```

e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)
m1 7014.50c 3.570e-5 $ air
8016.50c 7.840e-6
m2 1001.50c 1.487e-2 $ concrete
6012.50c 3.814e-2
8016.50c 4.152e-2
11023.50c 3.040e-4
12000.51c 5.870e-4
13027.50c 7.350e-4
14000.50c 6.037e-3
20000.51c 1.159e-2
26000.50c 1.968e-4
m3 6012.50c 3.921e-3 $ steel
26000.50c 8.349e-2
m4 6012.50c 6.230e-5 $ homogenized cell material
9019.50c 8.880e-5
13027.50c 8.420e-5
14000.50c 1.666e-5
17000.50c 8.880e-5
24000.50c 1.619e-4
25055.51c 1.703e-5
26000.50c 5.934e-4
28000.50c 4.563e-4
29000.50c 3.273e-5
m5 1001.50c 4.288e-2 $ roof
6012.50c 1.812e-2
8016.50c 1.896e-3
26000.50c 2.783e-2
m6 7014.50c 1.378e-5 $ homogenized process area
8016.50c 3.027e-6
6012.50c 3.824e-5
9019.50c 5.451e-5
13027.50c 5.169e-5
14000.50c 1.023e-5
17000.50c 5.451e-5
24000.50c 9.934e-5
25055.51c 1.045e-5
26000.50c 3.643e-4
28000.50c 2.801e-4
29000.50c 2.009e-5
m7 7014.50c 3.570e-5 $ homogenized ground floor 2% steel
8016.50c 7.840e-6
26000.50c 1.669e-3
6012.50c 7.842e-5
nps 50000000
print

```

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Table A-6.
X-333 Building Model with Western Face Source

x-333 building		+py	-py	+px	-px	+pz	-pz	
c	x333w							
c	western face source							
c	4.95% enriched optimum h/u source							
1	2	7.9654e-2	100	-112	200	-206	1	-2 \$ concrete ground
2	1	4.354e-5	100	-101	201	-209	2	-7 \$ as air (south)
3	1	4.354e-5	101	-115	200	-201	2	-7 \$ aw air (west)
4	7	1.791e-3	101	-114	201	-208	2	-3 \$ 1st level under cell
5	2	7.9654e-2	101	-112	201	-206	3	-4 \$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5 \$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5 \$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6 \$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7 \$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5 \$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5 \$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5 \$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5 \$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5 \$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5 \$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5 \$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5 \$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5 \$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5 301 \$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5 \$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5 \$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5 \$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5 \$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5 \$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5 \$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5 \$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5 \$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5 \$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5 \$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5 \$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5 \$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5 \$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5 \$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5 \$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5 \$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5 \$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5 \$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5 \$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5 \$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5 \$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5 \$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5 \$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5 \$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5 \$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5 \$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5 \$ c16
48	1	4.354e-5	113	-114*p1045X2004	2004	4	-5 \$ i6	
49	4	1.6021e-3	113	-114	204	-205	4	-5 \$ c17

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```

50  1  4.354e-5  113 -114 205 -207 4 -5 $ j7
51  4  1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1  4.354e-5 -301 $ cell level detector
200 1  4.354e-5 100 -101 200 -201 2 -7 $ asw air (southwest)
201 7  1.791e-3 101 -114 208 -206 2 -3 $ la
202 7  1.791e-3 114 -112 201 -206 2 -3 $ lb
203 1  4.354e-5 100 -101 209 -206 2 -7 $ ase
204 1  4.354e-5 115 -112 200 -201 2 -7 $ anw
900 0 -100:112:-200:206:-1:7 $ universe

1  pz -100
2  pz  0
3  pz 700
4  pz 720
5  pz 1050
6  pz 2370
7  pz 2380
100 py -3300.1 $ southern source surface
101 py  0
102 py 1250
103 py 3140
104 py 3780
105 py 5670
106 py 6310
107 py 8200
108 py 8840
109 py 10730
110 py 11370
111 py 13260
112 py 29500
113 py 13900
114 py 15790
115 py 15010
200 px -5100.1 $ western source surface
201 px  0
202 px 730
203 px 5380
204 px 6290
205 px 10940
206 px 44400
207 px 11670
208 px 16320
209 px 11760
301 s  6300 6150 871 150

301 s  6300 6150 871 150

mode n
imp:n 1 0 1 1 4 0 0 1 1 1 1 1 1 1 1 2 2 2 2 4
      4 4 4 4 3 3 3 2 1 1 1 1 1 1 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0 0
sdef erg=d1 pos= -5100 15000 100 $ western source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214

```

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```

0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
0.0645 0.121 0.111 0.0199
f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)

m1 7014.50c 3.570e-5 $ air
8016.50c 7.840e-6
m2 1001.50c 1.487e-2 $ concrete
6012.50c 3.814e-2
8016.50c 4.152e-2
11023.50c 3.040e-4
12000.51c 5.870e-4
13027.50c 7.350e-4
14000.50c 6.037e-3
20000.51c 1.159e-2
26000.50c 1.968e-4
m3 6012.50c 3.921e-3 $ steel
26000.50c 8.349e-2
m4 6012.50c 6.230e-5 $ homogenized cell material
9019.50c 8.880e-5
13027.50c 8.420e-5
14000.50c 1.666e-5
17000.50c 8.880e-5
24000.50c 1.619e-4
25055.51c 1.703e-5
26000.50c 5.934e-4
28000.50c 4.563e-4
29000.50c 3.273e-5
m5 1001.50c 4.288e-2 $ roof
6012.50c 1.812e-2
8016.50c 1.896e-3
26000.50c 2.783e-2
m6 7014.50c 1.378e-5 $ homogenized process area
8016.50c 3.027e-6
6012.50c 3.824e-5
9019.50c 5.451e-5
13027.50c 5.169e-5
14000.50c 1.023e-5
17000.50c 5.451e-5
24000.50c 9.934e-5
25055.51c 1.045e-5
26000.50c 3.643e-4
28000.50c 2.801e-4
29000.50c 2.009e-5
m7 7014.50c 3.570e-5 $ homogenized ground floor 2% steel
8016.50c 7.840e-6
26000.50c 1.669e-3
6012.50c 7.842e-5
nps 50000000
print

```

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Table A-7.
X-326 Building with Southern Tie Line Source

x-326 building			+py	-py	+px	-px	+pz	-pz	
c	x326st								
c	southern face tie line source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-114	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	301 \$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	\$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5	\$ j7
51	4	1.6021e-3	113	-114	207	-208	4	-5	\$ c18
101	1	4.354e-5	-301						

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```

200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 114 -112 200 -201 2 -7 $ asw
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 1800
103 py 2800
104 py 3200
105 py 4200
106 py 4600
107 py 5600
108 py 6000
109 py 7000
110 py 7400
111 py 8400
112 py 16800
113 py 8800
114 py 9800
200 px -3850.1 $ southern source surface
201 px 0
202 px 2000
203 px 3400
204 px 4100
205 px 6900
206 px 76000
207 px 7600
208 px 10400
301 s 3551 2500 881 150
mode n
imp:n 1 0 1 1 1 0 0 1 1 1 3 4 4 4 4 3 3 3 3 3
      3 3 2 2 2 2 2 1 1 1 1 1 1 1 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0
sdef erg=d1 pos= -3850 669 1339 $ southern source position in cm
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
      7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)

```

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m1	7014.50c	3.570e-5	\$ air
	8016.50c	7.840e-6	
m2	1001.50c	1.487e-2	\$ concrete
	6012.50c	3.814e-2	
	8016.50c	4.152e-2	
	11023.50c	3.040e-4	
	12000.51c	5.870e-4	
	13027.50c	7.350e-4	
	14000.50c	6.037e-3	
	20000.51c	1.159e-2	
	26000.50c	1.968e-4	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area
	8016.50c	3.027e-6	
	6012.50c	3.824e-5	
	9019.50c	5.451e-5	
	13027.50c	5.169e-5	
	14000.50c	1.023e-5	
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
nps	20000000		
print			

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Table A-8.
X-330 Building Model with Southern Tie Line Source

x-330 building		+py	-py	+px	-px	+pz	-pz		
c	x330st								
c	southern face tie line source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-114	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5	\$ j7
51	4	1.6021e-3	113	-114	207	-208	4	-5	\$ c18

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```

101 1 4.354e-5 -301
200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 114 -112 200 -201 2 -7 $ asw
900 0 -100:112:-200:206:-1:7 $ universe

```

```

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -4000.1 $ eastern source surface
101 py 0
102 py 2000
103 py 3300
104 py 3700
105 py 5000
106 py 5400
107 py 6700
108 py 7100
109 py 8400
110 py 8800
111 py 10100
112 py 19400
113 py 10500
114 py 11800
200 px -3850.1 $ southern source surface
201 px 0
202 px 600
203 px 2900
204 px 3700
205 px 6000
206 px 66300
207 px 6800
208 px 9100
301 s 3860 3000 881 100

```

mode n

```

imp:n 1 0 1 1 1 0 0 1 1 1 3 4 4 4 4 3 3 3 3 3
      3 3 2 2 2 2 2 1 1 1 1 1 1 1 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0

```

sdef erg=d1 pos= -3850 669 1339 \$ south tie line source

cut:n 1e50 0.017 -0.50 -0.25 0

```

sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20

```

```

spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199

```

f4:n 101

```

e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20

```

```

em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
      7.488e11 8.975e11

```

fc4 cell average dose rate (mrad/h)

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m1	7014.50c	3.570e-5	\$ air
	8016.50c	7.840e-6	
m2	1001.50c	1.487e-2	\$ concrete
	6012.50c	3.814e-2	
	8016.50c	4.152e-2	
	11023.50c	3.040e-4	
	12000.51c	5.870e-4	
	13027.50c	7.350e-4	
	14000.50c	6.037e-3	
	20000.51c	1.159e-2	
	26000.50c	1.968e-4	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area
	8016.50c	3.027e-6	
	6012.50c	3.824e-5	
	9019.50c	5.451e-5	
	13027.50c	5.169e-5	
	14000.50c	1.023e-5	
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	\$ homogenized ground level
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
nps	25000000		
print			

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Table A-9.
X-330 Building Model with Eastern Tie Line Source

x-330 building			+py	-py	+px	-px	+pz	-pz	
c x330et									
c eastern face tie line source									
c 4.95% enriched optimum h/u source									
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	400	-209	2	-7	\$ ae air (east)
3	1	4.354e-5	101	-112	200	-201	2	-7	\$ as air (south)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	301 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	\$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17

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```

50 1 4.354e-5 113 -114 205 -207 4 -5 $ j7
51 4 1.6021e-3 113 -114 207 -208 4 -5 $ c18
101 1 4.354e-5 -301 $ cell level det
200 1 4.354e-5 100 -101 200 -201 2 -7 $ ase air (southeast)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 100 -101 209 -206 2 -7 $ aee
204 1 4.354e-5 -400 100 201 2 -7 $ ae lower
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -6600.1 $ eastern source surface
101 py 0
102 py 2000
103 py 3300
104 py 3700
105 py 5000
106 py 5400
107 py 6700
108 py 7100
109 py 8400
110 py 8800
111 py 10100
112 py 19400
113 py 10500
114 py 11800
200 px -4550.1 $ southern source surface
201 px 0
202 px 600
203 px 2900
204 px 3700
205 px 6000
206 px 66300
207 px 6800
208 px 9100
209 px 9751 $ aee plane
301 s 3860 3000 881 100
400 p 1 1.448 0 0 $ cutoff plane
mode n
imp:n 1 1 0 1 4 0 0 1 1 4 1 1 1 4 1 1 1 1 0
      0 0 0 0 0 0 0 0 0 0 2 1 1 1 0 0
      0 0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0
sdef erg=d1 pos= 6600 -4550 1487 $ eastern source position in cm
cut:n le50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199
f4:n 101

```

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m1	7014.50c	3.570e-5	\$ air
	8016.50c	7.840e-6	
m2	1001.50c	1.487e-2	\$ concrete
	6012.50c	3.814e-2	
	8016.50c	4.152e-2	
	11023.50c	3.040e-4	
	12000.51c	5.870e-4	
	13027.50c	7.350e-4	
	14000.50c	6.037e-3	
	20000.51c	1.159e-2	
	26000.50c	1.968e-4	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area
	8016.50c	3.027e-6	
	6012.50c	3.824e-5	
	9019.50c	5.451e-5	
	13027.50c	5.169e-5	
	14000.50c	1.023e-5	
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	\$ homogenized ground level
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
nps	30000000		
print			

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Table A-10.
X-333 Building Model with Western Tie Line Source

x-333 building		+py	-py	+px	-px	+pz	-pz		
c	x333wt								
c	western face tie line source								
c	4.95% enriched optimum h/u source								
1	2	7.9654e-2	100	-112	200	-206	1	-2	\$ concrete ground
2	1	4.354e-5	100	-101	201	-209	2	-7	\$ as air (south)
3	1	4.354e-5	101	-115	200	-201	2	-7	\$ aw air (west)
4	7	1.791e-3	101	-114	201	-208	2	-3	\$ 1st level under cell
5	2	7.9654e-2	101	-112	201	-206	3	-4	\$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5	\$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5	\$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6	\$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7	\$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5	\$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5	\$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5	\$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5	\$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5	\$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5	\$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5	\$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5	\$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5	\$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5	\$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5	301 \$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5	\$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5	\$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5	\$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5	\$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5	\$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5	\$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5	\$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5	\$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5	\$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5	\$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5	\$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5	\$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5	\$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5	\$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5	\$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5	\$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5	\$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5	\$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5	\$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5	\$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5	\$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5	\$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5	\$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5	\$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5	\$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5	\$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5	\$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5	\$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5	\$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5	\$ j7
51	4	1.6021e-3	113	-114	207	-208	4	-5	\$ c18

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```

101 1 4.354e-5 -301 $ cell level detector
200 1 4.354e-5 100 -101 200 -201 2 -7 $ asw air (southwest)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
203 1 4.354e-5 100 -101 209 -206 2 -7 $ ase
204 1 4.354e-5 115 -112 200 -201 2 -7 $ anw
900 0 -100:112:-200:206:-1:7 $ universe

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -3300.1 $ southern source surface
101 py 0
102 py 1250
103 py 3140
104 py 3780
105 py 5670
106 py 6310
107 py 8200
108 py 8840
109 py 10730
110 py 11370
111 py 13260
112 py 29500
113 py 13900
114 py 15790
115 py 15010
200 px -4550.1 $ western source surface
201 px 0
202 px 730
203 px 5380
204 px 6290
205 px 10940
206 px 44400
207 px 11670
208 px 16320
209 px 11760
301 s 6300 6150 871 150
mode n
imp:n 1 0 1 1 4 0 0 1 1 1 1 1 1 1 1 2 2 2 2 4
      4 4 4 4 3 3 3 2 1 1 1 1 1 1 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0 0
sdef erg=d1 pos= -4550 9300 1487 $ western tie line source
cut:n 1e50 0.017 -0.50 -0.25 0
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00236 0.0132 0.017 0.0292 0.023 0.00725 0.004
      0.0138 0.00433 0.00234 0.00269 0.00593 0.0102 0.021 0.0214
      0.0246 0.0377 0.0408 0.0466 0.0651 0.0977 0.114 0.0798
      0.0645 0.121 0.111 0.0199

```

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```

f4:n 101
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 4.969e10 1.959e11 3.097e11 4.164e11 4.654e11 5.651e11
7.488e11 8.975e11
fc4 cell average dose rate (mrad/h)
m1 7014.50c 3.570e-5 $ air
8016.50c 7.840e-6
m2 1001.50c 1.487e-2 $ concrete
6012.50c 3.814e-2
8016.50c 4.152e-2
11023.50c 3.040e-4
12000.51c 5.870e-4
13027.50c 7.350e-4
14000.50c 6.037e-3
20000.51c 1.159e-2
26000.50c 1.968e-4
m3 6012.50c 3.921e-3 $ steel
26000.50c 8.349e-2
m4 6012.50c 6.230e-5 $ homogenized cell material
9019.50c 8.880e-5
13027.50c 8.420e-5
14000.50c 1.666e-5
17000.50c 8.880e-5
24000.50c 1.619e-4
25055.51c 1.703e-5
26000.50c 5.934e-4
28000.50c 4.563e-4
29000.50c 3.273e-5
m5 1001.50c 4.288e-2 $ roof
6012.50c 1.812e-2
8016.50c 1.896e-3
26000.50c 2.783e-2
m6 7014.50c 1.378e-5 $ homogenized process area
8016.50c 3.027e-6
6012.50c 3.824e-5
9019.50c 5.451e-5
13027.50c 5.169e-5
14000.50c 1.023e-5
17000.50c 5.451e-5
24000.50c 9.934e-5
25055.51c 1.045e-5
26000.50c 3.643e-4
28000.50c 2.801e-4
29000.50c 2.009e-5
m7 7014.50c 3.570e-5 $ homogenized ground floor 2% steel
8016.50c 7.840e-6
26000.50c 1.669e-3
6012.50c 7.842e-5
nps 40000000
print

```

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Table A-11.
X-326, X-330 and X-333 Ground Floor Model

ground level detector dose rates
c 2d model for ground floor detectors
c buildings x-326 x-330 x-333

c			+pz	-pz	-cz	+cz	
1	2	7.9654e-2	1	-2	-118		\$ concrete ground
2	1	4.354e-5	2	-7	-100		\$ outside air
3	2	7.9654e-2	3	-4	-118	100	\$ concrete floor (2nd level)
4	6	1.0003e-3	4	-5	-118	100	\$ homo process area
5	1	4.354e-5	5	-6	-118	100	\$ upper bay (2nd level)
6	5	9.0726e-2	6	-7	-118	100	\$ roof
7	7	1.791e-3	2	-3	-101	100	\$ erp
8	7	1.791e-3	2	-3	-102	101	
9	1	4.354e-5	2	-3	-103	102	\$ tails, 33-1-g
10	7	1.791e-3	2	-3	-104	103	
11	1	4.354e-5	2	-3	-105	104	\$ tails
12	7	1.791e-3	2	-3	-106	105	
13	1	4.354e-5	2	-3	-107	106	\$ se-6
14	7	1.791e-3	2	-3	-108	107	
15	1	4.354e-5	2	-3	-109	108	\$ se-6
16	7	1.791e-3	2	-3	-110	109	
17	1	4.354e-5	2	-3	-111	110	
18	7	1.791e-3	2	-3	-112	111	
19	1	4.354e-5	2	-3	-113	112	
20	7	1.791e-3	2	-3	-114	113	
21	1	4.354e-5	2	-3	-115	114	
22	7	1.791e-3	2	-3	-118	115	
100	0						

-1:7:118

1	pz	-100
2	pz	0
3	pz	700
4	pz	720
5	pz	1050
6	pz	2370
7	pz	2380
100	cz	4000
101	cz	4200
102	cz	7000
103	cz	7200
104	cz	7400
105	cz	7600
106	cz	7800
107	cz	8000
108	cz	8200
109	cz	8400
110	cz	8600
111	cz	8800
112	cz	9000
113	cz	9200
114	cz	9400
115	cz	9600
116	cz	10100
117	cz	10300
118	cz	60000

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```

mode n
imp:n 1 1 0 0 0 0 1.5 1.5 1.5 2 2 2 2.5 2.5 2.5 3 3 4 4 4 4 1 0
sdef erg=d1 pos= 0 0 100 $ centerline source position in cm
sil h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
spl 0 0.00261 0.0146 0.0189 0.0324 0.0259 0.00817 0.00445
      0.0152 0.0047 0.00255 0.00292 0.00641 0.011 0.0219 0.0235
      0.0269 0.0424 0.0459 0.0516 0.0712 0.101 0.114 0.0743
      0.0588 0.108 0.0945 0.016
f4:n 9 11 13 15 17 19 21
e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20
em4 0.0 6.636e10 2.616e11 4.136e11 5.561e11 6.215e11 7.546e11
      9.999e11 1.199e12
fc4 cell average dose rate (mrad/h)
m1 7014.50c 3.570e-5 $ air
      8016.50c 7.840e-6
m2 1001.50c 1.487e-2 $ concrete
      6012.50c 3.814e-2
      8016.50c 4.152e-2
      11023.50c 3.040e-4
      12000.51c 5.870e-4
      13027.50c 7.350e-4
      14000.50c 6.037e-3
      20000.51c 1.159e-2
      26000.50c 1.968e-4
m3 6012.50c 3.921e-3 $ steel
      26000.50c 8.349e-2
m4 6012.50c 6.230e-5 $ homogenized cell material
      9019.50c 8.880e-5
      13027.50c 8.420e-5
      14000.50c 1.666e-5
      17000.50c 8.880e-5
      24000.50c 1.619e-4
      25055.51c 1.703e-5
      26000.50c 5.934e-4
      28000.50c 4.563e-4
      29000.50c 3.273e-5
m5 1001.50c 4.288e-2 $ roof
      6012.50c 1.812e-2
      8016.50c 1.896e-3
      26000.50c 2.783e-2
m6 7014.50c 1.378e-5 $ homogenized x-333 process area
      8016.50c 3.027e-6
      6012.50c 3.824e-5
      9019.50c 5.451e-5
      13027.50c 5.169e-5
      14000.50c 1.023e-5
      17000.50c 5.451e-5
      24000.50c 9.934e-5
      25055.51c 1.045e-5
      26000.50c 3.643e-4
      28000.50c 2.801e-4
      29000.50c 2.009e-5
m7 7014.50c 3.570e-5 $ homogenized ground level
      8016.50c 7.840e-6
      26000.50c 1.669e-3
      6012.50c 7.842e-5

```

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Table A-12.
Atmospheric Precipitation Model

x-333 building		+py	-py	+px	-px	+pz	-pz	
c atmospheric precipitation model								
c western face source								
1	2	7.9654e-2	100	-112	200	-206	1	-2 \$ concrete ground
2	1	4.354e-5	100	-101	201	-206	2	-7 \$ as air (south)
3	8	4.3711e-5	101	-112	200	-201	2	-7 \$ aw air (west)
4	7	1.791e-3	101	-114	201	-208	2	-3 300 \$ 1st level
5	2	7.9654e-2	101	-112	201	-206	3	-4 \$ concrete floor
6	6	1.0003e-3	101	-114	208	-206	4	-5 \$ 2a homo process area
7	6	1.0003e-3	114	-112	201	-206	4	-5 \$ 2b homo process area
8	1	4.354e-5	101	-112	201	-206	5	-6 \$ upper bay
9	5	9.0726e-2	101	-112	201	-206	6	-7 \$ roof
10	1	4.354e-5	101	-102	201	-208	4	-5 \$ a1
11	1	4.354e-5	102	-103	201	-202	4	-5 \$ w1
12	4	1.6021e-3	102	-103	202	-203	4	-5 \$ c1
13	1	4.354e-5	102	-103	203	-204	4	-5 \$ i1
14	4	1.6021e-3	102	-103	204	-205	4	-5 \$ c2
15	1	4.354e-5	103	-104	201	-208	4	-5 \$ a2
16	1	4.354e-5	104	-105	201	-202	4	-5 \$ w2
17	4	1.6021e-3	104	-105	202	-203	4	-5 \$ c3
18	1	4.354e-5	104	-105	203	-204	4	-5 \$ i2
19	4	1.6021e-3	104	-105	204	-205	4	-5 \$ c4
20	1	4.354e-5	105	-106	201	-208	4	-5 301 \$ a3
21	1	4.354e-5	106	-107	201	-202	4	-5 \$ w3
22	4	1.6021e-3	106	-107	202	-203	4	-5 \$ c5
23	1	4.354e-5	106	-107	203	-204	4	-5 \$ i3
24	4	1.6021e-3	106	-107	204	-205	4	-5 \$ c6
25	1	4.354e-5	107	-108	201	-208	4	-5 \$ a4
26	1	4.354e-5	108	-109	201	-202	4	-5 \$ w4
27	4	1.6021e-3	108	-109	202	-203	4	-5 \$ c7
28	1	4.354e-5	108	-109	203	-204	4	-5 \$ i4
29	4	1.6021e-3	108	-109	204	-205	4	-5 \$ c8
30	1	4.354e-5	109	-110	201	-208	4	-5 \$ a5
31	1	4.354e-5	110	-111	201	-202	4	-5 \$ w5
32	4	1.6021e-3	110	-111	202	-203	4	-5 \$ c9
33	1	4.354e-5	110	-111	203	-204	4	-5 \$ i5
34	4	1.6021e-3	110	-111	204	-205	4	-5 \$ c10
35	1	4.354e-5	102	-103	205	-207	4	-5 \$ j1
36	4	1.6021e-3	102	-103	207	-208	4	-5 \$ c11
37	1	4.354e-5	104	-105	205	-207	4	-5 \$ j2
38	4	1.6021e-3	104	-105	207	-208	4	-5 \$ c12
39	1	4.354e-5	106	-107	205	-207	4	-5 \$ j3
40	4	1.6021e-3	106	-107	207	-208	4	-5 \$ c13
41	1	4.354e-5	108	-109	205	-207	4	-5 \$ j4
42	4	1.6021e-3	108	-109	207	-208	4	-5 \$ c14
43	1	4.354e-5	110	-111	205	-207	4	-5 \$ j5
44	4	1.6021e-3	110	-111	207	-208	4	-5 \$ c15
45	1	4.354e-5	111	-113	201	-208	4	-5 \$ a6
46	1	4.354e-5	113	-114	201	-202	4	-5 \$ w6
47	4	1.6021e-3	113	-114	202	-203	4	-5 \$ c16
48	1	4.354e-5	113	-114	203	-204	4	-5 \$ i6
49	4	1.6021e-3	113	-114	204	-205	4	-5 \$ c17
50	1	4.354e-5	113	-114	205	-207	4	-5 \$ j7
51	4	1.6021e-3	113	-114	207	-208	4	-5 \$ c18
100	1	4.354e-5	-300					

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```

101 1 4.354e-5 -301
200 1 4.354e-5 100 -101 200 -201 2 -7 $ asw air (southwest)
201 7 1.791e-3 101 -114 208 -206 2 -3 $ 1a
202 7 1.791e-3 114 -112 201 -206 2 -3 $ 1b
900 0 -100:112:-200:206:-1:7 $ universe

```

```

1 pz -100
2 pz 0
3 pz 700
4 pz 720
5 pz 1050
6 pz 2370
7 pz 2380
100 py -3500.1 $ southern source surface
101 py 0
102 py 1250
103 py 3140
104 py 3780
105 py 5670
106 py 6310
107 py 8200
108 py 8840
109 py 10730
110 py 11370
111 py 13260
112 py 29500
113 py 13900
114 py 15790
200 px -5500.1 $ western source surface
201 px 0
202 px 730
203 px 5380
204 px 6290
205 px 10940
206 px 44400
207 px 11670
208 px 16320
300 s 13000 1200 101 100
301 s 6300 6200 830 100

```

mode n

```

imp:n 1 0 1 1 4 0 0 1 1 4 1 1 1 9 10 1 1 1 12 13
      1 1 1 10 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
      0 0 0 0 0 0 0 0 0 0 0 1 20 0 0 0 0

```

sdef erg=d1 pos= -5100 15050 100 \$ western source position in cm

```

si1 h 1.00e-11 1e-8 3e-8 5e-8 1e-7 2.25e-7 3.25e-7 4e-7 8e-7
      1e-6 1.13e-6 1.3e-6 1.77e-6 3.05e-6 1e-5 3e-5 1e-4 5.5e-4
      0.003 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20

```

```

spl 0 0.00261 0.0146 0.0189 0.0324 0.0259 0.00817 0.00445
      0.0152 0.0047 0.00255 0.00292 0.00641 0.011 0.0219 0.0235
      0.0269 0.0424 0.0459 0.0516 0.0712 0.101 0.114 0.0743
      0.0588 0.108 0.0945 0.016

```

f4:n 100 101

```

e4 0.017 0.1 0.4 0.9 1.4 1.85 3.0 6.43 20

```

```

em4 0.0 6.636e10 2.616e11 4.136e11 5.561e11 6.215e11 7.546e11
      9.999e11 1.199e12

```

fc4 cell average dose rate (mrad/h)

```

m1 7014.50c 3.570e-5 $ air

```

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	8016.50c	7.840e-6	
m2	1001.50c	1.487e-2	\$ concrete
	6012.50c	3.814e-2	
	8016.50c	4.152e-2	
	11023.50c	3.040e-4	
	12000.51c	5.870e-4	
	13027.50c	7.350e-4	
	14000.50c	6.037e-3	
	20000.51c	1.159e-2	
	26000.50c	1.968e-4	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
m6	7014.50c	1.378e-5	\$ homogenized x-333 process area
	8016.50c	3.027e-6	
	6012.50c	3.824e-5	
	9019.50c	5.451e-5	
	13027.50c	5.169e-5	
	14000.50c	1.023e-5	
	17000.50c	5.451e-5	
	24000.50c	9.934e-5	
	25055.51c	1.045e-5	
	26000.50c	3.643e-4	
	28000.50c	2.801e-4	
	29000.50c	2.009e-5	
m7	7014.50c	3.570e-5	\$ homogenized ground level
	8016.50c	7.840e-6	
	26000.50c	1.669e-3	
	6012.50c	7.842e-5	
m8	7014.50c	3.570e-5	\$ air with rain
	8016.50c	8.0512e-6	
	1001.50c	4.2242e-7	
nps	30000000		
print			

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APPENDIX B. RESPONSE FUNCTIONS

The Henderson Free-In-Air flux-to-dose response functions used in this analysis are listed in Table B-1. These values were obtained by re-bining the 37-group response functions listed in Reference 22. The re-bining of the group structure was performed graphically, plotting the functions as a histogram, then transforming the group structure by conserving the area under each group.

For energies below 0.1 MeV, the response functions are zero. Consequently, only 8 of the 27-neutron groups used contribute to the dose rates evaluated.

Table B-1. Henderson Flux-to-Dose Response Functions for (27-Group)

Group No.	Energy Range MeV	Response Function Rad n ⁻¹ cm ²
1	20.0 - 6.43	5.13 X 10 ⁻⁹
2	6.43 - 3.00	4.28 X 10 ⁻⁹
3	3.00 - 1.85	3.23 X 10 ⁻⁹
4	1.85 - 1.40	2.66 X 10 ⁻⁹
5	1.40 - 0.9	2.38 X 10 ⁻⁹
6	0.9 - 0.4	1.77 X 10 ⁻⁹
7	0.4 - 0.1	1.12 X 10 ⁻⁹
8	0.1 - 0.017	2.84 X 10 ⁻¹⁰
9 - 27	0.017 - 1 x 10 ⁻¹¹	0.000