POEF-SH-38
Revision 1

LOCKHEED MARTIN

PORTSMOUTH GASEOUS DIFFUSION PLANT

Examination of Criticality Accident Alarm Coverage on the Operating Floors of Buildings X-333, X-330, and X-326 at the Portsmouth Gaseous Diffusion Plant

By
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March 1997

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Battelle

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FOREWORD TO REVISION 1

The Henderson Free-in-Air Flux-to-Dose response function [He93] was used in the first issuance of this report and in earlier analyses [We83, Ne94a, and Ne94b] of the Portsmouth Gaseous Diffusion Plant's (PORTS') Criticality Accident Alarm System (CAAS). This analysis was conservative in terms of determining detector response. It calculated the dose rate at CAAS detectors from a minimum accident of concern. A disadvantage of the Henderson Free-in-Air Flux-to-Dose response function was that the response fell off to insignificant values below neutron energies of 17 keV. Subsequent to the first issuance of this report, the actual CAAS detector response function was determined [Ro96]. The PORTS CAAS detectors were found to have a better response to neutrons of lower energies than was determined using the Henderson response function. Some detectors were located where the predicted Henderson dose rates were not expected to cause them to alarm. Detectors at these locations were reevaluated using the CAAS detector response function.

In the calculations performed for the first issuance of this report, the operating floors of the PORTS cascade buildings X-333, X-330, and X-326 were analyzed as isolated systems from the cell floors. Because cascade buildings X-333 and X-330 had regions within their operating floors where detector coverage was questionable, the analyses were extended to include the cell floors. The responses of selected cell floor detectors to specific operating floor accident sources were analyzed.

CAAS detectors are calibrated to alarm at, or slightly before, the attainment of a count rate of 60,000 counts per minute (cpm) [Ca96]. The CAAS detector response function is more accurately characterized in terms of detector count rate than absorbed dose rate. A unit called a Detector Response Unit, or DRU, has been adopted and is used throughout this report as the equivalent of a count rate of 60,000 cpm. Thus, for example, a calculated detector response of

300,000 cpm is reported as 5 DRU or 5 times the response necessary to meet the alarm set-point.

EXECUTIVE SUMMARY

This report summarizes the results of an analysis of the Criticality Accident Alarm System (CAAS) coverage of the operating floors (first floors) of cascade buildings X-333, X-330, and X-326 at the Portsmouth Gaseous Diffusion Plant (PORTS). CAAS coverage of the cascade buildings' cell floors (second floors) was evaluated in previous reports [Do95, Ne94a, and We83]. Coverage of the roadways around the three cascade buildings by the cell floor detectors was also described in an earlier report [Ne94b].

In order to evaluate coverage, the cascade buildings were modeled using the Monte Carlo N-Particle Transport Computer Code (MCNP) [Br93]. The MCNP was then used to calculate the CAAS detector response to neutrons from radiation sources equivalent to minimum accidents-of-concern [Am86, Le95]. The calculated CAAS detector count rate was compared with the PORTS criticality accident alarm set-point [Ca96].

The results of this evaluation indicate that the CAAS might not alarm if a minimum accident-of-concern occurs at certain locations on the Building X-333 operating floor . The lack of CAAS response is attributed to shielding provided by numerous concrete columns used to support the second floor (the cell floor) of the building, substructure buildings, containerized waste stored within the building, and the large distances to the CAAS detectors.

All potential accident locations evaluated on the operating floors of cascade buildings X-326 and X-330 were calculated to meet the alarm criteria. In some instances, a minimum accident-of-concern on the operating floor will be detected by a CAAS detector located on the cell floor.

1.0 INTRODUCTION

The Portsmouth Gaseous Diffusion Plant (PORTS), located in Piketon, Ohio, is one of two operating gaseous diffusion plants leased from the U.S. Department of Energy (DOE) by the United States Enrichment Corporation (USEC) and operated by Lockheed Martin Utility Services (LMUS). At these plants, uranium (U) in the form of uranium hexafluoride (UF_6) is enriched, using a gaseous diffusion process, from its naturally occurring isotopic concentration of about 0.7 weight percent ^{235}U, to approximately 5 weight percent ^{235}U. Throughout this report, enrichment values are given in weight percent ^{235}U.

The diffusion cascade processing equipment at PORTS is located in Buildings X-333, X-330, and X-326. These buildings were referred to as the cascade buildings. The highest enrichments were found in Building X-326.

Because enriched uranium operations are performed within the cascade buildings, the potential for a criticality accident in these buildings exists. A Criticality Accident Alarm System (CAAS) is in place to alarm in the event of a criticality accident. The CAAS is required to be designed to immediately detect the minimum accident-of-concern. A minimum accident-of-concern in an area with nominal shielding delivers the equivalent of an absorbed dose rate in free air of 20 rads per minute at a distance of 2 meters from the reacting material [Am86]. CAAS detectors are located throughout the PORTS cascade buildings.

This report summarizes the analysis that was performed to evaluate the CAAS response to selected minimum accidents-of-concern on the operating floor of the cascade buildings. Selection of potential accident locations was based, in part, on the maximum distance to the closest CAAS detector. The other factor in selecting potential accident locations for analysis was the amount of intervening shielding between the accident location and CAAS detector. If the CAAS was predicted to alarm under conditions of significant shielding, then the system presumably would alarm in response to all accidents greater than the minimum accident-of-concern, at closer distances, and with less shielding.

2.0 BUILDING DESCRIPTIONS

Cascade buildings X-333, X330, and X-326 are steel-framed, transite-covered, two-story buildings. These three buildings are briefly described below.

Diffusion equipment in each cascade building is located on the cell floor (second floor), and electrical switchgear and control instrumentation are located on the operating floor (first floor). The cell floor in Building X-333 is supported by concrete columns. The cell floors of Buildings X-326 and X-330 are supported by steel I-beams, each identified by a unique alpha-numeric designation. Figures 1, 2, and 3 illustrate the grid structure of the support columns in the cascade buildings. Table 1 lists the locations of the CAAS detectors in each cascade building.

Table 1. Location of CAAS Detectors

See Figures 1, 2, and 3 for the Column Locations

Building	Detector	Column Location
X-333	SE-1	41-Mb
	33-LS-1	LAW Station
	33-1G	20-C
	33-1	10-Fy*
	33-2	26-Fy*
	33-3	42-Fy*
	33-4	58-G*
	33-5	58-U*
	33-6	42-U*
	33-7	26-U*
	33-8	10-U*

Building	Detector	Column Location
X-330	TAILS	87-DD
	SE-2	65-Q
	CR	40-AA
	SE-3	30-S
	IP	7-AA
	29-1-E	86-BB*
	31-2-E	70-BB*
	31-4-E	54-BB*
	29-2-E	38-BB*
	29-4-E	22-BB*
	29-6-E	6-BB*
	29-1-W	86-F*
	31-2-W	70-F*
	31-4-W	54-F*
	29-2-W	38-F*
	29-4-W	22-F*
	29-6-W	6-F*
X-326	ERP	5-A
	SE-4	23-H
	SE-5	63-H
	SE-6	93-H
	PW	101-W
	NDA	NDA Lab
	27-1-E	7-E*
	27-3-E	27-E*
	25-2-E	48-E*
	25-4-E	67-E*

Building	Detector	Column Location
	25-6-E	87-E*
	25-7-E	97-E*
	27-1-W	7-S*
	27-3-W	27-S*
	25-2-W	47-S*
	25-4-W	67-S*
	25-6-W	87-S*
	25-7-W	97-S*

* Indicates detector located on cell floor

In addition to housing diffusion equipment, the cascade buildings are also used to store containers of low-level radioactively contaminated waste. This stored waste can shield the CAAS detectors from criticality accidents. The analysis described here included the shielding effects from areas where substantial quantities of containerized waste was stored. These areas are identified in Figures 1, 2, and 3.

2.1 Building X-333

Building X-333 is approximately 1,456 feet long, 970 feet wide, and 82 feet high. Its two floors have a combined space of about 65 acres. The cell floor (second floor) of the building is supported by approximately 2,925 18-inch square concrete columns. CAAS detectors are placed at eleven locations throughout Building X-333. Three detectors are located on the operating floor, as shown in Figure 1.

The largest diffusion equipment is housed in Building X-333. In addition, except for the stripping part of the cascade in Building X-330, Building X-333 has the lowest level of enrichment [Po87]. The larger size of the cell housings and the low enrichments were considered in the analysis of Building X-333.

The enrichment in Building X-333 is typically below 2 percent ^{235}U [Po87]. However, the low assay withdrawal (LAW) station located on the west side of the building can receive UF_6 enriched up to 10 percent.

2.2 Building X-330

Building X-330 is approximately 2,176 feet long, 640 feet wide, and 66 feet high. Its two floors have combined floor space of about 55 acres. CAAS detectors are placed at seventeen locations throughout the building. Five detectors are located on the operating floor, as shown in Figure 2.

UF_6 entering Building X-330 is typically enriched to approximately 2 percent ^{235}U. In Building X-330, the UF_6 is further enriched. Normal operational conditions result in a ^{235}U enrichment of less than 5 percent. The further enriched UF_6 is then sent to Building X-326. The facility for withdrawing depleted $UF_{6,}$ known as the TAILS facility, is located in the north-east end of Building X-330.

2.3 Building X-326

Building X-326 is approximately 2,230 feet long, 552 feet wide, and 62 feet high. Its two floors have a combined floor space of about 58 acres. CAAS detectors are placed at 18 locations throughout the building. Six of these locations are on the operating floor, as shown in Figure 3.

Equipment for producing highly enriched uranium (currently out of service) is located in Building X-326. Some of the equipment is used to purge light molecular weight gases, N_2 and O_2, from the cascade.

An extended range product (ERP) withdrawal facility is located at the north-east corner of Building X-326. Building X-326 also houses a ^{252}Cf Shuffler in the non-destructive assay (NDA) laboratory. This equipment is used to measure the fissile material content of waste. Beneath the shuffler is a small pit, constructed to house support equipment for the shuffler. A criticality accident in this pit would be very well shielded. Thus, this pit and the shuffler were specifically included in the analysis, and the response of a nearby CAAS detector to a shuffler criticality accident was calculated.

During operations, solid deposits of various uranium compounds form as "hold-up" material in all cascade equipment. This hold-up material has largely been recovered from the out of service equipment in Building X-326. However, it is still desirable for CAAS coverage to be maintained throughout the building.

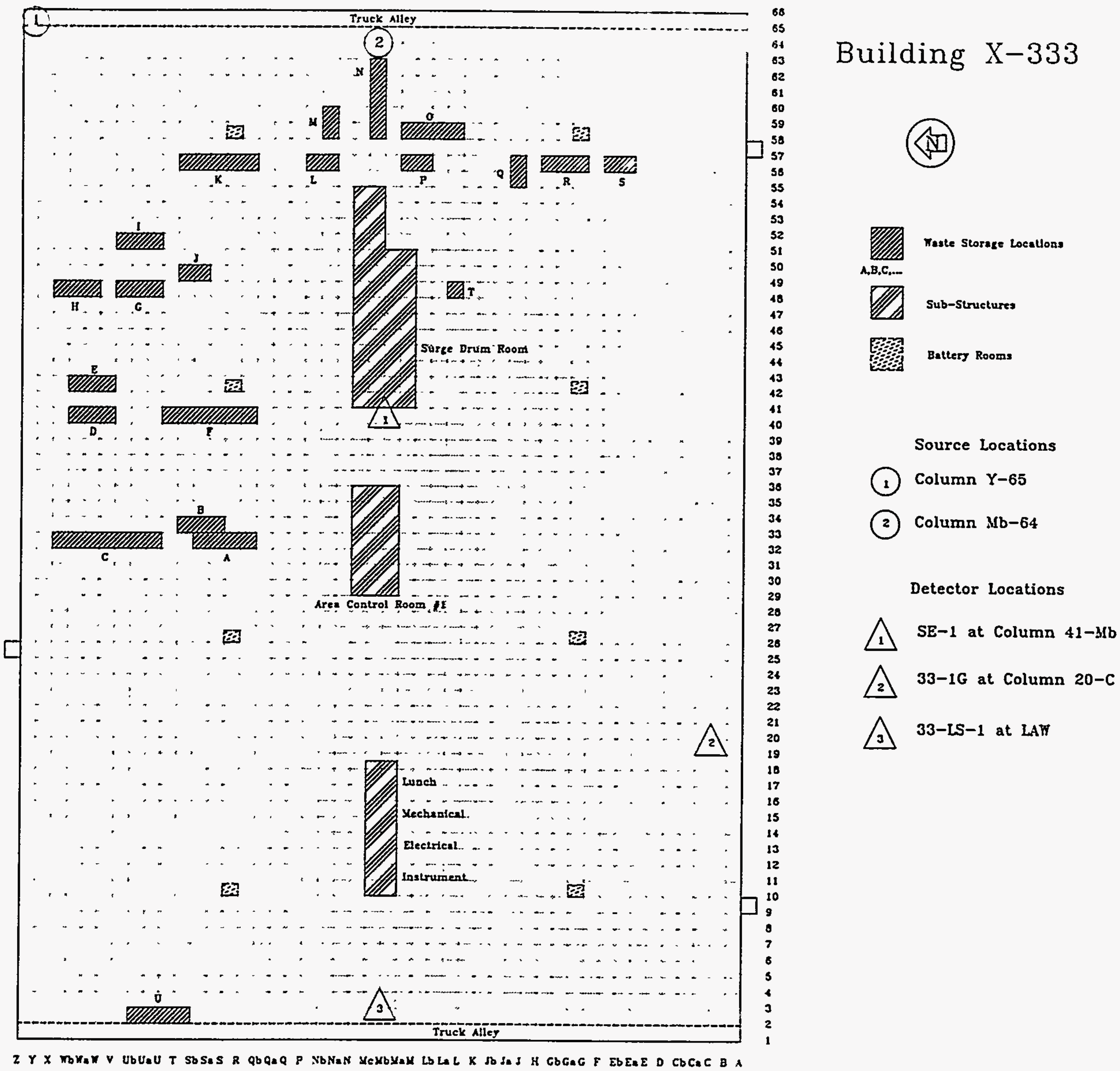

Figure 1. Building X-333 Operating Floor

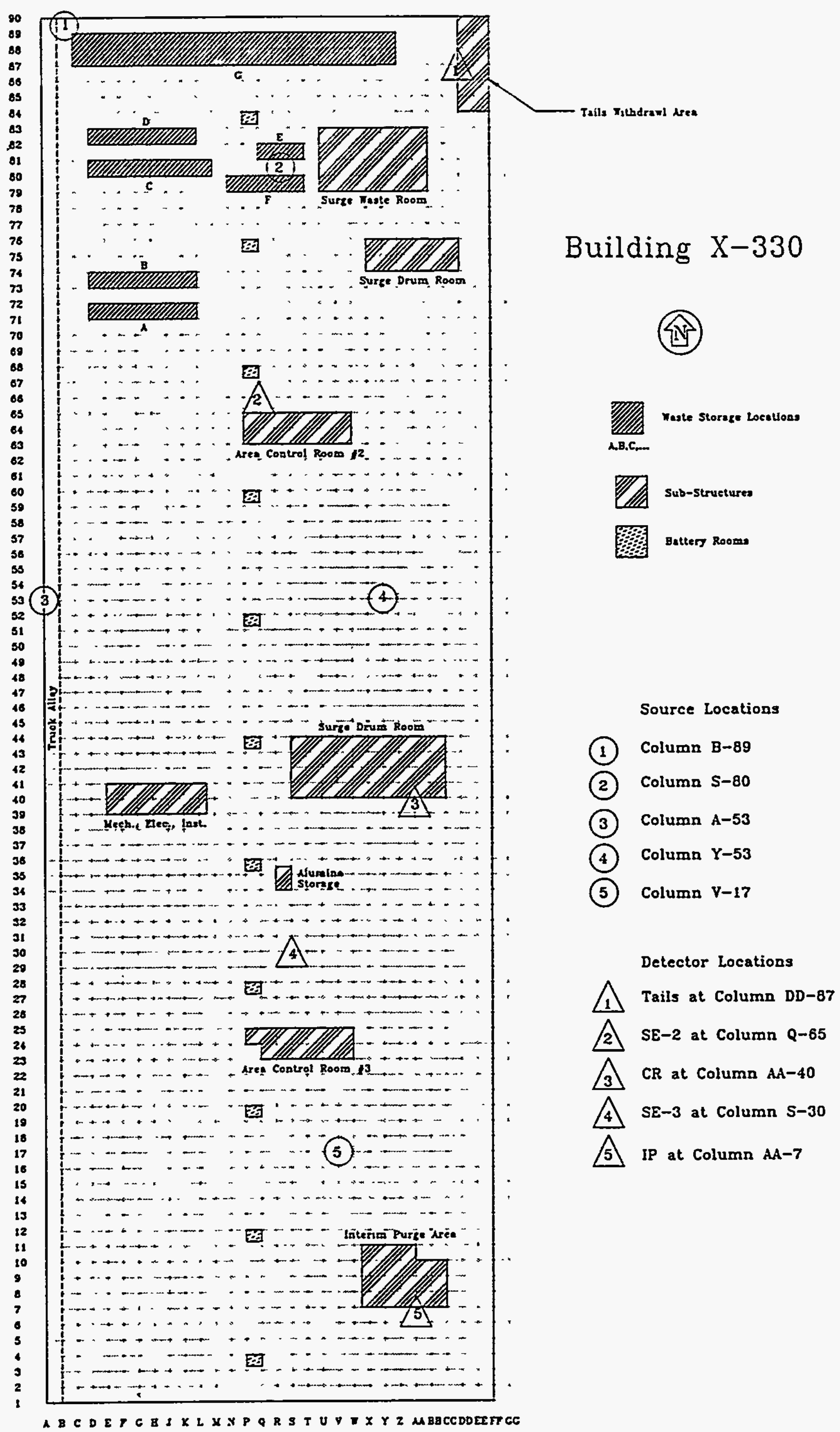

Figure 2. Building X-330 Operating Floor

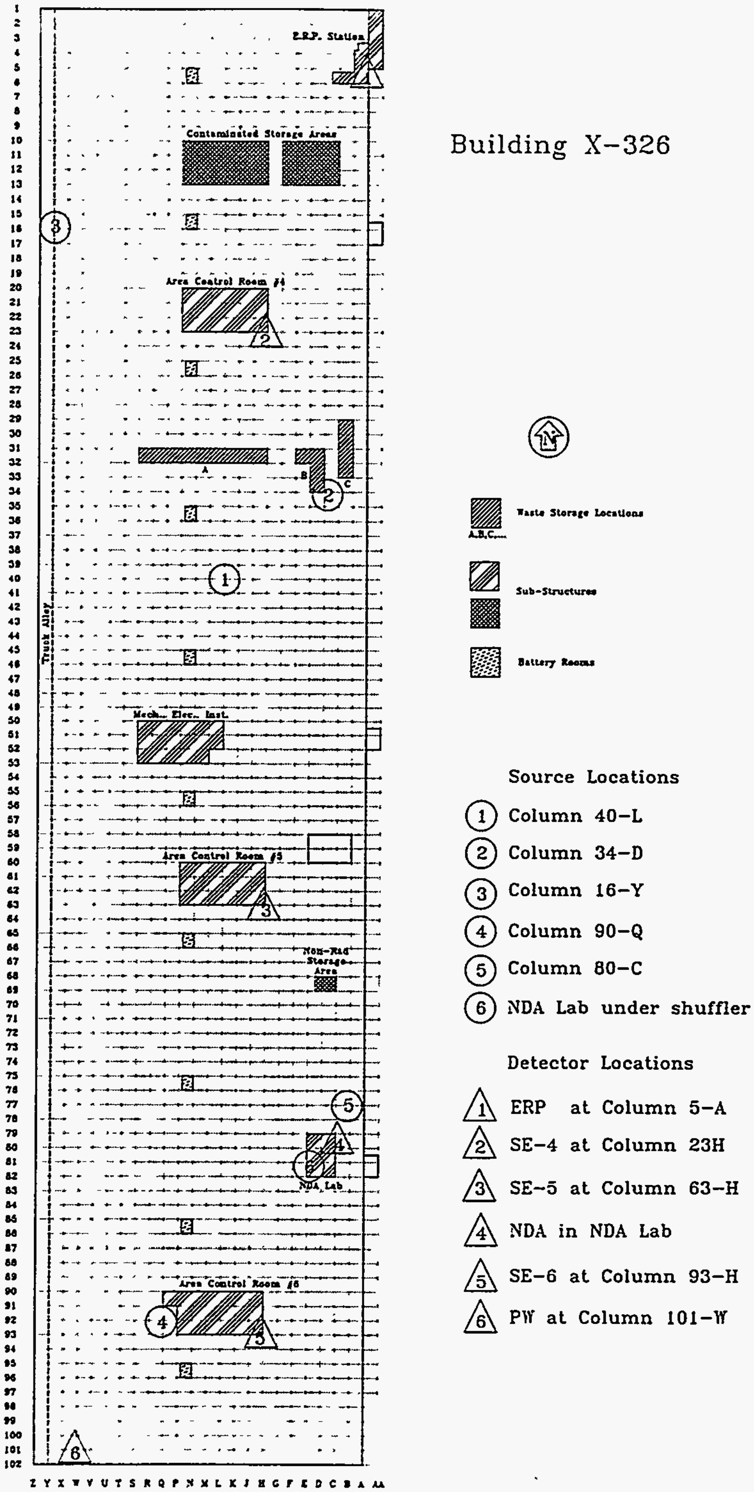

Figure 3. Building X-326 Operating Floor

3.0 ANALYSIS

The analysis of CAAS coverage of the cascade buildings' operating floors was performed using the Monte Carlo N-Particle Transport Code (MCNP) [Br93]. Three dimensional models of physical objects were created with MCNP by representing the surfaces of objects using surface equation parameters. The surfaces were combined using Boolean logic to describe volumetric regions. Each region was assigned elements or mixtures properties and respective densities. From these material descriptions, macroscopic cross sections were calculated by the MCNP for each region. Point-wise cross sections, derived from evaluated nuclear data files (ENDF/B-V) and supplied with the MCNP, were used [Mc94]. The trajectories and interactions of the neutrons were simulated using the Monte Carlo method. The cumulative result of tracking a large number of neutron histories gives rise to results called "tallies." Because of the statistical nature of simulations, every tally has an associated uncertainty or variance. Several methods were used to reduce the variance more quickly to allow the calculations to be completed more quickly. The SABRINA code [Va93] was used to obtain a graphical representation of an object modeled with the MCNP.

An approximation of the geometry and significant shielding within the cascade buildings was developed and incorporated into the MCNP input format. The power level and neutron source spectrum characteristics of a minimum accident-of-concern were taken from earlier work [Le95] to determine the source term. Flux tallies were collected at CAAS detector coordinates. Variance reduction methods, such as splitting and source biasing, were used in a manner which maintained a "fair game" to accurately represent the neutron flux spectrum at the detector coordinates. Finally, the detector response function was applied to the tally results to determine the detector response.

3.1 Building Models

The cascade buildings X-333, X-330, and X-326 were analyzed individually. Building components were simplified in order to allow the computer analysis to be completed in a reasonable amount of time. Simplifications included the elimination of doors and windows. All significant concrete walls and support columns were included in the models. Each facility was modeled as sitting on a 30-meter-thick concrete "ground" and surrounded by a hemisphere of air with a radius of 8 km. The concrete block walls of the buildings were modeled as half-density concrete of appropriate thickness. Interior structures, such as Area Control Rooms (ACRs), process cells, and battery rooms, were included in each model. SABRINA images of the operating floors of the cascade buildings, as modeled, are provided as Figures 4, 5, and 6. The concrete support columns in Building X-333 were included in the building model. The steel I-beam support columns in Buildings X-330 and X-326 were also included in their building models. Figure 7 shows the operating and cell floors of the Building X-330 model. A rectangular section of the cell floor is transparent in order to show the ground floor structures below.

The cell floors were included in the X-333 and X-330 building models as part of revision 1 of this report. The cell floors were modeled as being separated from the ground floors by a full density concrete floor. The roofs of the X-333 and X-330 building models were modeled as a 4-inch-thick homogenized roof material. The composition of this material is listed in Table 2. All of the process cells in Buildings X-333 and X-330 were modeled individually as rectangular parallelepipeds. The size of the process cell models varies according to the actual size of the process cells in the X-333 and X-330 facilities. The process cell floor model coupled to the ground floor model is shown graphically in Figure 7.

Waste storage areas were included in the models. These areas are identified in Figures 1, 2, and 3. Waste stored in the cascade buildings includes used Personal Protective Equipment (PPE), pea gravel from the roofs of the process buildings, dirt, scrap metal, floor sweepings, and oil absorbing media. The waste is not segregated by type. The shielding equivalent for this waste was assumed equivalent to oak wood at 50 percent density. The atomic number densities for wood were taken from the Standard Composition Library for SCALE [Bu93].

Each cascade building has several rooms for battery storage. Because the batteries stored in these rooms provide significant shielding, the rooms were included in the building models as hydrogeneous material with a density of one gram per cubic centimeter and an effective chemical formula of $H_2O_{1.5}$. The atomic number densities of air, concrete, steel, homogenized cell material, and the cascade building roofs were taken from a previous analysis [We83]. Table 2 lists the elemental components of materials used in the models and their atomic number densities.

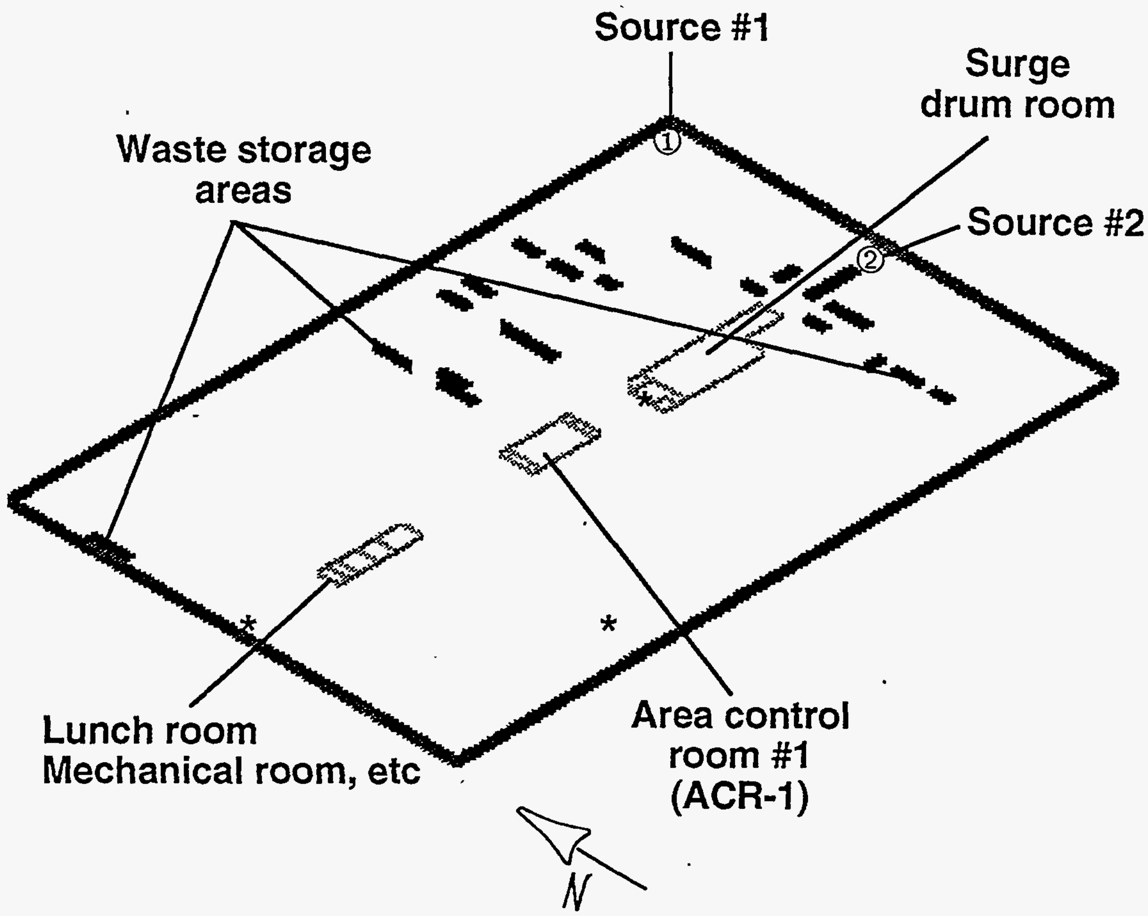

Figure 4. SABRINA Representation of the Building X-333 Operating Floor

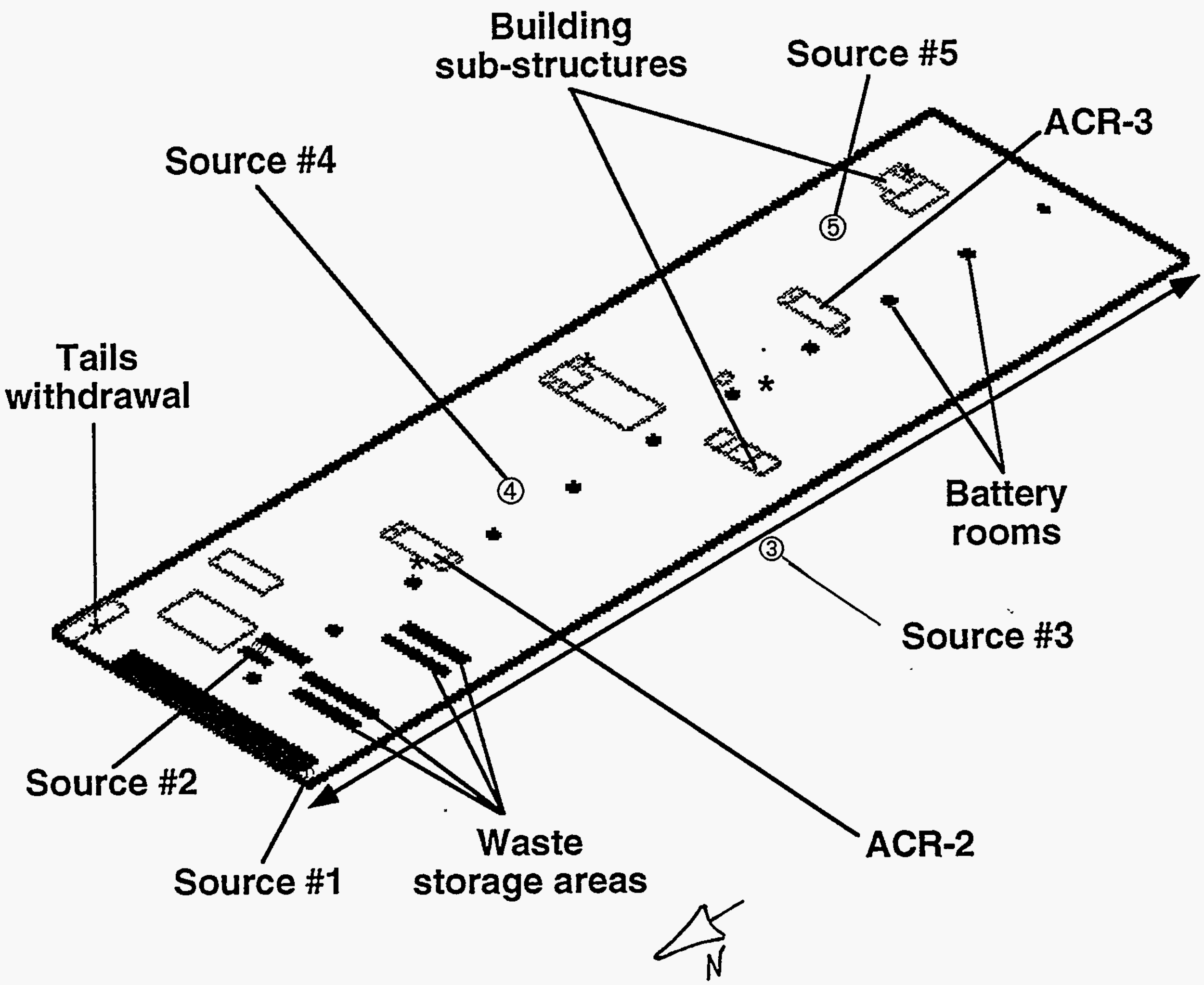

Figure 5. SABRINA Representation of the Building X-330 Operating Floor

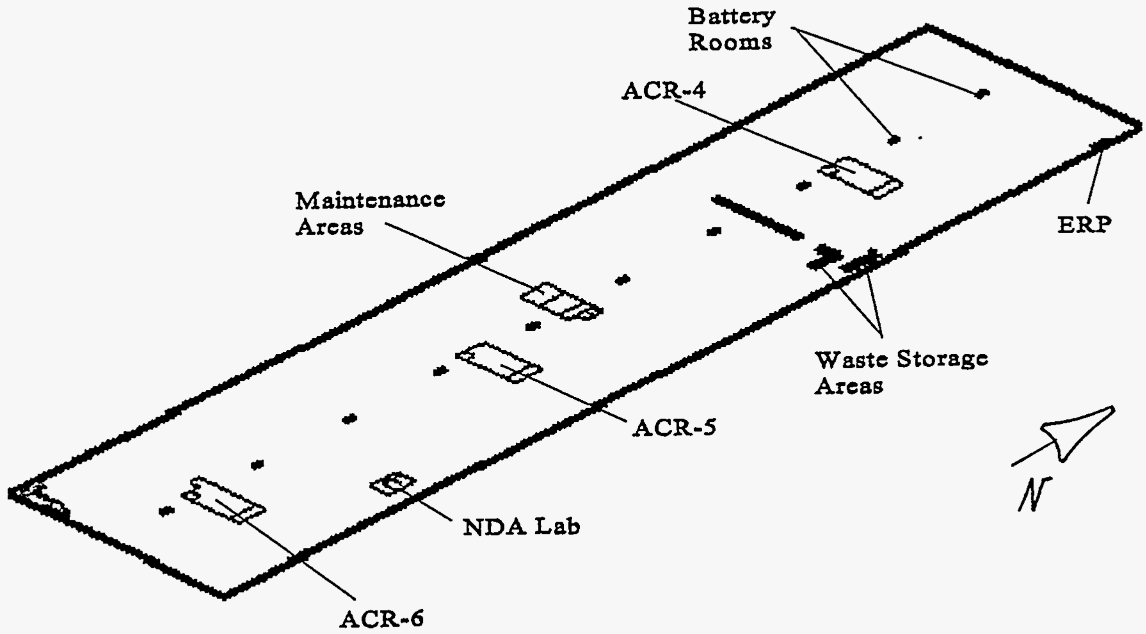

Figure 6. SABRINA Representation of the Building X-326 Operating Floor

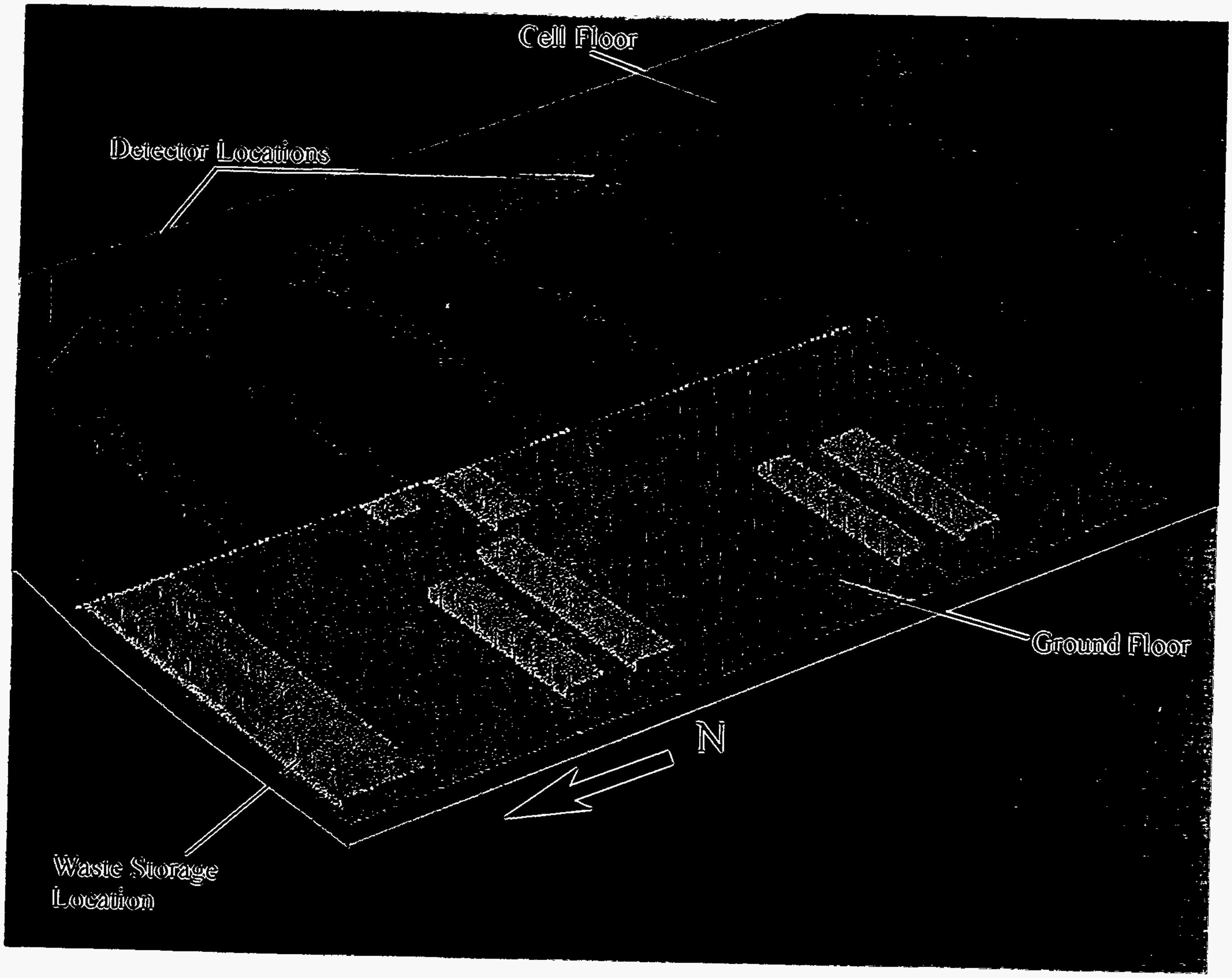

Figure 7. SABRINA Representation of the Building X-330 Cell and Operating Floors

Table 2. Material Compositions

Material	Element	Number Density (Atom barn^{-1} cm^{-1})
Air	Nitrogen	3.57E-05
	Oxygen	7.84E-06
Concrete	Hydrogen	1.49E-02
	Carbon	3.81E-03
	Oxygen	4.15E-02
	Sodium	3.04E-04
	Magnesium	5.87E-04
	Aluminum	7.35E-04
	Silicon	6.04E-03
	Calcium	1.16E-02
	Iron	1.97E-04
Hydrogeneous material in battery room, $H_2O_{1.5}$, 1 g cm^{-3}	Hydrogen	4.63E-02
	Oxygen	3.47E-02
Steel	Carbon	3.92E-03
	Iron	8.35E-02
Homogenized Cell Material	Carbon	6.23E-05
	Fluorine	8.88E-05
	Aluminum	8.42E-05
	Silicon	1.67E-05
	Chlorine	8.88E-05
	Chromium	1.62E-04
	Manganese	1.70E-05
	Iron	5.93E-04
	Nickel	4.56E-04
	Copper	3.27E-05

Material	Element	Number Density (Atom barn^{-1} cm^{-1})
Homogenized Roof	Hydrogen	4.29E-02
	Carbon	1.81E-02
	Oxygen	1.90E-03
	Iron	2.78E-02
Wood	Carbon	2.86E-01
	Hydrogen	4.76E-01
	Oxygen	2.38E-01

3.2 Source Term

To model the criticality accident sources used in the MCNP analysis completely, the source location, the source neutron production rate (power level) and the source neutron energy spectra must be known. The development of each is discussed below.

3.2.1 Source Locations

Source locations were chosen to maximize the distance between the source and the detector. Consideration was also given to the amount of intervening shielding between potential accident locations and the CAAS detectors. Physical inspection of the cascade buildings and inspection of the drawings of the operating floors of the buildings [Gr71, Gr77, Gr79, No56, and So56] showed that certain locations had significant shielding. Coordinates for sources representing potential accident locations were selected to maximize the distance between the source and the detector. Other locations, with smaller distances or lesser shielding between the source and detector, are expected to result in higher responses at the CAAS detector. Criticality accidents were considered possible throughout the cascade buildings.

Thus, a source could be located in a walkway rather than within equipment in order to determine the CAAS response. An outcome greater than 1 DRU at the CAAS implies that coverage is provided to other closer and less heavily shielded potential accident locations. Several different source locations were used in this analysis. These source locations are tabulated in Table 3 and are briefly described below.

Two sources locations within cascade building X-333 were selected to evaluate the CAAS response. These locations, shown in Figure 1, were chosen to maximize the distance between the source and detector. Figure 1 shows the significant shielding between the sources and detector. Both sources were modeled using a ^{235}U enrichment of 5 percent.

Five source locations within cascade building X-333 were selected to evaluate the CAAS response.. These locations, shown in Figure 2, were selected to maximize the distance between the source and the detector. Figure 2 shows significant shielding between the sources and detector. Sources 1 through 4 were modeled using an enrichment of 5 percent ^{235}U. The ^{235}U enrichment level for source 5 was raised to 20 percent. The ^{235}U enrichment increases as UF_6 moves up the cascade. With other conditions equal, the power level and neutron production rate required to produce a minimum accident-of-concern decrease with increasing ^{235}U enrichment [Le95].

Six source locations within cascade building X-326 were selected to evaluate the CAAS response. These locations are shown in Figure 3. Sources 1,2,4,5, and 6 were modeled using a ^{235}U enrichment of 100 percent. Source 3 was modeled using a ^{235}U enrichment of 20 percent. Although current plant operations do not enrich uranium to these levels, higher enriched material from past operations may be held up in the equipment. Source 6 was assumed to be located within the ^{252}Cf Shuffler pit. This pit is heavily shielded. A specific calculation was performed to determine the response of the nearby CAAS detector.

3.2.2 Source Power Level and Energy Spectrum

Source locations were modeled as isotropic point sources. The associated power level and neutron energy leakage spectrum were taken from other reports [Le95]. The level of enrichment was varied because enrichment increases as UF_6 moves up the cascade. In each model, however, the power level and neutron energy leakage spectrum satisfied the definition of a minimum accidents-of-concern [Am86].

Table 3. Criticality Accident Source Locations

Source	Building	Description	^{235}U Enrichment (%)	Power Level (W)
333-1	X-333	NE Corner of Building	5	2881
333-2	X-333	East side of storage area "N" in Figure 1	5	2881
330-1	X-330	NW corner of building	5	2881
330-2	X-330	Column S-80	5	2881
330-3	X-330	Column A-53 (on West wall)	5	2881
330-4	X-330	Column Y-53 (South of ACR-2)	5	2881
330-5	X-330	Column V-16 (South of ACR-3)	20	1722
326-1	X-326	Midway between ACR-4 & ACR-5	100	1281
326-2	X-326	Column 34-D	100	1281
326-3	X-326	Column 16-Y	20	1722
326-4	X-326	Column 90-Q	100	1281
326-5	X-326	Column 80-C	100	1281
326-6	X-326	Beneath ^{252}Cf Shuffler	100	1281

3.3 Flux Tallies

The CAAS detectors used at the PORTS site are calibrated to alarm at or slightly below a count rate of 60,000 counts per minute [Ca96]. A detector response unit (DRU) is defined as equivalent to a CAAS detector count rate of 60,000 counts per minute. A calculated detector response greater or equal to 1 DRU indicates that the CAAS is expected to alarm.

The CAAS detectors modeled in the MCNP calculation were located at coordinates corresponding to the currently installed CAAS detectors. A "tally" of the number and the energy of neutrons that pass through the detector volume is tracked during the Monte Carlo calculation along with relevant statistical information. The uncertainty associated with the tally is a measure of how well the tally is known. Other statistical tests also performed by MCNP aid in judging when a sufficient number of neutron histories have been tallied.

3.4 Flux to Detector Count Rate Conversion

The MCNP tally, normally given as neutron fluence per source neutron, was converted to detector count rate by applying the detector's response function. Details of the determination of the detector's response function are available [Ro96]. The CAAS detector response function is given in tabular form in Table 4 and in graphical form in Figure 8. The MCNP output gives the value of the integral (detector counts per source neutron). This quantity must be multiplied by the source neutron production rate to obtain the detector count rate.

Because the criticality accident sources used in this analysis have different levels of moderation and ^{235}U enrichments, different power levels and neutron spectra correspond to the minimum accident-of-concern. Using the appropriate values [Le95], the neutron source rates for each source term were calculated. The neutron source rates, in neutrons per second, correspond to enrichments of 5, 20, and 100 percent ^{235}U were 6.52×10^{13}, 5.20×10^{13}, and 5.47×10^{13}, respectively. Representative MCNP input listings for each of the cascade buildings are included in Appendix A.

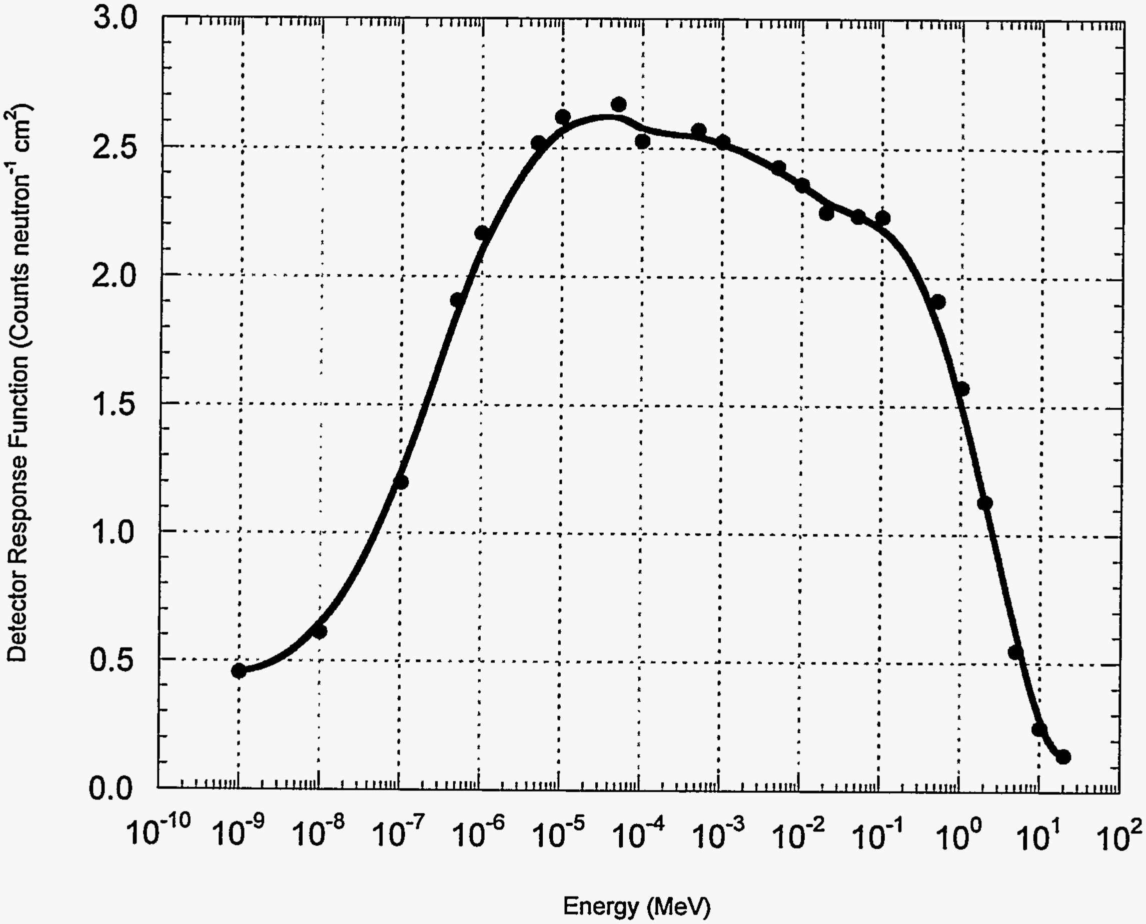

Figure 8. CAAS Detector Response Function

Table 4. Detector Response Function

Energy (MeV)	Detector Response Function (detector counts neutron^{-1} cm^2)
1.00E-09	0.46
1.00E-08	0.61
1.00E-07	1.20
5.00E-07	1.91
1.00E-06	2.17
5.00E-06	2.52
1.00E-05	2.62
5.00E-05	2.67
1.00E-04	2.53
5.00E-04	2.57
1.00E-03	2.53
5.00E-03	2.43
1.00E-02	2.36
2.00E-02	2.25
5.00E-02	2.24
1.00E-01	2.24
5.00E-01	1.91
1.00E+00	1.58
2.00E+00	1.13
5.00E+00	0.55
1.00E+01	0.25
2.00E+01	0.14

4.0 RESULTS

The results of the CAAS coverage analysis presented in Table 5, indicates the calculated detector response for the minimum accident-of-concern source location. The uncertainty calculated for each response is also given. Generally, the CAAS detector closest to the source was found to have the largest response. However, if the closest detector was significantly shielded, other detectors sometimes provided higher responses. Because of the thicknesses of materials between sources and detectors, only the detectors nearest the sources yielded statistically significant responses for the number of neutron histories in the analysis.

Table 5. Detector Responses

Source Location	Detector Location	Detector Response Units (DRU's)	Monte Carlo Uncertainty (DRU's)
333-1	Column 58-U(1)	4.6	0.3
333-2	Column 58-U(1)	0.3	>5(2)
330-1	Column 86-F(1)	26.1	2.6
330-2	Column 87-DD	passed(3)	
330-3	Column 65-Q	5.7	0.5
330-4	Column 40-AA	13.7	1.6
330-5	Column 30-S	passed(3)	
326-1	Column 23-H	passed(3)	
326-2	Column 23-H	passed(3)	
326-3	Column 23-H	passed(3)	
326-4	Column 63-H	passed(3)	
326-5	Column 93-H	passed(3)	
326-6	NDA Lab	114.9	9.2

(1) This detector is located on the cell floor.

(2) This analysis was discontinued before the normal acceptance criteria were satisfied because of the long execution time and the low response of the detector. This source is unlikely to cause the CAAS to alarm.

(3) The response of this detector was previously calculated (see report POEF-SH-38, rev. 0) using the Henderson Free-In-Air Flux to Dose response function. The values, while not accurately characterized by the detector's actual response, indicated that the detector was expected to alarm under conditions of a minimum accident-of-concern.

5.0 DISCUSSION

The source locations denoted as having "passed" in Table 5 were calculated to have a dose rate expected to cause the CAAS to alarm. The criterion for determining that a given source would cause a nearby CAAS detector to alarm, was based on a dose rate at the detector. The dose rate was calculated using the Henderson Free-in-Air Flux-to-Dose response function [He93]. Figure 8 shows the neutron response function of the CAAS detector. Figure 9 shows the Henderson Free-in-Air Flux-to-Dose response function. The CAAS detector has a higher response for neutrons in the thermal region than does the Henderson Free-in-Air Flux-to-Dose response function. Figure 10 is a neutron spectrum from the SHEBA critical assembly measured at a distance of 69 meters, with 13.3 centimeters of steel in front of the assembly [Fi83]. SHEBA is a critical assembly which uses uranyl fluoride solution enriched to 4.5 percent ^{235}U. One of the original functions of the SHEBA critical assembly was to evaluate CAAS detectors for uranium enrichment facilities in radiation fields expected in realistic accident scenarios.

The response of the PORTS CAAS detector to the SHEBA spectrum, using the CAAS detector response function in Figure 8, was calculated to be a factor of 4 greater than the response obtained using the Henderson Free-in-Air Flux-to-Dose response function [Ro96]. Critical accidents occurring in the cascade buildings will have neutron spectra similar to the SHEBA spectrum illustrated in Figure 10. Thus, any of the source locations shown as having previously "passed" with the Henderson Free-in-Air Flux-to-Dose response function are also likely to pass with the CAAS detector response function. These analyses were not reevaluated due to time and cost constraints.

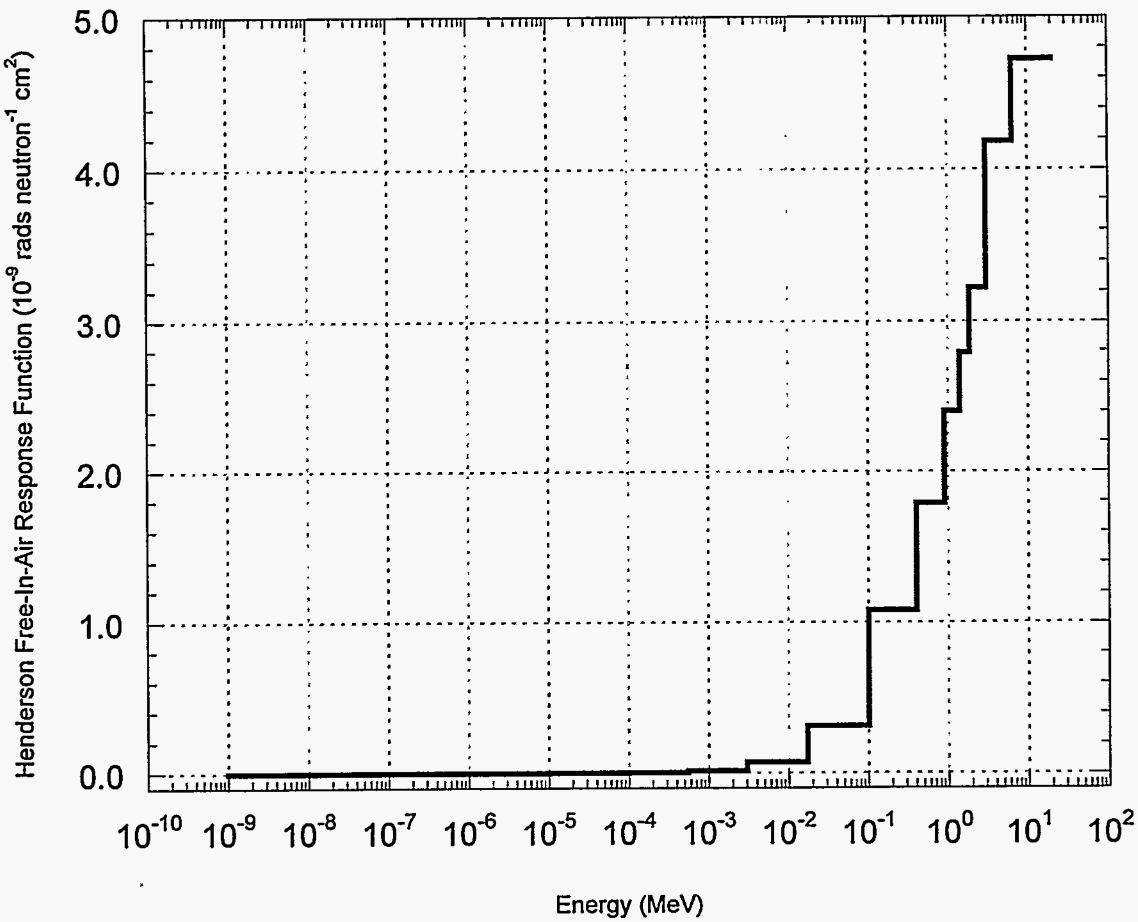

Figure 9. Henderson Free-In-Air Flux-to-Dose Response Function

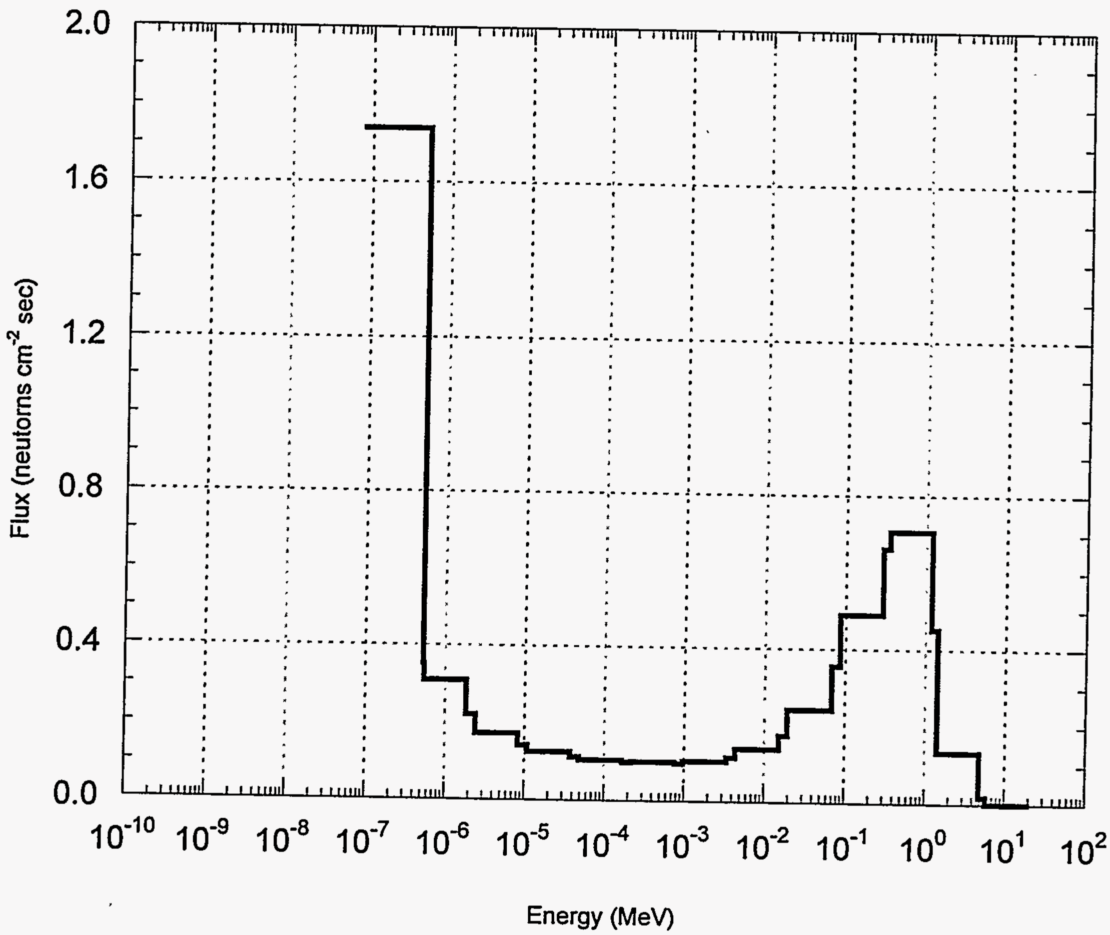

Figure 10. SHEBA Neutron Spectrum at 69 meters with 13.3 cm Steel Shield

Each MCNP calculation was executed until the detector tallies had a fractional uncertainty of about 10 percent and most of the other calculational criteria outlined in the MCNP manual [Br93] were satisfied. Judgement was used in ascertaining if an MCNP calculation was valid. For example, the figure-of-merit (FOM) criterion is related to the number of neutron histories tracked per unit CPU time. Because a given calculation can be executed on computers of differing speed, the FOM criterion might not be satisfied. However, we believe the result accurately reflects a realistic answer.

If a calculated detector response was greater than or equal to 1 DRU, the source location was considered to be covered by the CAAS. All source locations on the ground floor of Building X-330 generated a response of 1 DRU or greater in the detector nearest the source. All source locations examined in Building X-326 also generated detector responses greater than 1 DRU. Thus, criticality accidents occurring at any of these locations are likely to cause the CAAS to alarm.

In a given calculational run to confirm CAAS coverage within a cascade building, the MCNP, using a single source location, calculates the response of only a few detector locations. Moreover, the MCNP run-time increases as the number of locations for which detector responses are calculated increases. Thus, it is not possible to determine areal coverage of a CAAS detector with a single MCNP calculation. Each MCNP calculation requires a great deal of computational time to satisfy criteria for statistical acceptance. Some calculations take several weeks to complete. To reduce the time and costs of demonstrating CAAS coverage within a cascade building, several source locations, estimated on the basis of presumed maximum detector-source distance and/or shielding, were chosen to represent the worst-cases for evaluation.

Source location 333-1 in Building X-333 generated a detector response of 4.6 DRU's in the detector located at column 58-U on the cell floor of the building. No detectors on the ground floor responded to either source location 333-1 or source location 333-2. In addition, source location 333-2 did not generate a detector response greater than 1 DRU in any of the detectors on the ground or cell floors, suggesting that the area surrounding column Mb-65 may not be covered for the minimum accident-of-concern. The analysis was discontinued prior to satisfying the normal acceptance criteria because of the long execution time and the low response of the detector. Thus, a criticality accident at this source location is unlikely to cause the CAAS to alarm. The shielding provided by the concrete support columns in the building, the waste storage locations, and the surge drum room substructure is likely to be the cause of the detectors' failure to alarm.

Figure 11 is a plot of the results of analyses in the three cascade buildings as a function of the source-to-detector distance. This plot may be useful in estimating areas of coverage in the cascade buildings. The quantity and type of shielding material varies from location to location, which accounts for the large vertical spread in data points. This plot contains results only for source-detector pairs evaluated within the cascade buildings and is not applicable to other buildings that have different shielding materials and geometries. The plot assumes that increasing shielding is *approximately* proportional to increasing distance, and shows that 1) all sources at a distance of less than 300 feet have a CAAS detector response greater than 1 DRU and 2) all sources greater at a distance than 1,000 feet have a calculated CAAS detector response less than 1 DRU. Sources located 300 to 1,000 feet from a CAAS detector must be evaluated exactly to confirm areal coverage. However, all sources within 300 feet of a detector are not necessarily covered, especially if neutron shielding material is much greater than or much less than the "norm" in the buildings.

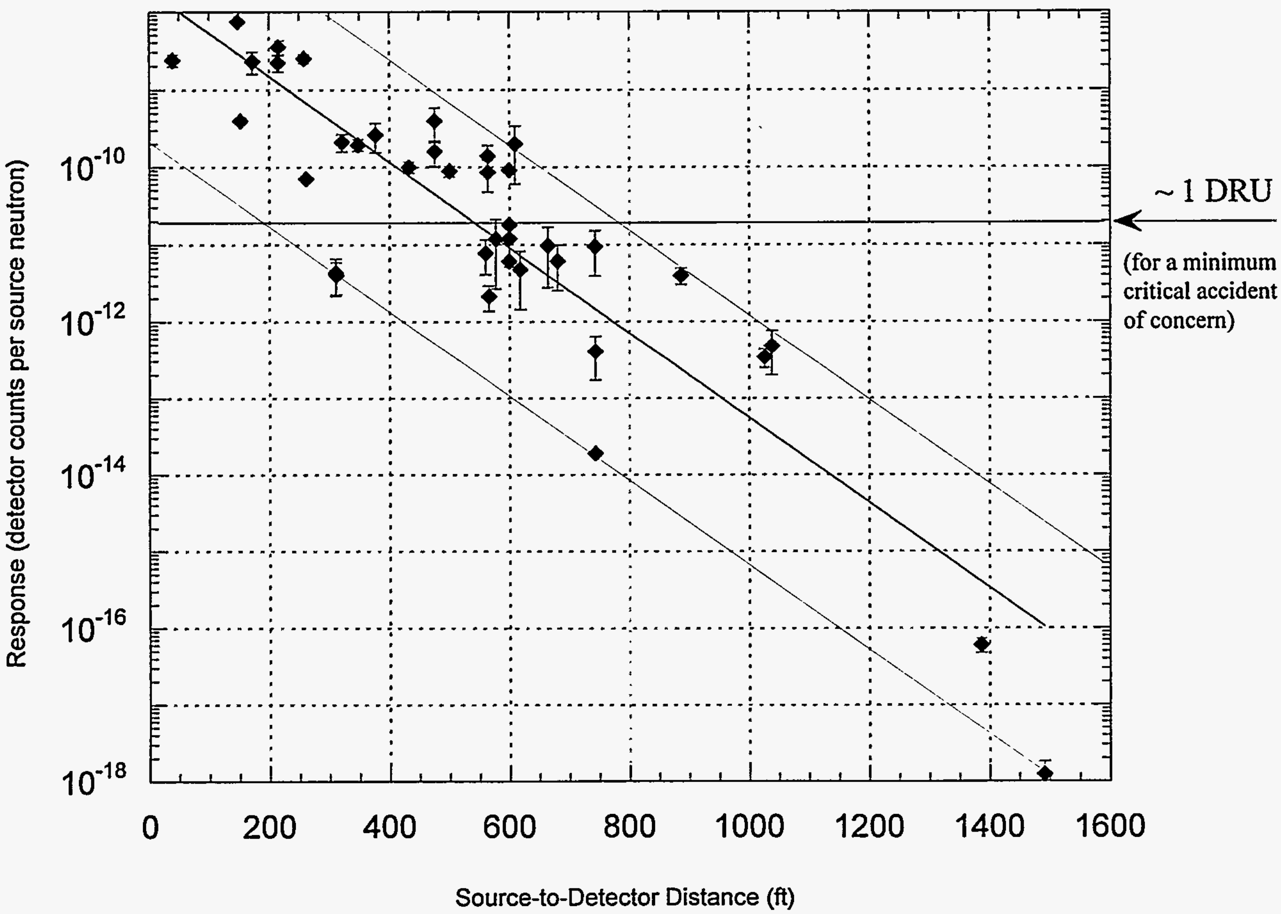

Figure 11. CAAS Detector Response versus Source-to-Detector Distance

6.0 CONCLUSIONS

All selected source locations in Buildings X-330 and X-326 were found to have detector responses sufficient to alarm to a minimum accident-of-concern. One source location within Building X-333, location 333-2 at column 64-Mb, did not yield the necessary response at a nearby CAAS detector. Thus, this section of the building may not have CAAS detector coverage.

This report is valid for the configuration of the cascade buildings only at the time when the models were made. Any significant addition, deletion, or rearrangement of neutron shielding material or detectors may invalidate these results.

7.0 REFERENCES

Am86 *American National Standard for Criticality Accident Alarm Systems*, ANSI/ANS-8.3-1986, American Nuclear Society, August 1986.

Br93 Briesmeister, J.F., Ed., *MCNP - A General Monte Carlo N-Particle Transport Code, Version 4A*, LA-12625, Los Alamos National Laboratory, (1993), available from the Radiation Safety Information Computational Center as CCC-200, Oak Ridge National Laboratory.

Bu93 Bucholz, J.A., Knight, J.R., Parks, C.V., Petrie, L.M., Turner, J.C., and Westfall, R.M., *Standard Composition Library in SCALE-4.2*, NUREG/CR-0200 revision 4, Volume 3, Section M8, ORNL/NUREG/CSD-2/V3/R4, Oak Ridge National Laboratory, November 1993, available from the Radiation Safety Information Computational Center as CCC-545, Oak Ridge National Laboratory.

Ca96 *Calibration of Neutron Criticality Monitor Model NCM-600*, Procedure XP4-GP-RI6500 revision 0, Portsmouth Gaseous Diffusion Plant, April, 1996.

Do95 Dobelbower, M.C., et al, *Verification of Criticality Accident Alarm System Detector Locations for the X-326 Process Cell Floor*, Portsmouth Gaseous Diffusion Plant, POEF-SH-34, August 1995.

Fi83 Fithian, C., et al, *Data Catalogue of the 1980 SHEBA Experiments*, H&R 224-1, H&R Technical Associates, Inc. for Portsmouth Gaseous Diffusion Plant, May 1983.

Gr71 *Ground Floor Plan - Unit X-29-1, Unit X-32-1 thru 5*, Drawing X-330 9A, revision 2, Portsmouth Gaseous Diffusion Plant, (1971).

Gr77 *Ground Floor Plan - Units 3, 4, 5, & 6, Drawing X-333 8A*, revision 2, Portsmouth Gaseous Diffusion Plant, (1977).

Gr79 *Ground Floor Plan - Units 1, 2, 7, & 8*, Drawing X-333 7A, revision 4, Portsmouth Gaseous Diffusion Plant, (1979) He93 *Henderson Free-In-Air Flux-to-Dose Conversion Factors*, derived from Henderson, B.J., "Conversion of Neutron of Gamma-Ray Flux to Absorbed Dose Rate," XDC-59-8-179, (August 1959), tabulated as a response function with MT No. 9027, "SCALE version 4.2: A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," NUREG/CR-0200, revision 4, (November 1993), available from the Radiation Safety Information Computational Center as CCC-545, Oak Ridge National Laboratory.

Le95 Lee, B.L., Dobelbower, M.C., and Tayloe Jr., R.W., *Calculated In-Air Leakage Spectra and Power Levels for the ANSI Standard Minimum Accident of Concern*, POEF-SH-31, Portsmouth Gaseous Diffusion Plant, July 1995.

Ne94a Negron, S.B. and Tayloe, Jr., R.W, *Analysis of the Proposed Relocation of the Neutron Criticality Clusters in the Process Buildings for the Portsmouth Gaseous Diffusion Plant*, Portsmouth Gaseous Diffusion Plant., POEF-SH-12, January 1994.

Ne94b Negron, S.B., Tayloe Jr., R.W., and Dobelbower, M.C., *Analysis of Criticality Alarm System Response to an Accidental Criticality Outside the Cascade Process Buildings at the Portsmouth Gaseous Diffusion Plant*, Portsmouth Gaseous Diffusion Plant, POEF-SH-19, July 1994.

No56 *North Half Ground Floor Plan - Unit X-27-1 thru 3 and Units X-25-1 and X-25-2*, Drawing X-326 8A, revision 0, Portsmouth Gaseous Diffusion Plant, (1956).

Mc94 MCNPDAT: MCNP, Version 4, Standard Neutron Cross Section Data Library Based in Part on ENDF/B-V, contributed by Los Alamos National Laboratory, available from the Radiation Safety Information Computational Center as DLC-105, Oak Ridge National Laboratory.

Po87 *Portsmouth Gaseous Diffusion Plant Final Safety Analysis Report*, GAT/GDP-1073, Portsmouth Gaseous Diffusion Plant, April 1987.

Ro96 Robinson, R. A., Battelle letter to Rumble, B. J., Portsmouth Gaseous Diffusion Plant, *Criticality Accident Alarm System Response Function Experimental Measurements*, October 14, 1996.

So56 *South Half Ground Floor Plan - Unit X-25-3 thru 7, Purge, and Product*, Drawing X-326 9A, revision 0, Portsmouth Gaseous Diffusion Plant, (1956).

Va93 Van Riper, K. A., *SABRINA User's Guide*, LA-UR-93-3696, Los Alamos National Loboratory, October 1993. Available from the Radiation Safety Information Computational Center as PSR-242, Oak Ridge National Laboratory.

We83 Westfall, R.M., and Knight, J.R., *Radiation Levels in a Gaseous Diffusion Plant Assuming a Low-Enriched Criticality Event Corresponding to the ANSI - Standard Minimum Accident of Concern*, ORNL/CSD/INF-82/7, Oak Ridge National Laboratory, January 1983.

Wo83 Woltz, F.E. and Duncan, J.M., *GDP Criteria for Radial Coverage and Alarm Set Point for Neutron Sensing Radiation Alarm Clusters*, GAT-DM-1535, Portsmouth Gaseous Diffusion Plant, May 1983.

APPENDIX A

SAMPLE MCNP INPUTS FOR BUILDINGS X-333, X-330, AND X-326

Listing A.1

Input for X-333

The model includes both the operating and cell floor for X-333.

```
This is a model of the first floor of the X333
c    Building to determine alarm coverage
c
c
c
c
c  ************************************************
c         cell cards
c  ************************************************
c
c
10     10 4.354e-5       180 -230 440 -450 1010 -1030  imp:n=1  $
20     10 4.354e-5       180 -230 460 -470 1010 -1030  imp:n=1  $
30     10 4.354e-5       180 -230 480 -490 1010 -1030  imp:n=1  $
40     10 4.354e-5       180 -230 500 -510 1010 -1030  imp:n=1  $
50     10 4.354e-5       180 -230 520 -530 1010 -1030  imp:n=1  $
60     10 4.354e-5       160 -230 560 -570 1010 -1030  imp:n=1  $
70     10 4.354e-5       160 -230 580 -620 1010 -1030  imp:n=1  $
80     10 4.354e-5       160 -170 630 -640 1010 -1030  imp:n=1  $
90     10 4.354e-5       180 -230 630 -640 1010 -1030  imp:n=1  $
100    10 4.354e-5       160 -170 690 -700 1010 -1030  imp:n=1  $
110    10 4.354e-5       160 -170 710 -760 1010 -1030  imp:n=1  $
120    10 4.354e-5       (180 -230 690 -760 1010 -1030):
                         (230 -250 740 -760 1010 -1030) imp:n=1 $
130    10 4.354e-5       240 -250 690 -730 1010 -1030  imp:n=1  $
140    10 4.354e-5       (160 -250 770 -820 1010 -1030):
                         (160 -200 820 -860 1010 -1030) imp:n=1 $
c
c      here are the concrete walls
c
150    20 3.9827e-2      150 -160 680 -870 1010 -1030 imp:n=1 $
160    20 3.9827e-2      170 -180 680 -770 1010 -1030 imp:n=1 $
170    20 3.9827e-2      200 -210 820 -870 1010 -1030 imp:n=1 $
180    20 3.9827e-2      230 -240 680 -740 1010 -1030 imp:n=1 $
190    20 3.9827e-2      250 -260 680 -830 1010 -1030 imp:n=1 $
200    20 3.9827e-2      160 -200 860 -870 1010 -1030 imp:n=1 $
205    20 3.9827e-2      210 -250 820 -830 1010 -1030 imp:n=1 $
210    20 3.9827e-2      160 -170 760 -770 1010 -1030 imp:n=1 $
220    20 3.9827e-2      180 -250 760 -770 1010 -1030 imp:n=1 $
230    20 3.9827e-2      160 -170 700 -710 1010 -1030 imp:n=1 $
240    20 3.9827e-2      240 -250 730 -740 1010 -1030 imp:n=1 $
250    20 3.9827e-2      160 -170 680 -690 1010 -1030 imp:n=1 $
260    20 3.9827e-2      180 -230 680 -690 1010 -1030 imp:n=1 $
270    20 3.9827e-2      240 -250 680 -690 1010 -1030 imp:n=1 $
280    20 3.9827e-2      160 -170 640 -650 1010 -1030 imp:n=1 $
290    20 3.9827e-2      180 -230 640 -650 1010 -1030 imp:n=1 $
300    20 3.9827e-2      160 -170 620 -630 1010 -1030 imp:n=1 $
310    20 3.9827e-2      180 -230 620 -630 1010 -1030 imp:n=1 $
320    20 3.9827e-2      160 -230 570 -580 1010 -1030 imp:n=1 $
330    20 3.9827e-2      160 -230 550 -560 1010 -1030 imp:n=1 $
340    20 3.9827e-2      150 -160 550 -650 1010 -1030 imp:n=1 $
345    20 3.9827e-2      170 -180 620 -650 1010 -1030 imp:n=1 $
350    20 3.9827e-2      230 -240 550 -650 1010 -1030 imp:n=1 $
360    20 3.9827e-2      170 -180 430 -540 1010 -1030 imp:n=1 $
370    20 3.9827e-2      230 -240 430 -540 1010 -1030 imp:n=1 $
```

```
380   20 3.9827e-2      180 -230 530 -540 1010 -1030 imp:n=1 $
390   20 3.9827e-2      180 -230 510 -520 1010 -1030 imp:n=1 $
400   20 3.9827e-2      180 -230 490 -500 1010 -1030 imp:n=1 $
410   20 3.9827e-2      180 -230 470 -480 1010 -1030 imp:n=1 $
420   20 3.9827e-2      180 -230 450 -460 1010 -1030 imp:n=1 $
430   20 3.9827e-2      180 -230 430 -440 1010 -1030 imp:n=1 $
c
c     storage areas
c
500   40 -0.375      80  -110 590 -600 1010 -1020 imp:n=1 $ lot A
510   40 -0.375      70  -100 600 -610 1010 -1020 imp:n=1 $     B
520   40 -0.375      20  -60  590 -600 1010 -1020 imp:n=1 $     C
530   40 -0.375      25  -40  660 -670 1010 -1020 imp:n=1 $     D
540   40 -0.375      60  -110 660 -670 1010 -1020 imp:n=1 $     F
550   40 -0.375      25  -40  720 -750 1010 -1020 imp:n=1 $     E
560   40 -0.375      40  -60  780 -790 1010 -1020 imp:n=1 $     G
570   40 -0.375      20  -30  780 -790 1010 -1020 imp:n=1 $     H
580   40 -0.375      40  -60  810 -840 1010 -1020 imp:n=1 $     I
590   40 -0.375      70  -90  790 -800 1010 -1020 imp:n=1 $     J
600   40 -0.375      70  -110 880 -890 1010 -1020 imp:n=1 $     K
610   40 -0.375      120 -140 880 -890 1010 -1020 imp:n=1 $     L
620   40 -0.375      130 -140 900 -920 1010 -1020 imp:n=1 $     M
630   40 -0.375      170 -200 900 -930 1010 -1020 imp:n=1 $     N
640   40 -0.375      240 -290 900 -910 1010 -1020 imp:n=1 $     O
650   40 -0.375      240 -270 880 -890 1010 -1020 imp:n=1 $     P
660   40 -0.375      300 -310 850 -890 1010 -1020 imp:n=1 $     Q
670   40 -0.375      320 -330 880 -890 1010 -1020 imp:n=1 $     R
680   40 -0.375      340 -350 880 -890 1010 -1020 imp:n=1 $     S
690   40 -0.375      280 -290 780 -790 1010 -1020 imp:n=1 $     T
700   40 -0.375       50  -80 410 -420 1010 -1020 imp:n=1 $     U
c
c   walls of building
c
705   30 8.7411e-2       15 -360 400 -405 1010 -1052 imp:n=8192 $ west wall
710   30 8.7411e-2       15 -360 940 -945 1010 -1052 imp:n=1 $ east wall
c
720   30 8.7411e-2       10   -15 400 -745 1010 -1052 imp:n=8192 $ north wall
722   30 8.7411e-2       10   -15 745 -772 1010 -1052 imp:n=4096 $ north wall
724   30 8.7411e-2       10   -15 772 -775 1010 -1052 imp:n=2048 $ north wall
726   30 8.7411e-2       10   -15 775 -785 1010 -1052 imp:n=1024 $ north wall
728   30 8.7411e-2       10   -15 785 -795 1010 -1052 imp:n=512 $ north wall
730   30 8.7411e-2       10   -15 795 -835 1010 -1052 imp:n=256 $ north wall
732   30 8.7411e-2       10   -15 835 -845 1010 -1052 imp:n=128 $ north wall
734   30 8.7411e-2       10   -15 845 -875 1010 -1052 imp:n=64 $ north wall
736   30 8.7411e-2       10   -15 875 -895 1010 -1052 imp:n=32 $ north wall
738   30 8.7411e-2       10   -15 895 -905 1010 -1052 imp:n=16 $ north wall
740   30 8.7411e-2       10   -15 905 -923 1010 -1052 imp:n=8 $ north wall
742   30 8.7411e-2       10   -15 923 -925 1010 -1052 imp:n=4 $ north wall
744   30 8.7411e-2       10   -15 925 -932 1010 -1052 imp:n=2 $ north wall
746   30 8.7411e-2       10   -15 932 -945 1010 -1052 imp:n=1 $ north wall
c
750   30 8.7411e-2      360 -365 400 -745 1010 -1052 imp:n=8192 $ south wall
752   30 8.7411e-2      360 -365 745 -772 1010 -1052 imp:n=4096 $ south wall
754   30 8.7411e-2      360 -365 772 -775 1010 -1052 imp:n=2048 $ south wall
756   30 8.7411e-2      360 -365 775 -785 1010 -1052 imp:n=1024 $ south wall
758   30 8.7411e-2      360 -365 785 -795 1010 -1052 imp:n=512 $ south wall
760   30 8.7411e-2      360 -365 795 -835 1010 -1052 imp:n=256 $ south wall
762   30 8.7411e-2      360 -365 835 -845 1010 -1052 imp:n=128 $ south wall
764   30 8.7411e-2      360 -365 845 -875 1010 -1052 imp:n=64 $ south wall
766   30 8.7411e-2      360 -365 875 -895 1010 -1052 imp:n=32 $ south wall
768   30 8.7411e-2      360 -365 895 -905 1010 -1052 imp:n=16 $ south wall
770   30 8.7411e-2      360 -365 905 -923 1010 -1052 imp:n=6 $ south wall
772   30 8.7411e-2      360 -365 923 -925 1010 -1052 imp:n=4 $ south wall
774   30 8.7411e-2      360 -365 925 -932 1010 -1052 imp:n=2 $ south wall
776   30 8.7411e-2      360 -365 932 -945 1010 -1052 imp:n=1 $ south wall
c
780   20 3.9827e-2      15 -360 405 -745 1040 -1050  imp:n=8192 $ concrete process floor
```

```
782    20 3.9827e-2       15 -360 745 -772 1040 -1050  imp:n=4096 $ concrete process floor
784    20 3.9827e-2       15 -360 772 -775 1040 -1050  imp:n=2048 $ concrete process floor
786    20 3.9827e-2       15 -360 775 -785 1040 -1050  imp:n=1024 $ concrete process floor
788    20 3.9827e-2       15 -360 785 -795 1040 -1050  imp:n=512 $ concrete process floor
790    20 3.9827e-2       15 -360 795 -835 1040 -1050  imp:n=256 $ concrete process floor
792    20 3.9827e-2       15 -360 835 -845 1040 -1050  imp:n=128 $ concrete process floor
794    20 3.9827e-2       15 -360 845 -875 1040 -1050  imp:n=64 $ concrete process floor
796    20 3.9827e-2       15 -360 875 -895 1040 -1050  imp:n=32 $ concrete process floor
798    20 3.9827e-2       15 -360 895 -905 1040 -1050  imp:n=16 $ concrete process floor
800    20 3.9827e-2       15 -360 905 -923 1040 -1050  imp:n=8 $ concrete process floor
802    20 3.9827e-2       15 -360 923 -925 1040 -1050  imp:n=4 $ concrete process floor
804    20 3.9827e-2       15 -360 925 -932 1040 -1050  imp:n=2 $ concrete process floor
806    20 3.9827e-2       15 -360 932 -940 1040 -1050  imp:n=1 $ concrete process floor
c
810    20 3.9827e-2       1000 -1010 -1998 imp:n=1 $ concrete floor
820    70 9.0726e-2       10 -365 400 -745 1052 -1055 imp:n=8192  $ roof
822    70 9.0726e-2       10 -365 745 -772 1052 -1055 imp:n=4096  $ roof
824    70 9.0726e-2       10 -365 772 -775 1052 -1055 imp:n=2048  $ roof
826    70 9.0726e-2       10 -365 775 -785 1052 -1055 imp:n=1024  $ roof
828    70 9.0726e-2       10 -365 785 -795 1052 -1055 imp:n=512  $ roof
830    70 9.0726e-2       10 -365 795 -835 1052 -1055 imp:n=256  $ roof
832    70 9.0726e-2       10 -365 835 -845 1052 -1055 imp:n=128  $ roof
834    70 9.0726e-2       10 -365 845 -875 1052 -1055 imp:n=64  $ roof
836    70 9.0726e-2       10 -365 875 -895 1052 -1055 imp:n=32  $ roof
838    70 9.0726e-2       10 -365 895 -905 1052 -1055 imp:n=16  $ roof
840    70 9.0726e-2       10 -365 905 -923 1052 -1055 imp:n=8  $ roof
842    70 9.0726e-2       10 -365 923 -925 1052 -1055 imp:n=4  $ roof
844    70 9.0726e-2       10 -365 925 -932 1052 -1055 imp:n=2  $ roof
846    70 9.0726e-2       10 -365 932 -945 1052 -1055 imp:n=1  $ roof
c
c  roofs on offices
c
900    30 8.7411e-2      170 -240 430 -540 1030 -1035 imp:n=1
                     $ west room roof
910    30 8.7411e-2      150 -240 550 -650 1030 -1035
                       imp:n=1 $ middle room roof
920    30 8.7411e-2       (150 -260 680 -830 1030 -1035):
                       (150 -210 830 -870 1030 -1035)
                        imp:n=1 $ west room roof
c
c  air in building
c
1000  0                 ((-80:110:-590:600:-1010:1020)
                        (-70:100:-600:610:-1010:1020)
                        (-20:60:-590:600:-1010:1020)
                        (-50:80:-410:420:-1010:1020)
                        (-150:240:-550:650:-1010:1035)
                        (-170:240:-430:540:-1010:1035)
                        (15 -290 405 -660 1010 -1040)) 1110
                        fill=1 imp:n=1                $ northwest air
1010   0                (-60:110:-660:670:-1010:1020)
                        (-25:40:-660:670:-1010:1020)
                        (-25:40:-720:750:-1010:1020)
                        (-40:60:-780:790:-1010:1020)
                        (-20:30:-780:790:-1010:1020)
                        (-40:60:-810:840:-1010:1020)
                        (-70:90:-790:800:-1010:1020)
                        (15 -110 660 -880 1010 -1040)
                        fill=1 imp:n=1                       $ air
1012   0                (-70:110:-880:890:-1010:1020)
                        (-120:140:-880:890:-1010:1020)
                        (-130:140:-900:920:-1010:1020)
                        (-170:200:-900:930:-1010:1020)
                        (-240:290:-900:910:-1010:1020)
                        (-240:270:-880:890:-1010:1020)
                        (15 -290 880 -940 1010 -1040)
                        fill=1 imp:n=1                       $ air
```

```
1014    0              ((-280:290:-780:790:-1010:1020)
                       (-150:260:-680:830:-1010:1035)
                       (-150:210:-830:870:-1010:1035)
                       (110 -290 660 -880 1010 -1040)) 1100 1210
                       fill=1 imp:n=1                  $.northeast air
1020    0              (-300:310:-850:890:-1010:1020)
                       (-320:330:-880:890:-1010:1020)
                       (-340:350:-880:890:-1010:1020)
                       (290 -360 660 -940 1010 -1040)
                       fill=1 imp:n=1                   $ southeast air
1030    0              (290 -360 405 -660 1010 -1040) 1120
                       fill=1 imp:n=1                  $ southwest air
c
c    repeated structures cells
c
1200    20 3.9827e-2   1520 -1500 1620 -1600  u=2    imp:n=1 $
1210    10 4.354e-5    -1520:1500:-1620:1600  u=2    imp:n=1 $
1220    10 4.354e-5    -1550 1540 -1650 1640 -1700 1730  u=1 lat=1
                       imp:n=1  fill=0:45 0:65 0:0
                        2 3035r                    $ repeated unit cell
c
c
1500    10 4.354e-5    -1100        imp:n=1  $ detector se-1
1510    10 4.354e-5    -1110        imp:n=1  $ detector 33-ls-1
1520    10 4.354e-5    -1120        imp:n=1  $ detector 33-1g
1530    10 4.354e-5    -1130        imp:n=1  $ detector 10-U
1540    10 4.354e-5    -1140        imp:n=1  $ detector 10-Fy
1550    10 4.354e-5    -1150        imp:n=1  $ detector 26-U
1560    10 4.354e-5    -1160        imp:n=1  $ detector 26-Fy
1570    10 4.354e-5    -1170        imp:n=1  $ detector 42-U
1580    10 4.354e-5    -1180        imp:n=1  $ detector 42-Fy
1590    10 4.354e-5    -1190        imp:n=1  $ detector 58-U
1600    10 4.354e-5    -1200        imp:n=1  $ detector 58-G
1610    10 4.354e-5    -1210        imp:n=1  $ detector 56-Mb ground floor
1998    10 4.354e-5    ((-10:365:-400:945) -1998 -1055 1010):
                       (-1998 1055) imp:n=1 $ air around building
1999     0             (-1000 -1999):(1998 -1999) imp:n=1 $ internal world
2000     0             1999 imp:n=0                        $ external world
c
2500    10 4.354e-5    15 -360 935 -940 1050 -1051 imp:n=1 $
c
2510    10 4.354e-5    (15 -360 405 -745 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=8192           $ air above proc cells
2512    10 4.354e-5    (15 -360 745 -772 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=4096           $ air above proc cells
2514    10 4.354e-5    (15 -360 772 -775 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=2048           $ air above proc cells
2516    10 4.354e-5    (15 -360 775 -785 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=1024           $ air above proc cells
2518    10 4.354e-5    (15 -360 785 -795 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=512           $ air above proc cells
2520    10 4.354e-5    (15 -360 795 -835 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=256           $ air above proc cells
2522    10 4.354e-5    (15 -360 835 -845 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=128           $ air above proc cells
2524    10 4.354e-5    (15 -360 845 -875 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
                       1200  imp:n=64          $ air above proc cells
2526    10 4.354e-5    (15 -360 875 -895 1051 -1052)
                       1130 1140 1150 1160 1170 1180 1190
```

```
                        1200  imp:n=32          $ air above proc cells
2528    10 4.354e-5     (15 -360 895 -905 1051 -1052)
                        1130 1140 1150 1160 1170 1180 1190
                        1200  imp:n=16          $ air above proc cells
2530    10 4.354e-5     (15 -360 905 -923 1051 -1052)
                        1130 1140 1150 1160 1170 1180 1190
                        1200  imp:n=8          $ air above proc cells
2532    10 4.354e-5     (15 -360 923 -925 1051 -1052)
                        1130 1140 1150 1160 1170 1180 1190
                        1200  imp:n=4          $ air above proc cells
2534    10 4.354e-5     (15 -360 925 -932 1051 -1052)
                        1130 1140 1150 1160 1170 1180 1190
                        1200  imp:n=2          $ air above proc cells
2536    10 4.354e-5     (15 -360 932 -940 1051 -1052)
                        1130 1140 1150 1160 1170 1180 1190
                        1200  imp:n=1          $ air above proc cells
c
2600    80  1.6021E-3    2000 -2010 2220 -2230 u=7 imp:n=1   $
2610    80  1.6021E-3    2020 -2030 2220 -2230 u=7 imp:n=1   $
2620    80  1.6021E-3    2040 -2050 2220 -2230 u=7 imp:n=1   $
2630    80  1.6021E-3    2060 -2070 2220 -2230 u=7 imp:n=1   $
2640    80  1.6021E-3    2080 -2090 2220 -2230 u=7 imp:n=1   $
2650    80  1.6021E-3    2000 -2010 2200 -2210 u=7 imp:n=1   $
2660    80  1.6021E-3    2020 -2030 2200 -2210 u=7 imp:n=1   $
2670    80  1.6021E-3    2040 -2050 2200 -2210 u=7 imp:n=1   $
2680    80  1.6021E-3    2060 -2070 2200 -2210 u=7 imp:n=1   $
2690    80  1.6021E-3    2080 -2090 2200 -2210 u=7 imp:n=1   $
2700    10 4.354e-5     ((-2000:2010:-2220:2230)
                        (-2020:2030:-2220:2230)
                        (-2000:2010:-2200:2210)
                        (-2020:2030:-2200:2210)) -2030 u=7 imp:n=1  $
2710    10 4.354e-5     ((-2040:2050:-2220:2230)
                        (-2060:2070:-2220:2230)
                        (-2040:2050:-2200:2210)
                        (-2060:2070:-2200:2210)) 2030 -2070
                        u=7 imp:n=1                     $
2720    10 4.354e-5     ((-2080:2090:-2220:2230)
                        (-2080:2090:-2200:2210)) 2070 u=7 imp:n=1  $
c
2750    0               -2095 12  -2250 402 u=6 lat=1 imp:n=1
                        fill=0:2 0:0 0:0
                        7 2r                                    $
c
2760    0               -362 13 -2240 403 u=5 lat=1 imp:n=1
                        fill=0:0 0:4 0:0
                        6 4r                                    $
c
2770    0               15 -360 405 -745 1050 -1051
                        fill=5 imp:n=8192                          $
2772    0               15 -360 745 -772 1050 -1051
                        fill=5 imp:n=4096                          $
2774    0               15 -360 772 -775 1050 -1051
                        fill=5 imp:n=2048                          $
2776    0               15 -360 775 -785 1050 -1051
                        fill=5 imp:n=1024                          $
2778    0               15 -360 785 -795 1050 -1051
                        fill=5 imp:n=512                         $
2780    0               15 -360 795 -835 1050 -1051
                        fill=5 imp:n=256                         $
2782    0               15 -360 835 -845 1050 -1051
                        fill=5 imp:n=128                         $
2784    0               15 -360 845 -875 1050 -1051
                        fill=5 imp:n=64                         $
2786    0               15 -360 875 -895 1050 -1051
                        fill=5 imp:n=32                         $
2788    0               15 -360 895 -905 1050 -1051
                        fill=5 imp:n=16                         $
```

```
2790   0          15 -360 905 -923 1050 -1051
                  fill=5 imp:n=8                    $
2792   0          15 -360 923 -925 1050 -1051
                  fill=5 imp:n=4                    $
2794   0          15 -360 925 -932 1050 -1051
                  fill=5 imp:n=2                    $
2796   0          15 -360 932 -935 1050 -1051
                  fill=5 imp:n=1                    $
c
c

c
c
c
c  ***********************************************
c         surface cards
c  ***********************************************
c
c
10    px   0              $
12    px   0.189          $
13    px   0.190          $
15    px   0.191          $
20    px   1463           $
25    px   1920           $
30    px   3078           $
40    px   3779           $
50    px   4328           $
60    px   5639           $
70    px   6370           $
80    px   7010           $
90    px   7559           $
100   px   8230           $
110   px   9510           $
120   px   11369          $
130   px   12009          $
140   px   12710          $
150   px   13259          $
160   px   13279          $
170   px   14021          $
180   px   14041          $
200   px   14752          $
210   px   14772          $
230   px   15464          $
240   px   15484          $
250   px   16286          $
260   px   16306          $
270   px   16825          $
280   px   17435          $
290   px   18075          $
300   px   20025          $
310   px   20665          $
320   px   21275          $
330   px   23165          $
340   px   23805          $
350   px   25116          $
360   px   29566          $
362   px   29566.01       $
365   px   29566.191      $
400   py   0              $
402   py   0.189          $
403   py   0.190          $
405   py   0.191          $
410   py   732            $
420   py   1402           $
430   py   6414           $
440   py   6434           $
```

```
450   py   7074           $
460   py   7094           $
470   py   7734           $
480   py   7754           $
490   py   9034           $
500   py   9054           $
510   py   10243          $
520   py   10263          $
530   py   12103          $
540   py   12123          $
c   545   py  17282.16        $
550   py   19347          $
560   py   19367          $
570   py   19885          $
580   py   19905          $
590   py   21287          $
600   py   21897          $
610   py   22629          $
620   py   23411          $
630   py   23431          $
640   py   23949          $
650   py   23969          $
660   py   26591          $
670   py   27292          $
680   py   27352          $
690   py   27372          $
700   py   27707          $
710   py   27727          $
720   py   28146          $
730   py   28195          $
740   py   28215          $
745   py   28529          $
750   py   28786          $
760   py   28835          $
770   py   28855          $
772   py   29749          $
775   py   30968          $
780   py   32047          $
785   py   32187          $
790   py   32748          $
795   py   33406          $
800   py   33449          $
810   py   34120          $
820   py   34311          $
830   py   34331          $
835   py   34625          $
840   py   34790          $
845   py   35845          $
850   py   36741          $
860   py   36891          $
870   py   36911          $
875   py   37064          $
880   py   37381          $
890   py   37990          $
895   py   38283          $
900   py   38935          $
905   py   39502          $
910   py   39606          $
920   py   40276          $
923   py   40721          $
925   py   41941          $
930   py   42227          $
932   py   43160          $
935   py   44279          $
940   py   44379          $
945   py   44379.191      $
1000   pz   -3000         $
```

```
1010  pz  0             $
1020  pz  197           $ top of drums
1030  pz  305           $ top of rooms
1035  pz  305.09        $ top of roof on rooms
1040  pz  838.2         $ top of first floor
1050  pz  868.68        $ process cell floor
1051  pz  1208.68       $ top of process cells
1052  pz  2504.6        $
1055  pz  2514.6        $
1100  s   14752 27241    200 50  $ detector se-1
1110  s   14752 1351     200 50  $ detector 33-1s-1
1120  s   28225 12933    200 50  $ detector 33-1g
1130  s   5639  6414     1368.68 50  $ detector 10-U
1140  s   23805 6414     1368.68 50  $ detector 10-Fy
1150  s   5639  17282.16 1368.68 50  $ detector 26-U
1160  s   23805 17282.16 1368.68 50  $ detector 26-Fy
1170  s   5639  28146    1368.68 50  $ detector 42-U
1180  s   23805 28146    1368.68 50  $ detector 42-Fy
1190  s   5639  38935    1368.68 50  $ detector 58-U
1200  s   23165 38935    1368.68 50  $ detector 58-G
1210  s   14000 37000    200 50      $ detector 56-Mb ground floor
c
c surfaces for repeating structures first floor
c
1520  px  -0.1          $
1500  px  45.72         $
c  1510  px  642.73        $
c  1530  px  642.83        $
1540  px  -0.01         $
1550  px  642.74        $
1620  py  -0.1          $
1600  py  45.72         $
c  1610  py  672.39        $
c  1630  py  672.49        $
1640  py  -0.01         $
1650  py  672.4         $
c  1710  pz  -0.1          $
1700  pz  900           $
c  1720  pz  900.1         $
1730  pz  -0.01         $
1998  so  80000         $
1999  so  10000000        $
c
c  surfaces for repeating structures in second floor
c
2000  px  1244.6         $
2010  px  3134.36        $
2020  px  3769.36        $
2030  px  5659.12        $
2040  px  6334.76        $
2050  px  8224.52        $
2060  px  8859.52        $
2070  px  10749.28       $
2080  px  11424.92       $
2090. px  13314.68       $
2095  px  14996.16       $
2200  py  731.5          $
2210  py  5364.48        $
2220  py  6278.88        $
2230  py  10911.84       $
2240  py  10911.85       $
2250  py  10911.86       $

c    ******************************************
c
c                source  term
c
```

```
c    ********************************************
sdef   pos=1.0 44378.0 968.68  erg=d1 vec=5638 -16232 400 dir=d2
c  sdef   sur=1998  nrm=-1   dir=d1
c  sb1   -21 2
sc1    from h/u=15 5% enrichment normalized to 2881 W
si1 h  1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
       3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
       1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
       0.003     0.017    0.1      0.4      0.9      1.4
       1.85      3.0      6.43     20
sp1 d  0            1.46e+2  8.00e+2  9.71e+2  1.50e+3  1.04e+3
       3.00e+2   1.62e+2  5.54e+2  1.74e+2  8.59e+1  1.04e+2
       2.53e+2   4.73e+2  9.48e+2  1.03e+3  1.18e+3  1.68e+3
       1.82e+3   2.18e+3  2.96e+3  4.36e+3  5.07e+3  3.40e+3
       2.72e+3   5.56e+3  4.90e+3  6.11e+2
c
c
sc2  source bias toward detector U-42
si2  -1 0.94 1
sp2  0  0.97 0.03
sb2  0  0.5  0.5
c    ********************************************
c
c              material cards
c
c    ********************************************
c
m10   7014.50c   3.570e-5   $ air
      8016.50c   7.840e-6
m20   1001.50c   1.487e-2   $ concrete
      6012.50c   3.814e-3
      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
m30   6012.50c   3.921e-3   $ steel
      26000.50c  8.349e-2
m40   6012.50c   6.0        $ wood
      1001.50c   10.0
      8016.50c   5.0
m70   1001.50c   4.288e-2
      6012.50c   1.812e-2
      8016.50c   1.896e-3
      26000.50c  2.783e-2    $ roof
m80   6012.50c   6.230e-5
      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   $ homogenized cell material
c
c
c      *****************************
c
c          tally cards
c
c      ******************************
c
fc4    track length detector se-1
f4:n   1500
```

```
fc14    track length detector 33-LS-1
f14:n   1510
fc24    track length detector 1g
f24:n   1520
fc34    track length detector 10-U
f34:n   1530
fc44    track length detector 10-Fy
f44:n   1540
fc54    track length detector 26-U
f54:n   1550
fc64    track length detector 26-Fy
f64:n   1560
fc74    track length detector 42-U
f74:n   1570
fc84    track length detector 42-Fy
f84:n   1580
fc94    track length detector 58-U
f94:n   1590
fc104   track length detector 58-G
f104:n  1600
fc114   track length detector 56-Mb ground floor
f114:n  1610
c   fc5     point detector se-1
c   f5:n    14752.02  27241.02  200.02  49
c   fc15    point detector 33-LS-1
c   f15:n   14752.02  1351.02  200.02  49
c   f25c    point detector 1g
c   f25:n   28225.02  12933.02  200.02  49
c  e0     1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
c       3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
c       1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
c       0.003     0.017    0.1      0.4      0.9      1.4
c       1.85      3.0      6.43     20
c
c
c  Response Function
c  ******************************
c
dE0   1.00E-09  1.00E-08        1.00E-07        5.00E-07
      1.00E-06  5.00E-06        1.00E-05        5.00E-05
      1.00E-04  5.00E-04        1.00E-03        5.00E-03
      1.00E-02  2.00E-02        5.00E-02        1.00E-01
      5.00E-01  1               2               5
      10        20
c
c
c
c
c
dF0   0.456683643    0.612833708   1.202405686   1.907520827
      2.170074239    2.524934685   2.619466509   2.665319206
      2.525689936    2.568979899   2.526120045   2.429598966
      2.361915675    2.254370492   2.239813349   2.236561929
      1.912907431    1.575113097   1.131268722   0.548312231
      0.248252542    0.142345613
c
c
c     **************************
c
c         peripheral cards
c
c     **************************
c
c  ptrac  file=asc  cell=1500 1510 1520
mode   n
c    17 keV cut off
c    cut:n  j  0.017
```

```
ctme  10
c  void
c  nps  99000000
prdmp  3j  4
c     dbcn   31277116122605
print
c
```

Listing A.2

Input for X-330

The model includes both the operating and cell floor for X-330.

```
Model of the entire X-330 building
c
c  *********************************************
c     cell cards
c  *********************************************
c
10   70   -1.0        10 -15 520 -531 810 -830 imp:n=1 $  battery rm. #1
20   10   4.354e-5    21 -50 441 -460 810 -830 imp:n=1 $
30   10   4.354e-5    21 -30 411 -430 810 -830 imp:n=1 $
50   10   4.354e-5    (21 -31 431 -440 810 -830):
                      (31 -40 411 -440 810 -830) imp:n=1 $
60   10   4.354e-5    41 -50 431 -440 810 -830 imp:n=1 $
70   70   -1.0        53 -54 520 -531 810 -830 imp:n=1 $  battery rm. #2
80   70   -1.0        55 -56 520 -531 810 -830 imp:n=1 $  battery rm. #3
90   10   4.354e-5    61 -80 481 -520 810 -830 imp:n=1 $
95   10   4.354e-5    71 -80 521 -530 810 -830 imp:n=1 $
100  10   4.354e-5    61 -70 471 -480 810 -830 imp:n=1 $
110  10   4.354e-5    71 -80 471 -480 810 -830 imp:n=1 $
120  70   -1.0        85 -88 520 -531 810 -830 imp:n=1 $  battery rm. #4
130  10   4.354e-5    91 -100 501 -510 810 -830 imp:n=1 $
140  70   -1.0        100 -105 520 -531 810 -830 imp:n=1 $  battery rm. #5
142  10   4.354e-5    111 -130 591 -600 810 -830 imp:n=1 $
143  10   4.354e-5    111 -130 571 -590 810 -830 imp:n=1 $
144  10   4.354e-5    111 -130 561 -570 810 -830 imp:n=1 $
145  10   4.354e-5    111 -130 541 -560 810 -830 imp:n=1 $
150  10   4.354e-5    (121 -150 441 -500 810 -830):
                      (121 -130 421 -441 810 -830) imp:n=1 $
170  10   4.354e-5    121 -130 411 -420 810 -830 imp:n=1 $
190  10   4.354e-5    131 -140 411 -440 810 -830 imp:n=1 $
200  10   4.354e-5    141 -150 431 -440 810 -830 imp:n=1 $
210  10   4.354e-5    141 -150 421 -430 810 -830 imp:n=1 $
220  10   4.354e-5    141 -150 411 -420 810 -830 imp:n=1 $
230  70   -1.0        145 -150 520 -531 810 -830 imp:n=1 $  battery rm. #6
240  70   -1.0        153 -154 520 -531 810 -830 imp:n=1 $  battery rm. #7
250  70   -1.0        155 -156 520 -531 810 -830 imp:n=1 $  battery rm. #8
260  10   4.354e-5    161 -170 521 -530 810 -830 imp:n=1 $
270  10   4.354e-5    171 -180 521 -530 810 -830 imp:n=1 $
280  10   4.354e-5    161 -180 481 -520 810 -830 imp:n=1 $
290  10   4.354e-5    161 -170 471 -480 810 -830 imp:n=1 $
300  10   4.354e-5    171 -180 471 -480 810 -830 imp:n=1 $
310  70   -1.0        185 -188 520 -531 810 -830 imp:n=1 $  battery rm. #9
320  10   4.354e-5    191 -200 401 -450 810 -830 imp:n=1 $
330  70   -1.0        195 -200 520 -531 810 -830 imp:n=1 $  battery rm. #10
340  10   4.354e-5    211 -230 480 -490 810 -830 imp:n=1 $
342  .10  4.354e-5    211 -230 450 -480 810 -830 imp:n=1 $
344  10   4.354e-5    211 -230 440 -450 810 -830 imp:n=1 $
346  10   4.354e-5    211 -230 421 -440 810 -830 imp:n=1 $
350  70   -1.0        235 -240 520 -531 810 -830 imp:n=1 $  battery rm. #11
360  10   4.354e-5    241 -250 399 -400 810 -830 imp:n=1 $
c
c
c      these are the concrete walls
c
c
500   20   3.9827e-2  20 -21 410 -461 810 -830 imp:n=1 $
510   20   3.9827e-2  30 -31 410 -431 810 -830 imp:n=1 $
520   20   3.9827e-2  40 -41 410 -441 810 -830 imp:n=1 $
```

```
530   20   3.9827e-2  50 -51 430 -461 810 -830 imp:n=1 $
540   20   3.9827e-2  21 -50 460 -461 810 -830 imp:n=1 $
550   20   3.9827e-2  21 -40 440 -441 810 -830 imp:n=1 $
555   20   3.9827e-2  41 -50 440 -441 810 -830 imp:n=1 $
560   20   3.9827e-2  21 -30 430 -431 810 -830 imp:n=1 $
570   20   3.9827e-2  41 -50 430 -431 810 -830 imp:n=1 $
580   20   3.9827e-2  21 -30 410 -411 810 -830 imp:n=1 $
590   20   3.9827e-2  31 -40 410 -411 810 -830 imp:n=1 $
600   20   3.9827e-2  60 -61 470 -521 810 -830 imp:n=1 $
610   20   3.9827e-2  70 -71 520 -531 810 -830 imp:n=1 $
620   20   3.9827e-2  70 -71 470 -481 810 -830 imp:n=1 $
630   20   3.9827e-2  80 -81 470 -531 810 -830 imp:n=1 $
640   20   3.9827e-2  61 -70 520 -521 810 -830 imp:n=1 $
645   20   3.9827e-2  71 -80 520 -521 810 -830 imp:n=1 $
650   20   3.9827e-2  71 -80 530 -531 810 -830 imp:n=1 $
660   20   3.9827e-2  61 -70 480 -481 810 -830 imp:n=1 $
670   20   3.9827e-2  71 -80 480 -481 810 -830 imp:n=1 $
680   20   3.9827e-2  61 -70 470 -471 810 -830 imp:n=1 $
690   20   3.9827e-2  71 -80 470 -471 810 -830 imp:n=1 $
700   20   3.9827e-2  90 -91 500 -511 810 -830 imp:n=1 $
710   20   3.9827e-2  100 -101 500 -511 810 -830 imp:n=1 $
720   20   3.9827e-2  91  -100 510 -511 810 -830 imp:n=1 $
730   20   3.9827e-2  91  -100 500 -501 810 -830 imp:n=1 $
740   20   3.9827e-2  120 -121 410 -501 810 -830 imp:n=1 $
750   20   3.9827e-2  130 -131 410 -441 810 -830 imp:n=1 $
760   20   3.9827e-2  140 -141 410 -441 810 -830 imp:n=1 $
770   20   3.9827e-2  150 -151 410 -501 810 -830 imp:n=1 $
780   20   3.9827e-2  121 -150 500 -501 810 -830 imp:n=1 $
790   20   3.9827e-2  131 -140 440 -441 810 -830 imp:n=1 $
795   20   3.9827e-2  141 -150 440 -441 810 -830 imp:n=1 $
800   20   3.9827e-2  141 -150 430 -431 810 -830 imp:n=1 $
810   20   3.9827e-2  121 -130 420 -421 810 -830 imp:n=1 $
820   20   3.9827e-2  141 -150 420 -421 810 -830 imp:n=1 $
830   20   3.9827e-2  121 -130 410 -411 810 -830 imp:n=1 $
840   20   3.9827e-2  131 -140 410 -411 810 -830 imp:n=1 $
850   20   3.9827e-2  141 -150 410 -411 810 -830 imp:n=1 $
860   20   3.9827e-2  160 -161 470 -531 810 -830 imp:n=1 $
870   20   3.9827e-2  170 -171 520 -531 810 -830 imp:n=1 $
880   20   3.9827e-2  170 -171 470 -481 810 -830 imp:n=1 $
890   20   3.9827e-2  180 -181 470 -531 810 -830 imp:n=1 $
900   20   3.9827e-2  161 -170 530 -531 810 -830 imp:n=1 $
910   20   3.9827e-2  171 -180 530 -531 810 -830 imp:n=1 $
920   20   3.9827e-2  161 -170 520 -521 810 -830 imp:n=1 $
930   20   3.9827e-2  171 -180 520 -521 810 -830 imp:n=1 $
940   20   3.9827e-2  161 -170 480 -481 810 -830 imp:n=1 $
950   20   3.9827e-2  171 -180 480 -481 810 -830 imp:n=1 $
960   20   3.9827e-2  161 -170 470 -471 810 -830 imp:n=1 $
970   20   3.9827e-2  171 -180 470 -471 810 -830 imp:n=1 $
980   20   3.9827e-2  190 -191 400 -451 810 -830 imp:n=1 $
990   20   3.9827e-2  200 -201 400 -451 810 -830 imp:n=1 $
1000  20   3.9827e-2  191 -200 450 -451 810 -830 imp:n=1 $
1010  20   3.9827e-2  191 -200 400 -401 810 -830 imp:n=1 $
1020  20   3.9827e-2  210 -211 480 -491 810 -830 imp:n=1 $
1022  20   3.9827e-2  210 -211 450 -480 810 -830 imp:n=1 $
1024  20   3.9827e-2  210 -211 440 -450 810 -830 imp:n=1 $
1026  20   3.9827e-2  210 -211 420 -440 810 -830 imp:n=1 $
1030  20   3.9827e-2  230 -231 480 -491 810 -830 imp:n=1 $
1032  20   3.9827e-2  230 -231 450 -480 810 -830 imp:n=1 $
1034  20   3.9827e-2  230 -231 440 -450 810 -830 imp:n=1 $
1036  20   3.9827e-2  230 -231 420 -440 810 -830 imp:n=1 $
1040  20   3.9827e-2  211 -230 490 -491 810 -830 imp:n=1 $
1050  20   3.9827e-2  211 -230 420 -421 810 -830 imp:n=1 $
1060  20   3.9827e-2  240 -241 398 -401 810 -830 imp:n=1 $
1070  20   3.9827e-2  250 -251 398 -401 810 -830 imp:n=1 $
1080  20   3.9827e-2  241 -250 400 -401 810 -830 imp:n=1 $
1090  20   3.9827e-2  241 -250 398 -399 810 -830 imp:n=1 $
1092  20   3.9827e-2  110 -111 540 -601 810 -830 imp:n=1 $
```

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1093  20   3.9827e-2  130 -131 540 -601 810 -830 imp:n=1 $
1094  20   3.9827e-2  111 -130 600 -601 810 -830 imp:n=1 $
1095  20   3.9827e-2  111 -130 590 -591 810 -830 imp:n=1 $
1096  20   3.9827e-2  111 -130 570 -571 810 -830 imp:n=1 $
1097  20   3.9827e-2  111 -130 560 -561 810 -830 imp:n=1 $
1098  20   3.9827e-2  111 -130 540 -541 810 -830 imp:n=1 $
c
c
c    steel walls
c
c
1100  30   8.7411e-2  1 -2 397 -611 810 -870 imp:n=1 $
1110  30   8.7411e-2  251 -252 1030 -611 810 -870 imp:n=1 $
1111  30   8.7411e-2  251 -252 595 -1030 810 -870 imp:n=1 $
1112  30   8.7411e-2  251 -252 580 -595  810 -870 imp:n=1 $
1113  30   8.7411e-2  251 -252 560 -580  810 -870 imp:n=1 $
1114  30   8.7411e-2  251 -252 1020 -560 810 -870 imp:n=1 $
1115  30   8.7411e-2  251 -252 530 -1020 810 -870 imp:n=1 $
1116  30   8.7411e-2  251 -252 510 -530  810 -870 imp:n=1 $
1117  30   8.7411e-2  251 -252 1000 -510 810 -870 imp:n=1 $
1118  30   8.7411e-2  251 -252 480 -1000 810 -870 imp:n=1 $
1119  30   8.7411e-2  251 -252 450 -480  810 -870 imp:n=1 $
1121  30   8.7411e-2  251 -252 440 -450  810 -870 imp:n=1 $
1122  30   8.7411e-2  251 -252 420 -440  810 -870 imp:n=1 $
1123  30   8.7411e-2  251 -252 397 -420  810 -870 imp:n=1 $
1120  30   8.7411e-2  2 -210 397 -398 810 -870 imp:n=1 $
1125  30   8.7411e-2  210 -251 397 -398 810 -870 imp:n=1 $
1130  30   8.7411e-2  2 -210 610 -611 810 -870 imp:n=1 $
1135  30   8.7411e-2  210 -251 610 -611 810 -870 imp:n=1 $
c
c
c   sub-structure roofs
c
c
1300  30   8.7411e-2  (20 -51 430 -461 830 -840):
                      (20 -41 410 -430 830 -840) imp:n=1 $
1310  30   8.7411e-2  (60 -81 470 -521 830 -840):
                      (70 -81 521 -531 830 -840) imp:n=1 $
1320  30   8.7411e-2  90 -101 500 -511 830 -840 imp:n=1 $
1330  30   8.7411e-2  120 -151 410 -501 830 -840 imp:n=1 $
1340  30   8.7411e-2  160 -181 470 -531 830 -840 imp:n=1 $
1350  30   8.7411e-2  190 -201 400 -451 830 -840 imp:n=1 $
1360  30   8.7411e-2  210 -231 480 -491 830 -840 imp:n=1 $
1362  30   8.7411e-2  210 -231 450 -480 830 -840 imp:n=1 $
1364  30   8.7411e-2  210 -231 440 -450 830 -840 imp:n=1 $
1366  30   8.7411e-2  210 -231 420 -440 830 -840 imp:n=1 $
1370  30   8.7411e-2  240 -251 398 -401 830 -840 imp:n=1 $
1380  30   8.7411e-2  110 -131 540 -601 830 -840 imp:n=1 $
c
c
c    concrete floor and ceiling
c
c
1400  0               (800 -810 -9998)
                      (-1:252:-397:611)  imp:n=1  $  this is the giant concrete floor
1410  20   7.9654e-2  2 -210 398 -610 850 -860 imp:n=1 $ south proc cell floor
1411  20   7.9654e-2  210 -251 1030 -610 850 -860 imp:n=1 $ north proc cell floor
1412  20   7.9654e-2  210 -251 595 -1030 850 -860 imp:n=1 $ north proc cell floor
1413  20   7.9654e-2  210 -251 580 -595  850 -860 imp:n=1 $ north proc cell floor
1414  20   7.9654e-2  210 -251 560 -580  850 -860 imp:n=1 $ north proc cell floor
1415  20   7.9654e-2  210 -251 1020 -560 850 -860 imp:n=1 $ north proc cell floor
1416  20   7.9654e-2  210 -251 530 -1020 850 -860 imp:n=1 $ north proc cell floor
1417  20   7.9654e-2  210 -251 510 -530  850 -860 imp:n=1 $ north proc cell floor
1418  20   7.9654e-2  210 -251 1000 -510 850 -860 imp:n=1 $ north proc cell floor
1419  20   7.9654e-2  210 -251 480 -1000 850 -860 imp:n=1 $ north proc cell floor
1420  20   7.9654e-2  210 -251 450 -480  850 -860 imp:n=1 $ north proc cell floor
1421  20   7.9654e-2  210 -251 440 -450  850 -860 imp:n=1 $ north proc cell floor
```

```
1422  20   7.9654e-2  210 -251 420 -440  850 -860 imp:n=1 $ north proc cell floor
1423  20   7.9654e-2  210 -251 398 -420  850 -860 imp:n=1 $ north proc cell floor
c
1450  20   7.9654e-2  1   -210 397 -611  800 -810 imp:n=1 $ south roof
1451  20   7.9654e-2  210 -252 1030 -611 800 -810 imp:n=1 $ north roof
1452  20   7.9654e-2  210 -252 595 -1030 800 -810 imp:n=1 $ north roof
1453  20   7.9654e-2  210 -252 580 -595  800 -810 imp:n=1 $ north roof
1454  20   7.9654e-2  210 -252 560 -580  800 -810 imp:n=1 $ north roof
1455  20   7.9654e-2  210 -252 1020 -560 800 -810 imp:n=1 $ north roof
1456  20   7.9654e-2  210 -252 530 -1020 800 -810 imp:n=1 $ north roof
1457  20   7.9654e-2  210 -252 510 -530  800 -810 imp:n=1 $ north roof
1458  20   7.9654e-2  210 -252 1000 -510 800 -810 imp:n=1 $ north roof
1459  20   7.9654e-2  210 -252 480 -1000 800 -810 imp:n=1 $ north roof
1460  20   7.9654e-2  210 -252 450 -480  800 -810 imp:n=1 $ north roof
1461  20   7.9654e-2  210 -252 440 -450  800 -810 imp:n=1 $ north roof
1462  20   7.9654e-2  210 -252 420 -440  800 -810 imp:n=1 $ north roof
1463  20   7.9654e-2  210 -252 397 -420  800 -810 imp:n=1 $ north roof
c
c     drum areas
c
1500  40  -0.375    1050 -1060 550  -1030 810 -820 imp:n=1 $ Drum area A
1510  40  -0.375    1070 -190  550  -1030 810 -820 imp:n=1 $ Drum area B
1520  40  -0.375    1080 -220  595  -1030 810 -820 imp:n=1 $ Drum area C
1522  40  -0.375    1080 -220  580  -595  810 -820 imp:n=1 $ Drum area C
1524  40  -0.375    1080 -220  560  -580  810 -820 imp:n=1 $ Drum area C
1526  40  -0.375    1080 -220  1020 -560  810 -820 imp:n=1 $ Drum area C
1530  40  -0.375    1090 -230  595  -1030 810 -820 imp:n=1 $ Drum area D
1532  40  -0.375    1090 -230  580  -595  810 -820 imp:n=1 $ Drum area D
1534  40  -0.375    1090 -230  560  -580  810 -820 imp:n=1 $ Drum area D
1536  40  -0.375    1090 -230  550  -560  810 -820 imp:n=1 $ Drum area D
1540  40  -0.375    220  -1090 510  -520  810 -820 imp:n=1 $ Drum area E
1542  40  -0.375    220  -1090 1000 -510  810 -820 imp:n=1 $ Drum area E
1550  40  -0.375    210  -1080 530  -1010 810 -820 imp:n=1 $ Drum area F
1552  40  -0.375    210  -1080 510  -530  810 -820 imp:n=1 $ Drum area F
1554  40  -0.375    210  -1080 1000 -510  810 -820 imp:n=1 $ Drum area F
1560  40  -0.375    1100 -1110 1030 -1040 810 -820 imp:n=1 $ Drum area G
1561  40  -0.375    1100 -1110 595  -1030 810 -820 imp:n=1 $ Drum area G
1562  40  -0.375    1100 -1110 580  -595  810 -820 imp:n=1 $ Drum area G
1563  40  -0.375    1100 -1110 560  -580  810 -820 imp:n=1 $ Drum area G
1564  40  -0.375    1100 -1110 1020 -560  810 -820 imp:n=1 $ Drum area G
1565  40  -0.375    1100 -1110 530  -1020 810 -820 imp:n=1 $ Drum area G
1566  40  -0.375    1100 -1110 510  -530  810 -820 imp:n=1 $ Drum area G
1567  40  -0.375    1100 -1110 1000 -510  810 -820 imp:n=1 $ Drum area G
1568  40  -0.375    1100 -1110 480  -1000 810 -820 imp:n=1 $ Drum area G
1569  40  -0.375    1100 -1110 450  -480  810 -820 imp:n=1 $ Drum area G
1570  40  -0.375    1100 -1110 440  -450  810 -820 imp:n=1 $ Drum area G
c
1600  0          (-1:-397:252:611:880) -9998 810  imp:n=1 $ air outside building
c
c  air in building
c
1700  0             (-10:15:-520:531:830)
                    (-53:54:-520:531:830)
                    (-20:41:-410:461:840)
                    (-41:51:-430:461:840)
                    (-55:56:-520:531:830)
                    (-60:81:-470:521:840)
                    (-70:81:-521:531:840)
                    (-85:88:-520:531:830)
                    (2 -90 398 -610 810 -850) 4040 4030  imp:n=1 fill=1 $ air 1
1710  0             (-90:101:-500:511:840)
                    (-100:105:-520:531:830)
                    (-120:151:-410:501:840)
                    (-145:150:-520:531:830)
                    (-153:154:-520:531:830)
                    (-110:131:-540:601:840)
                    (90 -155 398 -610 810 -850) 4020 imp:n=1 fill=1 $ air 2
```

```
1720  0            (-155:156:-520:531:830)
                   (-160:181:-470:531:840)
                   (-185:188:-520:531:830)
                   (-1050:1060:-550:1030:820)
                   (-1070:190:-550:1030:820)
                   (-190:201:-400:451:840)
                   (-195:200:-520:531:830)
                   (155 -210 398 -610 810 -850) 4010 imp:n=1 fill=1 $ air 3
c  1730  10   4.354e-5  (-210:1080:-1000:1010:820)
c                       (-1080:220:-1020:1030:820)
c                       (-220:1090:-1000:520:820)
c                       (-1090:230:-550:1030:820)
c                       (-210:231:-420:491:840)
c                       (-235:240:-520:531:830)
c                       (-1100:1110:-440:1040:820)
c                       (-240:401:840)
c                       (210 -251 398 -610 810 -850) 4000  imp:n=1 $ air 4
1730  0            (-1100:1110:-440:1040:820)
                   (210 -251 1030 -610 810 -850) imp:n=1 fill=1 $ air 4
1731  0            (-1080:220:-1020:1030:820)
                   (-1090:230:-550:1030:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 595 -1030 810 -850) imp:n=1 fill=1 $ air 4
1732  0            (-1080:220:-1020:1030:820)
                   (-1090:230:-550:1030:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 580 -595 810 -850) imp:n=1 fill=1 $ air 4
1733  0            (-1080:220:-1020:1030:820)
                   (-1090:230:-550:1030:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 560 -580 810 -850) imp:n=1 fill=1 $ air 4
1734  0            (-1080:220:-1020:1030:820)
                   (-1090:230:-550:1030:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 1020 -560 810 -850) imp:n=1 fill=1 $ air 4
1735  0            (-210:1080:-1000:1010:820)
                   (-235:240:-520:531:830)
                   (-1100:1110:-440:1040:820)
                   (210 -251 530 -1020 810 -850) imp:n=1 fill=1 $ air 4
1736  0            (-210:1080:-1000:1010:820)
                   (-235:240:-520:531:830)
                   (-220:1090:-1000:520:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 510 -530 810 -850) imp:n=1 fill=1 $ air 4
1737  0            (-210:1080:-1000:1010:820)
                   (-220:1090:-1000:520:820)
                   (-1100:1110:-440:1040:820)
                   (210 -251 1000 -510 810 -850) imp:n=1 fill=1 $ air 4
1738  0            (-210:231:-420:491:840)
                   (-1100:1110:-440:1040:820)
                   (210 -251 480 -1000 810 -850) imp:n=1 fill=1 $ air 4
1739  0            (-210:231:-420:491:840)
                   (-1100:1110:-440:1040:820)
                   (210 -251 450 -480 810 -850) imp:n=1 fill=1 $ air 4
1740  0            (-210:231:-420:491:840)
                   (-1100:1110:-440:1040:820)
                   (210 -251 440 -450 810 -850) imp:n=1 fill=1 $ air 4
1741  0            (-210:231:-420:491:840)
                   (210 -251 420 -440 810 -850) imp:n=1 fill=1 $ air 4
1742  0            (-240:401:840)
                   (210 -251 398 -420 810 -850) 4000 imp:n=1 fill=1 $ air 4
c
c
c  repeating structures cells
c
1800  30   8.7411e-2  (2000 -2010 2040 -2070):
                   (2010 -2020 2050 -2060):
```

```
                    (2020 -2030 2040 -2070) u=2 imp:n=1 $ I beam
1810  10   4.354e-5   (2010 -2020 2040 -2050):
                    (2010 -2020 2060 -2070):
                    (-2000:2030:-2040:2070) u=2 imp:n=1 $ air around I beam
1820   0              -3010 3000 -3030 3020 -3050 3040 .
                    u=1 lat=1 imp:n=1 fill=0:99 0:40 0:0
                    2 4099r                              $ lattice of cells
c
c  detector cells
c
1900  10  4.354e-5   -4000   imp:n=1  $ det. col. 87-DD
1910  10  4.354e-5   -4010   imp:n=1  $ det. col. 65-Q
1920  10  4.354e-5   -4020   imp:n=1  $ det. col. 40-AA
1930  10  4.354e-5   -4030   imp:n=1  $ det. col. 30-S
1940  10  4.354e-5   -4040   imp:n=1  $ det. col. 7-AA
c
c     internal and external world
c
2000  0           (9998 -9999):(-9998 -800) imp:n=1  $ internal world
2010  0           9999 imp:n=0                      $ external world
c
c
c  second story stuff
c
3000  10  4.354e-5   (2 -251 398 -610 5610 -870)
                     4050 4060 4070 4080 4090 4100
                     4110 4120 4130 4140 4150
                     4160 imp:n=1  $ 2ndstory air
3005  10  4.354e-5   (2 -5560 5580 -5590 860 -5610):
                     (2 -251  5590 -610  860 -5610):
                     (5570 -251 5580 -5590 860 -5610):
                     (2 -251 398 -5580 860 -5610) imp:n=1  $airaround
3010  80  9.0726e-2  1 -252 397 -611 870 -880 imp:n=1  $ roof
c
3500  10  4.354e-5   -4050   imp:n=1   $ det col 6-BB
3510  10  4.354e-5   -4060   imp:n=1   $ det col 6-F
3520  10  4.354e-5   -4070   imp:n=1   $ det col 22-BB
3530  10  4.354e-5   -4080   imp:n=1   $ det col 22-F
3540  10  4.354e-5   -4090   imp:n=1   $ det col 38-BB
3550  10  4.354e-5   -4100   imp:n=1   $ det col 38-F
3560  10  4.354e-5   -4110   imp:n=1   $ det col 54-BB
3570  10  4.354e-5   -4120   imp:n=1   $ det col 54-F
3580  10  4.354e-5   -4130   imp:n=1   $ det col 70-BB
3590  10  4.354e-5   -4140   imp:n=1   $ det col 70-F
3600  10  4.354e-5   -4150   imp:n=1   $ det col 86-BB
3610  10  4.354e-5   -4160   imp:n=1   $ det col 86-F
c
c
c  repeating structure cells for second floor
c
4000  90 1.6021E-3  5010 -5020 5130 -5140 imp:n=1 u=7 $
4010  90 1.6021E-3  5010 -5020 5110 -5120 imp:n=1 u=7 $
4020  90 1.6021E-3  5030 -5040 5130 -5140 imp:n=1 u=7 $
4030  90 1.6021E-3  5030 -5040 5110 -5120 imp:n=1 u=7 $
4080  10 4.354e-5 (4990 -5060 5090 -5160)
                  (-5010:5020:-5130:5140)
                  (-5010:5020:-5110:5120)
                  (-5030:5040:-5130:5140)
                  (-5030:5040:-5110:5120) imp:n=1 u=7 $
4100  0         -5050 5000 -5150 5100 -5410 5400
                 u=6 lat=1 imp:n=1 fill=0:0 0:5 0:0
                 7 5r
4200  0         -5510 5500 -5530 5520 -5550 5540
                 u=5 lat=1 imp:n=1 fill=0:11 0:0 0:0
                 6 4r 3 4r 6 6
c
4300  0          5560 -5570 5580 -5590 860 -5610
```

```
                fill=5 imp:n=1                    $ process cells
c
4400   90 1.6021E-3  5210 -5220 5330 -5340 imp:n=1 u=4 $
4410   90 1.6021E-3  5230 -5240 5330 -5340 imp:n=1 u=4 $
4420   90 1.6021E-3  5210 -5220 5310 -5320 imp:n=1 u=4 $.
4430   90 1.6021E-3  5230 -5240 5310 -5320 imp:n=1 u=4 $
4440   10 4.354e-5  (-5210:5220:-5330:5340)
                    (-5230:5240:-5330:5340)
                    (-5210:5220:-5310:5320)
                    (-5230:5240:-5310:5320) imp:n=1 u=4 $
4500   0         -5660 5650 -5680 5670 -5700 5690
                  u=3 lat=1 imp:n=1 fill=0:0 0:5 0:0
                  4 5r

c
c  ********************************************
c    surface cards
c  ********************************************
c
1     px  0         $
2     px  0.191     $
10    px  1752      $
15    px  2134      $
20    px  4450      $
21    px  4470      $
30    px  5212      $
31    px  5232      $
40    px  6584      $
41    px  6604      $
50    px  7346      $
51    px  7366      $
53    px  7498      $
54    px  8108      $
55    px  13472     $
56    px  14082     $
60    px  16398     $
61    px  16418     $
70    px  17160     $
71    px  17180     $
80    px  17922     $
81    px  17942     $
85    px  19446     $
88    px  20056     $
90    px  24506     $
91    px  24526     $
100   px  25400     $
101   px  25420     $
105   px  26030     $
110   px  28346     $
111   px  28366     $
120   px  29108     $
121   px  29128     $
130   px  29870     $
131   px  29890     $
140   px  31242     $
141   px  31262     $
145   px  31394     $
150   px  32004     $
151   px  32024     $
153   px  37368     $
154   px  37978     $
155   px  43343     $
156   px  43953     $
160   px  46269     $
161   px  46289     $
170   px  47031     $
171   px  47051     $
```

```
180  px  47793      $
181  px  47813      $
185  px  49317      $
188  px  49927      $
190  px  54376      $
191  px  54396      $
195  px  55290      $
200  px  55900      $
201  px  55920      $
210  px  58217      $
211  px  58237      $
220  px  59741      $
c  221  px  59761       $
230  px  61112      $
231  px  61132      $
235  px  61264      $
240  px  61874      $
241  px  61894      $
250  px  66304      $
251  px  66324      $
252  px  66324.191  $
397  py  0          $
398  py  0.191      $
399  py  20         $
400  py  1280       $
401  py  1300       $
410  py  2012       $
411  py  2032       $
420  py  2682       $
421  py  2702       $
430  py  3353       $
431  py  3373       $
440  py  4023       $
441  py  4043       $
450  py  5364       $
451  py  5384       $
460  py  5700       $
461  py  5720       $
470  py  6035       $
471  py  6055       $
480  py  6706       $
481  py  6726       $
490  py  7376       $
491  py  7396       $
500  py  8717       $
501  py  8737       $
510  py  9388       $
511  py  9408       $
520  py  10058      $
521  py  10078      $
530  py  10729      $
531  py  10749      $
540  py  12405      $
541  py  12425      $
550  py  12741      $
c  551  py  12761       $
560  py  13411      $
561  py  13431      $
570  py  14082      $
571  py  14102      $
580  py  14752      $
c  581  py  14772       $
590  py  15423      $
591  py  15443      $
595  py  16093      $
600  py  16764      $
601  py  16784      $
```

```
610  py  19507      $
611  py  19507.191  $
800  pz  -3000      $
 810  pz  0          $
820  pz  197        $ top of drums
830  pz  305        $ top of rooms
840  pz  305.09     $ top of roof on rooms
850  pz  665.48     $ bottom of proc cell floor
860  pz  685.8      $ top of process cell floor
870  pz  2010.57    $ bottom of roof
880  pz  2020.57    $ top of roof
c
c  here are drum area surfaces
c
1000  py  8046       $
1010  py  11400      $
1020  py  12070      $
1030  py  17435      $
1040  py  18105      $
1050  px  52242      $
1060  px  53004      $
1070  px  53766      $
1080  px  58979      $
1090  px  60351      $
1100  px  64190      $
1110  px  65714      $
c
c   repeating structures surfaces
c
2000  px  -0.01      $
2010  px  0.847      $
2020  px  29.633     $
2030  px  30.48      $
2040  py  -0.01      $
2050  py  7.1965     $
2060  py  8.0435     $
2070  py  15.24      $
3000  px  -0.001     $
3010  px  745.22     $
3020  py  -0.001     $
3030  py  629.26     $
3040  pz  -0.01      $
3050  pz  666        $
c
c    detector planes
c
4000  s  64190  1351  100 50  $ det. col. 87-DD
4010  s  47864  10058 100 50  $ det. col. 65-Q
4020  s  29057  3353  100 50  $ det. col. 40-AA
4030  s  21610  8717  100 50  $ det. col. 30-S
4040  s  4399   3353  100 50  $ det. col. 7-AA
4050  s  3688.1    2682  1185.8 50  $ det. 6-BB  cell floor
4060  s  3688.1    16093 1185.8 50  $ det. 6-F   cell floor
4070  s  15636.24 2682  1185.8 50  $ det. 22-BB cell floor
4080  s  15636.24 16093 1185.8 50  $ det. 22-F  cell floor
4090  s  27584.4  2682  1185.8 50  $ det. 38-BB cell floor
4100  s  27584.4  16093 1185.8 50  $ det. 38-F  cell floor
4110  s  39532.56 2682  1185.8 50  $ det. 54-BB cell floor
4120  s  39532.56 16093 1185.8 50  $ det. 54-F  cell floor
4130  s  51480.72 2682  1185.8 50  $ det. 70-BB cell floor
4140  s  51480.72 16093 1185.8 50  $ det. 70-F  cell floor
4150  s  63428.88 2682  1185.8 50  $ det. 86-BB cell floor
4160  s  63428.88 16093 1185.8 50  $ det. 86-F  cell floor
c
c
c surfaces for repeating structures on 2nd floor
c
```

```
4990  px  609.55   $
5000  px  609.57   $
5010  px  670.6    $
5020  px  2834.6   $
5030  px  3748.6   $
5040  px  5912.6   $
5050  px  6583.63  $
5060  px  6583.65  $
5090  py  2011.63  $
5100  py  2011.65  $
5110  py  2245.68  $
5120  py  3499.68  $
5130  py  3749.68  $
5140  py  5130.68  $
5150  py  5364.71  $
5160  py  5364.74  $
c  5200  px  609.61   $
5210  px  675.6    $
5220  px  2834.61  $
5230  px  3754.6   $
5240  px  5913.6   $
c  5250  px  6583.61  $
c  5300  py  2011.69  $
5310  py  2169.18  $
5320  py  3560.68  $
5330  py  3814.68  $
5340  py  5206.68  $
c  5350  py  5364.69  $
c  5390  pz  685.74   $
5400  pz  685.77   $
5410  pz  1025.84  $
c  5420  pz  1025.87  $
c
5500  px  609.58   $
5510  px  6583.62  $
5520  py  2011.66  $
5530  py  18776.9  $
5540  pz  685.78   $
5550  pz  1025.83  $
c
5560  px  609.59   $
5570  px  66320 $
5580  py  2011.67  $
5590  py  18776.89 $
c  5600  pz  685.79   $
5610  pz  1025.82  $
c
5650  px  609.56   $
5660  px  6583.64  $
5670  py  2011.64  $
5680  py  5364.72  $
5690  pz  685.76   $
5700  pz  1025.85  $
c
c   interal & external world planes
c
9998  so  80000     $ internal world
9999  so  1000000     $ external world

c    ******************************************
c
c               source  term
c
c    ******************************************
c
c   sdef   sur=9998  nrm=-1   dir=d1
c   sb1   -21 2
```

```
c
sdef    pos=66323  19506  1 erg=d1 vec=-2894.12 -3413 1184.8 dir=d2
sc1     from h/u=15 5% enrichment normalized to 2881 W
si1 h   1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
        3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
        1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
        0.003     0.017    0.1      0.4      0.9      1.4
        1.85      3.0      6.43     20
sp1 d   0         1.46e+2  8.00e+2  9.71e+2  1.50e+3  1.04e+3
        3.00e+2   1.62e+2  5.54e+2  1.74e+2  8.59e+1  1.04e+2
        2.53e+2   4.73e+2  9.48e+2  1.03e+3  1.18e+3  1.68e+3
        1.82e+3   2.18e+3  2.96e+3  4.36e+3  5.07e+3  3.40e+3
        2.72e+3   5.56e+3  4.90e+3  6.11e+2
c
sc2     these are angles for source
si2 h   -1  0.9848   1
sp2 d    0  0.9924  0.0076
sb2 d    0  0.1       0.9
c
c    *******************************************
c
c              material cards
c
c    *******************************************
c
m10    7014.50c   3.570e-5
       8016.50c   7.840e-6   $ air
m20    1001.50c   1.487e-2
       6012.50c   3.814e-3
       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   $ concrete
m30    6012.50c   3.921e-3
       26000.50c  8.349e-2   $ steel
m40    6012.50c   6.0
       1001.50c   10.0
       8016.50c   5.0        $ wood
c  m60   92238.50c  8.682e-3
c          9019.50c  5.209e-2   $ UF6
m70    1001.50c   2.0
       8016.50c   1.5        $ water
m80  1001.50c    4.288e-2
     6012.50c    1.812e-2
     8016.50c    1.896e-3
     26000.50c   2.783e-2    $ roof
m90  6012.50c    6.230e-5
     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   $ homogenized cell material
c
c
c      *****************************
c
c            tally cards
c
c      ******************************
c
```

```
c
fc4      track det 1. on col 87-DD
f4:n     1900
fc14     track det 2 on col. 65-Q
f14:n    1910
fc24     track det 3 on col. 40-AA
f24:n    1920
fc34     track det 4 on col. 30-S
f34:n    1930
fc44     track det 5 on col. 7-AA
f44:n    1940
fc54     track det 6 on col 6-BB 2 story
f54:n    3500
fc64     track det 6 on col 6-F 2 story
f64:n    3510
fc74     track det 6 on col 22-BB 2 story
f74:n    3520
fc84     track det 6 on col 22-F 2 story
f84:n    3530
fc94     track det 6 on col 38-BB 2 story
f94:n    3540
fc104     track det 6 on col 38-F 2 story
f104:n    3550
fc114     track det 6 on col 54-BB 2 story
f114:n    3560
fc124     track det 6 on col 54-F 2 story
f124:n    3570
fc134     track det 6 on col 70-BB 2 story
f134:n    3580
fc144     track det 6 on col 70-F 2 story
f144:n    3590
fc154     track det 6 on col 86-BB 2 story
f154:n    3600
fc164     track det 6 on col 86-F 2 story
f164:n    3610
c
c
c  fc5      point det 1. on col 87-DD
c  f5:n     64190  1351   100 49
c
c
c  fc15     point det 2 on col. 65-Q
c  f15:n    47864  10058  100  50
c  f25c     point det 3 on col. 40-AA
c  f25:n    29057  3353   100  50
c  f35c     point det 4 on col. 30-S
c  f35:n    21610  8717   100  50
c  f45c     point det 5 on col. 7-AA
c  f45:n    4399   3353   100  50
c  e0      1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
c        3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
c        1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
c        0.003     0.017    0.1      0.4      0.9      1.4
c        1.85      3.0      6.43     20
c
c  em0    0.0        6.03e-17. 2.46e-16  3.69e-16  6.52e-16  1.40e-15
c        2.54e-15  3.37e-15  5.39e-15  8.37e-15  9.93e-15  1.13e-14
c        1.42e-14  2.20e-14  5.46e-14  1.70e-13  5.43e-13  2.46e-12
c        1.35e-11  7.20e-11  3.12e-10  1.08e-9   1.79e-9   2.44e-9
c        2.79e-9   3.22e-9   4.18e-9   4.72e-9
c
c
c   New Response Function
c  ******************************
c
dE0   1.00E-09  1.00E-08        1.00E-07        5.00E-07
      1.00E-06  5.00E-06        1.00E-05        5.00E-05
```

```
        1.00E-04  5.00E-04        1.00E-03        5.00E-03
        1.00E-02  2.00E-02        5.00E-02        1.00E-01
        5.00E-01  1               2               5
        10        20
c
c
c
c
c
dF0     0.456683643    0.612833708   1.202405686   1.907520827
        2.170074239    2.524934685   2.619466509   2.665319206
        2.525689936    2.568979899   2.526120045   2.429598966
        2.361915675    2.254370492   2.239813349   2.236561929
        1.912907431    1.575113097   1.131268722   0.548312231
        0.248252542    0.142345613
c
c       **************************
c
c           peripheral cards
c
c       **************************
c
mode   n
c       17 keV cut off
c       cut:n  j  0.017
c  ptrac  file=asc max=50000
ctme  900
c    void
c  nps   90000000
prdmp  3j  4
c  dbcn   12j 30000000
print
```

Listing A.3

Input for X-326

The model includes only the operating floor for X-326.

```
This is a model of the first floor of the x326 process building
c
c   **************************************************************
c       cell cards
c   **************************************************************
c
c       air in rooms
c
5    10    4.354e-5  15  -30   797 -798 820 -840 900  imp:n=1 $
10   10    4.354e-5  62  -80   752 -760 820 -840  imp:n=1 $
20   10    4.354e-5  (62  -80   722 -750 820 -840):
                     (62  -70  702 -722 820 -840)  imp:n=1 $
30   10    4.354e-5  72  -80   702 -720 820 -840  imp:n=1 $
40   10    4.354e-5  202 -210 732 -740 820 -840  imp:n=1 $
50   10    4.354e-5  212 -220 732 -740 820 -840  imp:n=1 $
55   10    4.354e-5  222 -230 732 -740 820 -840  imp:n=1 $
60   10    4.354e-5  202 -240 722 -730 820 -840  imp:n=1 $
70   10    4.354e-5  202 -240 692 -720 820 -840  imp:n=1 $
80   10    4.354e-5  202 -240 682 -690 820 -840  imp:n=1 $
90   10    4.354e-5  272 -290 752 -760 820 -840  imp:n=1 $
100  10    4.354e-5  (272 -290 722 -750 820 -840):
                     (272 -280 702 -722 820 -840)  imp:n=1 $
110  10    4.354e-5  282 -290 702 -720 820 -840  imp:n=1 $
120  10    4.354e-5  (342 -350 782 -790 820 -840 950):
                     (350 -352 785 -790 820 -840) imp:n=1
125  10    4.354e-5  (352 -360 782 -790 835 -840)  imp:n=1 $
126  10    4.354e-5  (352 -360 782 -790 820 -835 1010)  imp:n=1 $
130  10    4.354e-5  342 -350 772 -780 820 -840  imp:n=1 $
140  10    4.354e-5  (352 -362 772 -780 820 -840):
                     (362 -370 772 -790 820 -840)  imp:n=1 $
150  10    4.354e-5  402 -430 752 -760 820 -840  imp:n=1 $
160  10    4.354e-5  (402 -430 722 -750 820 -840):
                     (402 -420 702 -722 820 -840):
                     (402 -410 692 -702 820 -840)  imp:n=1 $
170  10    4.354e-5  422 -430 702 -720 820 -840  imp:n=1 $
180  10    4.354e-5  (472 -490 642 -650 820 -840):
                     (482 -490 650 -660 820 -840)  imp:n=1 $
190  10    4.354e-5  492 -500 642 -670 820 -840  imp:n=1 $
200  10    4.354e-5  472 -480 632 -640 820 -840  imp:n=1 $
210  10    4.354e-5  482 -500 632 -640 820 -840 940  imp:n=1 $
220  10    4.354e-5  462 -470 622 -630 820 -840  imp:n=1 $
230  10    4.354e-5  (462 -470 602 -620 820 -840):
                     (470 -472 612 -620 820 -840):
                     (472 -490 612 -630 820 -840)  imp:n=1 $
240  10    4.354e-5  (472 -500 602 -610 820 -840):
                     (492 -500 610 -630 820 -840)  imp:n=1 $
c
c   battery rooms
c
250  70   -1.0    20   -30    710 -720 820 -850  imp:n=1  $ battery room
260  70   -1.0    40   -50    710 -720 820 -850  imp:n=1  $ battery room
270  70   -1.0    90   -100   710 -720 820 -850  imp:n=1  $ battery room
280  70   -1.0    160  -170   710 -720 820 -850  imp:n=1  $ battery room
290  70   -1.0    180  -190   710 -720 820 -850  imp:n=1  $ battery room
300  70   -1.0    250  -260   710 -720 820 -850  imp:n=1  $ battery room
310  70   -1.0    300  -310   710 -720 820 -850  imp:n=1  $ battery room
320  70   -1.0    320  -330   710 -720 820 -850  imp:n=1  $ battery room
```

```
330  70   -1.0    380  -390  710 -720 820 -850  imp:n=1  $ battery room
340  70   -1.0    440  -450  710 -720 820 -850  imp:n=1  $ battery room
c
c   here are the PCB storage lots
c
350  40  -0.375   120 -130 680 -760 820 -830  imp:n=1  $
360  40  -0.375   (120 -130 765 -783 820 -830):
                  (130 -150 770 -783 820 -830)  imp:n=1  $
370  40  -0.375   110 -140 790 -795 820 -830  imp:n=1  $
c
c   here are the concrete walls
c
380  20  3.9827e-2  14  -15  797 -798 820 -840  imp:n=1  $
385  20  3.9827e-2  14  -32  798 -800 820 -840  imp:n=1  $
390  20  3.9827e-2  30  -32  797 -798 820 -840  imp:n=1  $
395  20  3.9827e-2  14  -32  795 -797 820 -840  imp:n=1  $
400  20  3.9827e-2  60  -82  760 -762 820 -840  imp:n=1  $
410  20  3.9827e-2  60  -82  750 -752 820 -840  imp:n=1  $
420  20  3.9827e-2  70  -82  720 -722 820 -840  imp:n=1  $
430  20  3.9827e-2  60  -82  700 -702 820 -840  imp:n=1  $
440  20  3.9827e-2  60  -62  702 -750 820 -840  imp:n=1  $
450  20  3.9827e-2  60  -62  752 -760 820 -840  imp:n=1  $
460  20  3.9827e-2  80  -82  752 -760 820 -840  imp:n=1  $
470  20  3.9827e-2  80  -82  722 -750 820 -840  imp:n=1  $
480  20  3.9827e-2  80  -82  702 -720 820 -840  imp:n=1  $
490  20  3.9827e-2  70  -72  702 -720 820 -840  imp:n=1  $
500  20  3.9827e-2  200 -232 740 -742 820 -840  imp:n=1  $
510  20  3.9827e-2  200 -242 730 -732 820 -840  imp:n=1  $
520  20  3.9827e-2  200 -242 720 -722 820 -840  imp:n=1  $
530  20  3.9827e-2  200 -242 690 -692 820 -840  imp:n=1  $
540  20  3.9827e-2  200 -242 680 -682 820 -840  imp:n=1  $
550  20  3.9827e-2  200 -202 682 -690 820 -840  imp:n=1  $
560  20  3.9827e-2  200 -202 692 -720 820 -840  imp:n=1  $
570  20  3.9827e-2  200 -202 722 -730 820 -840  imp:n=1  $
580  20  3.9827e-2  200 -202 732 -740 820 -840  imp:n=1  $
590  20  3.9827e-2  210 -212 732 -740 820 -840  imp:n=1  $
600  20  3.9827e-2  220 -222 732 -740 820 -840  imp:n=1  $
610  20  3.9827e-2  230 -232 732 -740 820 -840  imp:n=1  $
620  20  3.9827e-2  240 -242 722 -730 820 -840  imp:n=1  $
630  20  3.9827e-2  240 -242 692 -720 820 -840  imp:n=1  $
640  20  3.9827e-2  240 -242 682 -690 820 -840  imp:n=1  $
650  20  3.9827e-2  270 -292 760 -762 820 -840  imp:n=1  $
660  20  3.9827e-2  270 -292 750 -752 820 -840  imp:n=1  $
670  20  3.9827e-2  280 -292 720 -722 820 -840  imp:n=1  $
680  20  3.9827e-2  270 -292 700 -702 820 -840  imp:n=1  $
690  20  3.9827e-2  270 -272 752 -760 820 -840  imp:n=1  $
700  20  3.9827e-2  290 -292 752 -760 820 -840  imp:n=1  $
710  20  3.9827e-2  290 -292 722 -750 820 -840  imp:n=1  $
720  20  3.9827e-2  290 -292 702 -720 820 -840  imp:n=1  $
730  20  3.9827e-2  280 -282 702 -720 820 -840  imp:n=1  $
740  20  3.9827e-2  270 -272 702 -750 820 -840  imp:n=1  $
750  20  3.9827e-2  340 -372 790 -792 820 -840  imp:n=1  $
760  20  3.9827e-2  340 -362 780 -782 820 -840  imp:n=1  $
770  20  3.9827e-2  340 -372 770 -772 820 -840  imp:n=1  $
780  20  3.9827e-2  340 -342 782 -790 820 -840  imp:n=1  $
790  20  3.9827e-2  350 -352 782 -785 820 -840  imp:n=1  $
800  20  3.9827e-2  360 -362 782 -790 820 -840  imp:n=1  $
810  20  3.9827e-2  370 -372 772 -790 820 -840  imp:n=1  $
820  20  3.9827e-2  350 -352 772 -780 820 -840  imp:n=1  $
830  20  3.9827e-2  340 -342 772 -780 820 -840  imp:n=1  $
840  20  3.9827e-2  400 -432 760 -762 820 -840  imp:n=1  $
850  20  3.9827e-2  400 -432 750 -752 820 -840  imp:n=1  $
860  20  3.9827e-2  420 -432 720 -722 820 -840  imp:n=1  $
870  20  3.9827e-2  410 -432 700 -702 820 -840  imp:n=1  $
880  20  3.9827e-2  400 -412 690 -692 820 -840  imp:n=1  $
890  20  3.9827e-2  400 -402 752 -760 820 -840  imp:n=1  $
900  20  3.9827e-2  430 -432 752 -760 820 -840  imp:n=1  $
```

```
910  20  3.9827e-2  430 -432 722 -750 820 -840  imp:n=1  $
920  20  3.9827e-2  430 -432 702 -720 820 -840  imp:n=1  $
930  20  3.9827e-2  420 -422 702 -720 820 -840  imp:n=1  $
940  20  3.9827e-2  410 -412 692 -700 820 -840  imp:n=1  $
950  20  3.9827e-2  400 -402 692 -750 820 -840  imp:n=1. $
960  20  7.9654e-2  490 -502 670 -672 820 -840  imp:n=1  $
970  20  7.9654e-2  480 -492 660 -662 820 -840  imp:n=1  $
980  20  7.9654e-2  470 -482 650 -652 820 -840  imp:n=1  $
990  20  7.9654e-2  470 -502 640 -642 820 -840  imp:n=1  $
1000 20  7.9654e-2  460 -502 630 -632 820 -840  imp:n=1  $
1010 20  7.9654e-2  460 -472 620 -622 820 -840  imp:n=1  $
1020 20  7.9654e-2  470 -492 610 -612 820 -840  imp:n=1  $
1030 20  7.9654e-2  460 -502 600 -602 820 -840  imp:n=1  $
1040 20  7.9654e-2  490 -492 662 -670 820 -840  imp:n=1  $
1050 20  7.9654e-2  500 -502 642 -670 820 -840  imp:n=1  $
1060 20  7.9654e-2  500 -502 632 -640 820 -840  imp:n=1  $
1070 20  7.9654e-2  500 -502 602 -630 820 -840  imp:n=1  $
1080 20  7.9654e-2  460 -462 602 -620 820 -840  imp:n=1  $
1090 20  7.9654e-2  460 -462 622 -630 820 -840  imp:n=1  $
1100 20  7.9654e-2  470 -472 632 -640 820 -840  imp:n=1  $
1110 20  7.9654e-2  470 -472 642 -650 820 -840  imp:n=1  $
1120 20  7.9654e-2  480 -482 652 -660 820 -840  imp:n=1  $
1130 20  7.9654e-2  490 -492 642 -660 820 -840  imp:n=1  $
1140 20  7.9654e-2  480 -482 632 -640 820 -840  imp:n=1  $
1150 20  7.9654e-2  470 -472 622 -630 820 -840  imp:n=1  $
1160 20  7.9654e-2  490 -492 612 -630 820 -840  imp:n=1  $
1170 20  7.9654e-2  470 -472 602 -610 820 -840  imp:n=1  $
c
c   here are the room roofs
c
1200 30  8.7411e-2  60  -82  700 -762 840 -850 imp:n=1  $
1205 30  8.7411e-2  14  -32  795 -800 840 -850 imp:n=1 $
1210 30  8.7411e-2  (200 -232 732 -742 840 -850):
                    (200 -242 680 -732 840 -850) imp:n=1  $
1220 30  8.7411e-2  270 -292 700 -762 840 -850 imp:n=1  $
1230 30  8.7411e-2  340 -372 770 -792 840 -850 imp:n=1  $
1240 30  8.7411e-2  (400 -432 700 -762 840 -850):
                    (400 -412 690 -700 840 -850) imp:n=1  $
1250 30  8.7411e-2  (490 -502 662 -672 840 -850):
                    (480 -502 652 -662 840 -850):
                    (470 -502 632 -652 840 -850):
                    (460 -502 600 -632 840 -850) imp:n=1  $
c
c  sheet metal walls
c
1300 30  8.7411e-2  10  -504 598 -600 820 -870 imp:n=1  $
1310 30  8.7411e-2  10  -12  600 -800 820 -870 imp:n=1  $
1320 30  8.7411e-2  10  -504 800 -802 820 -870 imp:n=1  $
1330 30  8.7411e-2  502 -504 600 -800 820 -870 imp:n=1  $
c
c   air inside building
c
1350 0              ((12  -110  600 -800 820 -860)
                    (-20:30:-710:720:-820:850)
                    (-40:50:-710:720:-820:850)
                    (-90:100:-710:720:-820:850)
                    (-60:82:-700:762:-820:850)
                    (-14:32:-795:800:-820:850)) 910
                    fill=1  imp:n=1  $ air 1
1360 0              (110 -190 600 -800 820 -860)
                    (-120:130:-680:760:-820:830)
                    (-120:130:-765:783:-820:830)
                    (-130:150:-770:783:-820:830)
                    (-110:140:-790:795:-820:830)
                    (-160:170:-710:720:-820:850)
                    (-180:190:-710:720:-820:850)
                    fill=1  imp:n=1  $ air 2
```

```
1370 0              ((190 -310 600 -800 820 -860)
                    (-200:242:-680:732:-820:850)
                    (-200:232:-732:742:-820:850)
                    (-270:292:-700:762:-820:850)
                    (-250:260:-710:720:-820:850)
                    (-300:310:-710:720:-820:850)) 920
                    fill=1  imp:n=1  $ air 3
1380 0              ((310 -440 600 -800 820 -860)
                    (-320:330:-710:720:-820:850)
                    (-380:390:-710:720:-820:850)
                    (-340:372:-770:792:-820:850)
                    (-400:432:-700:762:-820:850)
                    (-400:412:-690:700:-820:850)) 930
                    fill=1  imp:n=1  $ air 4
1390 0              (440 -502 600 -800 820 -860)
                    (-440:450:-710:720:-820:850)
                    (-490:502:-662:672:-820:850)
                    (-480:502:-652:662:-820:850)
                    (-470:502:-632:652:-820:850)
                    (-460:502:-600:632:-820:850)
                    fill=1  imp:n=1  $ air 5
c
c   here is californium thing
1392 30  8.7411e-2  -345 344 -788 787 -820 815  imp:n=1  $ steel lid
1394 50  -0.93      -345 344 -788 787 -815 814  imp:n=1  $ paraffin layer
1396 10  4.354e-5   -345 344 -788 787 -814 813  imp:n=1  $ air in pit
3000  0              820 -823 -1000             imp:n=1  $ the can
3010  80   -0.92     820 -823 1000  -1010       imp:n=1  $ poly around can
3020  80   -0.92     823 -825 -1010             imp:n=1  $ top of can
3030  80   -0.92     825 -835 -1010             imp:n=1  $ array area
c
1400 20  7.9654e-2  12 -502 600 -800 860 -870 imp:n=1    $ concrete roof
1500 10  4.354e-5   ((-10:504:-598:802:870) 820) -1998  imp:n=1  $ air around building
1600 10  4.354e-5   -900   imp:n=1      $ det. 5-A
1610 10  4.354e-5   -910   imp:n=1      $ det. 23-H
1620 10  4.354e-5   -920   imp:n=1      $ det. 63-H
1630 10  4.354e-5   -930   imp:n=1      $ det. 93-H
1640 10  4.354e-5   -940   imp:n=1      $ det. 101-W
1650 10  4.354e-5   -950   imp:n=1      $ det. NDA lab
c
1700 20  7.9654e-2  (813 -820 -1998)
                    (-787:788:-344:345) imp:n=1 $ concrete layer 1
1710 20  7.9654e-2  810 -813 -1998  imp:n=1           $ concrete ground L2
c
c  repeating structures cells
c
1800  30   8.7411e-2  (2000 -2010 2040 -2070):
                      (2010 -2020 2050 -2060):
                      (2020 -2030 2040 -2070) u=2 imp:n=1 $ I beam
1810  10   4.354e-5   (2010 -2020 2040 -2050):
                      (2010 -2020 2060 -2070):
                      (-2000:2030:-2040:2070) u=2 imp:n=1 $ air around I beam
1820   0               -3010 3000 -3030 3020 -3050 3040
                      u=1 lat=1 imp:n=1 fill=0:104 0:24 0:0
                      2 2624r                              $ lattice of cells
c
c
2000     0          (-1998 -810):(1998 -1999) imp:n=1   $ internal world
2010     0          1999  imp:n=0                     $ external world

c
c  **************************************************************
c     surface cards
c  **************************************************************
c
10   px   0        $
12   px   0.191    $
```

```
14    px   2012        $
15    px   2032        $
20    px   2713        $
30    px   3414        $
32    px   3434        $
40    px   9601        $
50    px   10302       $
60    px   13076       $
62    px   13096       $
70    px   14387       $
72    px   14407       $
80    px   15088       $
82    px   15108       $
90    px   16490       $
100   px   17191       $
110   px   19263       $
120   px   20665       $
130   px   21275       $
140   px   21796       $
150   px   22677       $
160   px   23378       $
170   px   24079       $
180   px   30267       $
190   px   30968       $
200   px   33741       $
202   px   33761       $
210   px   33985       $
212   px   34005       $
220   px   34442       $
222   px   34462       $
230   px   35052       $
232   px   35072       $
240   px   35753       $
242   px   35773       $
250   px   37155       $
260   px   37856       $
270   px   40630       $
272   px   40650       $
280   px   41940       $
282   px   41960       $
290   px   42642       $
292   px   42662       $
300   px   44044       $
310   px   44745       $
320   px   50932       $
330   px   51633       $
340   px   53706       $
342   px   53726       $
c     344  px    54036       $
344   px   54481       $
c     345  px    54097       $
345   px   54541.935       $
350   px   54407       $
352   px   54427       $
360   px   55108       $
362   px   55128       $
370   px   55717       $
372   px   55737       $
380   px   57821       $
390   px   58522       $
400   px   61295       $
402   px   61315       $
410   px   61998       $
412   px   62018       $
420   px   62606       $
422   px   62626       $
430   px   63304       $
```

```
432  px   63324      $
440  px   64709      $
450  px   65410      $
460  px   67483      $
462  px   67503      $
470  px   68184      $
472  px   68204      $
480  px   68489      $
482  px   68509      $
490  px   68885      $
492  px   68905      $
500  px   69474      $
502  px   69494      $
504  px   69494.191  $
598  py   -0.191     $
600  py   0          $
602  py   20         $
610  py   244        $
612  py   264        $
620  py   488        $
622  py   508        $
630  py   732        $
632  py   752        $
640  py   2195       $
642  py   2215       $
650  py   2926       $
652  py   2946       $
660  py   3658       $
662  py   3678       $
670  py   4023       $
672  py   4043       $
680  py   4389       $
682  py   4409       $
690  py   5852       $
692  py   5872       $
700  py   6584       $
702  py   6604       $
710  py   6949       $
720  py   7315       $
722  py   7335       $
730  py   8047       $
732  py   8067       $
740  py   8778       $
742  py   8798       $
750  py   10241      $
752  py   10261      $
760  py   10973      $
762  py   10993      $
765  py   12435      $
770  py   13167      $
772  py   13187      $
780  py   13533      $
782  py   13553      $
783  py   13899      $
785  py   14265      $
c    787  py   14061     $
787  py   13607      $
c   788  py   14122     $
788  py   13668      $
790  py   14630      $
792  py   14650      $
795  py   15362      $
797  py   15382      $
798  py   16073      $
800  py   16093      $
802  py   16093.191  $
810  pz  -3000       $ bottom of earth
```

```
813  pz  -30.48      $ bottom of pit
814  pz  -7.62       $ bottom of poly layer
815  pz  -2.54       $ bottom of steel lid
820  pz   0          $ floor
823  pz   84.455     $ top of barrel in Cf shuffler
825  pz   150        $ top of assay area in Cf shuffler
830  pz   197        $ top of drums
835  pz   300        $ top of storage cube in Cf shuffler
840  pz   305        $ top of rooms
850  pz   305.09     $ top of roof on rooms
860  pz   610        $ top of first floor
870  pz   686        $ process cell floor
900  s    2713.1  16022.1  100 50 $ det. col.5-A
910  s    15088.1  11044.1  100  50  $ det. col 23-H
920  s    42642.1  11044.1  100  50  $ det. col 63-H
930  s    63304.1  11044.1  100  50  $ det. col 93-H
940  s    68885.1  1463.1   100  50  $ det. col 101-W
950  s    53777    14579    100  50  $ det. in NDA lab
1000  c/z  54511.455  13637.455  28.575    $ inner cylinder in Cf shuffler
1010  c/z  54511.455  13637.455  69.215    $ outter cylinder in Cf shuffler
1998 so   800000     $
1999 so   1000000   $
c
c   repeating structures surfaces
c
2000  px  -0.01       $
2010  px  0.847       $
2020  px  29.633      $
2030  px  30.48       $
2040  py  -0.01       $
2050  py  7.1965      $
2060  py  8.0435      $
2070  py  15.24       $
3000  px  -0.001      $
3010  px  688.06      $
3020  py  -0.001      $
3030  py  764.77      $
3040  pz  -0.01       $
3050  pz  611         $
c

c
c    ******************************************
c
c                 source  term
c
c    ******************************************
c
c     sdef   sur=1998  nrm=-1   dir=d1
c     sb1   -21 2
c
sdef   pos=54511.48 13637.48 -30.1 erg=d1
sc1    from h/u=120 100% enrichment normalized to 1281 W
si1 h  1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
       3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
       1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
       0.003     0.017    0.1      0.4      0.9      1.4
       1.85      3.0      6.43     20
sp1 d  0         1.04e+2  5.67e+2  7.14e+2  1.28e+3  1.29e+3
       4.84e+2   2.74e+2  9.66e+2  3.17e+2  1.68e+2  1.92e+2
       4.79e+2   7.91e+2  1.79e+3  1.71e+3  2.09e+3  3.21e+3
       3.52e+3   3.99e+3  5.83e+3  8.89e+3  1.03e+4  7.25e+3
       5.88e+3   1.13e+4  1.02e+4  1.28e+3
c
c    ******************************************
c
c               material cards
```

```
c
c    *******************************************
c
m10   7014.50c   3.570e-5
      8016.50c   7.840e-6    $ air
m20   1001.50c   1.487e-2
      6012.50c   3.814e-3
      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    $ concrete
m30   6012.50c   3.921e-3
      26000.50c  8.349e-2    $ steel
m40   6012.50c   6.0
      1001.50c   10.0
      8016.50c   5.0         $ wood
m50   6012.50c   25
      1001.50c   52          $ paraffin
m70   1001.50c   2.0
      8016.50c   1.0         $ water
m80   8016.50c   1.0
      1001.50c   2.0         $ polyethylene
c
c
c      *****************************
c
c            tally cards
c
c      ******************************
c
fc4     track det 1. on col 5-A
f4:n    1600
fc14    track det 2 on col. 23-H
f14:n   1610
fc24    track det 3 on col. 63-H
f24:n   1620
fc34    track det 4 on col. 93-H
f34:n   1630
fc44    track det 5 on col. 101-W
f44:n   1640
fc54    track det 5 in NDA lab
f54:n   1650
c  e0     1.00e-11  1.00e-8  3.00e-8  5.00e-8  1.00e-7  2.25e-7
c       3.25e-7   4.00e-7  8.00e-7  1.00e-6  1.13e-6  1.3e-6
c       1.77e-6   3.05e-6  1.00e-5  3.00e-5  1.00e-4  5.5e-4
c       0.003     0.017    0.1      0.4      0.9      1.4
c       1.85      3.0      6.43     20
c
c  New Response Function
c ******************************
c
dE0    1.00E-09  1.00E-08       1.00E-07       5.00E-07
       1.00E-06  5.00E-06       1.00E-05       5.00E-05
       1.00E-04  5.00E-04       1.00E-03       5.00E-03
       1.00E-02  2.00E-02       5.00E-02       1.00E-01
       5.00E-01  1              2              5
       10        20
c
c
c
c
c
dF0    0.456683643    0.612833708   1.202405686   1.907520827
       2.170074239    2.524934685   2.619466509   2.665319206
```

```
          2.525689936    2.568979899    2.526120045    2.429598966
          2.361915675    2.254370492    2.239813349    2.236561929
          1.912907431    1.575113097    1.131268722    0.548312231
          0.248252542    0.142345613
c
c     **************************
c
c         peripheral cards
c
c     **************************
c
mode   n
c     17 keV cut off
c   cut:n  j  0.017
ctme  1800
c   ptrac   file=asc  max=100000
c      void
nps    50000000
prdmp  3j  4
c     dbcn   31277116122605
print
```