**A Comparison of Two Criticality Accident
Alarm System Detector Locations
for the X-700 Building at
the Portsmouth Gaseous Diffusion Plant**

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Under LMUS Contract 400183**

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EXECUTIVE SUMMARY

A previous analysis of the X-700 Building Criticality Accident Alarm System (CAAS) showed that some areas of the building may not adequately be covered by the one building CAAS detector in its current location.¹ This report compares the results of that analysis with a new analysis where the detector is in a different location.

The new detector location (outside of the storage area in the center of the building — near column B-7) showed coverage for all points previously analyzed. The new centralized detector location reduces the distance and shielding between the source points and the detector. This explains the difference in the level of response when compared to the original (actual) detector location in the new annex west of the building.

1.0 INTRODUCTION

The Portsmouth Gaseous Diffusion Plant (PORTS), located near 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 managed and operated by Lockheed Martin Utility Services (LMUS). At these plants, uranium (U), in the form of uranium hexafluoride (UF_6), is enriched through a gaseous diffusion process from its naturally occurring isotopic concentration of 0.7% ^{235}U up to about 5% ^{235}U with a plant maximum of 10% ^{235}U . The diffusion cascade process equipment is housed in Buildings X-333, X-330, and X-326. Support services, such as maintenance and decontamination operations, are provided by ancillary facilities at the PORTS site including the X-700 Maintenance Building.²

As uranium operations are performed within the process facilities at PORTS, the potential for a criticality accident exists. In the event of a criticality accident within a building at PORTS, a Criticality Accident Alarm System (CAAS) is in place to detect the criticality accident and sound an alarm. According to ANSI standard ANS-8.3-1986³ "American National Standard Criticality Accident Alarm System," the CAAS "shall be designed to detect immediately the minimum accident of concern." In order to meet this requirement, CAAS detectors are located at various positions throughout all of the cascade process buildings and in some of the support services buildings at PORTS.

A previous analysis of the X-700 Building showed that some areas of the plant may not be adequately covered by the one X-700 Building CAAS detector in its current location in the building annex on the west side of the building. This report documents the results of a comparison of the previous analysis with a new analysis where the detector is in a new, more centralized location outside of the offices in the center of the building.

2.0 FACILITY DESCRIPTION

The X-700 Converter Shop and Cleaning Building (the X-700 building) is a permanent structure located about 250 feet north of the X-720 Maintenance Building and 200 feet east of the X-705 Chemical Operations Building.² The X-705 and X-700 buildings are located about 270 feet south of the X-333 Process Building.

The X-700 building has a total floor area of about 104,000 square feet, and is divided into two main sections. The east section is an equipment and parts cleaning area. The west section houses the Converter Shop which is divided into three subsections: north, south, and the west addition. These respective subsections are the Barrier Shop, the Converter/Weld Shop, and the Stabilization Stand. A new addition to the west side of the north barrier shop area, the Radiation Instrument Calibration Facility, was completed in 1986.² The X-700 building contains one CAAS detector. This detector is located in the west subsection of the Converter Shop (the Stabilization Stand).^{4,5}

Figure 1 - A Schematic of the X-700 Building Showing the Source Locations and the Original and Proposed Detector Locations

Figure 2 – SABRINA⁷ Plot of the X-700 Building Model

3.0 ANALYSIS

To determine CAAS coverage in the X-700 building, a computer model was developed using the Monte Carlo N-Particle transport code, MCNP4A.⁶ The same model of the X-700 Building was used for both analyses in this report, the only difference being the location of the detector. The location of neutron sources representing minimum criticality accidents were identical in both analyses.

The calculated response of the detectors was used to determine CAAS coverage. If a criticality accident source location resulted in a detector response larger than the PORTS CAAS setpoint of 5 mrad/hr, then a criticality accident at that location would be detected and the CAAS coverage is determined to be adequate. If, however, the detector response was smaller than the PORTS CAAS setpoint, then a criticality accident at that source location may go undetected.

In the original analysis, the calculated detector response for each of the five source locations was below 5 mrad/hr. By moving the detector to a more centralized location outside of the offices in the center of the building, the calculated detector response was raised above 5 mrad/hr for the same 5 source locations. Figure 1 shows the locations of source points as well as the original and proposed detector locations.

3.1 FACILITY MODEL

The X-700 Building was modeled as a single-story structure approximately 520-feet long by 200-feet wide (excluding additions). The building model was divided into a high bay over the cleaning area, and a low bay over the rest of the building, the addition, and the calibration building. The outside walls were modeled as full-density homogeneous concrete. The interior walls consist of 8-inch concrete block walls, which were modeled as half-density concrete. The

calibration building wall geometry was simplified and modeled as one room with 3-foot thick concrete walls. The eight tanks located in the high bay cleaning area were simplified into one water-filled tank. A schematic drawing of the building model is shown in Figure 1, while Figure 2 is a SABRINA⁷ plot of the X-700 building model.

3.1.1 Material Compositions

For consistency with previous calculations of criticality alarm response in the PORTS buildings,⁸ the number densities of air, concrete, and steel used in this analysis were taken from Westfall et al.⁹ These number densities are given in Table 1.

Table 1 — Material Compositions

Material	Element	Number Density (Atom/(barn•cm))
Air	Nitrogen	3.570E-05
	Oxygen	7.840E-06
Concrete	Hydrogen	1.487E-02
	Carbon	3.814E-03
	Oxygen	4.152E-02
	Sodium	3.040E-04
	Magnesium	5.870E-04
	Aluminum	7.350E-04
	Silicon	6.037E-03
	Calcium	1.159E-02
	Iron	1.968E-04
Steel	Carbon	3.921E-03
	Iron	8.349E-02

3.2 SOURCE TERM

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

3.2.1 Source Locations

Source locations were chosen that would maximize the distance and/or shielding between the source and the detector. These source locations result in the smallest absorbed dose rates at the detectors. Therefore, any other source location would result in a smaller distance or smaller thickness of shielding between the source and detector and will be bounded by the cases analyzed. The identical five source locations were used for both models. These source locations are listed in Table 2 and shown in Figure 1.

Table 2 — Criticality Accident Source Locations in X-700 Model

Source #	Description	U-235 Enrichment (%)	Power Level (W)
S1	East side of building behind water tank	100	1281
S2	Northeast corner of building	100	1281
S3	Northwest corner of building	100	1281
S4	50-feet east of building (outside of building)	100	1281
S5	Southeast corner of building	100	1281

3.2.2 Source Power Level and Energy Spectrum

The criticality source used in this analysis was one that results in the minimum critical accident of concern as defined in ANSI/ANS 8.3-1986.³

The power level and source neutron energy spectrum for the source used was taken from POEF-SH-31.¹⁰ The power level for the criticality accident source used in the analysis is shown in Table 2. The source neutron energy spectrum for the criticality accident source modeled is listed in Table 3. All sources were modeled as isotropic point sources.

3.3 Flux Tallies

The CAAS detectors used at the PORTS site are set to alarm at an absorbed dose rate of 5 mrad/hr.¹¹ Values of the neutron flux in air, calculated by MCNP, will be converted to absorbed dose rates through the use of an appropriate flux to absorbed dose rate conversion factor (see section 3.5). Therefore, the detectors modeled in MCNP must tally the neutron flux spectra in air. The MCNP detectors were modeled as spheres with a 1-m diameter at locations corresponding to the currently installed CAAS detectors.³ The neutron fluence per source particle at the various detectors was tallied using a next event estimator (point detector) at the center of the detector spheres.

Table 3 — Source Terms for 100% Enriched ²³⁵U Sources

Upper Energy Limit (MeV)	Source Neutron Energy Spectra	Upper Energy Limit (MeV)	Source Neutron Energy Spectra
2.00E+01	1.28E+03	3.05E-06	7.91E+02
6.43E+00	1.02E+04	1.77E-06	4.79E+02
3.00E+00	1.13E+04	1.30E-06	1.92E+02
1.85E+00	5.88E+03	1.13E-06	1.68E+02
1.40E+00	7.25E+03	1.00E-06	3.17E+02
9.00E-01	1.03E+04	8.00E-07	9.66E+02
4.00E-01	8.89E+03	4.00E-07	2.74E+02

Upper Energy Limit (MeV)	Source Neutron Energy Spectra
1.00E-01	5.83E+03
1.70E-02	3.99E+03
3.00E-03	3.52E+03
5.50E-04	3.21E+03
1.00E-04	2.09E+03
3.00E-05	1.71E+03
1.00E-05	1.79E+03

Upper Energy Limit (MeV)	Source Neutron Energy Spectra
3.25E-07	4.84E+02
2.25E-07	1.29E+03
1.00E-07	1.28E+03
5.00E-08	7.14E+02
3.00E-08	5.67E+02
1.00E-08	1.04E+02
1.00E-11	0.00E+00

3.4 VARIANCE REDUCTION

Because the neutrons tracked in the Monte Carlo simulations have low probabilities of reaching a detector, the large size of the buildings coupled with the number of concrete structures in-between the sources and the detectors could result in calculations that require an enormous amount of computer time. To avoid extremely long computation times, variance-reduction techniques were used. The techniques included the use of point detectors and energy cut off in a particle's random walk.

3.5 FLUX TO ABSORBED DOSE RATE CONVERSION

MCNP was used to calculate the neutron fluence per source neutron at the modeled detector locations. In order to calculate the absorbed dose rate in the detectors, the neutron fluence per source neutron was first converted to neutron flux. Then, a flux to neutron absorbed dose rate conversion factor was applied.

To convert the neutron fluence per source particle to neutron flux, the neutron production rate (power level) of the source must be known. The source neutron production rate was determined according to the following equation:

$$N\left(\frac{n}{\text{sec}}\right) = \phi_p \left(\frac{n}{\text{cm}^2 \cdot \text{sec} \cdot W}\right) \times P(W) \times A(\text{cm}^2)$$

where

N = the source neutron production rate

ϕ_p = the neutron flux per unit power

P = power for the minimum critical accident of concern

A = the surface area of a sphere with radius 2 meters

Using the appropriate values for ϕ_p and P from POEF-SH-31, the neutron source rate for the source term was calculated. The neutron source rate for the criticality accident source modeled is shown in Table 4.

Table 4 — Criticality Accident Source Neutron Production Rate

U-235 Enrichment (%)	Power Level (W)	Neutron Production Rate (n/s)
100	1281	5.121×10^{13}

Next, a conversion factor was applied to the neutron flux to calculate the neutron absorbed dose rate. In this analysis, the neutron absorbed dose rate was calculated on a per energy bin basis. The absorbed dose rate at the detector was calculated using the following equation:

$$D\left(\frac{\text{mrad}}{\text{hr}}\right) = \sum_{i=1}^{27} N\left(\frac{n}{\text{sec}}\right) \times \phi_{i, \text{MCNP}} \left(\frac{\left(\frac{\#}{\text{cm}^2}\right)}{n}\right) \times k_i \left(\frac{\text{rad}}{\left(\frac{n}{\text{cm}^2}\right)}\right) \times \left(\frac{3600 \text{ sec}}{\text{hr}}\right) \times \left(\frac{1000 \text{ mrad}}{\text{rad}}\right)$$

where

D = neutron absorbed dose rate at detector

ϕ_{MCNP} = the neutron fluence per source particle at detector

N = source neutron production rate

k = neutron flux to neutron absorbed dose rate conversion factor

i = energy bin index

In this analysis, the Henderson Free in-Air Tissue kerma factors,¹³ as shown in Table 7, were used.

Table 5 — Henderson Free-in-Air Tissue Kerma Factors

Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))
1.00E-11	0.00E+00
1.00E-08	6.03E-17
3.00E-08	2.46E-16
5.00E-08	3.69E-16
1.00E-07	6.52E-16
2.25E-07	1.40E-15
3.25E-07	2.54E-15
4.00E-07	3.37E-15
8.00E-07	5.39E-15
1.00E-06	8.37E-15
1.13E-06	9.93E-15
1.30E-06	1.13E-14
1.77E-06	1.42E-14
3.05E-06	2.20E-14
1.00E-05	5.46E-14
3.00E-05	1.70E-13
1.00E-04	5.43E-13
5.50E-04	2.36E-12
3.00E-03	1.35E-11
1.70E-02	7.20E-11
1.00E-01	3.12E-10
4.00E-01	1.08E-09
9.00E-01	1.79E-09
1.40E+00	2.44E-09
1.85E+00	2.79E-09
3.00E+00	3.22E-09
6.43E+00	4.18E-09
2.00E+01	4.72E-09

4.0 RESULTS

Detector responses for each source location are presented in Table 6 for both of the detector locations analyzed in the X-700 models.

Table 6 — Detector Response for the Current and Proposed Locations

Source Location	Detector Response $\pm$ Standard Deviation (mrad/hr)	
	Current Detector Location near Column 9a-A5	Proposed Detector Location Near Column B-7
S1(Behind Tanks)	2.9 ± 0.20	25.56 ± 0.52
S2 (NE Corner)	0.5 ± 0.04	5.47 ± 0.22
S3 (NW Corner)	5.8 ± 1.26	122.0 ± 0.77
S4 (Outside-East)	3.8 ± 0.17	16.26 ± 1.08
S5 (SE Corner)	1.3 ± 0.09	133.2 ± 1.84

5.0 DISCUSSION

Source locations were chosen which would minimize detector response and which were also credible criticality accident locations. Due to the conservative nature of the selected source locations, all other locations within the range of selected source locations will result in a higher detector response and will, therefore, be bounded by these source locations.

The analysis determines coverage or non-coverage of a location by comparing calculated detector responses to the PORTS CAAS alarm setpoint of 5 mrad/hr. MCNP was run using point detectors to tally the neutron fluence per source particle. The problem was run until the detector tally had a fractional uncertainty of about 5%. At this point the response of this detector was calculated as outlined in section 3.5. If the calculated detector response was greater than or equal to 5 mrad/hr, the area was then considered to be covered by the CAAS.

Using this method, the coverage of the X-700 building by the detector in its current location could not be shown. However, by moving the detector to a more centralized location outside of the storage area in the center of the building (near column B-7), full coverage was shown. This includes the area east of the building, which has not been included in the analyses for the other Portsmouth buildings..

The major contributors to the low detector absorbed dose rates in the original analysis include the distances between the sources used in the evaluation and the detector, and the number of concrete walls that had to be penetrated before a neutron could reach the detector.

6.0 CONCLUSION

The CAAS detectors at PORTS are set to alarm at an absorbed dose rate of 5 mrad/hr. Full coverage of the X-700 building can be shown by moving the detector to a location outside of the storage area in the center of the building (near column B-7). Coverage could not be shown for the current detector location as documented in a previous report¹.

7.0 REFERENCES

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APPENDIX A

**SAMPLE MCNP INPUT FOR THE
NEW DETECTOR LOCATION**

```

x-700 Source located in the SE corner (furthest point from the detector)
c      Detector located south of the storage area in center of building (Column B-7)
c      *****
c
c      cell cards
c
c      *****
c
c
c cell#   material#   -density   surfaces   importance
c
10   10   7.9654e-2   -60 50 -998   imp:n=1   $ concrete
20   10   7.9654e-2   10 -18 39 -40 60 -65   imp:n=1   $ swm wall-1
25   10   7.9654e-2   13 -20 39 -40 60 -65   imp:n=1   $ swm wall-2
30   10   7.9654e-2   10 -20 30 -31 60 -70   imp:n=1   $ sen wall
40   10   7.9654e-2   10 -11 31 -42 60 -70   imp:n=1   $ wse wall-hb
45   10   7.9654e-2   10 -11 42 -39 60 -65   imp:n=1   $ wse wall-lb
50   10   7.9654e-2   19 -20 31 -42 60 -70   imp:n=1   $ wne wall-hb
55   10   7.9654e-2   19 -20 42 -39 60 -65   imp:n=1   $ wne wall-lb
60   20   9.0726e-2   10 -20 30 -42 70 -71   imp:n=1   $ roof-high bay
70   20   9.0726e-2   (10 -20 42 -40 65 -66):
      (12 -14 40 -45 65 -66)   imp:n=1   $ roof-low bay
80   10   3.4827e-2   11 -19 38 -42 60 -70   imp:n=1   $ wall "D"
90   10   7.9654e-2   21 -22 33 -34 60 -61   imp:n=1   $ tank wall
100  10   7.9654e-2   21 -24 34 -35 60 -61   imp:n=1   $ tank wall
110  10   7.9654e-2   23 -24 33 -34 60 -61   imp:n=1   $ tank wall
120  10   7.9654e-2   21 -24 32 -33 60 -61   imp:n=1   $ tank wall
140  50   -1.0       22 -23 33 -34 60 -61   imp:n=1   $ water in tank
150  10   3.4827e-2   25 -26 31 -36 60 -70   imp:n=1   $ storage room wall
160  10   3.4827e-2   25 -28 36 -37 60 -70   imp:n=1   $ storage room wall
170  10   3.4827e-2   27 -28 31 -36 60 -70   imp:n=1   $ storage room wall
180  30   4.354e-5   26 -27 31 -36 60 -70   imp:n=1   $ air in storage room
190  30   4.354e-5   11 -21 31 -38 60 -70   imp:n=1   $ south air
191  30   4.354e-5   21 -24 31 -32 60 -70   imp:n=1   $ air between tank
192  30   4.354e-5   21 -24 35 -38 60 -70   imp:n=1   $ middle air
193  30   4.354e-5   21 -24 32 -35 61 -70   imp:n=1   $ air over tanks
194  30   4.354e-5   25 -28 37 -38 60 -70   imp:n=1   $ west air
195  30   4.354e-5   24 -25 31 -38 60 -70   imp:n=1   $ north air
196  30   4.354e-5   28 -19 31 -38 60 -70   imp:n=1   $ air 7
200  10   3.4827e-2   13 -14 42 -39 60 -65   imp:n=1   $ wall "9"
210  10   3.4827e-2   15 -16 41 -39 60 -65   imp:n=1   $ stairs wall
220  10   3.4827e-2   17 -18 41 -39 60 -65   imp:n=1   $ stairs wall
230  10   3.4827e-2   15 -18 43 -41 60 -65   imp:n=1   $ stairs wall
240  30   4.354e-5   16 -17 41 -39 60 -65   imp:n=1   $ air in stairwell
250  10   7.9654e-2   12 -29 40 -44 60 -65   imp:n=1   $ addition wall
260  10   7.9654e-2   12 -14 44 -45 60 -65   imp:n=1   $ addition wall
270  10   7.9654e-2   13 -14 40 -44 60 -65   imp:n=1   $ addition wall
280  30   4.354e-5   29 -13 40 -44 60 -65   imp:n=1   $ air in addition
290  10   7.9654e-2   80 -81 40 -47 60 -65   imp:n=1   $ cal lab wall
300  10   7.9654e-2   80 -83 47 -48 60 -65   imp:n=1   $ cal lab wall
305  10   7.9654e-2   82 -83 40 -47 60 -65   imp:n=1
306  10   7.9654e-2   81 -82 40 -49 60 -65   imp:n=1   $ cal lab wall
307  20   9.0726e-2   80 -83 40 -48 65 -66   imp:n=1
310  30   4.354e-5   81 -82 49 -47 60 -65   imp:n=1   $ air in cal lab
320  30   4.354e-5   (11 -15 42 -39 60 -65):(15 -18 42 -43 60 -65):
      (18 -13 42 -40 60 -65)   imp:n=1   $ air in shop area
330  30   4.354e-5   14 -19 42 -39 60 -65   imp:n=1   $ air in re-tubing area
350  30   4.354e-5   (-10:-30:20:45:71) 60 -998   imp:n=1   $ outside air
351  30   4.354e-5   (10 -20 42 -40 66 -71):

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1996

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                (12 -14 40 -45 66 -71):
                (80 -83 40 -48 66 -71)      imp:n=1      $air above lb
352 30 4.354e-5 (14 -80 40 -45 60 -71):
                (80 -83 48 -45 60 -71):
                (83 -20 40 -45 60 -71)      imp:n=1      $north air
353 30 4.354e-5 10 -12 40 -45 60 -71      imp:n=1      $south air
360 0           (998 -999):(-998 -50)      imp:n=1      $ internal world
370 0           999 imp:n=0

```

c surface cards

c note: dimensions in centimeters

c

```

10 px 0.0
11 px 38.1
12 px 7925
13 px 9917
14 px 9937
15 px 7315
16 px 7335
17 px 8496
18 px 8534
19 px 15811.5
20 px 15849.6
21 px 5791
22 px 5811
23 px 12517
24 px 12537
25 px 14529
26 px 14549
27 px 15220
28 px 15240
29 px 7945
80 px 11148
81 px 11239.4
82 px 13809.1
83 px 13900.545

```

c

```

30 py 0.0
31 py 38.1
32 py 91.0
33 py 110.3
34 py 1105
35 py 1125.0
36 py 675.0
37 py 713.0
38 py 2438
39 py 6057.9
40 py 6096
41 py 4877
42 py 2454
43 py 4839
44 py 10465
45 py 10485
c 46 py 9327 $ detector
47 py 7526.477
48 py 7617.917
49 py 6187.44

```

c

```

50 pz -35.56 $ bottom of the concrete
60 pz 0.0    $ top of the concrete
61 pz 122
65 pz 1125.9

```

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```

66 pz 1134.7
70 pz 1430.6
71 pz 1439.6
998 so 20000 $ internal world
999 so 30000 $ boundary of universe

```

```

c *****

```

```

c

```

```

c material cards

```

```

c

```

```

c *****

```

```

c

```

```

m10 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

```

```

m20 1001.50c 4.288e-2 $ roof

```

```

6012.50c 1.812e-2

```

```

8016.50c 1.896e-3

```

```

26000.50c 2.783e-2

```

```

m30 7014.50c 3.57e-5 $ air

```

```

8016.50c 7.840e-6

```

```

m50 1001.50c 2.0

```

```

8016.50c 1.0 $ water

```

```

c

```

```

c

```

```

c

```

```

c *****

```

```

c

```

```

c peripherals

```

```

c

```

```

c *****

```

```

c

```

```

fc5 Detector!!!!

```

```

f5:n 7353 4788 200 50

```

```

e0 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

```

```

c

```

```

sdef pos=500 500 1 erg=d1

```

```

sc1 from h/u=120 100% enrichment normalized to 1281 W

```

```

sil 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

```

```

spl 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

```

```

mode n

```

```

cut:n j 0.017

```

```

c

```

```

ctme 7000

```

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nps 90000000
c
prtmp 3j 4
print

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APPENDIX B

ABSORBED DOSE RATE CALCULATION SPREADSHEETS

Source #1

This source is located on the floor between the tanks and the wall.						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm^2))	9A-A5 Detector Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-10			0		
5.47E+14	1.00E-07	6.03E-16		0	0	0
100% U-235	3.00E-07	2.46E-15		0	0	0
P = 1281 W	5.00E-07	3.69E-15		0	0	0
	1.00E-06	6.52E-15		0	0	0
	2.25E-06	1.40E-14		0	0	0
	3.25E-06	2.54E-14		0	0	0
	4.00E-06	3.37E-14		0	0	0
	8.00E-06	5.39E-14		0	0	0
	1.00E-05	8.37E-14		0	0	0
	1.13E-05	9.93E-14		0	0	0
	1.30E-05	1.13E-13		0	0	0
	1.77E-05	1.42E-13		0	0	0
	3.05E-05	2.20E-13		0	0	0
	1.00E-04	5.46E-13		0	0	0
	3.00E-04	1.70E-12		0	0	0
	1.00E-03	5.43E-12		0	0	0
	5.50E-03	2.46E-11		0	0	0
	3.00E-02	1.35E-10		0	0	0
	1.70E-01	7.20E-10		0	0	0
	1.00E-00	3.12E-09	2.06E-10	0.0296	3.51568E-06	1.04064E-07
	4.00E-00	1.08E-08	2.23E-10	0.0563	1.31739E-05	7.41693E-07
	9.00E-00	1.79E-08	1.84E-10	0.0448	1.80160E-05	8.07116E-07
	1.40E+01	2.44E-08	7.27E-11	0.0711	9.70312E-06	6.89892E-07
	1.85E+01	2.79E-08	4.91E-11	0.0687	7.49330E-06	5.14790E-07
	3.00E+01	3.22E-08	6.66E-11	0.0208	1.17305E-05	2.43995E-07
	6.43E+01	4.18E-08	2.93E-11	0.0263	6.69933E-06	1.76192E-07
	2.00E+02	4.72E-08	2.58E-12	0.1075	6.66115E-07	7.16073E-08
				Total AD (rad/s) =	7.09980E-05	1.43145E-06
				Total AD (mrad/hr) =	25.5592826	0.515320789

Source #2

This source is located in the NE corner of the building.						
	Upper Energy	Henderson Free in Air				
	Boundary (MeV)	Tissue Kerma Factor	9A-A5 Detector			
		(rads/(n/cm^2))	Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-10			0		
5.47E + 14	1.00E-07	6.03E-16		0	0	0
100% U-235	3.00E-07	2.46E-15		0	0	0
P = 1281 W	5.00E-07	3.69E-15		0	0	0
	1.00E-06	6.52E-15		0	0	0
	2.25E-06	1.40E-14		0	0	0
	3.25E-06	2.54E-14		0	0	0
	4.00E-06	3.37E-14		0	0	0
	8.00E-06	5.39E-14		0	0	0
	1.00E-05	8.37E-14		0	0	0
	1.13E-05	9.93E-14		0	0	0
	1.30E-05	1.13E-13		0	0	0
	1.77E-05	1.42E-13		0	0	0
	3.05E-05	2.20E-13		0	0	0
	1.00E-04	5.46E-13		0	0	0
	3.00E-04	1.70E-12		0	0	0
	1.00E-03	5.43E-12		0	0	0
	5.50E-03	2.46E-11		0	0	0
	3.00E-02	1.35E-10		0	0	0
	1.70E-01	7.20E-10		0	0	0
	1.00E-00	3.12E-09	2.21E-11	0.0889	3.77167E-07	3.35302E-08
	4.00E-00	1.08E-08	2.66E-11	0.1151	1.57142E-06	1.80871E-07
	9.00E-00	1.79E-08	2.13E-11	0.0831	2.08555E-06	1.73309E-07
	1.40E + 01	2.44E-08	1.47E-11	0.1371	1.96198E-06	2.68987E-07
	1.85E + 01	2.79E-08	1.10E-11	0.1421	1.67874E-06	2.38549E-07
	3.00E + 01	3.22E-08	2.33E-11	0.1047	4.10392E-06	4.29681E-07
	6.43E + 01	4.18E-08	1.24E-11	0.0231	2.83521E-06	6.54934E-08
	2.00E + 02	4.72E-08	2.29E-12	0.0427	5.91241E-07	2.52460E-08
				Total AD (rad/s) =	1.52052E-05	6.18617E-07
				Total AD (mrad/hr) =	5.4738837	0.22270203

Source #3

This source is located in the NW corner of the building.						
	Upper Energy	Henderson Free in Air				
	Boundary (MeV)	Tissue Kerma Factor	9A-A5 Detector			
		(rads/(n/cm^2))	Neutron Fluence/sp	Relative Error	Absorbed Dose	Error
					Rate (rads/s)	
Source Rate (n/s)	1.00E-10			0		
5.47E + 14	1.00E-07	6.03E-16		0	0	0
100% U-235	3.00E-07	2.46E-15		0	0	0
P = 1281 W	5.00E-07	3.69E-15		0	0	0
	1.00E-06	6.52E-15		0	0	0
	2.25E-06	1.40E-14		0	0	0
	3.25E-06	2.54E-14		0	0	0
	4.00E-06	3.37E-14		0	0	0
	8.00E-06	5.39E-14		0	0	0
	1.00E-05	8.37E-14		0	0	0
	1.13E-05	9.93E-14		0	0	0
	1.30E-05	1.13E-13		0	0	0
	1.77E-05	1.42E-13		0	0	0
	3.05E-05	2.20E-13		0	0	0
	1.00E-04	5.46E-13		0	0	0
	3.00E-04	1.70E-12		0	0	0
	1.00E-03	5.43E-12		0	0	0
	5.50E-03	2.46E-11		0	0	0
	3.00E-02	1.35E-10		0	0	0
	1.70E-01	7.20E-10		0	0	0
	1.00E-00	3.12E-09	3.54E-10	0.05	6.04151E-06	3.02075E-07
	4.00E-00	1.08E-08	4.13E-10	0.03	2.43984E-05	7.31952E-07
	9.00E-00	1.79E-08	4.52E-10	0.03	4.42567E-05	1.32770E-06
	1.40E + 01	2.44E-08	2.32E-10	0.02	3.09646E-05	6.19292E-07
	1.85E + 01	2.79E-08	2.19E-10	0.01	3.34222E-05	3.34222E-07
	3.00E + 01	3.22E-08	5.30E-10	0.01	9.33510E-05	9.33510E-07
	6.43E + 01	4.18E-08	4.00E-10	0.01	9.14584E-05	9.14584E-07
	2.00E + 02	4.72E-08	5.87E-11	0.01	1.51554E-05	1.51554E-07
				Total AD (rad/s) =	3.39048E-04	2.14846E-06
				Total AD (mrad/hr) =	122.0573568	0.773446504

Source #4

This source is located east of the building.						
	Upper Energy	Henderson Free in Air				
	Boundary (MeV)	Tissue Kerma Factor	9A-A5 Detector			
		(rads/(n/cm ²))	Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-10			0		
5.47E + 14	1.00E-07	6.03E-16		0	0	0
100% U-235	3.00E-07	2.46E-15		0	0	0
P = 1281 W	5.00E-07	3.69E-15		0	0	0
	1.00E-06	6.52E-15		0	0	0
	2.25E-06	1.40E-14		0	0	0
	3.25E-06	2.54E-14		0	0	0
	4.00E-06	3.37E-14		0	0	0
	8.00E-06	5.39E-14		0	0	0
	1.00E-05	8.37E-14		0	0	0
	1.13E-05	9.93E-14		0	0	0
	1.30E-05	1.13E-13		0	0	0
	1.77E-05	1.42E-13		0	0	0
	3.05E-05	2.20E-13		0	0	0
	1.00E-04	5.46E-13		0	0	0
	3.00E-04	1.70E-12		0	0	0
	1.00E-03	5.43E-12		0	0	0
	5.50E-03	2.46E-11		0	0	0
	3.00E-02	1.35E-10		0	0	0
	1.70E-01	7.20E-10		0	0	0
	1.00E-00	3.12E-09	8.20E-11	0.1056	1.39944E-06	1.47781E-07
	4.00E-00	1.08E-08	9.33E-11	0.0692	5.51179E-06	3.81416E-07
	9.00E-00	1.79E-08	7.90E-11	0.0441	7.73513E-06	3.41119E-07
	1.40E+01	2.44E-08	5.76E-11	0.2641	7.68776E-06	2.03034E-06
	1.85E+01	2.79E-08	2.62E-11	0.0573	3.99846E-06	2.29112E-07
	3.00E+01	3.22E-08	5.88E-11	0.2019	1.03567E-05	2.09101E-06
	6.43E+01	4.18E-08	3.19E-11	0.0506	7.29381E-06	3.69067E-07
	2.00E+02	4.72E-08	4.61E-12	0.0497	1.19023E-06	5.91543E-08
				Total AD (rad/s) =	4.51733E-05	2.99508E-06
				Total AD (mrad/hr) =	16.26238614	1.078227676

Source #5

This source is located in the southeast corner of the building.						
	Upper Energy	Henderson Free in Air				
	Boundary (MeV)	Tissue Kerma Factor	9A-A5 Detector			
		(rads/(n/cm ²))	Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-10			0		
5.47E+14	1.00E-07	6.03E-16		0	0	0
100% U-235	3.00E-07	2.46E-15		0	0	0
P = 1281 W	5.00E-07	3.69E-15		0	0	0
	1.00E-06	6.52E-15		0	0	0
	2.25E-06	1.40E-14		0	0	0
	3.25E-06	2.54E-14		0	0	0
	4.00E-06	3.37E-14		0	0	0
	8.00E-06	5.39E-14		0	0	0
	1.00E-05	8.37E-14		0	0	0
	1.13E-05	9.93E-14		0	0	0
	1.30E-05	1.13E-13		0	0	0
	1.77E-05	1.42E-13		0	0	0
	3.05E-05	2.20E-13		0	0	0
	1.00E-04	5.46E-13		0	0	0
	3.00E-04	1.70E-12		0	0	0
	1.00E-03	5.43E-12		0	0	0
	5.50E-03	2.46E-11		0	0	0
	3.00E-02	1.35E-10		0	0	0
	1.70E-01	7.20E-10		0	0	0
	1.00E-00	3.12E-09	5.31E-10	0.0484	9.06226E-06	4.38613E-07
	4.00E-00	1.08E-08	5.91E-10	0.0371	3.49139E-05	1.29531E-06
	9.00E-00	1.79E-08	5.53E-10	0.0298	5.41459E-05	1.61355E-06
	1.40E+01	2.44E-08	3.19E-10	0.0698	4.25763E-05	2.97183E-06
	1.85E+01	2.79E-08	2.57E-10	0.0567	3.92215E-05	2.22386E-06
	3.00E+01	3.22E-08	5.21E-10	0.0206	9.17658E-05	1.89038E-06
	6.43E+01	4.18E-08	3.71E-10	0.0245	8.48277E-05	2.07828E-06
	2.00E+02	4.72E-08	5.21E-11	0.0227	1.34514E-05	3.05346E-07
				Total AD (rad/s) =	3.69965E-04	5.12221E-06
				Total AD (mrad/hr) =	133.1873146	1.843995609