**VERIFICATION OF CRITICALITY ACCIDENT ALARM
SYSTEM DETECTOR LOCATIONS FOR THE
X-326 PROCESS CELL FLOOR**

August 1995

by

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EXECUTIVE SUMMARY

Criticality Accident Alarm System (CAAS) detectors on the cell floor of the X-326 process building at the Portsmouth Gaseous Diffusion Plant (PORTS) are located at a height of 5 m above the cell floor. It has been suggested that this height be lowered to 1 m to alleviate accelerated system failures caused by the elevated temperatures at 5 m and to reduce the frequency of injury to maintenance personnel lifting the approximately 90-lb units into position. Work has been performed which analyzed the effect of relocating the CAAS detectors on the process floors of the X-333 and X-330 buildings from their current height to a height of 1 m¹. This earlier work was based on criticality accidents occurring in low enriched material (5% ²³⁵U) and was limited to the X-333 and X-330 buildings and the low enriched areas of X-326. It did not consider the residual higher enriched material in the X-326 building. This report analyzes the effect on criticality alarm coverage of lowering the CAAS detectors. This analysis is based on criticality accidents resulting from higher enriched material which may be present as "hold-up" in the process equipment within the X-326 building.

The criticality accident alarm detectors at the PORTS facility are set to alarm at a neutron absorbed dose rate of 5 mrad/hr. The calculated absorbed dose rates presented in this report show that the detectors examined that produce an alarm for the given criticality event at their current height will also produce an alarm if located at a height of 1 meter. Therefore, lowering the detectors will not result in a loss of coverage within the building.

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 managed and operated by Martin Marietta Utility Services (MMUS). At these plants, uranium (U), in the form of uranium hexafluoride (UF_6), is enriched via a gaseous diffusion process from its naturally occurring isotopic concentration of about 0.7% ^{235}U , up to about 5% ^{235}U . However, current operations allow a maximum production enrichment of 10% ^{235}U . The diffusion cascade process equipment is housed in buildings X-333, X-330, and X-326.

Presently, Criticality Accident Alarm System (CAAS) detectors on the cell floor of the X-326 building are located at a height of 5 m above the cell floor. It has been suggested that this height be lowered to 1 m. Lowering the detector height was deemed beneficial because it could reduce the potential for worker injury when the approximately 90 pound alarms were removed for maintenance. Also, due to the large thermal gradient present in the process building, lowering the detector would reduce the temperature of the detectors' operating environment. This may serve to reduce the incidence of battery failure resulting from elevated temperatures.

Previous work was performed that analyzed the effect of relocating the CAAS detectors on the process floors of the X-333, X-330, and the low enriched areas of X-326 from their current height of approximately 5 m to a height of approximately 1 m (ref 1). This earlier work was based on criticality accidents occurring in low enriched material (5% ^{235}U). It did not apply to the the high enriched material in the X-326 building. The purpose of this report is to analyze the effect on criticality alarm coverage of lowering the CAAS detectors on the cell floor of the X-326 building from a height of 5 m to a height of 1 m, and to verify existing coverage at their current height. This analysis is based on criticality

accidents resulting from the higher enriched material which may be present as "hold-up" in the process equipment within the X-326 building.

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2.0 FACILITY DESCRIPTION

The X-326 process facility is comprised of the X-326 building and all the cascade process equipment contained within the building. The X-326 building is a two story building approximately 2,230 ft long, 552 ft wide and 62 ft high. Its two floors have a combined floor space of approximately 58 acres². The lower floor, called the operating floor, contains the electrical switch gear and control instrumentation, while the upper floor, called the cell floor, contains the diffusion process equipment.

On the cell floor, the diffusion process takes place in stages. Twelve stages are grouped together in a process cell. Purge cells have six stages per cell. Twenty process cells are then, in turn, grouped together into units. The X-326 process building contains three different types of units, X-25 units, X-27 units, and purge and product units. The arrangement of these different types of units within the process building is shown in Figure 1.^{12,13} Units X-27-1 through X-27-3 and units X-25-1 through X-25-6 each contain 20 process cells. The X-25-7 unit and the purge and product unit each contain 10 cells. Uranium leaves each stage in two streams, a slightly enriched stream and a slightly depleted stream. The enriched stream from each stage is used as feed to the following stage. All of the stages are then connected to form an enrichment cascade.

Uranium in the cascade process equipment is in the chemical form UF_6 . In the past, uranium entered the northeast corner of the X-326 building with an enrichment of approximately 5% ^{235}U and was further enriched to assays of greater than 97% ^{235}U . Presently, the X-326 facility is primarily used as a top end for the enrichment process, with a top enrichment of about 10% ^{235}U .

Several CAAS detectors are located throughout the X-326 building. Twelve detectors are currently located on the cell floor above the cascade process equipment (ref 8). These

Figure 1. A view of the cell floor of the X-326 process building showing the arrangement of units within the building. Also shown are the current locations of the CAAS detectors on the cell floor. (not to scale)

detectors are mounted on vertical support columns at a height of 5 m above the process cell floor. The location of each of these detectors is shown in Figure 1.

3.0 ANALYSIS

The CAAS detectors on the cell floor of the X-326 building are located at a height of 5 m. As previously discussed, it has been suggested that these detectors be relocated to a height of 1 m. An analysis has been performed using the monte carlo code MCNP³ to determine the impact of lowering the CAAS detectors on the extent of criticality accident alarm coverage provided on the process cell floor.

To determine the effect of lowering these detectors, an MCNP model of the X-326 building was developed. In this model, CAAS detectors were modeled at positions corresponding to the existing CAAS detectors and at their proposed new positions (on the same columns but at a height of 1 m). Next, criticality accidents were modeled at various locations throughout the facility and the detector response was calculated for each detector location. Finally, the response of the detectors at the 1 m height was compared to the response of the detectors at the 5 m height to determine if criticality alarm coverage on the process cell floor is maintained.

The development of the MCNP model and the analysis of the results was performed in five steps. First, a suitable geometry, approximating the facility, was developed. Second, an accurate source term describing an appropriate criticality event was determined. Third, the CAAS detectors were modeled and flux tallies were implemented in a manner which provided an accurate value of the flux spectrum at the detector locations. Fourth, variance reduction techniques were employed such that the problem could be solved in a timely manner while still generating accurate results. Finally, a flux to dose conversion was applied to the tally results to determine the CAAS detector's response. These five steps are described in detail in the sections that follow.

3.1 Facility Model

The X-326 building was modeled as a two-story structure, 2280 ft long by 552 ft wide and 62 ft tall.^{10,11,14} A side view of one end of the X-326 building model, which indicates floor and ceiling heights, is shown in Figure 2. The first floor of the building was modeled as a large empty bay, 21 ft high. The second floor was separated from the first floor by an 8-in thick concrete slab. The second floor was modeled as 38 ft high and contains the process cells. A 4-in thick tar and steel roof was modeled covering the building.⁴ The ground was modeled as a 1-ft thick slab of concrete. Finally, a large hemisphere of air (with a radius of 8 km) surrounding the building was included in the model.

The process cell floor of the X-326 building contains all of the process units. Three different types of process units were modeled. The first process unit model (denoted X25/X27) represents an X-27 unit (units 1-3) or an X-25 unit (units 1-6). The second unit modeled (denoted X-25-7) represents unit X-25-7. The third unit modeled (denoted Purge/Product) represents the purge and product unit. Each of these unit models is discussed briefly below.

X25/X27 Unit Model: The X25/X27 unit model consists of 20 process cells. Each process cell is approximately 87 ft long by 33 ft 9 in wide by 11 ft 2 in tall. The length and width of the process cell were taken from references 15 and 16. Process cell heights varied across the cell. For the model, an average value was used. In order to maintain consistency with previous calculations, this value was taken from reference 4. Each unit consists of 2 rows of 10 process cells. The rows of cells are separated by 27 ft of air.^{15,16} Within each row, the cells are separated by 14 ft of air. This unit model is illustrated in Figure 3.

X-25-7 Unit Model: The X-25-7 unit was modeled as a single row of 10 process cells. The dimensions of the process cells in this unit are identical to the process cell

Figure 2. Side View of the North End of the X-326 Building Model

Figure 3. The X25/X27 Unit Model

dimensions in the X25/X27 unit model. The X-25-7 unit model is shown in Figure 4.

Purge/Product Unit Model: The purge and product unit was modeled as a single row of 10 process cells. The process cells in this unit are of varying size; however, they are always smaller than the cells in the X25/X27 unit model. The Purge/Product unit model is also shown in Figure 4.

These three different unit models were then arranged to form the model of the X-326 building process floor. Nine of the X25/X27 unit models were placed side by side along the building's west wall, starting from the north end of the building. The ninth X25/X27 unit model is followed by the X-25-7 unit model. This, in turn, is followed by the Purge/Product unit model. The air between each unit is accounted for in the unit models. The arrangement of all of the unit models is shown in Figure 5. Additionally, a Sabrina⁵ representation of the south end of the building model, showing the X-25-7 and Purge/Product unit models, is shown in Figure 6.

For consistency with previous calculations of criticality accident alarm detector response in the PORTS buildings, the number densities used in this analysis were taken from reference 4. The actual number densities used throughout the report are given in Table 1.

Figure 4. The X-25-7 and Purge/Product Unit Models

Figure 5. The Arrangement of X25/X27, X-27-7 and Purge/Product Unit Models to Form the Process Cell Floor of the X-326 Building Model. (not to scale)

Figure 6. SABRINA Representation of the South End of the X-326 Building Model, Including the X-25-7 and Purge/Product Unit Models

Table 1. Material Compositions

Material	Element	Number Density (Atom barn ⁻¹ cm ⁻¹)
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
Homogenized Cell Material	Carbon	6.230E-05
	Fluorine	8.880E-05
	Aluminum	8.420E-05
	Silicon	1.666E-05
	Chlorine	8.880E-05
	Chromium	1.619E-04
	Manganese	1.703E-05
	Iron	5.934E-04
	Nickel	4.563E-04
	Copper	3.273E-05
Homogenized Roof	Hydrogen	4.288E-02
	Carbon	1.812E-02
	Oxygen	1.896E-03
	Iron	2.783E-02

3.2 Source Term

To completely model the criticality accident 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 such that when the detectors are lowered to a height of 1 m above the process floor, the thickness of homogenized process cell between the source and the detector would be maximized. Since the homogenized process cell is the primary attenuating medium in the facility, these source locations result in the smallest absorbed dose rates at the detectors. Therefore, any other source location would result in a smaller thickness of homogenized process cell between the source and detector and will be bounded by the cases analyzed.

Three different source locations were utilized in this analysis. The first source, S1, was located in the Purge/Product unit model at the south end of the building. The second source, S2, was located in the X-27-1 unit model at the north end of the building. The third source, S3, was placed in the X-25-1 unit model. All source locations are shown in Figure 7.

Figure 7. Source and Detector Locations on the Cell Floor in the X-326 Building Model

3.2.2 Source Strength

The criticality sources used in this analysis were those that result in the minimum critical accident of concern as defined in ANSI/ANS 8.3-1986.⁶ The source strengths used varied with the location of the source in the facility. As the UF_6 material moves through the cascade in the process building the ^{235}U enrichment increases. Therefore, the criticality accidents that may occur in different locations in the building will most likely result from material enriched to different levels. As shown in POEF-SH-31, neutron energy spectra and power levels for the minimum critical accident of concern vary for sources with different ^{235}U enrichments.⁷

In this analysis, the neutron energy spectra and power level for S1, in the north end of the building, were those that result from the minimum critical accident of concern for an optimally moderated sphere of UO_2F_2 with a ^{235}U enrichment of 20%. This is representative of the enrichment which previously entered the facility. Although the UF_6 entering the X-326 building is no longer enriched to 20% ^{235}U , material with this enrichment may still be present in the building. Additionally, a minimum accident of concern from an optimally moderated 20% ^{235}U sphere will produce a lower detector response than that of a minimum accident of concern from an optimally moderated 10% ^{235}U sphere. Therefore, 20% ^{235}U was considered in the analysis. The neutron energy spectra and power level for S2, in the south end of the building, were those that result from the minimum critical accident of concern for an optimally moderated sphere of UF_6 with a ^{235}U enrichment of 100%. This is representative of the material which previously exited the facility. Again, material with this level of ^{235}U enrichment is no longer produced by the process equipment. However, this material may also still be present in the building or process equipment and was, therefore, considered in the analysis. Finally, the neutron energy spectra and power level for S3, approximately in the middle of the building, were those that result from the minimum critical accident of concern for an optimally moderated sphere of UF_6 with a ^{235}U enrichment of 20%.

All power levels and neutron source spectra were taken from POEF-SH-31 assuming the Henderson flux to dose response function.⁷ Source strengths for both the 20% and 100% ²³⁵U enriched sources are tabulated in Table 2. All sources were modeled as isotropic point sources and were placed at a height of 1 m above the process floor. This height was chosen to provide consistency with previous calculations¹.

Table 2. Source Terms for 100% and 20% ²³⁵U Enriched Sources

Upper Energy Limit (MeV)	Source Strength (number cm ⁻² s ⁻¹ W ⁻¹)	
	20% ²³⁵ U Enriched	100% ²³⁵ U Enriched
2.00E+01	8.56E+02	1.28E+03
6.43E+00	6.84E+03	1.02E+04
3.00E+00	7.43E+03	1.13E+04
1.85E+00	3.89E+03	5.88E+03
1.40E+00	4.74E+03	7.25E+03
9.00E-01	6.66E+03	1.03E+04
4.00E-01	5.67E+03	8.89E+03
1.00E-01	3.81E+03	5.83E+03
1.70E-02	2.77E+03	3.99E+03
3.00E-03	2.41E+03	3.52E+03
5.50E-04	2.27E+03	3.21E+03
1.00E-04	1.52E+03	2.09E+03
3.00E-05	1.25E+03	1.71E+03
1.00E-05	1.30E+03	1.79E+03
3.05E-06	5.72E+02	7.91E+02
1.77E-06	3.31E+02	4.79E+02
1.30E-06	1.40E+02	1.92E+02
1.13E-06	1.39E+02	1.68E+02

Upper Energy Limit (MeV)	Source Strength (number $\text{cm}^{-2} \text{s}^{-1} \text{W}^{-1}$)	
	20% ^{235}U Enriched	100% ^{235}U Enriched
1.00E-06	2.44E+02	3.17E+02
8.00E-07	7.40E+02	9.66E+02
4.00E-07	2.29E+02	2.74E+02
3.25E-07	3.83E+02	4.84E+02
2.25E-07	1.38E+03	1.29E+03
1.00E-07	1.97E+03	1.28E+03
5.00E-08	1.24E+03	7.14E+02
3.00E-08	1.11E+03	5.67E+02
1.00E-08	1.80E+02	1.04E+02
1.00E-11	0.00E+00	0.00E+00

3.3 Flux Tallies

The CAAS detectors used in the X-326 building at PORTS are set to alarm at an absorbed dose rate in tissue of 5 mrad/hr⁹. Values of the neutron flux in air, calculated by MCNP, are 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 CAAS detectors were modeled as spheres of air with a 1 m diameter. The detectors were modeled at heights of 1 and 5 m above the process cell floor at positions corresponding to their current locations⁸. These detector locations are the same as those shown in Figure 1. The neutron fluence at the various detectors was calculated using a track length estimator of neutron fluence in the detector sphere. A SABRINA representation of the X-326 building model cell floor, including the modeled detectors, is shown in Figure 8.

Figure 8. SABRINA Representation of the X-326 Building Model Cell Floor.
(The modeled detectors are also shown.)

3.4 Variance Reduction

This problem was run as an analog monte carlo problem and, as such, variance reduction was not implemented.

3.5 Flux to Absorbed Dose Rate Conversion

MCNP calculated the neutron fluence per source neutron at the modeled detector locations. In order to calculate the absorbed dose rate in the detector, 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 calculate the neutron absorbed dose rate in the detector.

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

$$N\left(\frac{\text{neutrons}}{\text{sec}}\right) = \phi_p \left(\frac{\#}{\text{cm}^2\text{-sec-watt}}\right) * P(W) * A(\text{cm}^2)$$

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 the detector sphere (r=2m)

Because the criticality accident sources used in this analysis have differing levels of moderation and ^{235}U enrichments, different power levels and neutron spectra correspond to the minimum accident of concern. Using the appropriate values for ϕ_p and P from POEF-

SH-31, the neutron source rates for each source term were calculated. The neutron source rate corresponding to the 20% ^{235}U enriched source term, S1 and S3, is 5.202×10^{13} n/s. The neutron source rate corresponding to the 100% ^{235}U enriched source term, S2, is 5.467×10^{13} n/s. It should be noted that these neutron sources are based on the Henderson Flux to Dose Conversion Factors in POEF-SH-31 and should not be used with any other response function.

A neutron flux to neutron absorbed dose rate 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:

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

where

- D = neutron absorbed dose rate at detector
- $\phi_{i,\text{mcnp}}$ = 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 flux to dose conversion factors, as shown in Table 3, were used.

Table 3. Henderson Free-in-Air Flux-to-Dose Conversion Factors

Upper Energy Boundary (MeV)	Henderson Free in Air Flux-to-Dose Conversion 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

In this analysis, a source was placed at one of the three source locations, as shown in Figure 7, and the detector response for each individual detector (at both the 1 m and 5 m heights) was calculated in turn. A complete MCNP input file for one of the source locations is included in Appendix A. The fluence per source neutron values calculated by MCNP at the detector locations were converted to absorbed dose rates using the methodology presented in section 3.5. These calculations are also included in Appendix B.

The detector responses for each source location (S1, S2, and S3) and for each detector height are presented in Tables 4 through 6, respectively. The detectors are identified by the number of the column on which they are mounted. As a result of the large thicknesses of material between the source and the detectors, only the detectors nearest the source yielded a statistically significant response for the computer time used.

Table 4. Detector Response of Four Detectors Nearest S1 (the South Source)

Detector Location (Column Number)	Current Height		1 Meter Height	
	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)
97E	374	23	248	19
97T	286	20	144	13
87E	52	9	27	6
87S	38	7	14	5

Table 5. Detector Response of Two Detectors Nearest S2 (the North Source)

Detector Location (Column Number)	Current Height		1 Meter Height	
	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)
7S	179	20	111	15
7E	156	19	153	19

Table 6. Detector Response of Four Detectors Nearest S3 (the Middle Source)

Detector Location (Column Number)	Current Height		1 Meter Height	
	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)	Detector Response (mrad/hr)	Standard Deviation (mrad/hr)
27S	93	12	33	7
27E	79	11	51	9
47S	55	9	22	5
48E	54	9	40	9

5.0 DISCUSSION

In the MCNP analysis, detectors were modeled at both the current height of the CAAS detectors and at their proposed new height of 1 m. For a given source location, detector responses were calculated in all detectors, at both the current and new heights. If, for a given detector location (column number), the response in both the higher and lower position was sufficient to result in an alarm, then detector coverage was maintained for the new detector location. If, however, the response in the higher position was sufficient to cause an alarm and the response in the lower position was not, then inadequate coverage would be provided by detectors at the proposed new locations.

Statistically significant detector responses were only obtained for those detectors nearest the source. This, for the most part, is due to the immense size of the X-326 building and the fact that it contains a large number of process cells. This results in great distances and large amounts of homogenized process cell between the source and detectors in the building model. As a consequence, detector response decreases rapidly with distance from the source. Another major reason for the limited detector response is the variance reduction and computation time used in the MCNP calculation. In order to provide the most accurate values of detector response, no variance reduction was employed. As a result large computation times were encountered. Unreasonable computation time would be required to obtain statistically significant responses in detectors more than three or four rows of process cells from the source.

Instead of increasing the computation time to unreasonable lengths of time, detector responses were calculated for several bounding cases and then symmetry arguments were applied to show that sufficient coverage exists in the remainder of the building. For the first source, S1, detector responses for detectors on columns 97E, 97T, 87E, and 87S indicate that lowering the detectors will not result in a loss of coverage. Source and detector

locations are shown in Figure 7. Similarly for the north end of the building, the response to source S2 in detectors located on columns 7S and 7E indicate that lowering the detectors will not result in a loss of coverage. This indicates that criticality coverage in the north and south end of the building will be maintained if the CAAS detectors are lowered. Due to the symmetry of the units and the detectors in the middle of the building (units X-27-2, X-27-3 and X-25-1 through 6) a source placed in the center of the detectors located on columns 27E, 27S, 48E, and 47S (in unit X-25-1) will provide a result that will be representative of the remaining units and detectors in the middle of the building. For example, if a source were to be located in the center of the detectors on columns 48E, 47S, 67E, and 67S (see Figure 7), the geometrical arrangement of process cells and detectors around the source will be nearly identical to the case analyzed. The only difference is that one of the detectors may actually be closer to the source. This is because the case analyzed was a bounding case for shielding and distance between the source and the detector. As a result of this symmetry, any other criticality accident location will result in detector responses as high or higher than those calculated in the case analyzed. The calculated detector responses for this source, S3, also indicate that lowering the detectors will not result in a loss of coverage. Due to symmetry, this result can be applied to the other units in the center of the building. Therefore, lowering the detectors will not result in a loss of criticality coverage on the cell floor of the X-326 building.

6.0 CONCLUSION

The criticality alarm detectors at the PORTS facility are set to alarm at a neutron absorbed dose rate value of 5 mrad/hr. As can be seen from the calculated absorbed dose rates presented in Tables 4 through 6, all of the detectors that alarm for the given criticality event at their current height in the process building will also alarm if located at a height of 1 m. This includes minimum accidents of concern spanning enrichments from 10 to 100% ^{235}U . Therefore, lowering the detectors will not result in a loss of coverage.

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Detector Locations for the X-326 Process Cell Floor**Page 30*

Appendix A - MCNP Input File

This is a model of building x326

c by c and j 4 - 4 - 95

c

c

```
10 4 1.6021E-3 20 -30 210 -230 732 -742 imp:n=1 u=2 $
20 4 1.6021E-3 40 -50 210 -230 732 -742 imp:n=1 u=2 $
30 4 1.6021E-3 20 -30 260 -280 732 -742 imp:n=1 u=2 $
40 4 1.6021E-3 40 -50 260 -280 732 -742 imp:n=1 u=2 $
50 4 1.6021E-3 20 -30 290 -320 732 -742 imp:n=1 u=2 $
60 4 1.6021E-3 40 -50 290 -320 732 -742 imp:n=1 u=2 $
70 4 1.6021E-3 20 -30 330 -360 732 -742 imp:n=1 u=2 $
80 4 1.6021E-3 40 -50 330 -360 732 -742 imp:n=1 u=2 $
90 4 1.6021E-3 20 -30 370 -390 732 -742 imp:n=1 u=2 $
100 4 1.6021E-3 40 -50 370 -390 732 -742 imp:n=1 u=2 $
110 4 1.6021E-3 20 -30 410 -440 732 -742 imp:n=1 u=2 $
120 4 1.6021E-3 40 -50 410 -440 732 -742 imp:n=1 u=2 $
130 4 1.6021E-3 20 -30 450 -480 732 -742 imp:n=1 u=2 $
140 4 1.6021E-3 40 -50 450 -480 732 -742 imp:n=1 u=2 $
150 4 1.6021E-3 20 -30 490 -520 732 -742 imp:n=1 u=2 $
160 4 1.6021E-3 40 -50 490 -520 732 -742 imp:n=1 u=2 $
170 4 1.6021E-3 20 -30 540 -560 732 -742 imp:n=1 u=2 $
180 4 1.6021E-3 40 -50 540 -560 732 -742 imp:n=1 u=2 $
190 4 1.6021E-3 20 -30 580 -600 732 -742 imp:n=1 u=2 $
200 4 1.6021E-3 40 -50 580 -600 732 -742 imp:n=1 u=2 $
210 1 4.354E-5 (13 -63 203 -613 732 -742)
      ((203 -210):(230 -260):(280 -290):(320 -330)
      :(360 -370):(390 -410):(440 -450):(480 -490)
      :(520 -540):(560 -580):(600 -613):(13 -20)
      :(30 -40):(50 -63))
      imp:n=1 u=2 $ air around process equipment (repeated struc)
300 0 -62 12 -612 202 -741 731
      lat=1 u=1 imp:n=1 fill=0:8 0:0 0:0
      2 8r
400 0 10 -70 200 -610 730 -740 800
      805 810 815 820 825 830 835
      840 845 imp:n=1 fill=1
500 1 4.354E-5 10 -130 610 -620 730 -740 imp:n=1 $ air next to process equip
510 2 7.9654E-2 -998 700 -710 imp:n=1 $ concrete floor/ground
520 1 4.354E-5 10 -130 200 -620 710 -720 imp:n=1 $ air in first floor
530 2 7.9654E-2 10 -130 200 -620 720 -730 imp:n=1 $ concrete floor
540 1 4.354E-5 10 -130 200 -620 740 -750
      860 865 870 875 880 885 890 895
      900 905 910 915 imp:n=1 $ air above process equip
550 5 9.0726E-2 10 -130 200 -620 750 -760 imp:n=1 $ roof
600 4 1.6021E-3 80 -90 210 -230 730 -740 imp:n=1 $
610 4 1.6021E-3 100 -120 220 -240 730 -740 imp:n=1 $
620 4 1.6021E-3 80 -90 260 -280 730 -740 imp:n=1 $
630 4 1.6021E-3 100 -120 250 -270 730 -740 imp:n=1 $
640 4 1.6021E-3 80 -90 290 -320 730 -740 imp:n=1 $
650 4 1.6021E-3 110 -120 300 -310 730 -740 imp:n=1 $
660 4 1.6021E-3 80 -90 330 -360 730 -740 imp:n=1 $
670 4 1.6021E-3 110 -120 340 -350 730 -740 imp:n=1 $
680 4 1.6021E-3 80 -90 370 -390 730 -740 imp:n=1 $
690 4 1.6021E-3 110 -120 380 -400 730 -740 imp:n=1 $
700 4 1.6021E-3 80 -90 410 -440 730 -740 imp:n=1 $
710 4 1.6021E-3 110 -120 420 -430 730 -740 imp:n=1 $
720 4 1.6021E-3 80 -90 450 -480 730 -740 imp:n=1 $
730 4 1.6021E-3 110 -120 460 -470 730 -740 imp:n=1 $
740 4 1.6021E-3 80 -90 490 -520 730 -740 imp:n=1 $
750 4 1.6021E-3 110 -120 500 -510 730 -740 imp:n=1 $
760 4 1.6021E-3 80 -90 540 -560 730 -740 imp:n=1 $
770 4 1.6021E-3 100 -120 530 -550 730 -740 imp:n=1 $
780 4 1.6021E-3 80 -90 580 -600 730 -740 imp:n=1 $
790 4 1.6021E-3 100 -120 570 -590 730 -740 855 imp:n=1 $
800 1 4.354E-5 (70 -90 200 -610 730 -740)
      ((200 -210):(230 -260):(280 -290):(320 -330):
```

```

(360 -370):(390 -410):(440 -450):(480 -490):
(520 -540):(560 -580):(600 -610):(70 -80)) imp:n=1
810 1 4.354E-5 (90 -130 200 -610 730 -740 850 855)
((200 -220):(240 -250):(270 -300):(310 -340):
(350 -380):(400 -420):(430 -460):(470 -500):
(510 -530):(550 -570):(590 -610):(90 -100):
(100 -110 270 -530):(120 -130)) imp:n=1 $ air around process cells
900 1 4.354E-5 ((-10:130:-200:620) 710 -998):
((10 -130 200 -620 760) -998) imp:n=1 $ air around building
910 0 (998 -999 700):(-999 -700) imp:n=1 $ internal void
920 1 4.354E-5 -800 imp:n=1 $ detector 1 L
921 1 4.354E-5 -805 imp:n=1 $ detector 2 L
922 1 4.354E-5 -810 imp:n=1 $ detector 3 L
923 1 4.354E-5 -815 imp:n=1 $ detector 4 L
924 1 4.354E-5 -820 imp:n=1 $ detector 5 L
925 1 4.354E-5 -825 imp:n=1 $ detector 6 L
926 1 4.354E-5 -830 imp:n=1 $ detector 7 L
927 1 4.354E-5 -835 imp:n=1 $ detector 8 L
928 1 4.354E-5 -840 imp:n=1 $ detector 9 L
929 1 4.354E-5 -845 imp:n=1 $ detector 10 L
930 1 4.354E-5 -850 imp:n=1 $ detector 11 L
931 1 4.354E-5 -855 imp:n=1 $ detector 12 L
932 1 4.354E-5 -860 imp:n=1 $ detector 1 U
933 1 4.354E-5 -865 imp:n=1 $ detector 2 U
934 1 4.354E-5 -870 imp:n=1 $ detector 3 U
935 1 4.354E-5 -875 imp:n=1 $ detector 4 U
936 1 4.354E-5 -880 imp:n=1 $ detector 5 U
937 1 4.354E-5 -885 imp:n=1 $ detector 6 U
938 1 4.354E-5 -890 imp:n=1 $ detector 7 U
939 1 4.354E-5 -895 imp:n=1 $ detector 8 U
940 1 4.354E-5 -900 imp:n=1 $ detector 9 U
941 1 4.354E-5 -905 imp:n=1 $ detector 10 U
942 1 4.354E-5 -910 imp:n=1 $ detector 11 U
943 1 4.354E-5 -915 imp:n=1 $ detector 12 U
999 0 999 imp:n=0 $ external void

```

```

10 px 0.0 $ north end of building
12 px -0.001 $
13 px -0.01 $
20 px 686.0 $
30 px 3338.0 $
40 px 4161.0 $
50 px 6812.0 $
62 px 6888.001 $
63 px 6888.01 $
70 px 61992.0 $
80 px 62678.0 $
90 px 65339.0 $
100 px 66101.0 $
110 px 66162.0 $
120 px 67564.0 $
130 px 69494.0 $ south face of building
200 py 0.0 $ west face of building
202 py -0.001 $
203 py -0.01 $
210 py 796.0 $
220 py 823.0 $
230 py 1825.0 $
240 py 1829.0 $
250 py 2255.0 $
260 py 2259.0 $
270 py 3261.0 $
280 py 3288.0 $
290 py 3722.0 $
300 py 3780.0 $
310 py 4694.0 $
320 py 4751.0 $

```

330	py	5185.0	\$	
340	py	5243.0	\$	
350	py	6157.0	\$	
360	py	6214.0	\$	
370	py	6648.0	\$	
380	py	6675.0	\$	
390	py	7677.0	\$	
400	py	7742.0	\$	
410	py	8111.0	\$	
420	py	8138.0	\$	
430	py	9083.0	\$	
440	py	9140.0	\$	
450	py	9574.0	\$	
460	py	9601.0	\$	
470	py	10516.0	\$	
480	py	10603.0	\$	
490	py	11037.0	\$	
500	py	11064.0	\$	
510	py	11979.0	\$	
520	py	12066.0	\$	
530	py	12497.0	\$	
540	py	12500.0	\$	
550	py	13472.0	\$	
560	py	13529.0	\$	
570	py	13929.0	\$	
580	py	13963.0	\$	
590	py	14905.0	\$	
600	py	14992.0	\$	
610	py	15362.0	\$	
612	py	15362.001	\$	
613	py	15362.01	\$	
620	py	16825.0	\$	east face of building
700	pz	-100.0	\$	bottom of concrete ground
710	pz	0.0	\$	top of concrete ground
720	pz	651.0	\$	ceiling of first floor
730	pz	671.0	\$	top of concrete (cell floor)
731	pz	670.99	\$	top of concrete (cell floor)
732	pz	670.999	\$	
740	pz	1011.0	\$	top of process cells
741	pz	1011.001	\$	top of process cells
742	pz	1011.01	\$	
750	pz	1883.0	\$	bottom of roof
760	pz	1893.0	\$	top of roof
800	s	4084 5121 771 50.0	\$	detector 1 L
805	s	4084 13899 771 50.0	\$	detector 2 L
810	s	17861 5121 771 50.0	\$	detector 3 L
815	s	17861 13899 771 50.0	\$	detector 4 L
820	s	31638 5121 771 50.0	\$	detector 5 L
825	s	32339 13899 771 50.0	\$	detector 6 L
830	s	45415 5121 771 50.0	\$	detector 7 L
835	s	45415 13899 771 50.0	\$	detector 8 L
840	s	59192 5121 771 50.0	\$	detector 9 L
845	s	59192 13899 771 50.0	\$	detector 10 L
850	s	66081 4389 771 50.0	\$	detector 11 L
855	s	66081 13899 771 50.0	\$	detector 12 L
860	s	4084 5121 1171 50.0	\$	detector 1 L
865	s	4084 13899 1171 50.0	\$	detector 2 L
870	s	17861 5121 1171 50.0	\$	detector 3 L
875	s	17861 13899 1171 50.0	\$	detector 4 L
880	s	31638 5121 1171 50.0	\$	detector 5 L
885	s	32339 13899 1171 50.0	\$	detector 6 L
890	s	45415 5121 1171 50.0	\$	detector 7 L
895	s	45415 13899 1171 50.0	\$	detector 8 L
900	s	59192 5121 1171 50.0	\$	detector 9 L
905	s	59192 13899 1171 50.0	\$	detector 10 L
910	s	66081 4389 1171 50.0	\$	detector 11 L
915	s	66081 13899 1171 50.0	\$	detector 12 L

998 so 800000 \$
999 so 900000 \$ enclosing sphere

mode n

c *****

c

c source term

c

c *****

sdef pos=67565 9144 771 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 tally cards

c

c *****

f4:n 920

f14:n 921

f24:n 922

f34:n 923

f44:n 924

f54:n 925

f64:n 926

f74:n 927

f84:n 928

f94:n 929

f104:n 930

f114:n 931

f124:n 932

f134:n 933

f144:n 934

f154:n 935

f164:n 936

f174:n 937

f184:n 938

f194:n 939

f204:n 940

f214:n 941

f224:n 942

f234:n 943

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 *****

c

c material cards

c

c *****

m1 7014.50c 3.570e-5 \$ air

8016.50c 7.840e-6

m2 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	
m3	6012.50c	3.921e-3	\$ steel
	26000.50c	8.349e-2	
m4	6012.50c	6.230e-5	\$ homogenized cell material
	9019.50c	8.880e-5	
	13027.50c	8.420e-5	
	14000.50c	1.666e-5	
	17000.50c	8.880e-5	
	24000.50c	1.619e-4	
	25055.51c	1.703e-5	
	26000.50c	5.934e-4	
	28000.50c	4.563e-4	
	29000.50c	3.273e-5	
m5	1001.50c	4.288e-2	\$ roof
	6012.50c	1.812e-2	
	8016.50c	1.896e-3	
	26000.50c	2.783e-2	
nps	36000000		
ctme	720		
c	dbcn 2j 35 36 1000		
print			

Appendix B - Spreadsheets for Absorbed Dose Rate Calculations

Detector Response for UPPER Detectors in the x326 Building (South Source) S1						
The source is located at the center of the Purge/Product unit along the south edge of the unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 12 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.47E+13	1.00E-08	6.03E-17	5.01E-11	0.1929	1.6526E-13	3.19E-14
100% U-235	3.00E-08	2.46E-16	2.41E-10	0.0837	3.24264E-12	2.71E-13
H/U = 120	5.00E-08	3.69E-16	2.49E-10	0.0872	5.01987E-12	4.38E-13
P = 1281 W	1.00E-07	6.52E-16	4.62E-10	0.0639	1.64548E-11	1.05E-12
	2.25E-07	1.40E-15	2.71E-10	0.0915	2.07454E-11	1.9E-12
	3.25E-07	2.54E-15	7.57E-11	0.1951	1.05106E-11	2.05E-12
	4.00E-07	3.37E-15	2.76E-11	0.3278	5.09195E-12	1.67E-12
	8.00E-07	5.39E-15	1.58E-10	0.1378	4.66465E-11	6.43E-12
	1.00E-06	8.37E-15	3.81E-11	0.2862	1.74529E-11	5E-12
	1.13E-06	9.93E-15	9.49E-12	0.4206	5.15106E-12	2.17E-12
	1.30E-06	1.13E-14	1.98E-11	0.3868	1.22577E-11	4.74E-12
	1.77E-06	1.42E-14	4.18E-11	0.2862	3.24613E-11	9.29E-12
	3.05E-06	2.20E-14	1.26E-10	0.1648	1.51596E-10	2.5E-11
	1.00E-05	5.46E-14	1.74E-10	0.139	5.20447E-10	7.23E-11
	3.00E-05	1.70E-13	2.13E-10	0.1302	1.97531E-09	2.57E-10
	1.00E-04	5.43E-13	2.41E-10	0.1209	7.16731E-09	8.67E-10
	5.50E-04	2.46E-12	3.02E-10	0.1069	4.0569E-08	4.34E-09
	3.00E-03	1.35E-11	2.14E-10	0.127	1.57982E-07	2.01E-08
	1.70E-02	7.20E-11	2.53E-10	0.116	9.9738E-07	1.16E-07
	1.00E-01	3.12E-10	3.05E-10	0.1056	5.19583E-06	5.49E-07
	4.00E-01	1.08E-09	3.46E-10	0.0994	2.0411E-05	2.03E-06
	9.00E-01	1.79E-09	2.52E-10	0.1181	2.46902E-05	2.92E-06
	1.40E+00	2.44E-09	1.17E-10	0.1752	1.56229E-05	2.74E-06
	1.85E+00	2.79E-09	6.88E-11	0.2237	1.0499E-05	2.35E-06
	3.00E+00	3.22E-09	1.05E-10	0.1847	1.85248E-05	3.42E-06
	6.43E+00	4.18E-09	3.13E-11	0.2757	7.14922E-06	1.97E-06
	2.00E+01	4.72E-09	2.60E-12	1	6.70255E-07	6.7E-07
				Total AD (rad/s) =	0.000103969	6.48E-06
				Total AD (mrad/hr) =	374.2885972	23.32584

Detector 11				Detector 10			
Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error	Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0			0.00E+00	0		
4.08E-11	0.1994	1.3441E-13	2.68E-14	0.00E+00	0	0	0
2.33E-10	0.0895	3.13772E-12	2.81E-13	1.36E-11	0.3312	1.83139E-13	6.07E-14
1.96E-10	0.0964	3.94641E-12	3.8E-13	1.53E-11	0.344	3.08499E-13	1.06E-13
2.99E-10	0.0791	1.06696E-11	8.44E-13	2.57E-11	0.2765	9.145E-13	2.53E-13
2.00E-10	0.1104	1.5335E-11	1.69E-12	1.67E-11	0.3591	1.28107E-12	4.6E-13
5.35E-11	0.2379	7.42958E-12	1.77E-12	3.21E-12	0.6706	4.4632E-13	2.99E-13
2.90E-11	0.3075	5.33658E-12	1.64E-12	3.42E-12	1	6.29943E-13	6.3E-13
1.05E-10	0.1733	3.09022E-11	5.36E-12	5.94E-12	0.552	1.75167E-12	9.67E-13
1.32E-11	0.4602	6.02062E-12	2.77E-12	4.14E-12	1	1.89323E-12	1.89E-12
3.22E-11	0.3195	1.74579E-11	5.58E-12	0.00E+00	0	0	0
9.22E-12	0.5207	5.69666E-12	2.97E-12	0.00E+00	0	0	0
3.34E-11	0.292	2.59479E-11	7.58E-12	7.21E-12	0.7106	5.59538E-12	3.98E-12
8.05E-11	0.1974	9.683E-11	1.91E-11	5.09E-12	0.7121	6.11727E-12	4.36E-12
1.39E-10	0.1579	4.14417E-10	6.54E-11	8.02E-12	0.5905	2.39472E-11	1.41E-11
1.60E-10	0.1502	1.49005E-09	2.24E-10	8.05E-12	0.6022	7.47911E-11	4.5E-11
1.40E-10	0.159	4.16438E-09	6.62E-10	3.33E-11	0.3374	9.88033E-10	3.33E-10
2.36E-10	0.1204	3.17991E-08	3.83E-09	4.06E-11	0.2907	5.46565E-09	1.59E-09
2.07E-10	0.129	1.52648E-07	1.97E-08	2.25E-11	0.3622	1.66028E-08	6.01E-09
2.23E-10	0.1286	8.77293E-07	1.13E-07	1.14E-11	0.4887	4.50688E-08	2.2E-08
2.41E-10	0.1226	4.10512E-06	5.03E-07	2.54E-11	0.378	4.33725E-07	1.64E-07
2.54E-10	0.1169	1.50196E-05	1.76E-06	4.58E-11	0.2878	2.70632E-06	7.79E-07
2.08E-10	0.1275	2.03098E-05	2.59E-06	3.23E-11	0.3706	3.158E-06	1.17E-06
1.01E-10	0.1879	1.34518E-05	2.53E-06	1.40E-11	0.505	1.86425E-06	9.41E-07
5.02E-11	0.2531	7.6601E-06	1.94E-06	1.39E-11	0.5524	2.12071E-06	1.17E-06
6.89E-11	0.2242	1.21206E-05	2.72E-06	1.46E-11	0.4728	2.56832E-06	1.21E-06
1.45E-11	0.444	3.30569E-06	1.47E-06	7.11E-12	0.5866	1.62572E-06	9.54E-07
9.61E-12	0.5883	2.48022E-06	1.46E-06	0.00E+00	0	0	0
Total AD (rad/s) =				Total AD (rad/s) =			
286.2756706				1.45453E-05			
20.32328				52.36297309			
Total AD (mrad/hr) =				Total AD (mrad/hr) =			
7.9521E-05				9.28104			

Detector 9 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
2.28E-13	1	7.50966E-16	7.51E-16
1.52E-11	0.3686	2.05051E-13	7.56E-14
1.64E-11	0.3831	3.31827E-13	1.27E-13
2.74E-11	0.2648	9.77018E-13	2.59E-13
8.89E-12	0.4947	6.80441E-13	3.37E-13
2.05E-12	0.7089	2.85237E-13	2.02E-13
9.78E-13	1	1.80137E-13	1.8E-13
3.70E-12	0.7778	1.09127E-12	8.49E-13
5.75E-12	0.7204	2.6314E-12	1.9E-12
0.00E+00	0	0	0
0.00E+00	0	0	0
0.00E+00	0	0	0
1.23E-12	1	1.48158E-12	1.48E-12
1.91E-11	0.4004	5.71361E-11	2.29E-11
1.66E-11	0.4523	1.54115E-10	6.97E-11
1.92E-11	0.4222	5.69389E-10	2.4E-10
2.43E-11	0.3876	3.26497E-09	1.27E-09
4.27E-12	1	3.15384E-09	3.15E-09
2.45E-11	0.3869	9.62434E-08	3.72E-08
4.58E-11	0.2858	7.80373E-07	2.23E-07
4.13E-11	0.296	2.43686E-06	7.21E-07
3.56E-11	0.3097	3.4829E-06	1.08E-06
7.86E-12	0.7214	1.04872E-06	7.57E-07
4.87E-12	0.7334	7.42603E-07	5.45E-07
7.79E-12	0.651	1.37182E-06	8.93E-07
2.52E-12	1	5.76169E-07	5.76E-07
0.00E+00	0	0	0
Total AD (rad/s) =		1.05429E-05	1.93E-06
Total AD (mrad/hr) =		37.95440917	6.955938

Detector Response for LOWER Detectors in the x326 Building (South Source) S1						
The source is located at the center of the Purge/Product unit along the south edge of the unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 12 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.47E+13	1.00E-08	6.03E-17	4.68E-11	0.1865	1.54262E-13	2.88E-14
100% U-235	3.00E-08	2.46E-16	2.35E-10	0.09	3.16686E-12	2.85E-13
H/U = 120	5.00E-08	3.69E-16	2.73E-10	0.0905	5.50493E-12	4.98E-13
P = 1281 W	1.00E-07	6.52E-16	3.40E-10	0.0775	1.21161E-11	9.39E-13
	2.25E-07	1.40E-15	1.78E-10	0.1149	1.36286E-11	1.57E-12
	3.25E-07	2.54E-15	5.44E-11	0.2471	7.55179E-12	1.87E-12
	4.00E-07	3.37E-15	1.54E-11	0.3705	2.84132E-12	1.05E-12
	8.00E-07	5.39E-15	8.88E-11	0.1907	2.61752E-11	4.99E-12
	1.00E-06	8.37E-15	3.22E-11	0.3087	1.47123E-11	4.54E-12
	1.13E-06	9.93E-15	1.29E-11	0.4647	7.02635E-12	3.27E-12
	1.30E-06	1.13E-14	2.55E-11	0.3391	1.57385E-11	5.34E-12
	1.77E-06	1.42E-14	2.93E-11	0.3003	2.27382E-11	6.83E-12
	3.05E-06	2.20E-14	7.16E-11	0.2065	8.61011E-11	1.78E-11
	1.00E-05	5.46E-14	1.56E-10	0.1483	4.64257E-10	6.88E-11
	3.00E-05	1.70E-13	1.24E-10	0.1719	1.14952E-09	1.98E-10
	1.00E-04	5.43E-13	1.71E-10	0.1427	5.06425E-09	7.23E-10
	5.50E-04	2.46E-12	2.09E-10	0.1359	2.80969E-08	3.82E-09
	3.00E-03	1.35E-11	2.21E-10	0.1315	1.63288E-07	2.15E-08
	1.70E-02	7.20E-11	2.09E-10	0.1404	8.23859E-07	1.16E-07
	1.00E-01	3.12E-10	2.71E-10	0.1137	4.62454E-06	5.26E-07
	4.00E-01	1.08E-09	2.56E-10	0.1181	1.51029E-05	1.78E-06
	9.00E-01	1.79E-09	1.94E-10	0.1397	1.9013E-05	2.66E-06
	1.40E+00	2.44E-09	6.69E-11	0.2432	8.91932E-06	2.17E-06
	1.85E+00	2.79E-09	4.69E-11	0.2741	7.14906E-06	1.96E-06
	3.00E+00	3.22E-09	4.92E-11	0.2664	8.66481E-06	2.31E-06
	6.43E+00	4.18E-09	1.93E-11	0.3839	4.41662E-06	1.7E-06
	2.00E+01	4.72E-09	0.00E+00	0	0	0
				Total AD (rad/s) =	6.89124E-05	5.22E-06
				Total AD (mrad/hr) =	248.0846939	18.80118

Detector 11 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error	Detector 10 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0			0.00E+00	0		
3.19E-11	0.2369	1.05128E-13	2.49E-14	6.22E-12	0.571	2.0501E-14	1.17E-14
1.40E-10	0.1122	1.88156E-12	2.11E-13	1.17E-11	0.4299	1.57778E-13	6.78E-14
1.68E-10	0.1078	3.38781E-12	3.65E-13	1.06E-11	0.3636	2.13828E-13	7.77E-14
2.70E-10	0.0891	9.63815E-12	8.59E-13	3.08E-11	0.2319	1.09749E-12	2.55E-13
9.85E-11	0.1423	7.53875E-12	1.07E-12	1.52E-11	0.4508	1.16215E-12	5.24E-13
3.20E-11	0.3138	4.43988E-12	1.39E-12	1.63E-12	1	2.25741E-13	2.26E-13
1.24E-11	0.4558	2.27924E-12	1.04E-12	2.98E-12	1	5.49326E-13	5.49E-13
5.90E-11	0.2225	1.73804E-11	3.87E-12	1.36E-12	1	4.01157E-13	4.01E-13
2.04E-11	0.3891	9.31201E-12	3.62E-12	1.43E-12	1	6.52205E-13	6.52E-13
4.03E-12	0.8221	2.1887E-12	1.8E-12	0.00E+00	0	0	0
4.97E-12	0.5842	3.06835E-12	1.79E-12	0.00E+00	0	0	0
2.08E-11	0.3592	1.6183E-11	5.81E-12	2.55E-12	1	1.97905E-12	1.98E-12
4.79E-11	0.2652	5.76128E-11	1.53E-11	9.34E-12	0.5926	1.12321E-11	6.66E-12
1.16E-10	0.1651	3.46971E-10	5.73E-11	6.90E-12	0.7076	2.05904E-11	1.46E-11
1.11E-10	0.1732	1.0347E-09	1.79E-10	1.70E-11	0.4607	1.57583E-10	7.26E-11
8.32E-11	0.2001	2.47085E-09	4.94E-10	1.08E-11	0.5044	3.21379E-10	1.62E-10
1.60E-10	0.1468	2.15209E-08	3.16E-09	7.07E-12	0.7029	9.50226E-10	6.68E-10
1.31E-10	0.1677	9.66669E-08	1.62E-08	2.04E-11	0.3849	1.50881E-08	5.81E-09
1.54E-10	0.1531	6.07669E-07	9.3E-08	1.63E-11	0.4789	6.41796E-08	3.07E-08
1.56E-10	0.155	2.66109E-06	4.12E-07	6.01E-12	0.7154	1.02437E-07	7.33E-08
1.69E-10	0.1461	9.95788E-06	1.45E-06	3.05E-11	0.3463	1.80026E-06	6.23E-07
1.23E-10	0.1651	1.20192E-05	1.98E-06	2.99E-11	0.3295	2.93077E-06	9.66E-07
5.78E-11	0.2542	7.71602E-06	1.96E-06	7.70E-12	0.7146	1.02698E-06	7.34E-07
1.85E-11	0.4181	2.81648E-06	1.18E-06	4.02E-12	1	6.12504E-07	6.13E-07
1.86E-11	0.3783	3.27437E-06	1.24E-06	4.37E-12	1	7.69708E-07	7.7E-07
2.83E-12	1	6.468E-07	6.47E-07	6.88E-13	1	1.57145E-07	1.57E-07
1.02E-12	1	2.62003E-07	2.62E-07	0.00E+00	0	0	0
Total AD (rad/s) =				Total AD (rad/s) =			
Total AD (mrad/hr) =				Total AD (mrad/hr) =			
4.00837E-05				7.48054E-06			
144.3011874				26.92993657			
3.67E-06				1.69E-06			
13.22162				6.086508			

Detector 9 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
1.28E-12	1	4.21635E-15	4.22E-15
5.02E-12	0.6447	6.75424E-14	4.35E-14
1.62E-11	0.3749	3.26877E-13	1.23E-13
3.10E-11	0.2574	1.10394E-12	2.84E-13
1.46E-11	0.3928	1.1174E-12	4.39E-13
2.43E-12	1	3.37066E-13	3.37E-13
0.00E+00	0	0	0
4.83E-12	0.5486	1.42238E-12	7.8E-13
2.20E-12	0.7159	1.00684E-12	7.21E-13
0.00E+00	0	0	0
0.00E+00	0	0	0
0.00E+00	0	0	0
9.44E-13	1	1.1353E-12	1.14E-12
1.34E-11	0.5068	3.99489E-11	2.02E-11
3.65E-12	1	3.3894E-11	3.39E-11
0.00E+00	0	0	0
1.22E-11	0.5264	1.64074E-09	8.64E-10
1.35E-11	0.5138	9.95881E-09	5.12E-09
1.52E-11	0.4683	5.96533E-08	2.79E-08
4.88E-12	0.8747	8.326E-08	7.28E-08
1.17E-11	0.5995	6.89275E-07	4.13E-07
2.25E-11	0.3898	2.19713E-06	8.56E-07
0.00E+00	0	0	0
0.00E+00	0	0	0
0.00E+00	0	0	0
4.02E-12	1	9.17748E-07	9.18E-07
0.00E+00	0	0	0
Total AD (rad/s) =		3.95874E-06	1.32E-06
Total AD (mrad/hr) =		14.251476	4.765907

Detector Response for UPPER Detectors in the x326 Building (North Source) S2						
The source is located at the center of the X27-1 unit along the north edge of the unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 1 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.20E+13	1.00E-08	6.03E-17	1.13E-11	0.4892	3.54277E-14	1.73E-14
20% U-235	3.00E-08	2.46E-16	1.40E-10	0.1424	1.78905E-12	2.55E-13
H/U = 60	5.00E-08	3.69E-16	1.06E-10	0.1618	2.04312E-12	3.31E-13
P = 1722 W	1.00E-07	6.52E-16	1.87E-10	0.1357	6.34028E-12	8.6E-13
	2.25E-07	1.40E-15	1.26E-10	0.1811	9.20437E-12	1.67E-12
	3.25E-07	2.54E-15	4.00E-11	0.3704	5.28776E-12	1.96E-12
	4.00E-07	3.37E-15	2.21E-11	0.4247	3.87298E-12	1.64E-12
	8.00E-07	5.39E-15	4.56E-11	0.3429	1.27841E-11	4.38E-12
	1.00E-06	8.37E-15	2.05E-11	0.4913	8.91928E-12	4.38E-12
	1.13E-06	9.93E-15	1.55E-11	0.6223	8.02334E-12	4.99E-12
	1.30E-06	1.13E-14	1.89E-11	0.5796	1.11121E-11	6.44E-12
	1.77E-06	1.42E-14	1.78E-11	0.5286	1.31183E-11	6.93E-12
	3.05E-06	2.20E-14	6.04E-11	0.3053	6.91657E-11	2.11E-11
	1.00E-05	5.46E-14	9.93E-11	0.2356	2.82E-10	6.64E-11
	3.00E-05	1.70E-13	7.63E-11	0.2806	6.74592E-10	1.89E-10
	1.00E-04	5.43E-13	7.34E-11	0.2834	2.07366E-09	5.88E-10
	5.50E-04	2.46E-12	1.11E-10	0.2276	1.42419E-08	3.24E-09
	3.00E-03	1.35E-11	1.72E-10	0.1983	1.20543E-07	2.39E-08
	1.70E-02	7.20E-11	8.41E-11	0.2639	3.1499E-07	8.31E-08
	1.00E-01	3.12E-10	1.28E-10	0.2238	2.07934E-06	4.65E-07
	4.00E-01	1.08E-09	2.24E-10	0.1647	1.25597E-05	2.07E-06
	9.00E-01	1.79E-09	1.49E-10	0.2063	1.39146E-05	2.87E-06
	1.40E+00	2.44E-09	5.77E-11	0.306	7.33E-06	2.24E-06
	1.85E+00	2.79E-09	3.94E-11	0.4133	5.71263E-06	2.36E-06
	3.00E+00	3.22E-09	2.75E-11	0.4717	4.60125E-06	2.17E-06
	6.43E+00	4.18E-09	1.42E-11	0.5818	3.09116E-06	1.8E-06
	2.00E+01	4.72E-09	0.00E+00	0	0	0
				Total AD (rad/s) =	4.97416E-05	5.59E-06
				Total AD (mrad/hr) =	179.0696789	20.13869

Detector 2 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
2.55E-11	0.3444	7.997E-14	2.75E-14
1.09E-10	0.1837	1.39207E-12	2.56E-13
1.02E-10	0.1689	1.9654E-12	3.32E-13
2.05E-10	0.1313	6.96134E-12	9.14E-13
1.10E-10	0.1903	8.01938E-12	1.53E-12
1.25E-11	0.6108	1.64659E-12	1.01E-12
2.19E-11	0.5302	3.8369E-12	2.03E-12
3.16E-11	0.36	8.84814E-12	3.19E-12
2.29E-11	0.4943	9.95781E-12	4.92E-12
1.10E-11	0.7147	5.69547E-12	4.07E-12
8.75E-12	0.8002	5.14406E-12	4.12E-12
2.10E-11	0.5045	1.54917E-11	7.82E-12
3.66E-11	0.3745	4.19401E-11	1.57E-11
9.95E-11	0.2343	2.82516E-10	6.62E-11
7.61E-11	0.2761	6.7264E-10	1.86E-10
1.06E-10	0.2292	3.00671E-09	6.89E-10
1.85E-10	0.1841	2.36895E-08	4.36E-09
1.48E-10	0.2093	1.03613E-07	2.17E-08
1.34E-10	0.2188	5.03069E-07	1.1E-07
1.73E-10	0.1925	2.81512E-06	5.42E-07
1.88E-10	0.1865	1.05474E-05	1.97E-06
6.39E-11	0.2879	5.95104E-06	1.71E-06
6.62E-11	0.3031	8.40831E-06	2.55E-06
2.91E-11	0.4129	4.23019E-06	1.75E-06
2.81E-11	0.4704	4.70418E-06	2.21E-06
2.83E-11	0.4312	6.15565E-06	2.65E-06
0.00E+00	0	0	0
Total AD (rad/s) =		4.34463E-05	5.35E-06
Total AD (mrad/hr) =		156.4066615	19.25213

Detector Response for LOWER Detectors in the x326 Building (North Source) S2						
The source is located at the center of the X27-1 unit along the north edge of the unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 1 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.20E+13	1.00E-08	6.03E-17	1.47E-11	0.468	4.60449E-14	2.15E-14
20% U-235	3.00E-08	2.46E-16	1.24E-10	0.1579	1.58476E-12	2.5E-13
H/U = 60	5.00E-08	3.69E-16	1.45E-10	0.1569	2.79197E-12	4.38E-13
P = 1722 W	1.00E-07	6.52E-16	2.32E-10	0.1299	7.8654E-12	1.02E-12
	2.25E-07	1.40E-15	1.19E-10	0.1844	8.68343E-12	1.6E-12
	3.25E-07	2.54E-15	3.47E-11	0.4027	4.57924E-12	1.84E-12
	4.00E-07	3.37E-15	1.87E-11	0.4299	3.27001E-12	1.41E-12
	8.00E-07	5.39E-15	3.58E-11	0.4079	1.00326E-11	4.09E-12
	1.00E-06	8.37E-15	6.11E-12	0.9336	2.6599E-12	2.48E-12
	1.13E-06	9.93E-15	7.40E-12	1	3.82224E-12	3.82E-12
	1.30E-06	1.13E-14	6.81E-12	0.71	4.0008E-12	2.84E-12
	1.77E-06	1.42E-14	2.41E-12	1	1.7801E-12	1.78E-12
	3.05E-06	2.20E-14	8.96E-11	0.2519	1.02588E-10	2.58E-11
	1.00E-05	5.46E-14	1.06E-10	0.237	3.0073E-10	7.13E-11
	3.00E-05	1.70E-13	1.05E-10	0.2372	9.29114E-10	2.2E-10
	1.00E-04	5.43E-13	1.55E-10	0.2264	4.38908E-09	9.94E-10
	5.50E-04	2.46E-12	1.28E-10	0.2186	1.63266E-08	3.57E-09
	3.00E-03	1.35E-11	1.39E-10	0.2089	9.79344E-08	2.05E-08
	1.70E-02	7.20E-11	1.50E-10	0.2056	5.61423E-07	1.15E-07
	1.00E-01	3.12E-10	1.63E-10	0.2008	2.64619E-06	5.31E-07
	4.00E-01	1.08E-09	1.16E-10	0.2317	6.52555E-06	1.51E-06
	9.00E-01	1.79E-09	1.09E-10	0.234	1.01909E-05	2.38E-06
	1.40E+00	2.44E-09	4.61E-11	0.3652	5.84604E-06	2.13E-06
	1.85E+00	2.79E-09	7.69E-12	1	1.11608E-06	1.12E-06
	3.00E+00	3.22E-09	1.08E-11	0.7129	1.80324E-06	1.29E-06
	6.43E+00	4.18E-09	9.27E-12	0.7108	2.01575E-06	1.43E-06
	2.00E+01	4.72E-09	0.00E+00	0	0	0
				Total AD (rad/s) =	3.08252E-05	4.22E-06
				Total AD (mrad/hr) =	110.970613	15.17902

Detector 2 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
2.41E-11	0.329	7.5672E-14	2.49E-14
1.34E-10	0.1655	1.71782E-12	2.84E-13
1.19E-10	0.1594	2.27795E-12	3.63E-13
2.19E-10	0.1242	7.41691E-12	9.21E-13
7.13E-11	0.2411	5.19336E-12	1.25E-12
7.86E-12	0.828	1.0386E-12	8.6E-13
1.20E-11	0.703	2.09655E-12	1.47E-12
2.22E-11	0.5343	6.21482E-12	3.32E-12
1.52E-11	0.546	6.6053E-12	3.61E-12
1.02E-11	0.5671	5.25066E-12	2.98E-12
7.90E-12	0.8163	4.64256E-12	3.79E-12
4.86E-11	0.3436	3.58981E-11	1.23E-11
3.10E-11	0.4032	3.54854E-11	1.43E-11
1.02E-10	0.2282	2.91039E-10	6.64E-11
8.00E-11	0.2779	7.0746E-10	1.97E-10
1.29E-10	0.2189	3.64955E-09	7.99E-10
1.09E-10	0.2482	1.39471E-08	3.46E-09
9.15E-11	0.2589	6.42703E-08	1.66E-08
1.62E-10	0.1977	6.08222E-07	1.2E-07
1.80E-10	0.1878	2.91542E-06	5.48E-07
1.34E-10	0.2127	7.5489E-06	1.61E-06
1.19E-10	0.2291	1.10852E-05	2.54E-06
4.85E-11	0.3581	6.16195E-06	2.21E-06
2.20E-11	0.5147	3.19204E-06	1.64E-06
4.13E-11	0.3734	6.91364E-06	2.58E-06
1.17E-11	0.7466	2.54881E-06	1.9E-06
5.88E-12	1	1.4438E-06	1.44E-06
Total AD (rad/s) =		4.2501E-05	5.41E-06
Total AD (mrad/hr) =		153.0036502	19.48024

Detector Response for UPPER Detectors in the x326 Building (Middle Source) S3						
The source is located in the X-25-1 unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 3 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.47E+13	1.00E-08	6.03E-17	1.84E-11	0.3157	6.05365E-14	1.91E-14
100% U-235	3.00E-08	2.46E-16	3.97E-11	0.2045	5.34273E-13	1.09E-13
H/U = 120	5.00E-08	3.69E-16	3.89E-11	0.2237	7.85243E-13	1.76E-13
P = 1281 W	1.00E-07	6.52E-16	6.80E-11	0.1698	2.42309E-12	4.11E-13
	2.25E-07	1.40E-15	3.09E-11	0.2769	2.36333E-12	6.54E-13
	3.25E-07	2.54E-15	8.30E-12	0.5666	1.15239E-12	6.53E-13
	4.00E-07	3.37E-15	1.10E-11	0.5776	2.02468E-12	1.17E-12
	8.00E-07	5.39E-15	1.75E-11	0.4033	5.17004E-12	2.09E-12
	1.00E-06	8.37E-15	3.02E-12	1	1.38022E-12	1.38E-12
	1.13E-06	9.93E-15	3.67E-12	1	1.99282E-12	1.99E-12
	1.30E-06	1.13E-14	1.01E-11	0.5874	6.26296E-12	3.68E-12
	1.77E-06	1.42E-14	6.31E-12	0.6201	4.89593E-12	3.04E-12
	3.05E-06	2.20E-14	3.64E-11	0.3226	4.38149E-11	1.41E-11
	1.00E-05	5.46E-14	4.14E-11	0.3103	1.23719E-10	3.84E-11
	3.00E-05	1.70E-13	4.23E-11	0.3013	3.9336E-10	1.19E-10
	1.00E-04	5.43E-13	4.09E-11	0.2957	1.21294E-09	3.59E-10
	5.50E-04	2.46E-12	3.58E-11	0.3293	4.81366E-09	1.59E-09
	3.00E-03	1.35E-11	4.11E-11	0.2945	3.03649E-08	8.94E-09
	1.70E-02	7.20E-11	3.84E-11	0.3106	1.51283E-07	4.7E-08
	1.00E-01	3.12E-10	5.27E-11	0.2632	8.99329E-07	2.37E-07
	4.00E-01	1.08E-09	6.97E-11	0.2247	4.11289E-06	9.24E-07
	9.00E-01	1.79E-09	7.47E-11	0.2327	7.30707E-06	1.7E-06
	1.40E+00	2.44E-09	3.27E-11	0.3185	4.36767E-06	1.39E-06
	1.85E+00	2.79E-09	3.46E-11	0.3325	5.28375E-06	1.76E-06
	3.00E+00	3.22E-09	9.05E-12	0.6456	1.59249E-06	1.03E-06
	6.43E+00	4.18E-09	9.03E-12	0.6539	2.06463E-06	1.35E-06
	2.00E+01	4.72E-09	0.00E+00	0	0	0
				Total AD (rad/s) =	2.58161E-05	3.42E-06
				Total AD (mrad/hr) =	92.93791791	12.3165

Detector 4 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error	Detector 5 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0			0.00E+00	0		
1.60E-12	1	5.2797E-15	5.28E-15	0.00E+00	0	0	0
2.96E-11	0.2239	3.9807E-13	8.91E-14	2.57E-11	0.3071	3.45909E-13	1.06E-13
4.90E-11	0.2009	9.87508E-13	1.98E-13	2.48E-11	0.2685	4.99762E-13	1.34E-13
7.53E-11	0.1663	2.68336E-12	4.46E-13	5.14E-11	0.214	1.83223E-12	3.92E-13
3.38E-11	0.2574	2.58659E-12	6.66E-13	1.96E-11	0.362	1.50025E-12	5.43E-13
4.70E-12	0.5861	6.53209E-13	3.83E-13	1.46E-11	0.4176	2.02241E-12	8.45E-13
1.50E-12	0.8721	2.76716E-13	2.41E-13	1.51E-12	1	2.78273E-13	2.78E-13
1.40E-11	0.488	4.12558E-12	2.01E-12	2.87E-11	0.3462	8.45807E-12	2.93E-12
5.17E-12	0.7327	2.36428E-12	1.73E-12	7.60E-12	0.7091	3.47705E-12	2.47E-12
3.48E-12	1	1.88709E-12	1.89E-12	1.10E-12	1	5.95038E-13	5.95E-13
1.21E-12	1	7.48498E-13	7.48E-13	3.19E-12	1	1.97358E-12	1.97E-12
8.92E-12	0.6229	6.92158E-12	4.31E-12	1.81E-12	1	1.40214E-12	1.4E-12
1.12E-11	0.4728	1.34584E-11	6.36E-12	1.28E-11	0.5481	1.53399E-11	8.41E-12
2.89E-11	0.3348	8.63869E-11	2.89E-11	4.10E-11	0.2942	1.22523E-10	3.6E-11
1.81E-11	0.3883	1.68336E-10	6.54E-11	3.62E-11	0.3357	3.36141E-10	1.13E-10
2.58E-11	0.3775	7.67114E-10	2.9E-10	2.77E-11	0.3596	8.22113E-10	2.96E-10
4.29E-11	0.2736	5.76769E-09	1.58E-09	3.91E-11	0.2918	5.25627E-09	1.53E-09
5.89E-11	0.2619	4.3492E-08	1.14E-08	4.31E-11	0.2874	3.18021E-08	9.14E-09
3.71E-11	0.3129	1.4617E-07	4.57E-08	2.24E-11	0.3761	8.80025E-08	3.31E-08
4.76E-11	0.2762	8.1171E-07	2.24E-07	5.48E-11	0.2408	9.35464E-07	2.25E-07
7.88E-11	0.2207	4.65187E-06	1.03E-06	5.33E-11	0.2696	3.14808E-06	8.49E-07
5.63E-11	0.2569	5.50604E-06	1.41E-06	3.16E-11	0.3309	3.08825E-06	1.02E-06
2.87E-11	0.3432	3.82746E-06	1.31E-06	1.75E-11	0.4472	2.33324E-06	1.04E-06
7.98E-12	0.6209	1.21781E-06	7.56E-07	1.05E-11	0.5975	1.5999E-06	9.56E-07
1.70E-11	0.4436	2.99188E-06	1.33E-06	7.21E-12	0.7131	1.26986E-06	9.06E-07
1.19E-11	0.5604	2.71805E-06	1.52E-06	1.25E-11	0.504	2.86028E-06	1.44E-06
0.00E+00	0	0	0	0.00E+00	0	0	0
Total AD (rad/s) =		2.19213E-05	3.08E-06	Total AD (rad/s) =		1.53614E-05	2.59E-06
Total AD (mrad/hr) =		78.91670591	11.08787	Total AD (mrad/hr) =		55.30120637	9.330348

Detector 6 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
8.40E-13	1	2.76965E-15	2.77E-15
2.02E-11	0.2964	2.71364E-13	8.04E-14
1.86E-11	0.3192	3.74921E-13	1.2E-13
2.00E-11	0.3267	7.11899E-13	2.33E-13
2.65E-11	0.2827	2.02963E-12	5.74E-13
2.07E-12	0.8189	2.87177E-13	2.35E-13
4.24E-12	1	7.81821E-13	7.82E-13
0.00E+00	0	0	0
0.00E+00	0	0	0
0.00E+00	0	0	0
6.65E-12	0.7298	4.107E-12	3E-12
6.76E-12	0.6014	5.24656E-12	3.16E-12
1.46E-11	0.4759	1.75707E-11	8.36E-12
3.04E-11	0.3421	9.07345E-11	3.1E-11
7.25E-12	0.6373	6.73371E-11	4.29E-11
2.29E-11	0.4121	6.79467E-10	2.8E-10
1.17E-11	0.5454	1.56789E-09	8.55E-10
2.55E-11	0.4099	1.88482E-08	7.73E-09
4.75E-11	0.3198	1.86842E-07	5.98E-08
4.52E-11	0.2809	7.70187E-07	2.16E-07
4.75E-11	0.2751	2.80657E-06	7.72E-07
3.66E-11	0.2908	3.57677E-06	1.04E-06
2.30E-11	0.4253	3.06441E-06	1.3E-06
1.83E-11	0.4581	2.79171E-06	1.28E-06
7.63E-12	0.5633	1.34239E-06	7.56E-07
2.29E-12	1	5.2267E-07	5.23E-07
0.00E+00	0	0	0
Total AD (rad/s) =		1.50828E-05	2.43E-06
Total AD (mrad/hr) =		54.29822885	8.749934

Detector Response for LOWER Detectors in the x326 Building (Middle Source) S3						
The source is located in the X-25-1 unit						
	Upper Energy Boundary (MeV)	Henderson Free in Air Tissue Kerma Factor (rads/(n/cm ²))	Detector 3 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
Source Rate (n/s)	1.00E-11		0.00E+00	0		
5.47E+13	1.00E-08	6.03E-17	7.47E-12	0.5814	2.46162E-14	1.43E-14
100% U-235	3.00E-08	2.46E-16	2.86E-11	0.2693	3.85108E-13	1.04E-13
H/U = 120	5.00E-08	3.69E-16	3.38E-11	0.2218	6.81696E-13	1.51E-13
P = 1281 W	1.00E-07	6.52E-16	4.84E-11	0.2163	1.72602E-12	3.73E-13
	2.25E-07	1.40E-15	2.24E-11	0.2879	1.71512E-12	4.94E-13
	3.25E-07	2.54E-15	4.83E-12	1	6.70948E-13	6.71E-13
	4.00E-07	3.37E-15	4.17E-12	1	7.69003E-13	7.69E-13
	8.00E-07	5.39E-15	1.00E-11	0.5813	2.94596E-12	1.71E-12
	1.00E-06	8.37E-15	6.17E-12	0.77	2.8241E-12	2.17E-12
	1.13E-06	9.93E-15	0.00E+00	0	0	0
	1.30E-06	1.13E-14	3.95E-12	1	2.44031E-12	2.44E-12
	1.77E-06	1.42E-14	6.52E-12	0.5826	5.06137E-12	2.95E-12
	3.05E-06	2.20E-14	1.69E-12	1	2.0384E-12	2.04E-12
	1.00E-05	5.46E-14	1.25E-11	0.4824	3.73341E-11	1.8E-11
	3.00E-05	1.70E-13	1.84E-11	0.3947	1.70552E-10	6.73E-11
	1.00E-04	5.43E-13	3.73E-11	0.3297	1.1062E-09	3.65E-10
	5.50E-04	2.46E-12	3.17E-11	0.3651	4.26804E-09	1.56E-09
	3.00E-03	1.35E-11	3.42E-11	0.3409	2.52596E-08	8.61E-09
	1.70E-02	7.20E-11	4.08E-11	0.3011	1.60601E-07	4.84E-08
	1.00E-01	3.12E-10	2.12E-11	0.3517	3.62102E-07	1.27E-07
	4.00E-01	1.08E-09	4.75E-11	0.2848	2.80671E-06	7.99E-07
	9.00E-01	1.79E-09	2.52E-11	0.3977	2.4658E-06	9.81E-07
	1.40E+00	2.44E-09	9.32E-12	0.6197	1.24302E-06	7.7E-07
	1.85E+00	2.79E-09	2.12E-12	1	3.23759E-07	3.24E-07
	3.00E+00	3.22E-09	3.17E-12	1	5.57517E-07	5.58E-07
	6.43E+00	4.18E-09	4.98E-12	0.8649	1.13907E-06	9.85E-07
	2.00E+01	4.72E-09	0.00E+00	0	0	0
Total AD (rad/s) =					9.08944E-06	1.9E-06
Total AD (mrad/hr) =					32.72198934	6.829431

Detector 4 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error	Detector 5 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0	0	0	0.00E+00	0	0	0
0.00E+00	0	0	0	3.41E-12	1	1.1256E-14	1.13E-14
2.18E-11	0.3114	2.93448E-13	9.14E-14	1.25E-11	0.3757	1.68044E-13	6.31E-14
1.93E-11	0.2794	3.88704E-13	1.09E-13	1.89E-11	0.3155	3.81912E-13	1.2E-13
3.72E-11	0.2496	1.32497E-12	3.31E-13	3.73E-11	0.2365	1.33039E-12	3.15E-13
4.69E-11	0.2573	3.59307E-12	9.24E-13	2.28E-11	0.3007	1.74785E-12	5.26E-13
1.10E-12	1	1.52648E-13	1.53E-13	2.82E-12	1	3.91035E-13	3.91E-13
0.00E+00	0	0	0	3.41E-12	0.814	6.28719E-13	5.12E-13
6.11E-12	0.6196	1.79905E-12	1.11E-12	8.60E-12	0.7163	2.53405E-12	1.82E-12
4.37E-12	0.8473	2.00113E-12	1.7E-12	0.00E+00	0	0	0
8.13E-12	0.5902	4.41229E-12	2.6E-12	0.00E+00	0	0	0
6.50E-12	0.714	4.01505E-12	2.87E-12	0.00E+00	0	0	0
2.20E-12	0.893	1.70563E-12	1.52E-12	0.00E+00	0	0	0
1.02E-11	0.5979	1.2225E-11	7.31E-12	1.36E-11	0.4506	1.6389E-11	7.38E-12
1.65E-11	0.5156	4.93701E-11	2.55E-11	3.38E-11	0.3383	1.01015E-10	3.42E-11
1.51E-11	0.5131	1.3992E-10	7.18E-11	1.35E-11	0.512	1.2548E-10	6.42E-11
2.37E-11	0.4481	7.04064E-10	3.15E-10	8.16E-12	0.6617	2.4213E-10	1.6E-10
2.89E-11	0.3496	3.89224E-09	1.36E-09	3.70E-11	0.3198	4.96993E-09	1.59E-09
2.67E-11	0.3693	1.9682E-08	7.27E-09	2.62E-11	0.3701	1.93577E-08	7.16E-09
3.73E-11	0.3128	1.46699E-07	4.59E-08	2.33E-11	0.3611	9.17604E-08	3.31E-08
4.79E-11	0.2764	8.16563E-07	2.26E-07	2.52E-11	0.4152	4.29327E-07	1.78E-07
2.83E-11	0.3427	1.66867E-06	5.72E-07	4.26E-11	0.3127	2.51666E-06	7.87E-07
2.98E-11	0.3601	2.9129E-06	1.05E-06	2.24E-11	0.395	2.19446E-06	8.67E-07
2.88E-11	0.3591	3.84405E-06	1.38E-06	0.00E+00	0	0	0
1.38E-12	0.8323	2.10844E-07	1.75E-07	1.01E-12	1	1.53515E-07	1.54E-07
1.51E-11	0.4732	2.65822E-06	1.26E-06	0.00E+00	0	0	0
7.89E-12	0.652	1.80298E-06	1.18E-06	2.47E-12	1	5.64997E-07	5.65E-07
0.00E+00	0	0	0	0.00E+00	0	0	0
Total AD (rad/s) =		1.40854E-05	2.53E-06	Total AD (rad/s) =		5.97553E-06	1.32E-06
Total AD (mrad/hr) =		50.70753334	9.093697	Total AD (mrad/hr) =		21.5119128	4.757422

Detector 6 Neutron Fluence/sp	Relative Error	Absorbed Dose Rate (rads/s)	Error
0.00E+00	0		
1.32E-12	1	4.35517E-15	4.36E-15
1.32E-11	0.3954	1.78007E-13	7.04E-14
1.58E-11	0.3135	3.17819E-13	9.96E-14
2.80E-11	0.269	9.96359E-13	2.68E-13
1.33E-11	0.4511	1.0207E-12	4.6E-13
0.00E+00	0	0	0
0.00E+00	0	0	0
1.14E-11	0.5225	3.37072E-12	1.76E-12
0.00E+00	0	0	0
2.38E-12	1	1.29383E-12	1.29E-12
0.00E+00	0	0	0
2.68E-12	1	2.07905E-12	2.08E-12
6.33E-12	0.5989	7.61397E-12	4.56E-12
1.57E-11	0.4798	4.68323E-11	2.25E-11
1.51E-11	0.4925	1.40037E-10	6.9E-11
8.58E-12	0.5847	2.54594E-10	1.49E-10
1.89E-11	0.43	2.54218E-09	1.09E-09
3.10E-11	0.3409	2.28987E-08	7.81E-09
1.25E-11	0.5167	4.92136E-08	2.54E-08
4.50E-11	0.3464	7.67482E-07	2.66E-07
1.28E-11	0.3925	7.53172E-07	2.96E-07
1.59E-11	0.4683	1.56076E-06	7.31E-07
2.37E-11	0.4858	3.16248E-06	1.54E-06
7.60E-12	0.7151	1.15879E-06	8.29E-07
7.68E-12	0.6329	1.35112E-06	8.55E-07
9.79E-12	0.6116	2.2372E-06	1.37E-06
0.00E+00	0	0	0
Total AD (rad/s) =		1.10661E-05	2.52E-06
Total AD (mrad/hr) =		39.83802993	9.066992