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Neutron Energy Spectrum Characterization of the TREAT High Bay

by

Konner M. Casanova

A thesis

submitted in partial fulfillment

of the requirements for the degree of

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To the Graduate Faculty:

The members of the committee appointed to examine the thesis of Konner M. Casanova find it satisfactory and recommend that it be accepted.

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Table of Contents

List of Figures

List of Tables

Neutron Energy Spectrum Characterization of the TREAT High Bay

Thesis Abstract – Idaho State University (2020)

Gold foil and Bonner sphere measurements were taken in the TREAT high bay to determine the neutron energy spectrum and flux at various locations. The Bonner spheres are used to estimate the free air neutron flux and spectra. Gold foils provide thermal flux information in more locations in the TREAT high bay then were able to be measured with Bonner spheres. The generated neutron flux and spectrum can be used as process knowledge for radiological Tier 1 and Tier 2 release per DOE-STD-6004-2016, "Clearance and Release of Personal Property from Accelerator Facilities". Spectrum data was used with ORIGEN to conservatively calculate activation and decay of all naturally occurring elements (z=1-83). Activation data was used with a wide variety of materials to determine which elements and materials are a concern for activation. This release methodology is preliminary and is currently only applicable for items greater than 10 ft from the bio-shield on the first floor. Further work needs to be done to apply this methodology to the 2nd floor, 3rd floor, and basement of TREAT or items closer than 10 ft from the bio-shield.

Key Words: neutron spectrum, TREAT, Bonner Sphere, gold foil

1 Introduction

The Transient Reactor Test (TREAT) facility provides Idaho National Laboratory (INL) with capabilities for testing nuclear reactor fuels under severe accident conditions. Because of the unique design of TREAT, the reactor can undergo massive transients depositing over 2.9 GJ of energy in a safe manner exposing test specimens to intense fission heating, even to the point of fuel melting. This capability makes TREAT ideal for research and development of next generation nuclear reactor fuels that are accident tolerant.

TREAT is an air-cooled thermal graphite moderated reactor with highly enriched uranium sparsely dispersed within graphite blocks. Surrounding the reactor core and graphite reflector are thick slabs of concrete referred to as the bio-shield which provides radiation shielding to the reactor high bay where TREAT is located.[1] Although the bio-shield is effective, there is still a significant amount of radiation that escapes from the shielded area during reactor operations, prompting evacuation of the TREAT facility and remote operation during reactor transients. Even during low power steady state operations, there are measurable gamma and neutron radiation fields outside the bio-shield within the TREAT facility.

Neutron radiation can interact with materials changing the atomic structure and making them radioactive. This process is called neutron activation. This can happen to any material including equipment, the facility structure, and research devices making all material within the TREAT high bay suspect as radioactive material. Some materials are more susceptible to neutron activation than others and some materials will decay faster than others making them effectively non-radioactive after some period of time.

Material exposed to a neutron field is controlled as radioactive until proven otherwise. It is desirable to be able to release this material from radiological controls to save money on disposal costs of legacy materials and provide further capabilities to potential customers. Currently, equipment for research present during reactor operations must be controlled as radioactive material, requiring researchers to sacrifice the equipment and TREAT to pay for disposal. To release current and legacy material at TREAT, the potential activation of that material must have sufficient process knowledge to demonstrate what the potential for activation is and provide sufficient technical basis to look for those potential activation products. Previous measurements of the neutron energy spectrum and flux outside of the bio-shield at the level of detail required to perform activation evaluations has not been documented.

The neutron flux and energy spectrum must be known to adequately perform neutron activation evaluations. The neutron energy spectrum was determined using Bonner spheres and Monte Carlo N-Particle (MCNP) calculations. The neutron flux was determined empirically with gold foil activation and Bonner sphere measurements. MCNP calculations were used to support the empirical evaluation and refine the model. Each method has limitations and is incomplete by itself; however, together they support the characteristics of the neutron field in the TREAT facility outside the bio-shield.

2 Background

2.1 TREAT

The TREAT facility provides INL with capabilities for testing nuclear reactor fuels under severe accident conditions. Because of the unique design of TREAT, the reactor can undergo massive transients with pulses up to 2900 MJ in a fraction of a second in a safe manner. TREAT is also capable of performing shaped pulses where controls rods are removed in a controlled manner to create custom power histories. These transients expose test specimens to intense fission heating, even to the point of fuel melting. This capability makes TREAT ideal for research and development of next generation nuclear reactor fuels that are accident tolerant.

TREAT is an air-cooled thermal graphite moderated reactor with highly enriched uranium sparsely dispersed within graphite blocks. This simple design provides a very fast-acting highly negative temperature coefficient of reactivity. Surrounding the sides and top of the reactor core are thick slabs of concrete referred to as the bio-shield which provides radiation shielding to the reactor high bay where TREAT is located. Although the bio-shield is effective, there is still a significant amount of radiation that escapes from the shielded area during reactor operations, prompting evacuation of the TREAT facility and remote operation during reactor transients. Even during low power steady state operations, there are measurable gamma and neutron radiation fields outside the bio-shield within the TREAT facility. Steady state operations are at a maximum power of 120 kw.

There are many penetrations in the bio-shield, some are beam paths to provide irradiation capabilities and others are for instrumentation. There is a hodoscope on the north side of the reactor, thermal column on the east side, removable shield block on the south side, and radiography area on the west side. In addition to these irradiation areas, there are 14 irradiation holes on each side of the reactor with the exception of the east side. Most of these irradiation holes are covered with panels but are believed to have shield plugs. The irradiation holes extend through the bio-shield to the graphite reflector and step down in size half-way through. The hole near the edge is eight inches in diameter and near the reflector is six inches in diameter. Elevated radiation levels are found in front of hole 11 which may not have complete shielding. A plan view of TREAT is shown in Figure 1 which shows the side penetrations. There are also penetrations on top of the reactor for reactor ventilation and instrumentation.

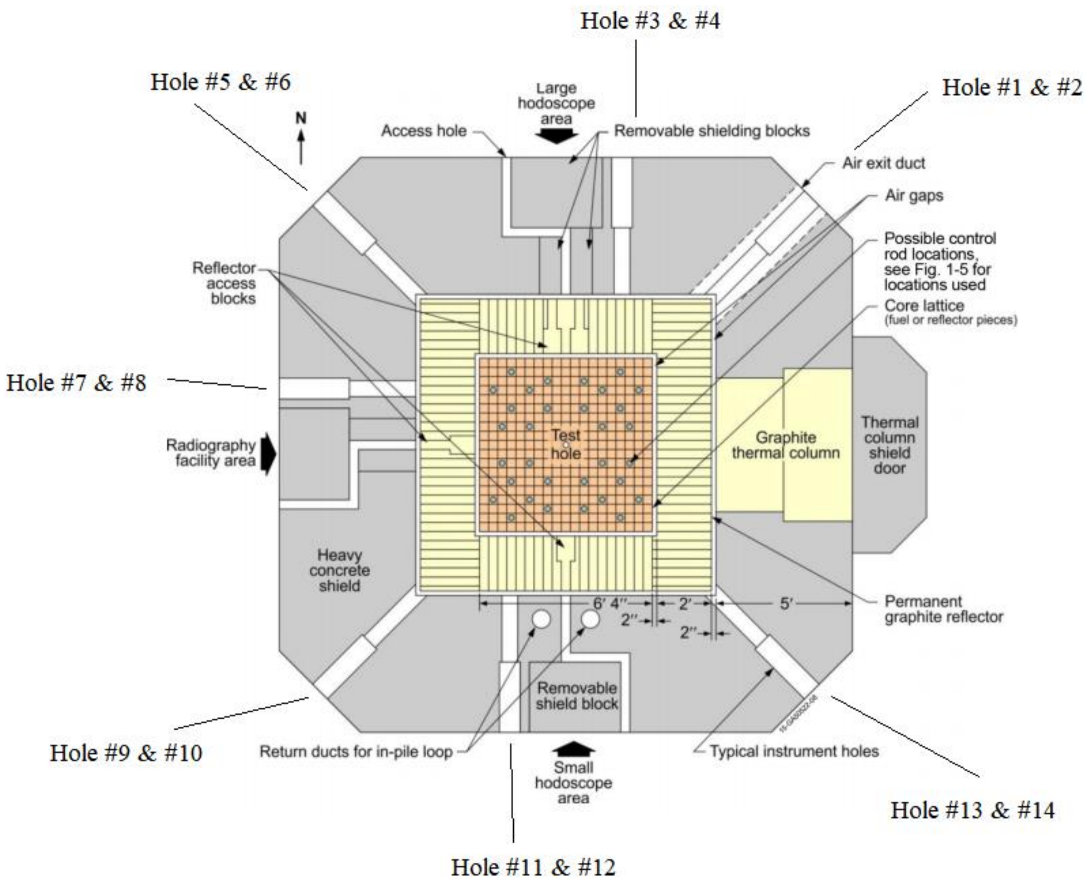

Figure 1. TREAT Plan View.

The work done in INL/EXT-18-45035, "Baseline Radiological Conditions for the Transient Reactor Test (TREAT) Restart,"[2] determined the baseline radiological conditions for the TREAT reactor building and provides the most complete radiological survey of TREAT to date. The surveys identify localized hot spots and general area radiation levels but does not provide any information on the neutron energy spectrum in the TREAT high bay. The localized hot spots found in INL/EXT-18-45035 agree well with the work done is this report. Surveys were performed with the ThermoFisher Scientific NRD 9" Neutron Ball.

2.2 Gold Foil Activation

Neutron activation of thin foils of various materials is a common way of approximating a neutron flux and can be used to estimate a neutron energy spectrum. Using foil activation to unfold a neutron energy spectrum is problematic due to propagation of experimental errors and requires a set of foils that are sensitive to neutron activation at different energies. The work done by McElroy et. al demonstrates a mathematical procedure to unfold neutron foil activation results into a neutron energy spectrum.[3] After a best fit spectrum is found, McElroy et. al. found the integral neutron flux accuracy is 10-30% at any point in the spectrum.

Due to limitations with foil activation compatibility with counting resources, only gold foils were activated in this work. Gold foil activations were performed at various locations in the TREAT high bay with various energy transients ranging from 100 MJ to 2200 MJ. Some foils were placed in cadmium covers to provide thermal to fast neutron ratios (cadmium ratios). The total activity combined with the transient size, foil mass, and thickness were used to calculate a pCi/g-GJ activity, as well as cadmium ratios at various locations.

2.3 Bonner Sphere

A Bonner Sphere is a neutron detection device that can be used to determine neutron energy spectra. A neutron detector sensitive to thermal neutrons is placed inside a various sized spheres of polyethylene. Different sizes of sphere will provide different degrees of moderation for incoming neutrons. The bare detector and small spheres will be sensitive to thermal neutrons and the detector inside large spheres will be sensitive to fast neutrons. The work done by Bramblet et. al. shows that Li^6I scintillators placed in polyethylene moderating spheres of various sizes produces different detector energy efficiencies.[4] These efficiencies can be used to determine the shape of a neutron energy spectrum. This method is used in this report to determine the neutron energy spectrum in the TREAT high bay. The size of spheres used by Bramblet et. al. ranged from two to twelve inches in diameter, similar to the spheres used in this report.

Bonner sphere measurements were taken at the east thermal column 6 inches away from the shield door, 10 feet south of the bio-shield in line with the hole 11 penetration, and 16.25 ft north of the bio-shield. The Bonner spheres are Ludlum model 42-5 consisting of a 12-inch, 10-inch, 8-inch, 5-inch cadmium covered, 3-inch cadmium covered, and 2 inch-high density polyethylene spheres with a 4 mm × 4 mm $^6LiI(Eu)$ crystal detector. A solver determined a 238-group neutron energy spectrum based on the seven Bonner sphere measurements (six spheres plus bare detector). This method is based on fundamental equations used to describe generic neutron energy spectrums. A Maxwell-Boltzmann distribution was used for thermal energies.[5] A Watt fission spectrum was used for fast energies.[6] Finally, a $\frac{1}{E^x}$ spectrum was used between the fast and thermal energies. The $\frac{1}{E^x}$ spectrum requires two parameters that are fractions of the peak thermal and peak fast flux.

Using these three equations, four parameters are required to create a spectrum with an arbitrary number of energy groups and the approximate shape of most simple neutron energy spectrums. A complete description of the solver is presented in Section 3.3. Verification of the solver was done by taking Bonner sphere measurements at Health Physics Instrumentation Laboratory (HPIL) Low Scatter Laboratory (LSL) and comparing with MCNP transport code results. The HPIL LSL is a well characterized neutron environment that can be reproduced in MCNP and has a simple spectrum. The verification is presented in Section 4.3.1. The solver predicted spectrums at the LSL for a bare ^{252}Cf and D_2O moderated ^{252}Cf source matched well with the MCNP generated spectrums.

2.4 MCNP and ORIGEN

MCNP is a general-purpose Monte-Carlo type transport code. MCNP models of TREAT were created to assist characterizing the neutron flux and energy spectrum outside the bio-shield. These calculations have limited utility for two primary reasons. First, the efficient shielding design leads to poor statistics outside the bio-shield. Second, the weak points in the shield design are the penetrations. Therefore, the MCNP model has inaccuracies, as well as high uncertainties. The MCNP models of TREAT provide a third source of neutron flux and energy spectrum information in addition to gold foils and Bonner spheres.

MCNP does fulfill a vital role in the analysis by determining the energy dependent response of the Bonner spheres and for verification of the Bonner sphere calculated neutron fields at the HPIL LSL. The work done by Vega-Carrillo et. al. demonstrates that an accurate Bonner sphere response matrix can be calculated by Monte Carlo method calculations.[7] The Bonner sphere response matrix in this report is calculated using the same method. Response matrices calculated by Vega-Carrillo et. al. were for the bare detector and 2, 3, 5, 8, 10, 12 inch diameter polyethylene spheres with 23 energy groups ranging from 2.5E-8 MeV to 100 MeV. This work uses similar sized spheres but many more energy groups.

Once a representative spectrum for the TREAT facility was determined using gold foil activation, MCNP, and Bonner spheres, the COUPLE and ORIGEN modules of SCALE were used to perform activation and decay calculations for naturally occurring elements.[8,9,10] SCALE is a comprehensive modeling and simulation suite for nuclear safety analysis and design. ORIGEN is an isotopic activation and decay code and COUPLE generates libraries for ORIGEN based on given neutron energy spectrum. Calculations were performed for various durations of activation and decay.

The required decay times, to meet the recommendations for a DOE-STD-6004-2016, "Clearance and Release of Personal Property from Accelerator Facilities"[11] Tier 2 release were calculated and release controls developed. DOE-STD-6004-2016 establishes radioactive material release criteria based on a 3-tiered clearance criteria. Tier 1 criteria is for material with radioactivity indistinguishable from background. Tier 2 criteria is for material with radioactivity less than the screening levels of ANSI N13.12-2013, "Surface and Volume Radioactivity Standards for Clearance."[12] Tier 3 criteria is for material radioactivity above the screening levels.

3 Methodology

3.1 Gold Foil Activation

Gold foils were obtained from the INL physics lab with identification numbers inscribed. The foils are approximately 0.5-inch diameter and 6 mils thick. Each foil was weighed on an Ohaus Pioneer scale (ID# 556227) with an accuracy of ± 0.0009 grams. The average foil mass was 0.4009 grams. Individual foil masses were used for calculations.

Cadmium covers were obtained from Shieldwerx.[13] The covers have a specified purity of 99.95% but for calculations are assumed to be 100% cadmium. The thickness of the covers is specified to be 0.020 inches.

Gold foils were placed throughout the TREAT facility during twelve transients ranging in energy from 100 MJ to 2200 MJ. Locations were chosen to confirm known penetrations had shielding present and for potential boundary locations for material release.

The gold foil activities were measured at the TREAT Reactor Metrology Laboratory in Lab B5 at the INL Research Center (IRC) with two high-purity germanium (HPGe) detectors in lead shielded caves. A typical detector configuration is shown in Figure 2. The HPGe detectors are ORTEC model GMX50-83-ICS-E-A connected to ORTEC model DSPEC 50 digital signal processors. Due to the low activities, foils were counted on contact with the HPGe face. This geometry has an absolute efficiency of 7.053 ± 0.09% for detector 1 and 8.015 ± 0.10% for detector 2. The resulting gamma spectrums from the gold foils were analyzed with the PeakEasy software[14] to determine the 411.80210 keV gamma count rate. This information, combined with the Au-198 half-life of 2.6949 days, 411.80 keV gamma branching ratio of 95.62%, individual gold foil mass, and transient size was used to calculate a pCi/g-GJ for each gold foil irradiated.

Figure 2. HPGe Detector Configuration.

3.2 MCNP Model

The MCNP model used in this analysis is a half-slotted core provided by TREAT Reactor Engineering. The graphite thermal column and some of the concrete bio-shield penetrations were added. Radiological survey results indicate the shielding associated with hole 11 on the south side of the reactor is less effective than other penetrations, therefore, hole 11 was analyzed with the shield plugs removed. The exact shielding configuration in hole 11 is not known, adding uncertainty in the model. A factor of ten higher than other high bay area gold foil activation results, as well as, high Bonner sphere measurements on the east side of the reactor indicated that it was necessary to include the graphite thermal column to the model. The bio-shield is magnetite concrete, which was also updated in the model using magnetite concrete from Reference 15. The MCNP model is shown in Figure 3 and Figure 4. An example open hole 11 MCNP input file is shown in Appendix C – MCNP Inputs.

The top center shield plug was removed to facilitate instrumentation in the core. This condition is not permanent and if the shielding is moved or replaced it will affect the neutron environment outside the bio shield. A bin full of borated poly beads and lead shot has been placed over the penetration to provide both gamma and neutron shielding for personnel access near the top of the reactor. The amount and orientation of this improvised shielding is not documented and is variable and is therefore, estimated in the model. Not included in the model is the TREAT building structure. Given these uncertainties and unknowns, the confidence in the MCNP generated neutron fields outside of the bio-shield is low. The MCNP results do give an estimate of the neutron energy spectrum and are useful for comparing with the Bonner sphere generated spectrum but differences are expected.

A fixed source for the TREAT reactor core was generated by voxelization of the fuel region and tallying the fission density in each voxel. This fission density was then translated into an MCNP fixed source. The ADVANTG code was used to generate weight windows to bias the problem in space and energy to the specified tally regions.[16] Without the use of some variance reduction technique, generating a spectrum outside of the bio-shield with reasonable statistics would take a prohibitively long time. F4 track-length flux tallies with the SCALE 238-group energy distribution were calculated at various locations with this technique.

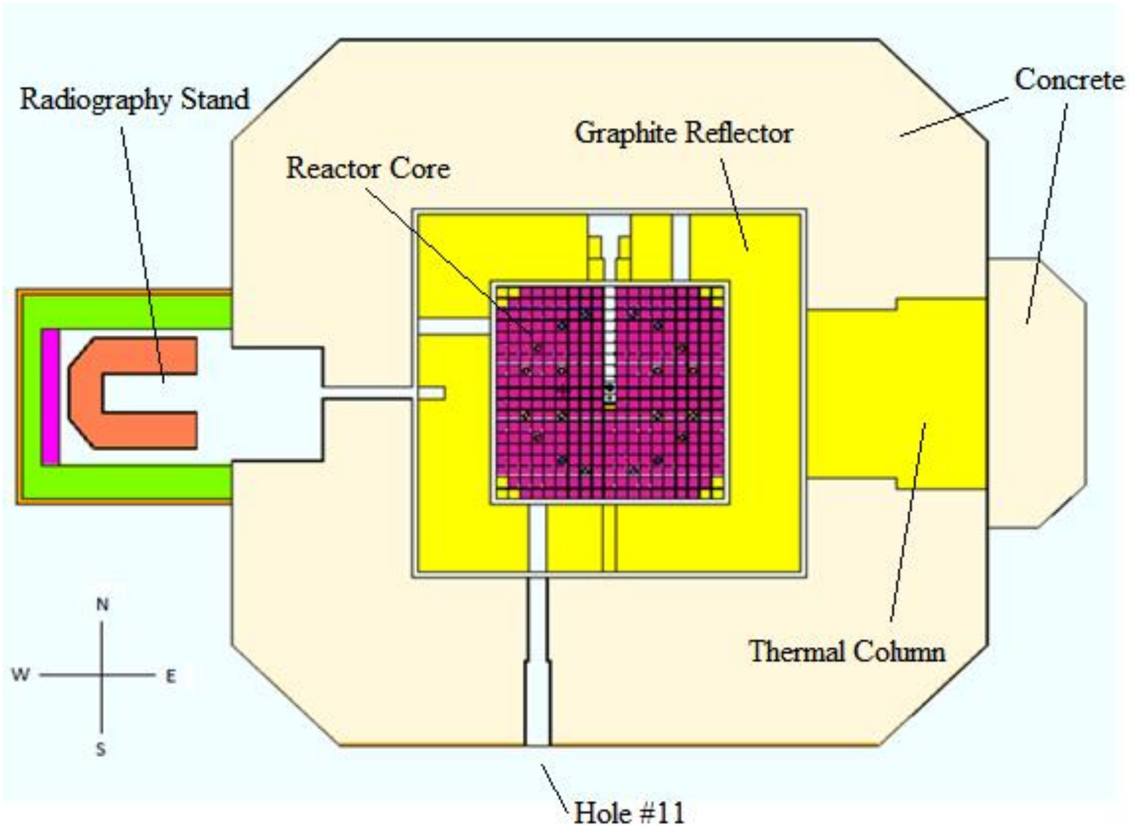

Figure 3. MCNP Model of TREAT Reactor Plan View.

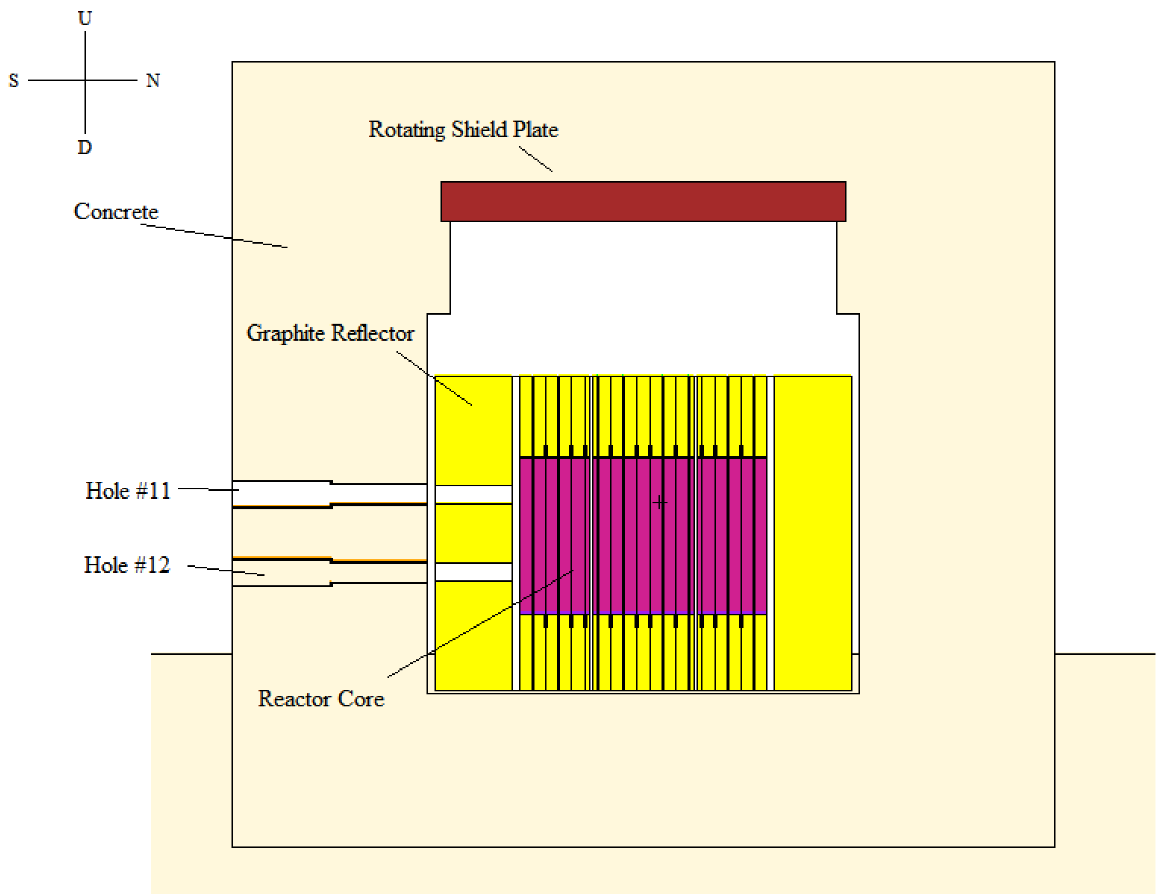

Figure 4. MCNP Model of TREAT Reactor Elevation View.

3.3 Bonner Spheres Solver Derivation

Bonner sphere measurements are used as a method to approximate total flux and spectrum shape. The Bonner spheres used were obtained from HPIL and is the Ludlum 42-5-4 model. The difference between the 42-5-4 and the 42-5 model is that the 3” and 5” spheres are lined with a thin 0.032-inch cadmium sheet. The Bonner spheres consist of a 4 mm × 4 mm ^{6}LiI(Eu) crystal scintillator detector and is used either bare or inside a 2”, 3”, 5”, 8”, 10”, or 12” high density polyethylene sphere for a total of seven detector configurations per location. Measurements were taken at the HPIL facility for verification, as well as various location within the TREAT high bay main floor.

To unfold the neutron energy spectrum from the Bonner sphere measurements, the 238-group energy dependent response is calculated for each ball using MCNP. An example of the 12” Bonner sphere MCNP input file is shown in Appendix C – MCNP Inputs. A solver was built in Excel based on the Bonner spheres response and fundamental neutron physics equations which were checked by hand calculations. The solver uses four parameters to build a neutron energy spectrum and then folds this spectrum through the response matrix for each detector configuration to calculate detector responses. The calculated response is compared with the measured response. The four parameters are adjusted using a steepest decent method until the calculated response and measured response converge.[17]

The neutron energy spectrum is created by combining the thermal, epithermal, and fast components, which are calculated from equations. The thermal flux is calculated by:[5]

$$\Phi_T(E) = C_T \frac{E}{(kT_n)^2} \exp\left(-\frac{E}{kT_n}\right)$$

Where: $\Phi_T(E)$ = thermal neutron flux as a function of energy

C_T = thermal flux scaling factor

E = energy

k = Boltzmann constant

T_n =effective neutron temperature

Absorption in a system can shift the thermal equilibrium neutron energy spectrum to higher or lower energies. To account for this shift, the effective neutron temperature is used instead of the room or moderator temperature. The effective neutron temperature is calculated by determining the peak thermal neutron flux energy and converting to temperature. The thermal flux scaling factor is adjusted by the solver and changes the overall magnitude of the thermal flux.

The fast flux is calculated using the Watt fission spectrum by:[6]

$$\Phi_F(E) = C_F \exp\left(-\frac{E}{a}\right) \sinh\left(\sqrt{bE}\right)$$

Where: $\Phi_F(E)$ = fast neutron flux as a function of energy

C_F = fast flux scaling factor

E = energy

a b =Watt fission spectrum constants

The Watt fission spectrum constants a and b are specific to fissionable isotopes and are commonly available.[6] Values for a and b are 0.988 and 2.249 respectively for TREAT calculations and 1.180 and 1.03419 respectively for HPIL LSL calculations. The fast flux scaling factor is adjusted by the solver and changes the overall magnitude of the fast flux.

The epithermal flux assumes a 1/E spectrum between the thermal and fast flux. This is calculated using a logarithmic transformation of the slope intercept equation of a line between two points. The two points are a fraction (C_{EF} and C_{ET}) of the peak thermal flux and a fraction of the peak fast flux. These values are adjusted by the solver and change the slope and magnitude of the epithermal flux. When the fast or thermal flux is higher than the epithermal flux, the overlapping spectral elements are blended to avoid any discontinuities. The epithermal flux is calculated by:

$$\Phi_E(E) = bE^m$$

Where: $\Phi_E(E)$ = epithermal neutron flux as a function of energy

E = energy

b = Φ_{PF}/E_{PF}^m or Φ_{PT}/E_{PT}^m

Φ_{XX} = flux at peak fast or peak thermal flux

E_{XX} = energy at peak fast or peak thermal flux

m = slope in log-log space, $\ln(C_{EF}\Phi_{PF}/C_{ET}\Phi_{PT})/\ln(E_{PF}/E_{PT})$

C_{EF}, C_{ET} = 1/E end point scaling factors

These three spectrum components are added together to make a single spectrum and then folded through the detector response matrix. An example of how these three spectrum components add together to make a complete simple spectrum is shown in Figure 5. Spectrum folding through the detector response matrix is calculated by:

$$R = \sum_{i=1}^{238} \varphi_i M_i$$

Where: R = detector response

φ_i = neutron flux in the ith energy group

M_i = response matrix in the ith energy group

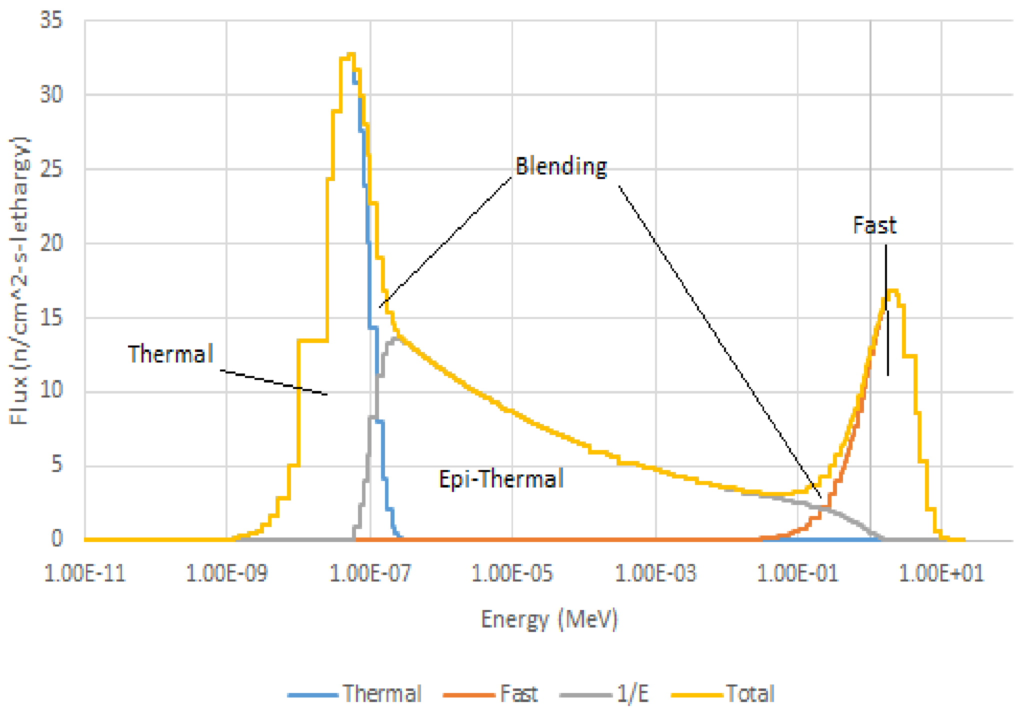

Figure 5. Bonner Sphere Neutron Energy Spectrum Components.

Detailed models of the detector were built in MCNP and detector response to 238 neutron energies were calculated. An F4 track-length flux tally over the ^{6}LiI(Eu) crystal was used with an FM tally multiplier of atom density of ^{6}LiI(Eu) times (n,t) reaction of ^{6}LiI(Eu). This resulted in 1,666 calculations to obtain the response matrix for each detector configuration. Each calculation was run until a <1% uncertainty was met or 1E9 particles were run with the vast majority reaching the 1% uncertainty criteria. The MCNP model of the 2” detector is shown in Figure 6 and the MCNP generated detector responses are shown in Figure 7. This was also done for a model of the gold foils and cadmium covered gold foils that were activated. This allows the solver to predict activation and cadmium ratios to compare with the gold foil data.

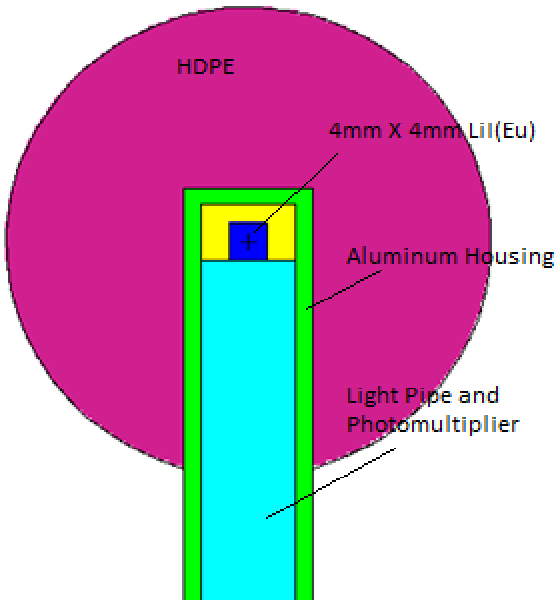

Figure 6. MCNP Model of 2” Bonner Sphere and Detector.

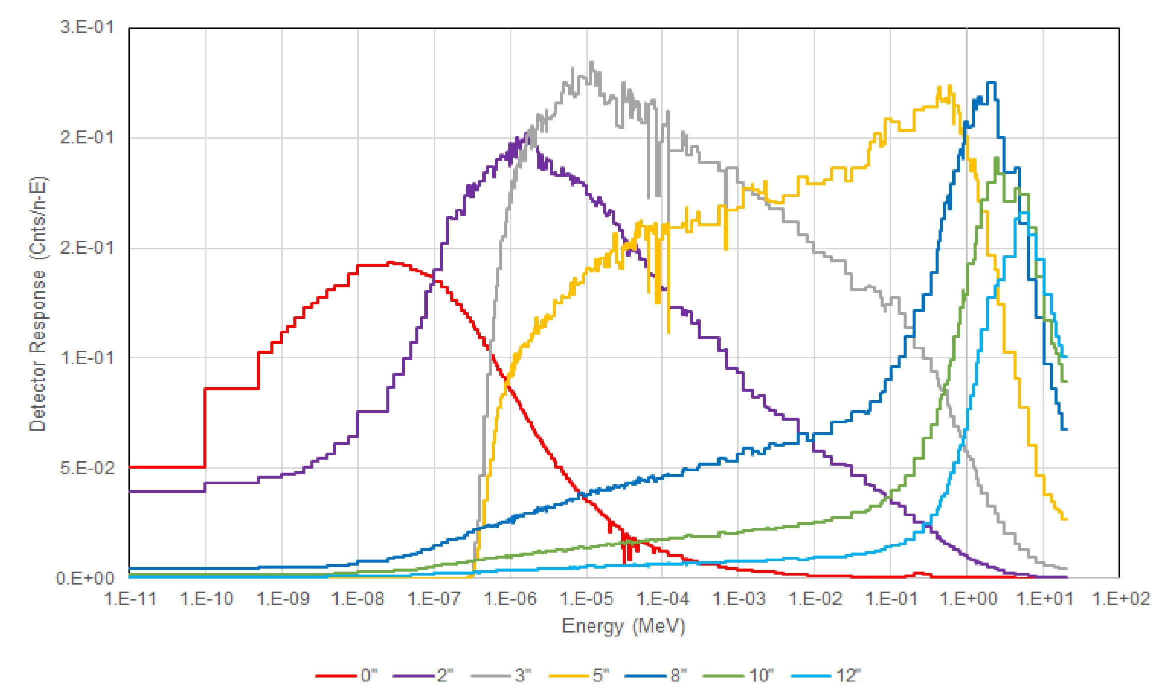

Figure 7. Bonner Sphere Response.

The solver adjusts the variables C_T, C_F, C_{EF}, and C_{ET} using a steepest decent method to minimize the figure of merit.[17] The figure of merit (FOM) is the Chi-squared value for the calculated and measured responses. Chi-squared is calculated by:[18]

$$\chi^2 = \sum \frac{(y_i - y(x_i))^2}{\sigma_i^2}$$

Where: χ^2 = chi-squared

y_i = measured response of configuration i

$y(x_i)$ = calculated response of configuration i

σ_i^2 = variance of the measured response of configuration i

The minimum variance is set to 10% when performing Chi-squared calculations. This minimum variance is set to account for experimental variations not controlled, such as personnel walking by detectors and increasing reflection. The results from the solver is a 238-group neutron energy spectrum approximation. The solver flowchart is shown in Figure 8.

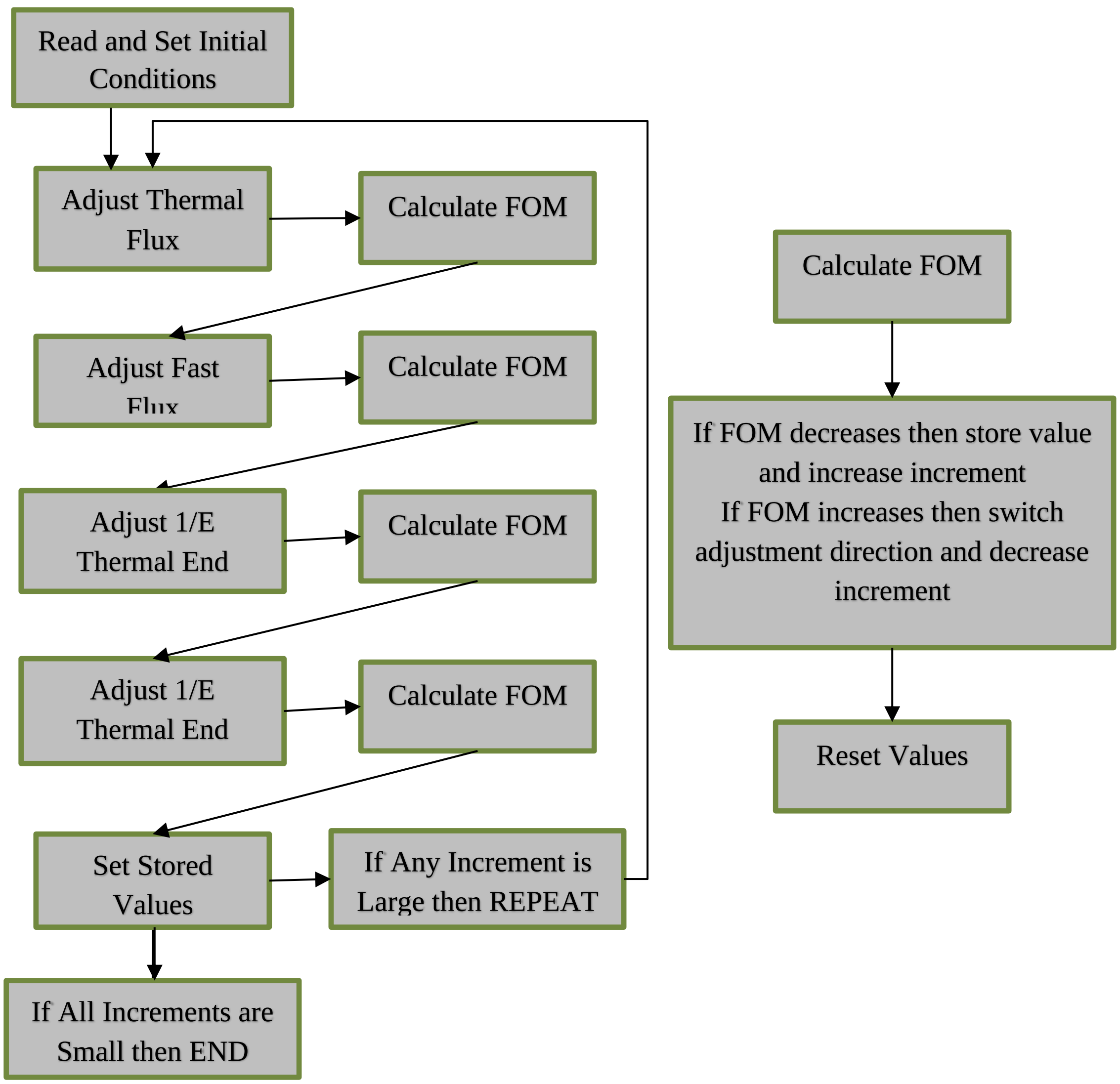

Figure 8. Solver Flowchart.

Confidence intervals of the spectrum are calculated by using reduced Chi-squared which divides the Chi-squared result by the number of degrees of freedom. There are seven samples and four constraints resulting is three degrees of freedom for this application. The reduced Chi-squared value corresponding to 95% confidence is 2.605.[18] The solver increases and decreases each parameter while maintaining a reduced Chi-squared value of 2.605 and saves these spectra. The 95% confidence interval is then the maximum and minimum of these saved spectra for each energy group. The 95% confidence interval is also reported for the total flux.

3.4 ORIGEN Activation and Decay

The spectrum generated from the Bonner spheres was used with COUPLE and ORIGEN from the SCALE 6.2.2 software package.[19] COUPLE takes the 238-group neutron energy spectrum generated from the Bonner spheres and folds it through the JEFF-3.0/A neutron activation file containing data for 774 target nuclides and more than 12,000 neutron-induced reactions.[19] The result is a one group cross section ORIGEN library used for the ORIGEN activation and decay calculation. The total fluence for a 2.90 GJ transient (approximated from the Bonner spheres and the gold foil data) is used over a one second activation time in the ORIGEN input and one gram of every naturally occurring element from z=1-83 to calculate activities after various time periods of decay. This results in 83 separate calculations, one for each element. Activities are also calculated for one week, one month, and one year of activation, as well as 35 years with 24 years of decay to address potential activity of legacy material. It is assumed that three 2.90 GJ per week are performed for these calculations. An example ORIGEN input file for a one week activation of hydrogen is shown in Appendix D - ORIGEN Inputs. These results are then compared with the radiological release limits and suggested controls are developed.

The neutron flux/spectrum predicted by the Bonner spheres are in “free air,” meaning it is the flux/spectrum striking the surface of the Bonner spheres. The COUPLE/ORIGEN calculation treat this “free air” spectrum as though it is the average spectrum within the material being activated. This is a very conservative approximation because the attenuation or self-shielding of neutrons as they pass through materials with large absorption cross-sections leads to substantially less activation in a "real world" setting (except for very thin materials).

4 Calculations and Results

4.1 Gold Foil Activation Results

Gold foils were activated at various locations in the TREAT high bay to assist in determining the total flux at these locations. These foils were exposed to twelve transients of multiple sizes; therefore, the foil activity is normalized to pCi/g-GJ. This allows the foil data to represent a transient of any size. The minimum detectable level (MDL) for the detector configuration was 0.04 Bq (1.08 pCi). This value was used along with foil mass and transient size for foils with no reported counts to produce maximum activity reported with less than (<) values. Radiological surveys show higher neutron dose rates during steady state operations near hole 11 on the south side of the reactor, the escape hatch on the north east corner of the reactor, and the east thermal column. Foils were placed in these locations, as well as each bio-shield penetration to ensure shield plugs are installed. Foils were positioned such that the foil face were perpendicular to the direction to the center of the reactor. Three foils were found misaligned after activation and these locations were remeasured.

The data is presented graphically in Figure 9 through Figure 13 to show positions of the foils. The goal of this exercise was to determine areas of low activation to justify radiological free release of potentially activated material. Because of the very low activation in these areas, there is higher uncertainty in the results. The average uncertainty for the entire gold foil data set is ± 19% based on count rate. Hole 11 was measured multiple times with multiple sized transients to determine uncertainty in the transient size. The hole

11 results are shown in Table 1. The 99 and 274 MJ transients were not big enough to produce statistics at hole 11 consistent with the rest of the data set as shown in Table 1. These two transients were used to activate foils in higher flux areas on top of the bio-shield and in the sub-pile room. Disregarding the 99 and 274 MJ transients, the hole 11 standard deviation is about 12.5% which is less than the uncertainty based on counting statistics. This uncertainty is discounted in further analysis.

Table 1. Hole 11 Results.

Transient Size (MJ)	Hole 11 (pCi/g-GJ)	Error (pCi/g-GJ))	Error (%)
99	56.71	23.55	41.5%
274	36.77	14.64	39.8%
561	29.30	5.44	18.6%
600	28.16	4.35	15.4%
865	22.87	3.81	16.7%
1025	32.40	4.58	14.1%
1147	26.44	2.87	10.8%
1338	33.62	2.83	8.4%
2174	29.12	1.61	5.5%

The activity per gram per GJ is presented in Figure 9 through Figure 13 for the south first floor, north first floor, second floor, third floor, and sub-pile room. The maximum activity is shown in the figures for locations that were measured multiple times. The bold numbers along the edge of the figures represent the distance in feet from the edge of the reactor bio-shield to the foil location, except for the area within the bio-shield and the sub-pile room which shows distance from reactor center-line. The results are color coded with green representing <MDL, yellow is 10 pCi/g-GJ, and red is 20 pCi/g-GJ or higher with color gradients between.

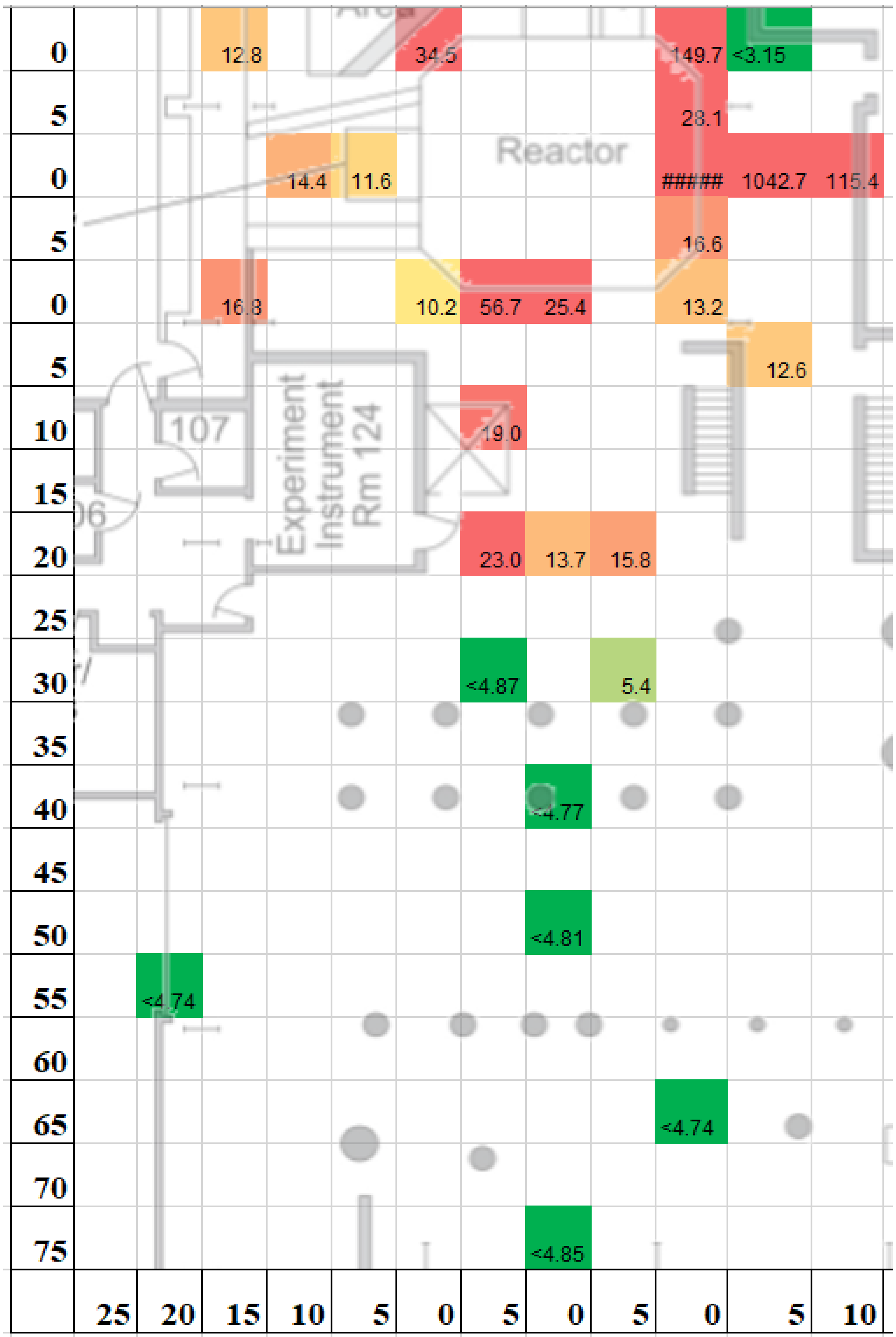

Figure 9. South 1st Floor Gold Foil Activation Results (pCi/g-GJ).

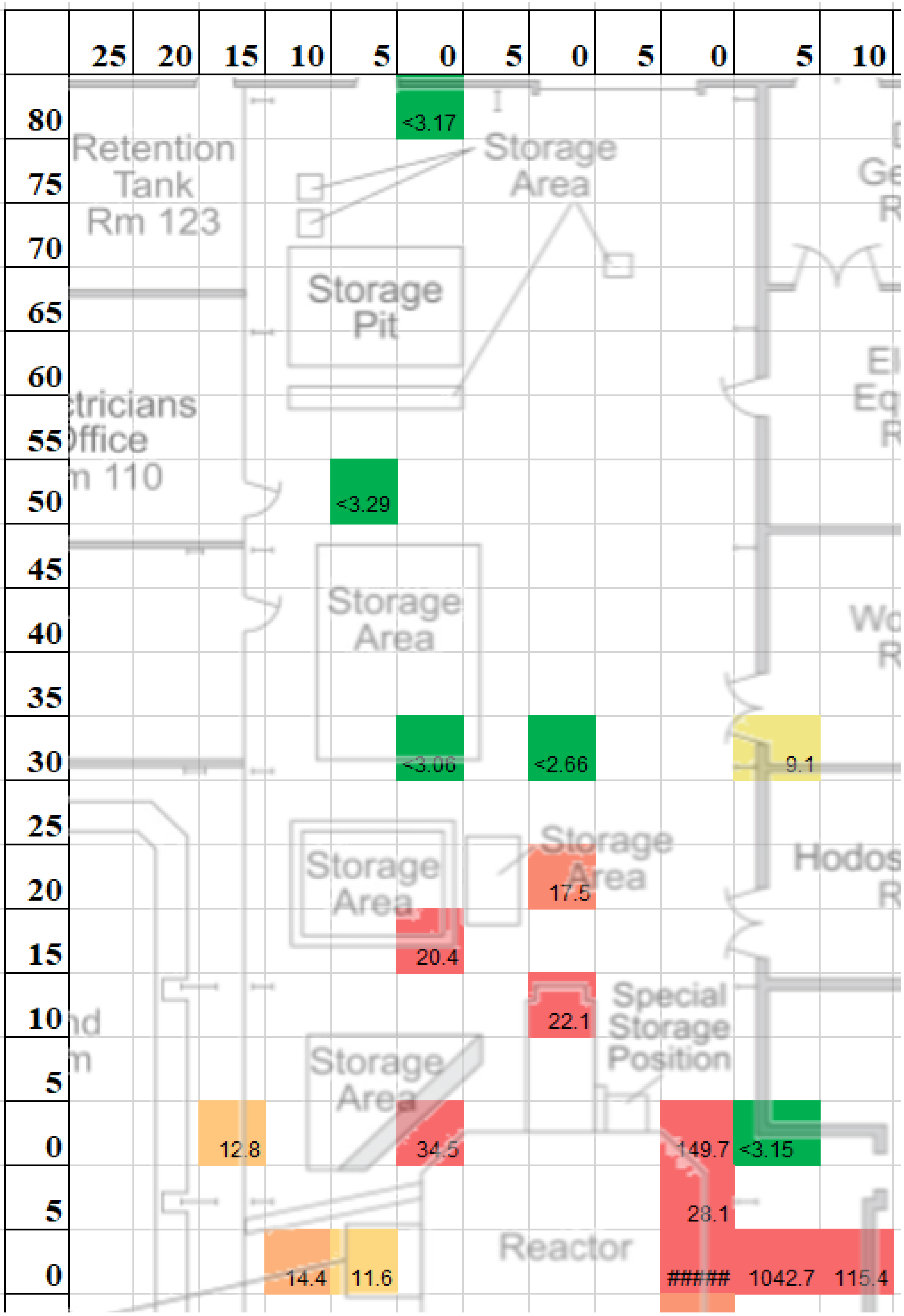

Figure 10. North 1st Floor Gold Foil Activation Results (pCi/g-GJ).

Figure 11. 2nd Floor Gold Foil Activation Results (pCi/g-GJ).

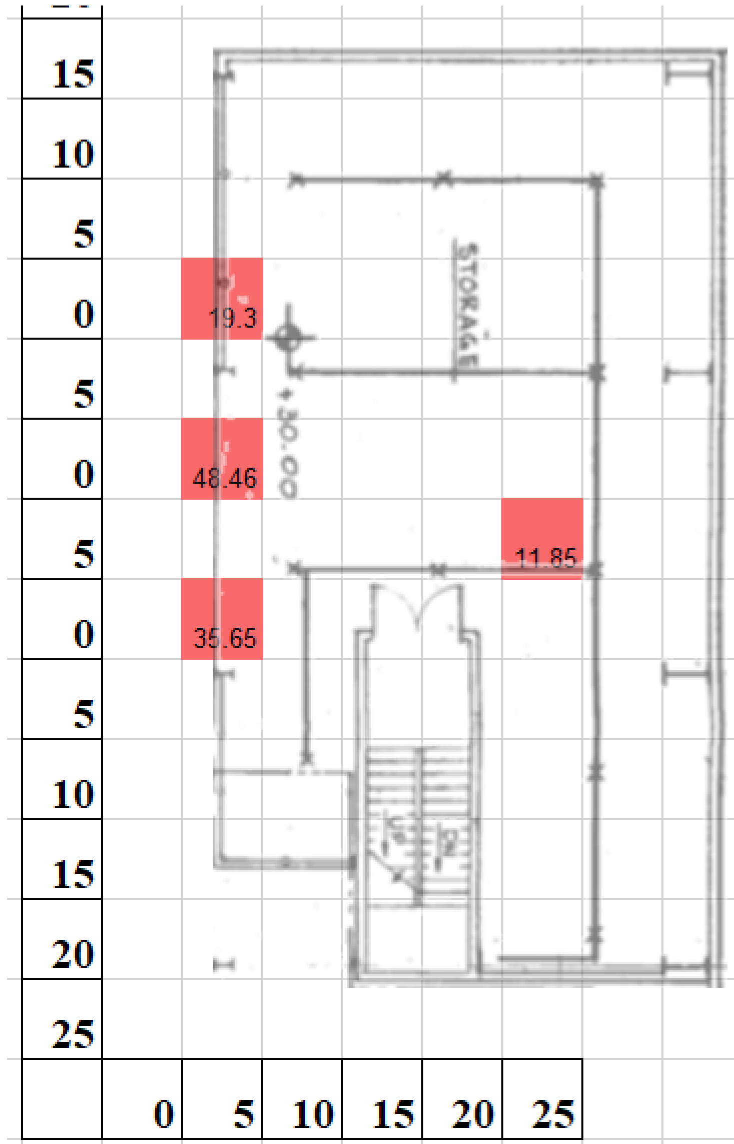

Figure 12. 3rd Floor Gold Foil Activation Results (pCi/g-GJ).

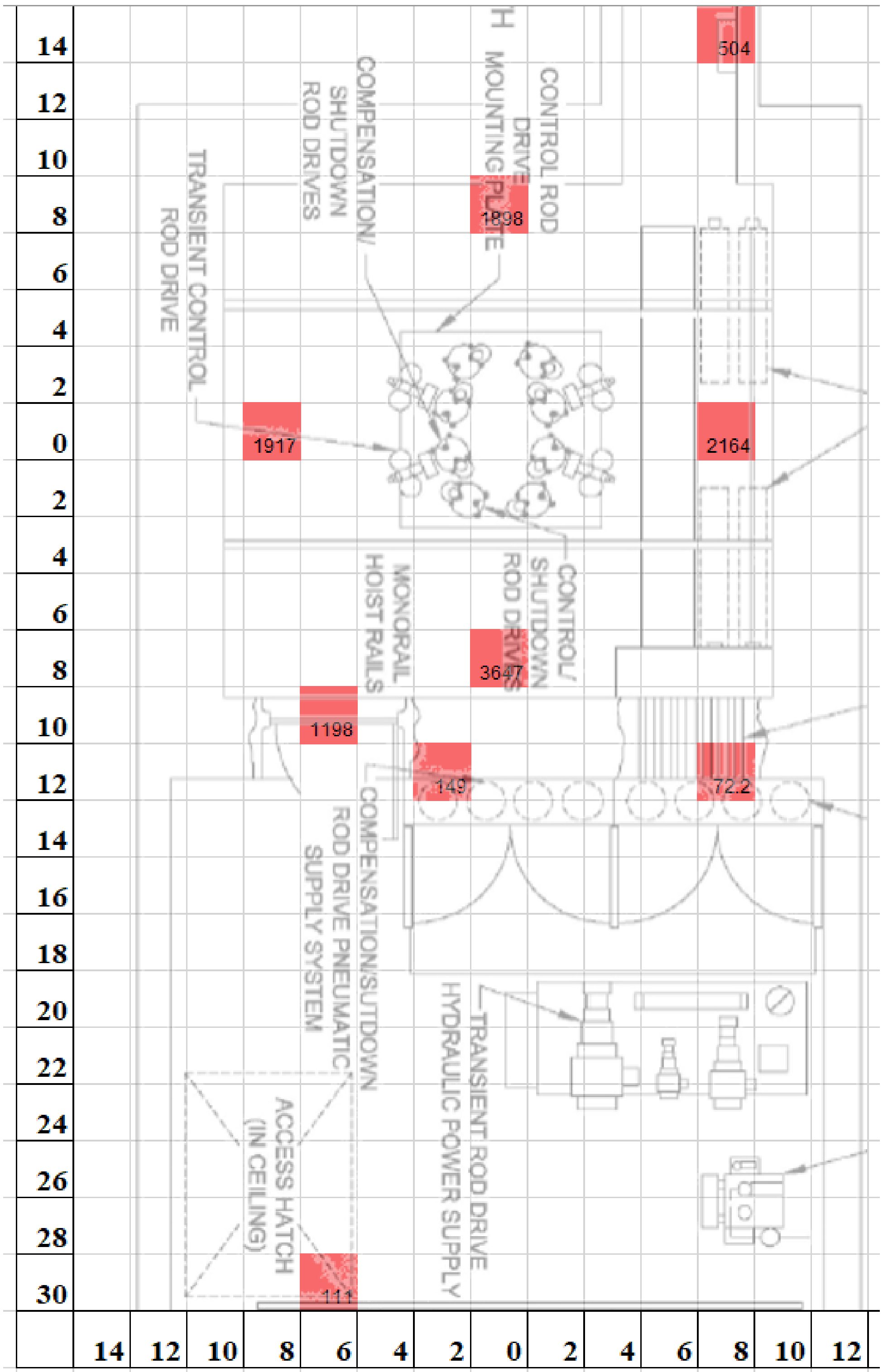

Figure 13. Sub-Pile Room Gold Foil Activation Results (pCi/g-GJ).

The gold foil results suggest a distance of at least 40 ft from the edge of the bio-shield on the first floor is needed to have activation of less than 1 pCi/g for a single transient. Areas on the second floor, third floor, and sub-pile room all have neutron activation greater than 10 pCi/g. Any radiological free release closer than 40 ft on the first floor or any other floor depends on decay and will need further analysis. These conclusions are only valid for gold activation based on neutron energy spectrum and activation cross-sections for a single transient.

To determine activation of other materials of interest, the neutron energy spectrum must be known. An example of the effects that the spectrum can have on activation is the difference between results for activation between the south hole 11 and the thermal column. Radiological surveys indicate higher neutron dose rate near hole 11 (20 mrem/hr)[2] than at the east thermal column (2 mrem/hr)[2], however, gold foil activation is two orders of magnitude higher at the east thermal column (2953 pCi/g-GJ) than at hole 11 (56.7 pCi/g-GJ). This effect is caused by the difference the neutron energy spectrum can have on activation, as well as radiological survey meter sensitivity.

Gold foils were placed in cadmium covers to approximate the shape of the neuron spectrum. Cadmium has a high thermal capture cross section and gold has a capture resonance just above thermal energies at about 5E-6 MeV. Activation results similar for bare and cadmium covered foils suggest neutron energies high enough that the cadmium capture cross section has little effect. Higher ratios suggest the majority of neutrons are in the thermal range. These ratios provide qualitative evidence of the neutron energy spectrum, but a detailed spectrum cannot be determined with these results. The gold and cadmium capture cross sections are shown in Figure 14. The bare and cadmium covered gold foil activation results are shown in Table 2. With the exception of the thermal column, the average bare foil to cadmium covered foil ratio is 2.4 with small variations. This suggests that these areas all have similar spectra. The thermal column has a much higher ratio at 134.4 - 182.5, suggesting a much higher relative thermal flux. This is an expected result because the graphite thermal column is effective at thermalizing neutrons but not completely stopping neutrons, allowing a higher percentage of thermal neutrons outside of the reactor bio-shield. Once the spectrum has been approximated by other methods, the gold foil data is used to validate the spectrum, as well as determine the total flux at a wider range of locations.

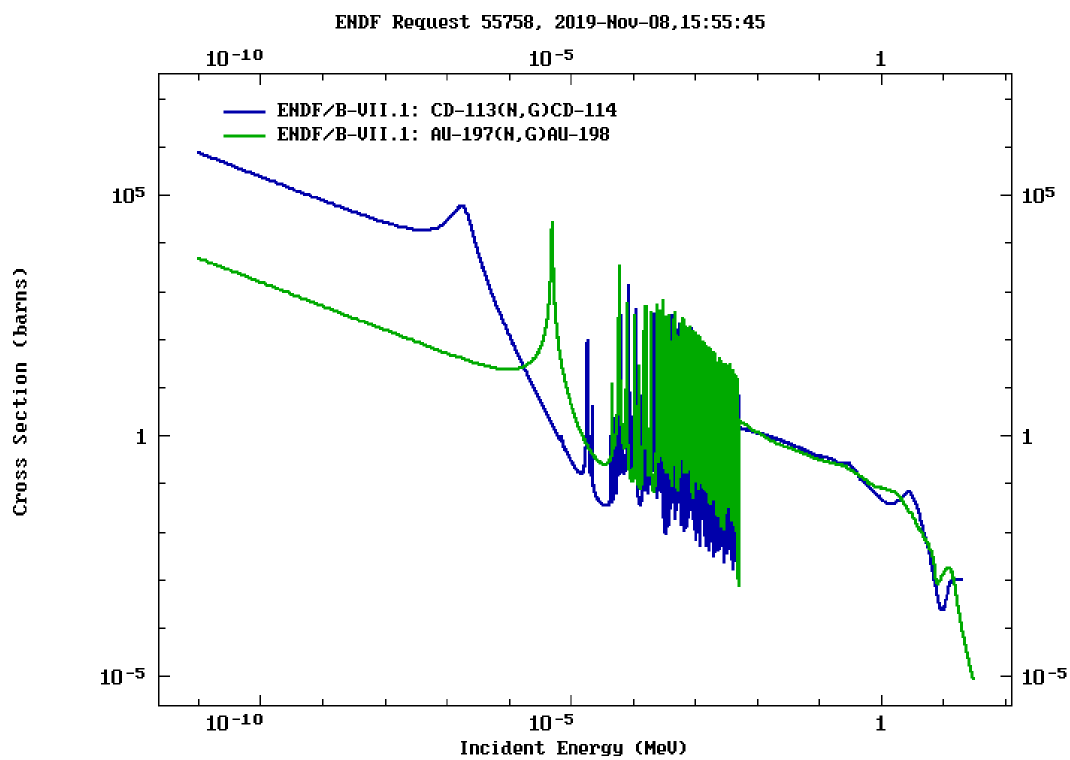

Figure 14. Gold and Cadmium Capture Cross Section.[20]

Table 2. Cadmium Covered Gold Foil Activation Results.

Location	Bare (pCi/g-GJ)	Cd Covered (pCi/g-GJ)	Ratio
East Thermal Column	2.49E+03	1.36E+01	1.82E+02
East Thermal Column 6"	1.04E+03	7.76E+00	1.34E+02
1st Floor Escape Hatch	5.04E+02	2.52E+02	2.00E+00
Radiography Port	1.44E+01	8.91E+00	1.62E+00
S Hole 11	3.36E+01	1.57E+01	2.15E+00
NW Hole 5	3.08E+00	1.66E+00	1.86E+00
N 20ft Centered	1.75E+01	5.64E+00	3.11E+00
N 195" Corner 1	2.04E+01	1.40E+01	1.45E+00
S 10ft Centered	1.51E+01	6.69E+00	2.26E+00
S 10ft Hole 11	1.90E+01	5.82E+00	3.27E+00
S 20ft Centered	1.04E+01	2.41E+00	4.30E+00
2nd Floor S End	2.56E+01	9.74E+00	2.62E+00
2nd Floor 12ft S of Center	4.20E+01	1.35E+01	3.10E+00
3rd Floor 10ft S	3.57E+01	1.76E+01	2.02E+00
Sub-Pile E Wall	2.16E+03	1.04E+03	2.09E+00
Sub-Pile S Wall	3.65E+03	1.96E+03	1.86E+00
Sub-Pile N Wall	1.90E+03	8.21E+02	2.31E+00
Sub-Pile W Wall	1.92E+03	1.03E+03	1.86E+00

4.2 MCNP Spectrum Calculation Results

MCNP was used to calculate the neutron energy spectrum at the TREAT east thermal column, 10 ft in front of hole 11, and at the HPIL Low Scatter Laboratory with a bare and moderated Cf-252 source. The TREAT reactor model was obtained from TREAT reactor engineering and modified as described in Section 3.2. The SCALE 238-group was used for the tally over a 2-foot cube at both TREAT locations. The MCNP model is shown in Figure 15 and Figure 16. ADVANTG was used to create weight windows as a variance reduction technique but the spectrum statistics are still relatively poor. The shielding in hole 11 is not well known. Radiological surveys show higher flux in front of hole 11 than any of the 14 holes suggesting that something is different in hole 11. Because of this, hole 11 is modeled with the shield plugs removed. This shield plug has probably been replaced with one that has a penetration with direct line of sight filled with cables. The other unknown with the hole 11 location is the significant amount of sky-shine coming from the top of the core. To run instrumentation cables into the core, shield plugs have been removed directly above the centerline of the core. To compensate for the lack of shielding, a bin full of poly and lead beads has been placed over the hole. This is approximated in the model but adds uncertainty.

The hole 11 spectrum is difficult to model and calculate in MCNP but is important because it is representative of the spectrum at distances farther away from the bio-shield which will be free released. An F4 track length flux tally over a two-foot cubic volume placed ten feet from the bio-shield in front of hole 11 was calculated with hole 11 open and closed. The calculation was run for the closed case for six days with 16 threads in parallel with a total flux uncertainty of 2.0%. The open case was run for 13 days with 16 threads in parallel with a total flux uncertainty of 16.1% uncertainty demonstrating the difficulty of this calculation. Figure 17 shows the spectrum calculated by MCNP with hole 11 open and closed as well as the Bonner Sphere calculated spectrum presented in the next section. The figure shows the configuration of Hole 11 can have many orders of magnitude effect of the total flux but also the Bonner Sphere calculated spectrum falls between these two extremes.

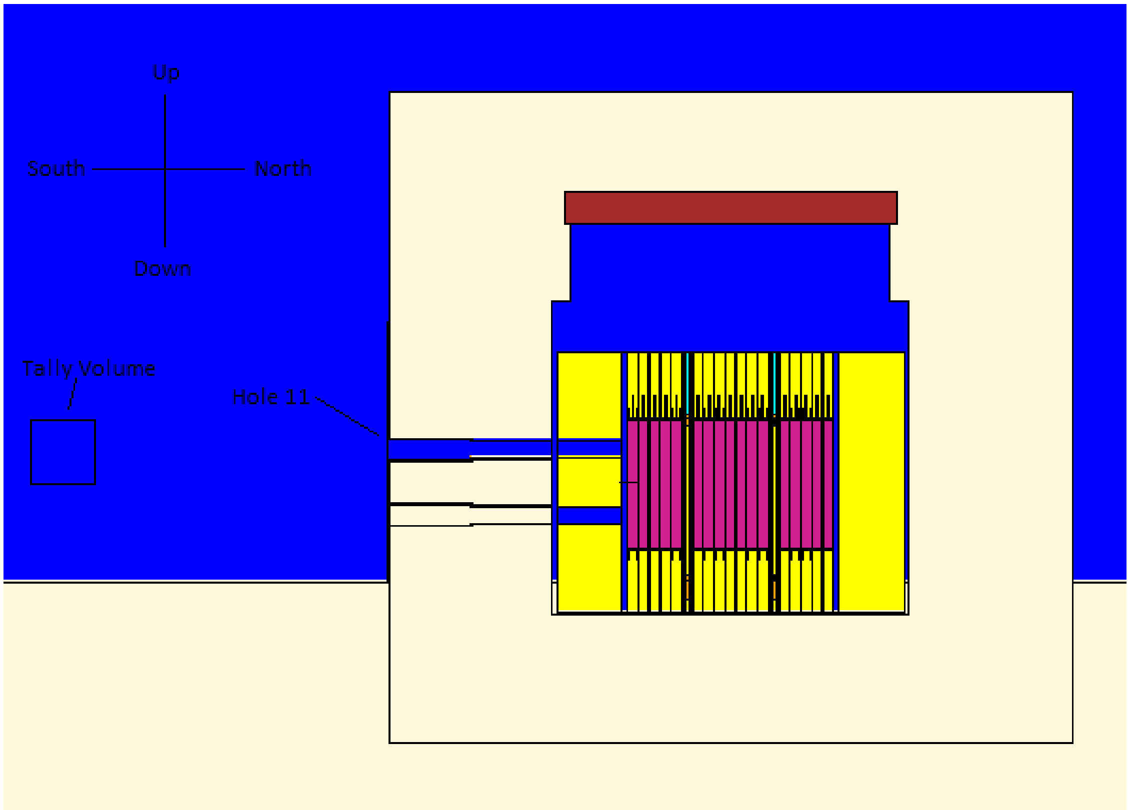

Figure 15. Hole 11 MCNP Model.

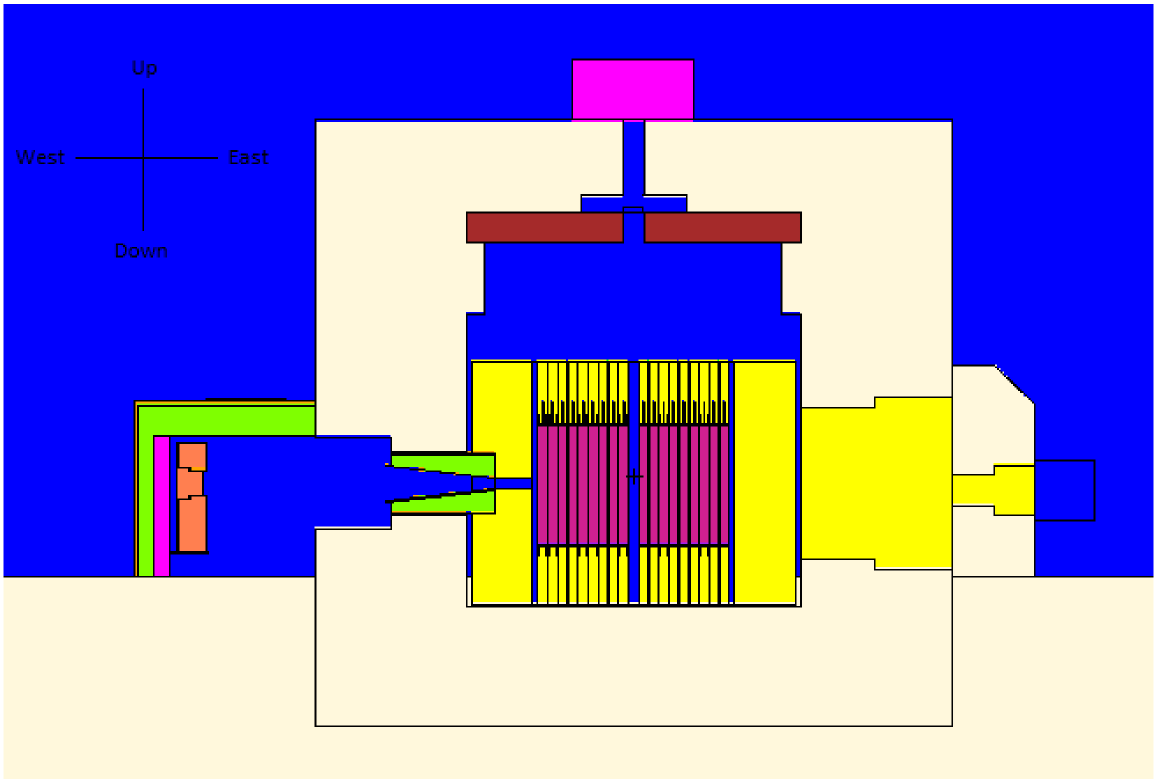

Figure 16. East Thermal Column MCNP Model.

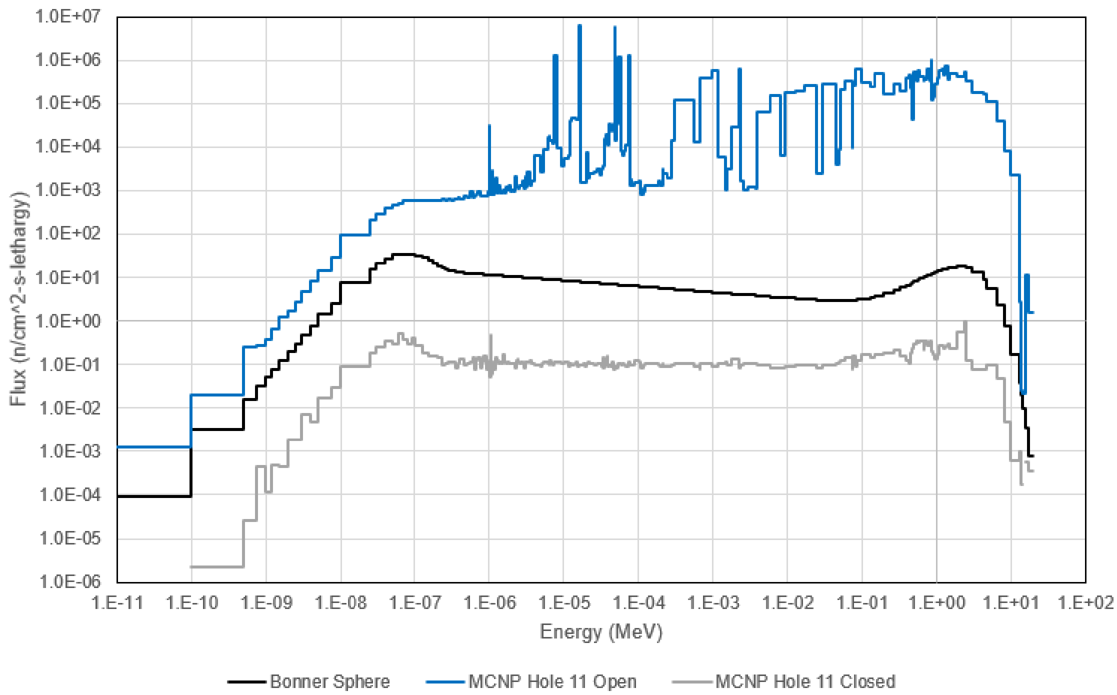

Figure 17. Bonner Sphere and MCNP Comparison of Hole 11 Spectrum.

The HPIL LSL was modeled in MCNP because Bonner sphere measurements were taken for verification and those results are compared to the MCNP results. HPIL is a controlled environment that is simple to model which means the MCNP generated spectrum should be close to reality. HPIL has a 12.72-inch inner diameter sphere filled with heavy water (D_2O) and a thin 0.02-inch cadmium shell which can be placed over the Cf-252 source. The D_2O sphere is shown in Figure 18.

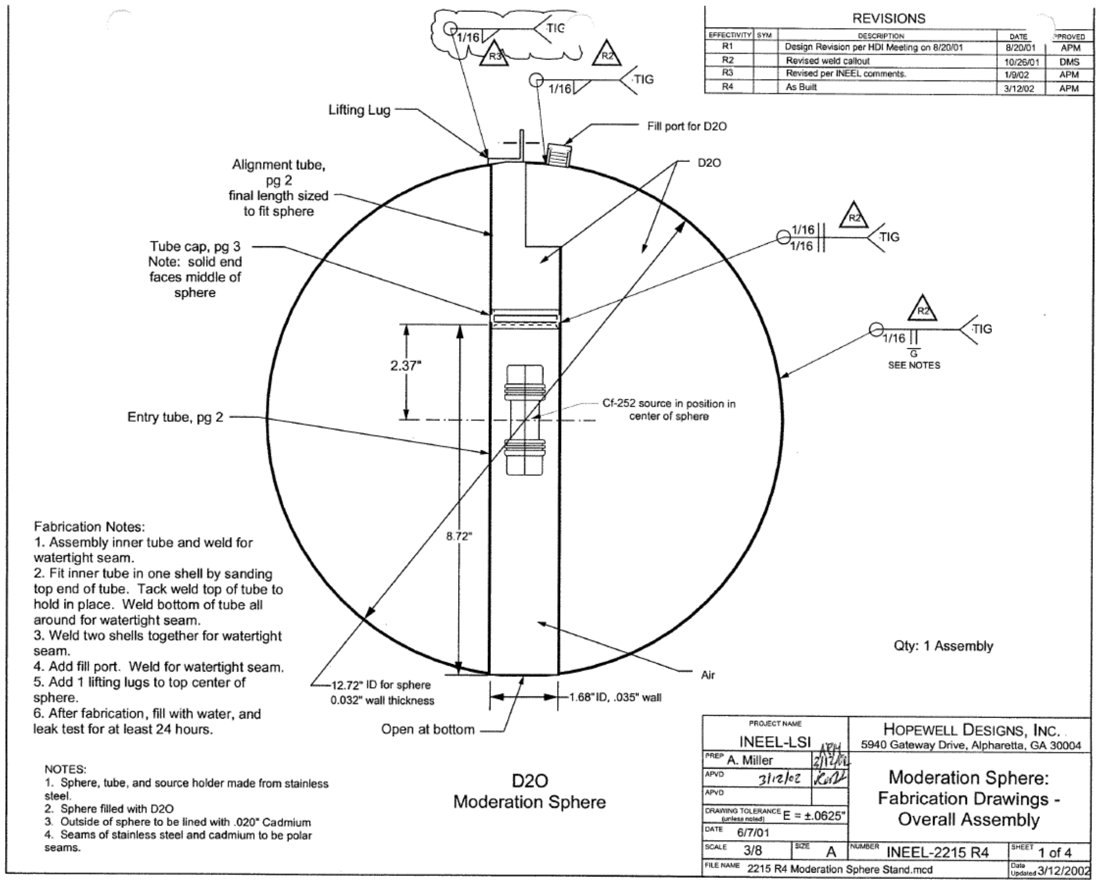

Figure 18. HPIL D_2O Moderation Sphere.

4.3 Bonner Sphere Measurement Spectrum Results

4.3.1 HPIL Bonner Sphere Verification

Bonner sphere measurements were taken at the HPIL Low Scatter Laboratory to validate that the Bonner sphere solver can generate an adequate representation of the neutron energy spectrum. A Cf-252 source (S# SR-Cf-3021OR) was used with the detector 107.8 cm away. The source had a neutron emission rate of 4.456E7 n/s on 8/25/2015. The measurements were taken on 9/19/2019 resulting in a neutron emission rate of 1.535E7 n/s during the measurements. The predicted Bonner sphere solver spectrum is compared with the spectrum calculated from MCNP and is shown in Figure 19 and Figure 20. The dashed lines are the upper and lower 95% confidence interval of the Bonner sphere results calculated by reduced chi squared. The solver predicted Bonner sphere response and the measured response are compared in Table 3 and Table 4.

To calculate the 95% confidence intervals, the solver is run again but with a modified FOM. Instead of the FOM increasing as chi-squared is reduced, the FOM increases as the chi-squared value approaches the chi value corresponding to a 95% confidence combined with the goal of maximizing or minimizing one of the four parameters. The solver converges on a solution eight times and saves each of the eight spectra. The upper and lower 95% confidence interval lines are then the maximum or minimum of each point in the eight spectra.

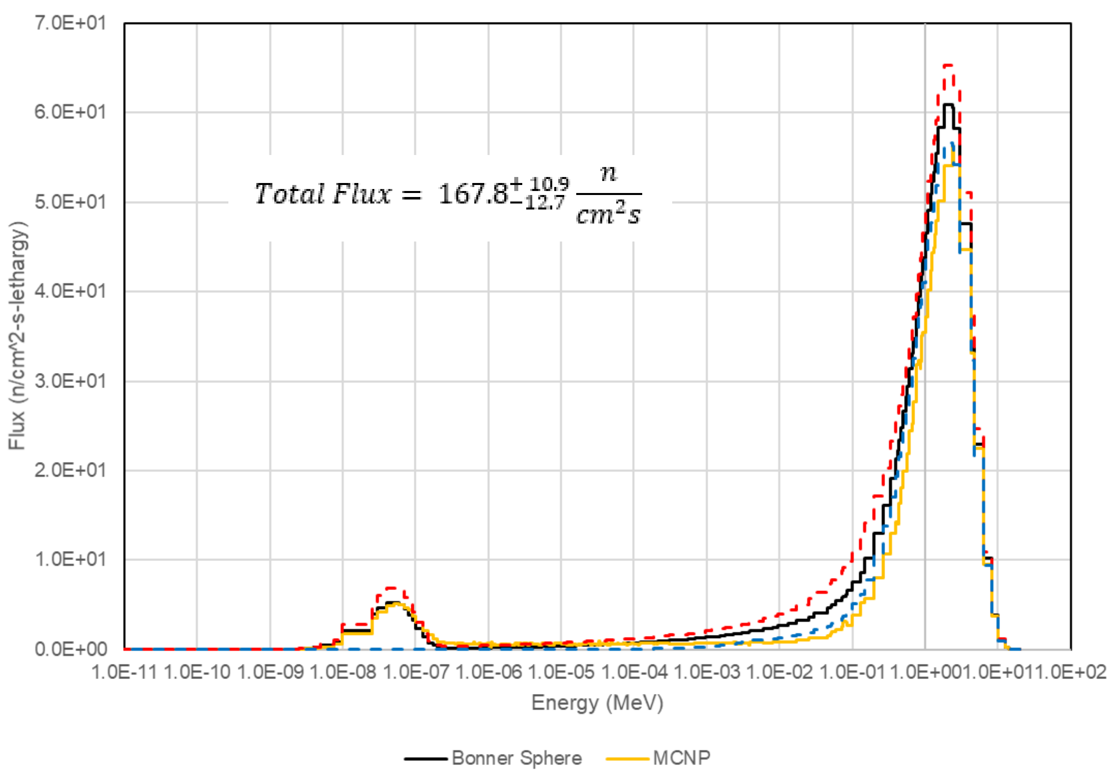

Figure 19. Bonner Sphere HPIL Bare.

Table 3. Bonner Sphere HPIL Bare Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	1.577	1.579	0.16%
2"	3.710	3.691	-0.51%
3"Cd	9.657	9.758	1.05%
5"Cd	25.973	25.808	-0.64%
8"	27.743	27.391	-1.27%
10"	20.363	20.379	0.08%
12"	13.723	13.734	0.08%

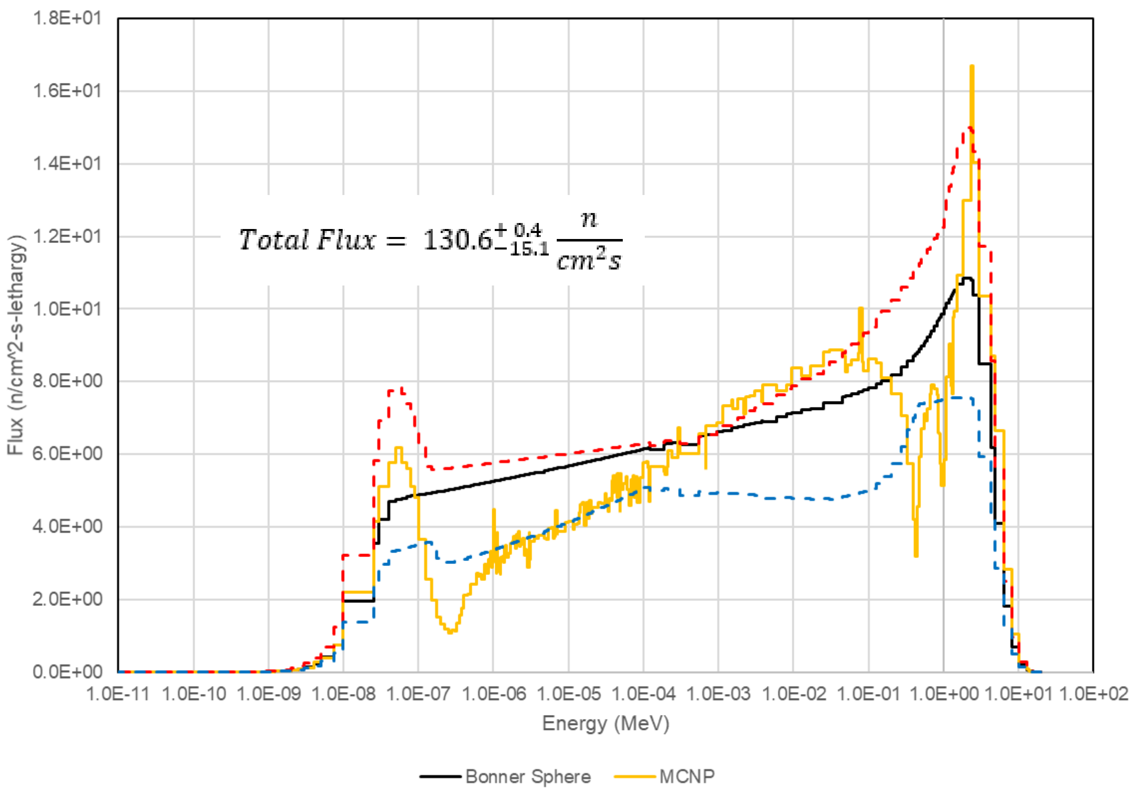

Figure 20. Bonner Sphere HPIL Moderated.

Table 4. Bonner Sphere HPIL Moderated Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	3.677	3.687	0.28%
2"	11.563	11.544	-0.17%
3"Cd	16.420	16.266	-0.94%
5"Cd	18.823	18.788	-0.19%
8"	10.273	10.561	2.80%
10"	6.110	6.009	-1.66%
12"	3.467	3.370	-2.79%

Figure 19 and Figure 20 show that the Bonner sphere solver predicts relative thermal to fast flux very well, but it cannot predict complex details in the neutron energy spectrum. The bare Cf-252 spectrum shape is predicted very well because of its simplicity, but when the source is covered with the D_2O sphere, which has a thin cadmium shell, the spectrum becomes far more complicated. Having only four parameters, the solver can only approximate these details by averaging them and smoothing out these details. The MCNP total flux for the bare source is 137.4 n/cm^2-s ± 0.20% and the Bonner sphere predicted total flux is $167.8\,^{+10.9}_{-12.7}$ n/cm^2-s which is a total difference of 18%. The MCNP total flux for the moderated source is 121.8 n/cm^2-s ± 0.21% and the Bonner sphere predicted total flux is $130.6\,^{+0.4}_{-15.1}$ n/cm^2-s which is a total difference of 6.7%. The difference in spectrum shape and total flux predicted by the Bonner spheres is small compared to the conservatism in the radiological release methodology. The consistency of the measured and calculated detector responses in Table 3 and Table 4 show that calculated neutron energy spectrum fits well with the measured detector responses. The Bonner sphere results are adequate for the purposes of approximating the neutron energy spectrum at TREAT for radiological free release.

4.3.2 TREAT Bonner Sphere Results

Bonner sphere measurements were taken in the TREAT high bay 1st floor at three locations, north, south, and east of the core. Measurements were taken south of the core in line with Hole 11 because this is where the highest radiological dose rate is measured at any appreciable distance from the bio-shield. Measurements were taken north of the reactor to verify the south flux bounds the north. Measurements were taken at the east thermal column to verify the high gold foil activation and high cadmium covered foil ratio at this location. Measurements were also taken at the north location with the radiography port open and closed to determine the effect the radiography port has on flux.

The north location is 16.25 ft north of the bio-shield and approximetly even with the west corner of the bio-shield. The results for the north location are shown in Figure 21, Figure 22, Table 5, and Table 6. Again in these figures, the dashed lines in the figures indicate the upper and lower 95% confidence interval of the Bonner sphere results. The results show good agreement with the measured count rate with the exception of the 12" sphere which has a relatively low count rate. The total flux as determined by the Bonner sphere solver with the radiography port closed is $103.4^{+2.3}_{-11.1}$ n/cm^2-s and the total flux with the radiography port open is $145.0^{+3.9}_{-15.8}$ n/cm^2-s which is a 40% increase. The solver calculated gold foil activity is 14.3 pCi/g-GJ and cadmium ratio of 1.76, and the measured activity is 20.38 pCi/g-GJ and cadmium ratio of 1.45, which shows good agreement.

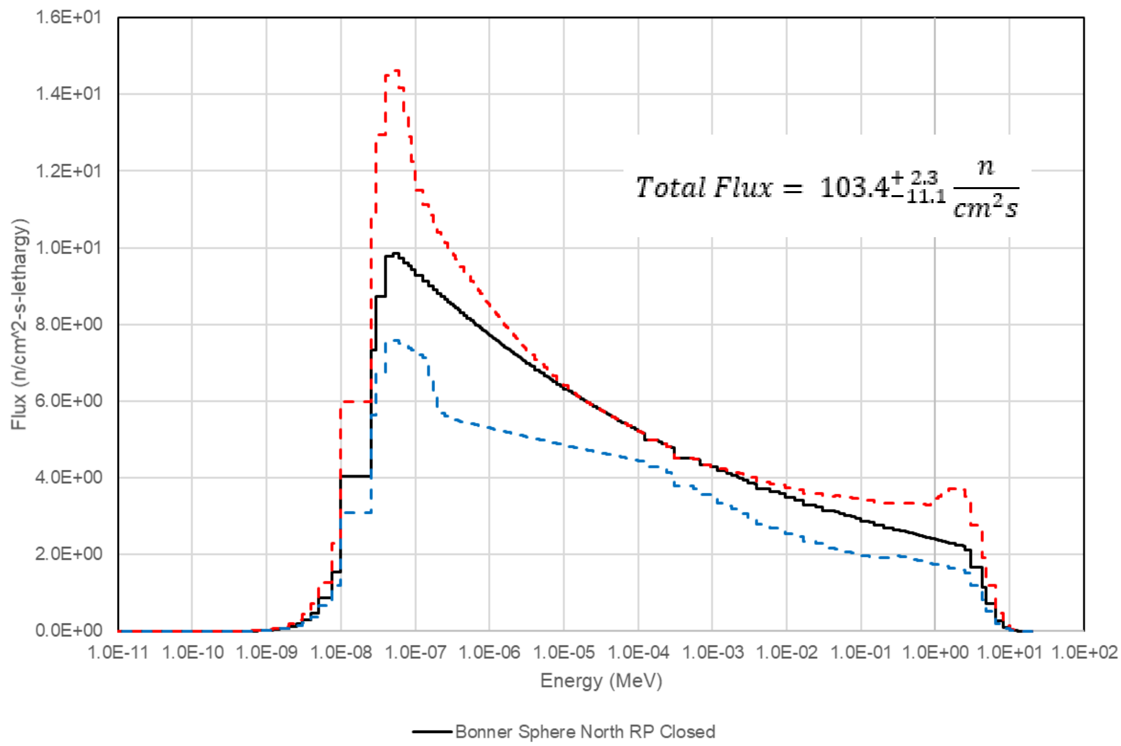

Figure 21. Bonner Sphere Spectrum North with Radiography Port Closed.

Table 5. Bonner Sphere Spectrum North with Radiography Port Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	6.067	6.045	-0.35%
2"	12.250	12.727	3.90%
3"Cd	12.733	12.385	-2.73%
5"Cd	11.453	10.888	-4.93%
8"	4.988	4.857	-2.63%
10"	2.151	2.276	5.78%
12"	0.922	1.068	15.86%

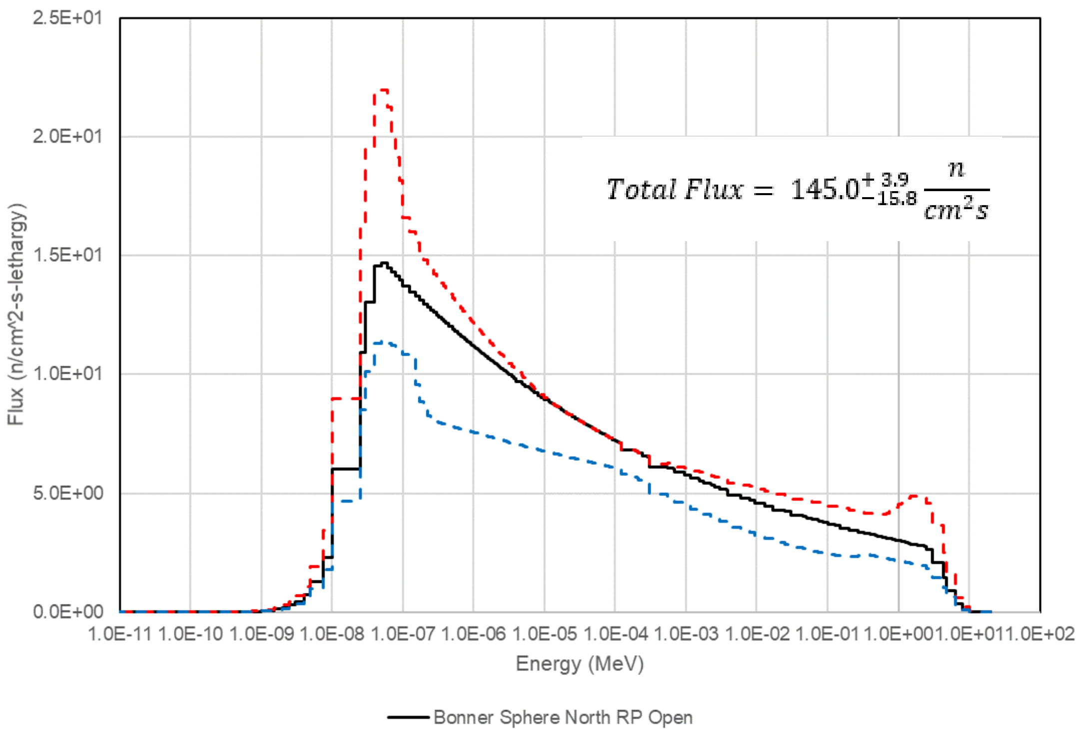

Figure 22. Bonner Sphere Spectrum North with Radiography Port Open.

Table 6. Bonner Sphere Spectrum North with Radiography Port Open Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	8.727	8.860	1.53%
2"	18.245	18.134	-0.61%
3"Cd	17.117	17.104	-0.07%
5"Cd	15.063	14.759	-2.02%
8"	6.832	6.518	-4.59%
10"	2.870	3.013	4.99%
12"	0.789	1.394	76.76%

The east thermal column had gold foil activation that was much higher than other areas with similar dose rates. This area will be restricted from radiological free release, however, it is valuable in explaining the gold foil and radiological dose measurements. The Bonner sphere calculated results are shown in Figure 23 and Table 7. The results show the spectrum is very thermalized at the east thermal column and has a much higher flux at 2798^{+281}_{-330} n/cm^2-s. This explains the high gold foil activation, which is sensitive to thermal energies compared to the radiological dose measurements, which are sensitive to high energies. The solver calculated gold foil activity is 704.9 pCi/g-GJ and the cadmium ratio is 64.0 while the measured activity is 1042.7 ± 4 pCi/g-GJ and the cadmium ratio is 134. The cadmium ratio is very sensitive to the steepness of the thermal spectrum which can be affected by absorption in the scattering medium. Considering this, the results are still in good agreement with foil results.

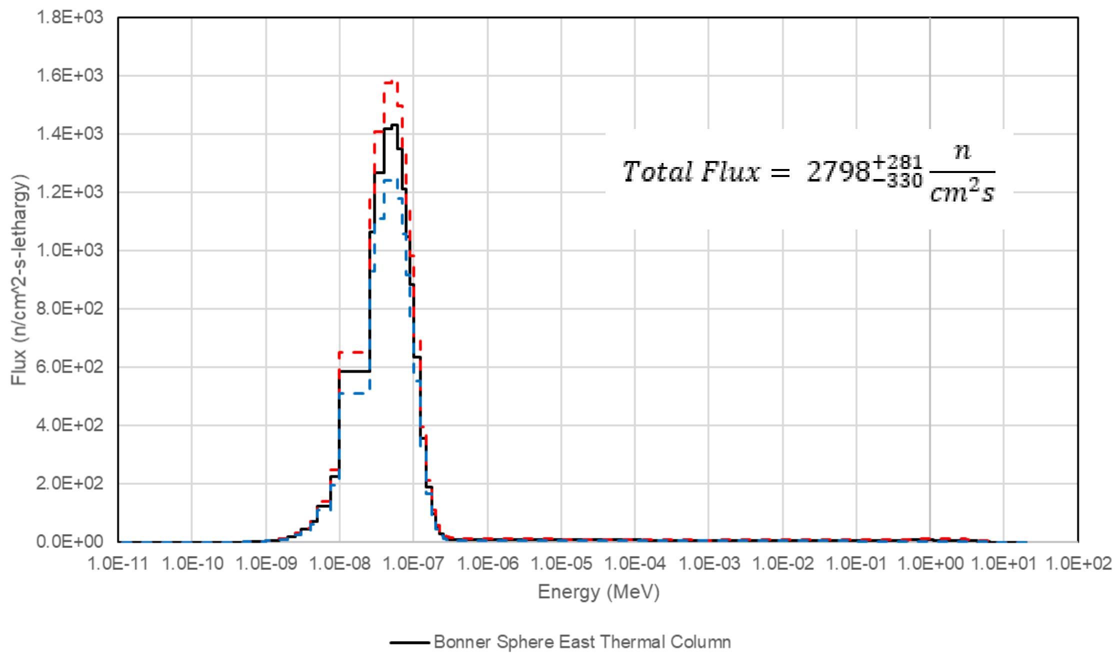

Figure 23. Bonner Sphere Spectrum East Thermal Column.

Table 7. Bonner Sphere Spectrum East Thermal Column Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	406.060	380.305	-6.34%
2"	265.047	281.575	6.24%
3"Cd	18.087	18.462	2.07%
5"Cd	19.533	18.885	-3.32%
8"	41.280	36.427	-11.76%
10"	13.603	14.939	9.82%
12"	5.940	6.075	2.27%

The south Bonner sphere measurements were taken 10 ft south of the bio-shield in line with hole 11 which has higher radiological dose measurements. The Bonner sphere calculated results are shown in Figure 24 and Table 8. The total flux at the south location is $199.5^{+15.4}_{-15.5}$ n/cm^2-s which is higher than the north location with the radiography port open. Figure 25 shows the north spectrum with the radiography port open and closed as well as the south spectrum. The figure shows that the south spectrum is bounding for the north location except for slightly higher values in the epi-thermal range when the radiography port is open. Because the radiography port is only open for a fraction of TREAT operations, the south spectrum is bounding for the north location. The south spectrum is used for all COUPLE/ORIGEN calculations and is tabulated in Appendix A – South TREAT High Bay Neutron Energy Spectrum. The solver calculated gold foil activity is 29.4 pCi/g-GJ and the cadmium ratio is 2.6 while the measured activity is 19.0 pCi/g-GJ and the cadmium ratio is 3.27. This shows good agreement.

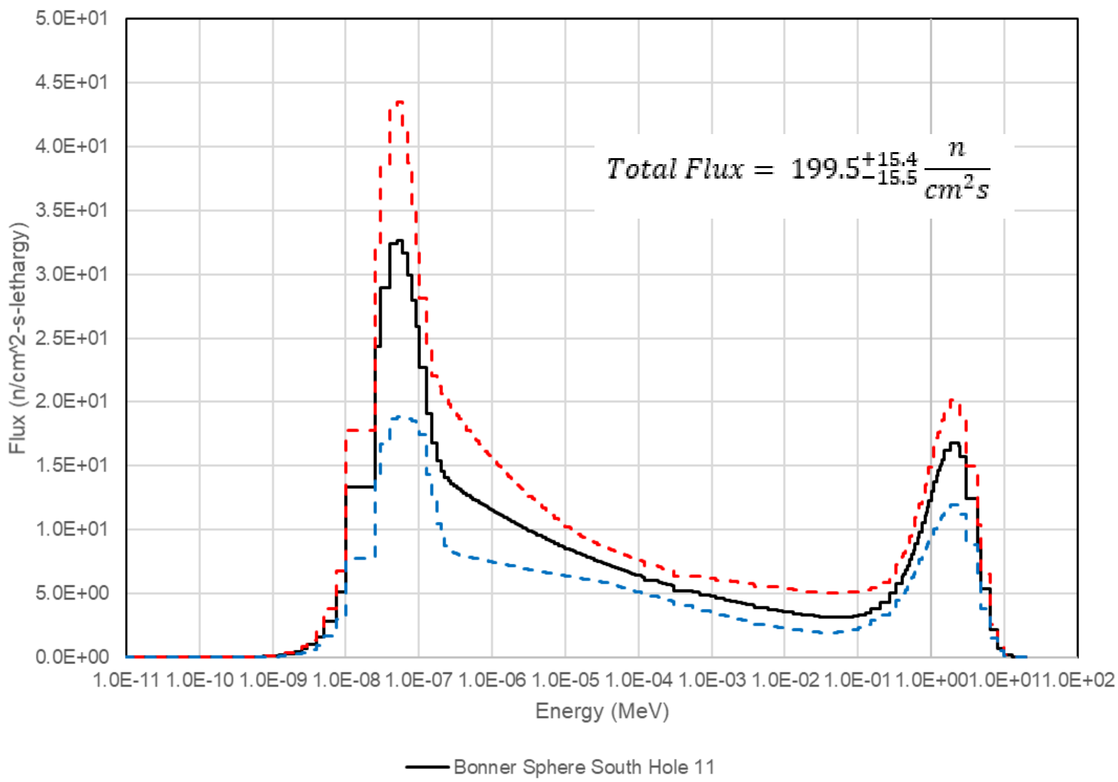

Figure 24. Bonner Sphere Spectrum South Hole 11.

Table 8. Bonner Sphere Spectrum South Hole 11 Results.

Bonner Sphere	Measured (Cnts/s)	Calculated (Cnts/s)	Percent Difference
0"	14.137	13.815	-2.27%
2"	20.560	21.307	3.63%
3"Cd	17.620	16.881	-4.19%
5"Cd	17.663	17.595	-0.39%
8"	10.740	11.704	8.98%
10"	7.565	7.105	-6.08%
12"	5.455	4.239	-22.29%

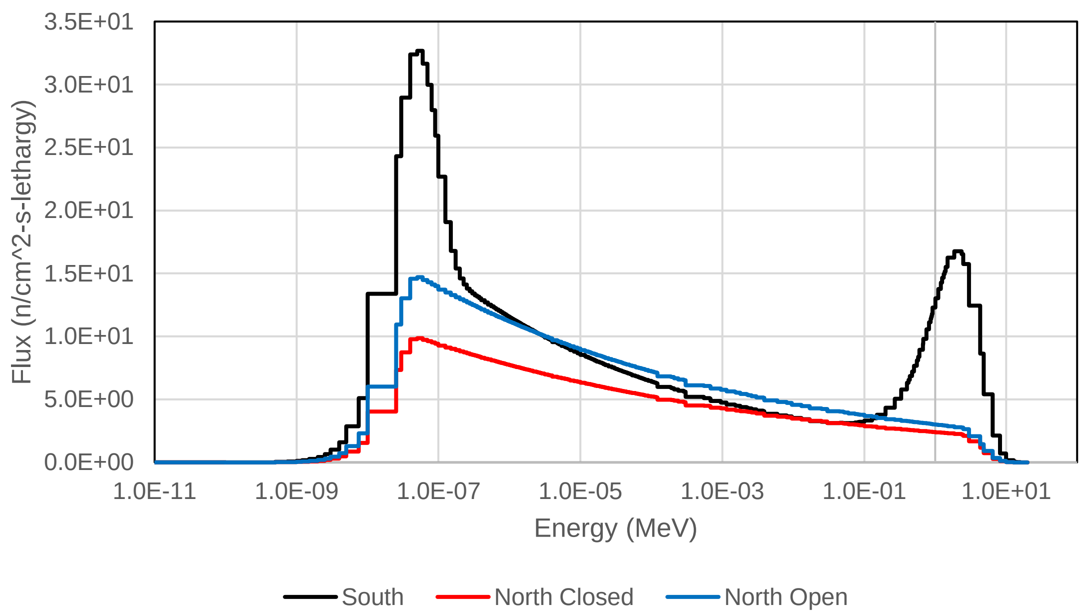

Figure 25. Comparison of North and South Spectrums.

The Bonner sphere predicted gold foil results range from 30% below to 50% above the measured gold foil results for the three locations. There is considerable uncertainty in both measurement techniques that justify these results are in agreement. This includes an average uncertainty due to gold foil counting statistics of 19%. Another uncertainty, which is difficult to quantify, is the uncertainty in the neutron beam. For example, the neutrons from hole 11 are expected to be collimated making exact location of the foils and Bonners spheres very important. The Bonners spheres are also sensitive to orientation, having different efficiencies for neutrons impingent from different angles. The intent of the generated spectrum is to approximate the general spectrum shape. This approximation is a smoothed spectrum that can miss the effects of resonances and cross sections peaks. For these reasons, Bonner sphere predicted gold foil and measured gold foil results that are within a factor of two are considered to be in agreement. Any non-conservatism that may be introduced by uncertainty in the neutron energy spectrum is compensated by conservatisms presented in the next section such as transient size, transient frequency, impurities, and use of a free air spectrum.

4.4 ORIGEN Activation and Decay Results

The neutron energy spectrum calculated in Section 4.3 for the south high bay was used with ORIGEN to determine activation of materials. The maximum transient size for TREAT is 2.90 GJ which was conservatively used for every activation transient.[1] For more than a single transient, it is assumed TREAT will perform a maximum of three transients per week with the maximum transient energy. This results in 8.7 GJ per week. This is a conservative assumption because TREAT rarely performs transients this large or this often. One gram of every naturally occurring element (z=1-83) was used in the calculation to determine the activity from one gram of pure natural element. This results in 83 calculations for every activation. Varying decay times were used to determine the necessary decay time required to be releasable. Legacy material present in the high bay during operations from 1959-1994 was analyzed for release. During this time, TREAT generated a total of 2,600,580.8 MJ of energy. TREAT was then restarted in November of 2017. The ORIGEN calculation therefore assumes 8.7 GJ per week for 5.729 years

(2.6 million MJ at 8.7 GJ/week) followed by a 24-year decay period. Naturally occurring radioisotopes are not included in the reported activity because their activity is not associated with exposure at TREAT.

Most materials considered for release consist of more than one element. The sum of the activity from each element must also be less than the screening levels (SLs) in Reference 12. To address mixed materials, the elemental weight percent for each material was taken from the PNNL Compendium of Material Compositions Data for Radiation Transport Modeling[15] for concretes, metals, plastics, from the ERM Battery Waste Management Life Cycle Assessment[21] for batteries, and from ASM Volume 16 High-Speed Tool Steels[22] for tool steel. The elemental weight percentages were then multiplied by the calculated elemental activity and summed to determine an activity per gram for each mixed material. Tool steel was not included in Reference 15 but was added because of the high cobalt content. Most materials in Reference 15 have elemental weight percentages reported to within 1%; however, this does not include potential impurities with concentrations less than one percent that could have a significant impact on the overall neutron activation of the material. To address impurities, one gram of earth's crust containing the natural occurring composition for each element was added to all non-metals.[23] The activity of the impurities is added but not the mass, conservatively increasing the specific activity of the materials.

A reasonable set of impurities was created for ferrous and non-ferrous metals by taking the maximum weight percent of the measured impurities for ferrous and non-ferrous metals from Reference 24. Elements that are present greater than one weight percent concentration were not considered impurities and the maximum weight percent below one percent was used. For elements not listed, 1 ppm is assumed. The activity from these impurities is added but not the mass, conservatively increasing the specific activity of metals. The impurity compositions are shown in Appendix B – Impurity Compositions. The activity for each element and the activity for materials is used in the following section to develop suggested radiological release controls.

4.5 Development of Radiological Release Controls

DOE-STD-6004-2016 (Ref. 11) provides guidance on the clearance and release of personal property from accelerator facilities in accordance with 10 CFR 835 and DOE O 458.1.[25,26] While TREAT is not an accelerator facility, the same activated material release limits apply based on guidance in DOE OE-3:2016-7 which states that DOE-STD-6004-2016 Tier 2 release criteria meet the DOE O 458.1 pre-approved authorization limits.[27]

The standard uses a tiered system to release material that may have residual activity based on SLs derived in Reference 12. This analysis addresses volumetric activation and does not address potential surface activity. Tier 1 is for activated material indistinguishable from background (IFB), Tier 2 is for material with activity less than or equal to the SLs, and Tier 3 is for material with activity higher than the SLs. This analysis can be used to supplement the process knowledge criteria found in DOE O 458.1. The summary of SLs from Reference 11 are shown in Table 9.

Table 9. ANSI N13.12-2013 Screening Levels (SLs) for Surface Activity and Volumetric Activity.

Radionuclide Groups	**Surface SLs (dpm /100 cm²)**	**Volume SLs (pCi/g)**
Group 1: High-energy gamma, radium, thorium, transuranics, and mobile beta-gamma emitters (e.g., ^{22}Na, ^{46}Sc, ^{54}Mn, ^{56}Co, ^{60}Co, ^{65}Zn, ^{125}Sb, ^{134}Cs, ^{152}Eu, ^{154}Eu)	600	3
Group 2: uranium and selected beta-gamma emitters (e.g., ^{57}Co, ^{58}Co, ^{59}Fe, ^{113}Sn, ^{124}Sb)	6,000	30
Group 3: General beta-gamma emitters (e.g., ^{7}Be)	60,000	300
Group 4: Low-energy beta-gamma Emitters (e.g., ^{3}H, ^{45}Ca, ^{63}Ni)	600,000	3,000
Group 5: Low-energy beta emitters (e.g., ^{55}Fe)	600,000	30,000

These screening levels are for guidance only and have not been approved for release of material and equipment by DOE O 458.1. The following outline provides background, guidance, and the framework for evaluation of potential activated personal property located outside of the bio-shield at the TREAT reactor.

DOE-STD-6004-2016 states that the detection capability of instrumentation used for clearance of personal property is below the ANSI volume SLs with uncertainty included. For conservatism and to meet the expectations of the standard, the Group 1 volume SL of 3 pCi/g will be reduced to 1 pCi/g and applied to all isotopes except for tritium (H-3). Tritium is predominantly produced by activation of lithium and results in relatively higher activity than other isotopes. In all cases the tritium activity is less than 3,000 pCi/g and reported separately. Tritium is reported separately in anticipation for less restrictive tritium limits in the future. Naturally occurring radioactive isotopes are not included and are not a concern because this activity is not a result of neutron activation.

A summary of the results is shown in Table 10. Legacy material not included in Table 10 Limit H can be assumed to have no residual activity at the time of restart in November 2017.

The PNNL materials Gadolinium Oxysulfide, Gadolinium Silicate, Li Doped Glass Scintillators, Lithium Amide, Lithium Fluoride, Lithium Gadolinium Borate, Lithium Hydride, Lithium Iodide, Lithium Oxide, Lithium Tetraborate, and Zinc Selenide are all materials used for radiation detection. These materials are all grouped into a single detector category in Table 10. Tool steel has a high cobalt concentration with activity greater than 1 pCi/g after one year of activation. Tool steels are used for cutting tools such as drills, taps, bits, saw blades, files, chisels, and some knifes. Tantalum may be of interest for research and becomes greater than 1 pCi/g after a single transient and has a relatively long half-life. Electronics contain precious metals such as tantalum, gold, and silver. These elements potentially result in greater than 1 pCi/g. This excludes copper wires and the housing. Aluminum 2090 contains lithium resulting in tritium activity greater than 1 pCi/g. Aluminum 2090 is predominantly used in the aerospace industry for its decreased density and is not likely to be present in TREAT. Some batteries contain cobalt with high activation of lithium resulting in tritium. Photographic emulsion contains high concentrations of silver. Paint thinner contains high concentrations of chlorine. These materials may be released based on detailed knowledge of the elemental compositions and sufficient decay times based on further activation and decay analysis.

Table 10. Material Activation Results for 10 ft Away from the Bio-shield on the 1st Floor Summary.

Limit	Activation	Decay Time	Material > 1 pCi/g	Material > 1 pCi/g (no H^3)
A	A Maximum of 2.9 GJ (1 transient)	A Minimum of 1 Week	Electronics, Detectors, Sc, Sb, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Ta, Re, Ir, Au	Electronics, Detectors, Sc, Sb, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Ta, Re, Ir, Au
B	A Maximum of 8.7 GJ (1 week)	A Minimum of 1 Week	Electronics, Detectors, Li, Sc, Sb, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Ta, Re, Os, Ir, Au	Electronics, Detectors, Sc, Sb, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Ta, Re, Os, Ir, Au
C	A Maximum of 34.8 GJ (1 month)	A Minimum of 1 Week	Electronics, Detectors, Li, Sc, Cr, Co, In, Sb, Cs, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Hf, Ta, Re, Os, Ir, Au, Hg	Electronics, Detectors, Sc, Cr, Co, In, Sb, Cs, Sm, Eu, Tb, Ho, Tm, Yb, Lu, Hf, Ta, Re, Os, Ir, Au, Hg
D	A Maximum of 452.4 GJ (1 year)	A Minimum of 3 Months	Electronics, Aluminum 2090, Detectors, Paint Thinner, PVDC, Photographic Emulsion, Tool Steel, Batteries, Li, Cl, Sc, Co, Se, Ag, In, Sb, Cs, Eu, Gd, Tb, Tm, Hf, Ta, Ir	Electronics, Detectors, Paint Thinner, PVDC, Photographic Emulsion, Tool Steel, Batteries, Cl, Sc, Co, Se, Ag, In, Sb, Cs, Eu, Gd, Tb, Tm, Hf, Ta, Ir
E	A Maximum of 452.4 GJ (1 year)	A Minimum of 6 Months	Electronics, Aluminum 2090, Detectors, Photographic Emulsion, Tool Steel, Batteries, Li, Sc, Co, Se, Ag, Sb, Cs, Eu, Gd, Tb, Tm, Hf, Ta, Ir	Electronics, Detectors, Photographic Emulsion, Tool Steel, Batteries, Sc, Co, Se, Ag, Sb, Cs, Eu, Gd, Tb, Tm, Hf, Ta, Ir

Limit	Activation	Decay Time	Material > 1 pCi/g	Material > 1 pCi/g (no H^3)
F	A Maximum of 1450 GJ (500 transients)	A Minimum of 6 Months	Electronics, Aluminum 2090, Detectors, Photographic Emulsion, Tool Steel, Batteries, Zinc, Li, Sc, Co, Ag, Sb, Cs, Sm, Eu, Gd, Tb, Tm, Ta, Ir, Tl	Electronics, Detectors, Photographic Emulsion, Tool Steel, Batteries, Zinc, Sc, Co, Ag, Sb, Cs, Sm, Eu, Gd, Tb, Tm, Ta, Ir, Tl
G	A Maximum of 2900 GJ (1000 transients)	A Minimum of 1 Year	Electronics, Aluminum 2090, Inconel-718, Detectors, Photographic Emulsion, Tool Steel, Batteries, Zinc, Li, Sc, Co, Ag, Cs, Sm, Eu, Tb, Er, Tm, Ta, Ir, Tl	Electronics, Inconel-718, Detectors, Photographic Emulsion, Tool Steel, Batteries, Zinc, Sc, Co, Ag, Cs, Sm, Eu, Tb, Er, Tm, Ta, Ir, Tl
H	A Maximum of 2600.581 GJ (historical operation)	24 Years	Aluminum 2090, Detectors, Batteries, Li, Co, Eu	Co, Eu

An example is provided to clarify the use of Table 10. Suppose a plastic conduit (PVDC) on the south wall of the TREAT high bay (greater than 10 ft from the bio shield) is being evaluated for release that has been present since the initial construction of TREAT. First, Limit H must be checked to ensure that legacy activation is not a concern. PVDC is not listed under Limit H as a material with greater than 1 pCi/g so it may be assumed to have no residual activity from legacy operations. Next, PVDC must be checked for activation from current operations. The PVDC has been exposed to greater than 12 but less than 156 transients, therefore, Limit D or E applies. PVDC is listed as a material with greater than 1 pCi/g on Limit D, therefore, cannot be released under this control. PVDC is not listed as a material with greater than 1 pCi/g under Limit E, therefore, the material can be released from radioactive controls after decaying a minimum of 6 months in an area with no neutron exposure.

5 Conclusions

Gold foil and Bonner sphere measurements were taken in the TREAT high bay to determine the neutron energy spectrum and flux at various locations. The Bonner spheres are used to estimate the free air neutron flux and spectra and generate a neutron flux and spectrum that can be used as Tier 1 and Tier 2 release process knowledge. This neutron energy spectrum was used with ORIGEN to conservatively activate and then decay all naturally occurring elements (z=1-83). Activation data was used with a wide variety of materials to determine which pure elements and materials are a concern for activation. These results are summarized in Table 10 and meet the requirements of DOE-STD-6004-2016 (Ref. 11) for a Tier 2 release. This release methodology is preliminary and is currently only applicable for items greater than 10 ft from the bio-shield on the first floor. Further work needs to be done to apply this methodology to the 2nd floor, 3rd floor, and basement of TREAT or items closer than 10 ft from the bio-shield.

6 Future Work

Elevated neutron flux on the second and third floors made Bonner sphere measurements difficult and outside the scope of this work. Radiological work planning needs to be done to access these areas while TREAT is operating at steady state. Future Bonner sphere measurements in these areas could expand the process knowledge and material release methodology to these areas.

Efforts are currently being made to bring a thick steel enclosure into the TREAT high bay to use as a low-background gamma counting resource. The low-background counter will be used as additional process knowledge and can be used to support Tier 1 indistinguishable from background releases. The low-background counter could be used to validate the neutron spectrum derived in this work by activating and counting a wider variety of materials and determining if the derived neutron spectrum predicts the correct activation. This work would be especially useful for electronics which are very conservatively represented in this work. Refinement could remove some of the conservatism and allow for release of more material.

The shielding that is placed on top of the reactor is not permanent. If this shielding is replaced or modified the results in this work may not be valid anymore. This is true for any modifications to the shielding. Future work may involve replacing the shielding on top of the reactor and at hole 11 and deriving less restrictive release limits that this work derived.

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Appendix A – South TREAT High Bay Neutron Energy Spectrum

Table 11. South TREAT High Bay Neutron Energy Spectrum

Group #	Energy Group (MeV)	Flux (n/cm2-s)
1	1.73E+01-2.00E+01	0.000103
2	1.57E+01-1.73E+01	0.000339
3	1.46E+01-1.57E+01	0.000703
4	1.38E+01-1.46E+01	0.000913
5	1.28E+01-1.38E+01	0.002606
6	1.00E+01-1.28E+01	0.041044
7	8.19E+00-1.00E+01	0.140845
8	6.43E+00-8.19E+00	0.512757
9	4.80E+00-6.43E+00	1.581171
10	4.30E+00-4.80E+00	0.942136
11	3.00E+00-4.30E+00	4.491535
12	2.48E+00-3.00E+00	3.002976
13	2.35E+00-2.48E+00	0.854919
14	1.85E+00-2.35E+00	4.039863
15	1.50E+00-1.85E+00	3.409259
16	1.40E+00-1.50E+00	1.070001
17	1.36E+00-1.40E+00	0.484374
18	1.32E+00-1.36E+00	0.436246
19	1.25E+00-1.32E+00	0.764551
20	1.20E+00-1.25E+00	0.582967
21	1.10E+00-1.20E+00	1.197342
22	1.01E+00-1.10E+00	1.113071
23	9.20E-01-1.01E+00	1.146077
24	9.00E-01-9.20E-01	0.259155
25	8.75E-01-9.00E-01	0.326196
26	8.61E-01-8.75E-01	0.182448
27	8.20E-01-8.61E-01	0.543961
28	7.50E-01-8.20E-01	0.941906
29	6.79E-01-7.50E-01	0.975617
30	6.70E-01-6.79E-01	0.125193
31	6.00E-01-6.70E-01	0.985472
32	5.73E-01-6.00E-01	0.386188
33	5.50E-01-5.73E-01	0.331804
34	5.00E-01-5.50E-01	0.737984
35	4.70E-01-5.00E-01	0.438641
36	4.40E-01-4.70E-01	0.45184
37	4.20E-01-4.40E-01	0.305076

Group #	Energy Group (MeV)	Flux (n/cm2-s)
38	4.00E-01-4.20E-01	0.308514
39	3.30E-01-4.00E-01	1.11208
40	2.70E-01-3.30E-01	1.01264
41	2.00E-01-2.70E-01	1.301871
42	1.50E-01-2.00E-01	1.086341
43	1.28E-01-1.50E-01	0.54788
44	1.00E-01-1.28E-01	0.828865
45	8.50E-02-1.00E-01	0.523274
46	8.20E-02-8.50E-02	0.11458
47	7.50E-02-8.20E-02	0.282798
48	7.30E-02-7.50E-02	0.085344
49	6.00E-02-7.30E-02	0.613861
50	5.20E-02-6.00E-02	0.44706
51	5.00E-02-5.20E-02	0.122792
52	4.50E-02-5.00E-02	0.33006
53	3.00E-02-4.50E-02	1.266488
54	2.50E-02-3.00E-02	0.588461
55	1.70E-02-2.50E-02	1.263683
56	1.30E-02-1.70E-02	0.916394
57	9.50E-03-1.30E-02	1.104698
58	8.03E-03-9.50E-03	0.613399
59	6.00E-03-8.03E-03	1.087368
60	3.90E-03-6.00E-03	1.664235
61	3.74E-03-3.90E-03	0.169714
62	3.00E-03-3.74E-03	0.903848
63	2.58E-03-3.00E-03	0.63455
64	2.29E-03-2.58E-03	0.510715
65	2.20E-03-2.29E-03	0.173686
66	1.80E-03-2.20E-03	0.879256
67	1.55E-03-1.80E-03	0.671062
68	1.50E-03-1.55E-03	0.149177
69	1.15E-03-1.50E-03	1.223475
70	9.50E-04-1.15E-03	0.908665
71	6.83E-04-9.50E-04	1.610605
72	6.70E-04-6.83E-04	0.096937
73	5.50E-04-6.70E-04	1.00548
74	3.05E-04-5.50E-04	3.064605
75	2.85E-04-3.05E-04	0.380044
76	2.40E-04-2.85E-04	0.975336
77	2.10E-04-2.40E-04	0.773609

Group #	Energy Group (MeV)	Flux (n/cm2-s)
78	2.08E-04-2.10E-04	0.070151
79	1.93E-04-2.08E-04	0.441721
80	1.86E-04-1.93E-04	0.203711
81	1.22E-04-1.86E-04	2.53034
82	1.19E-04-1.22E-04	0.156387
83	1.15E-04-1.19E-04	0.21556
84	1.08E-04-1.15E-04	0.398268
85	1.00E-04-1.08E-04	0.492328
86	9.00E-05-1.00E-04	0.681511
87	8.20E-05-9.00E-05	0.609936
88	8.00E-05-8.20E-05	0.163134
89	7.60E-05-8.00E-05	0.340448
90	7.20E-05-7.60E-05	0.36126
91	6.75E-05-7.20E-05	0.434437
92	6.50E-05-6.75E-05	0.255774
93	6.10E-05-6.50E-05	0.433111
94	5.90E-05-6.10E-05	0.228798
95	5.34E-05-5.90E-05	0.689666
96	5.20E-05-5.34E-05	0.185377
97	5.06E-05-5.20E-05	0.191089
98	4.92E-05-5.06E-05	0.197143
99	4.83E-05-4.92E-05	0.130109
100	4.70E-05-4.83E-05	0.192833
101	4.52E-05-4.70E-05	0.27714
102	4.40E-05-4.52E-05	0.191779
103	4.24E-05-4.40E-05	0.265065
104	4.10E-05-4.24E-05	0.241357
105	3.96E-05-4.10E-05	0.250828
106	3.91E-05-3.96E-05	0.092023
107	3.80E-05-3.91E-05	0.207192
108	3.70E-05-3.80E-05	0.194312
109	3.55E-05-3.70E-05	0.30282
110	3.46E-05-3.55E-05	0.188719
111	3.38E-05-3.46E-05	0.183387
112	3.33E-05-3.38E-05	0.110328
113	3.18E-05-3.33E-05	0.342484
114	3.13E-05-3.18E-05	0.118255
115	3.00E-05-3.13E-05	0.305174
116	2.75E-05-3.00E-05	0.655399
117	2.50E-05-2.75E-05	0.726169

Group #	Energy Group (MeV)	Flux (n/cm2-s)
118	2.25E-05-2.50E-05	0.812888
119	2.10E-05-2.25E-05	0.538573
120	2.00E-05-2.10E-05	0.38382
121	1.90E-05-2.00E-05	0.406077
122	1.85E-05-1.90E-05	0.212216
123	1.70E-05-1.85E-05	0.677219
124	1.60E-05-1.70E-05	0.490213
125	1.51E-05-1.60E-05	0.471689
126	1.44E-05-1.51E-05	0.389374
127	1.38E-05-1.44E-05	0.381164
128	1.29E-05-1.38E-05	0.53018
129	1.19E-05-1.29E-05	0.67643
130	1.15E-05-1.19E-05	0.288887
131	1.00E-05-1.15E-05	1.191827
132	9.10E-06-1.00E-05	0.817159
133	8.10E-06-9.10E-06	1.021775
134	7.15E-06-8.10E-06	1.111687
135	7.00E-06-7.15E-06	0.190985
136	6.75E-06-7.00E-06	0.328764
137	6.50E-06-6.75E-06	0.342781
138	6.25E-06-6.50E-06	0.35797
139	6.00E-06-6.25E-06	0.374481
140	5.40E-06-6.00E-06	0.97464
141	5.00E-06-5.40E-06	0.7206
142	4.75E-06-5.00E-06	0.484359
143	4.00E-06-4.75E-06	1.641578
144	3.73E-06-4.00E-06	0.679575
145	3.50E-06-3.73E-06	0.624217
146	3.15E-06-3.50E-06	1.043784
147	3.05E-06-3.15E-06	0.322732
148	3.00E-06-3.05E-06	0.165883
149	2.97E-06-3.00E-06	0.101034
150	2.87E-06-2.97E-06	0.345243
151	2.77E-06-2.87E-06	0.359073
152	2.67E-06-2.77E-06	0.373987
153	2.57E-06-2.67E-06	0.390115
154	2.47E-06-2.57E-06	0.407608
155	2.38E-06-2.47E-06	0.383086
156	2.30E-06-2.38E-06	0.354495
157	2.21E-06-2.30E-06	0.415791

Group #	Energy Group (MeV)	Flux (n/cm2-s)
158	2.12E-06-2.21E-06	0.435325
159	2.00E-06-2.12E-06	0.613887
160	1.94E-06-2.00E-06	0.322795
161	1.86E-06-1.94E-06	0.448307
162	1.77E-06-1.86E-06	0.531047
163	1.68E-06-1.77E-06	0.562379
164	1.59E-06-1.68E-06	0.597392
165	1.50E-06-1.59E-06	0.63676
166	1.45E-06-1.50E-06	0.372735
167	1.40E-06-1.45E-06	0.387509
168	1.35E-06-1.40E-06	0.403428
169	1.30E-06-1.35E-06	0.420629
170	1.25E-06-1.30E-06	0.439267
171	1.23E-06-1.25E-06	0.22715
172	1.20E-06-1.23E-06	0.232436
173	1.18E-06-1.20E-06	0.237959
174	1.15E-06-1.18E-06	0.243735
175	1.14E-06-1.15E-06	0.099175
176	1.13E-06-1.14E-06	0.100161
177	1.12E-06-1.13E-06	0.101165
178	1.11E-06-1.12E-06	0.102188
179	1.10E-06-1.11E-06	0.103231
180	1.09E-06-1.10E-06	0.104294
181	1.08E-06-1.09E-06	0.105378
182	1.07E-06-1.08E-06	0.106484
183	1.06E-06-1.07E-06	0.107611
184	1.05E-06-1.06E-06	0.108762
185	1.04E-06-1.05E-06	0.109936
186	1.03E-06-1.04E-06	0.111134
187	1.02E-06-1.03E-06	0.112357
188	1.01E-06-1.02E-06	0.113605
189	1.00E-06-1.01E-06	0.11488
190	9.75E-07-1.00E-06	0.292943
191	9.50E-07-9.75E-07	0.301534
192	9.25E-07-9.50E-07	0.310613
193	9.00E-07-9.25E-07	0.320221
194	8.50E-07-9.00E-07	0.671463
195	8.00E-07-8.50E-07	0.717507
196	7.50E-07-8.00E-07	0.769894
197	7.00E-07-7.50E-07	0.829999

Group #	Energy Group (MeV)	Flux (n/cm2-s)
198	6.50E-07-7.00E-07	0.899618
199	6.25E-07-6.50E-07	0.479743
200	6.00E-07-6.25E-07	0.501871
201	5.50E-07-6.00E-07	1.077828
202	5.00E-07-5.50E-07	1.194215
203	4.50E-07-5.00E-07	1.336836
204	4.00E-07-4.50E-07	1.515449
205	3.75E-07-4.00E-07	0.840956
206	3.50E-07-3.75E-07	0.906782
207	3.25E-07-3.50E-07	0.983268
208	3.00E-07-3.25E-07	1.073418
209	2.75E-07-3.00E-07	1.181734
210	2.50E-07-2.75E-07	1.315438
211	2.25E-07-2.50E-07	1.486985
212	2.00E-07-2.25E-07	1.719289
213	1.75E-07-2.00E-07	2.056558
214	1.50E-07-1.75E-07	2.586093
215	1.25E-07-1.50E-07	3.479648
216	1.00E-07-1.25E-07	5.063081
217	9.00E-08-1.00E-07	2.731776
218	8.00E-08-9.00E-08	3.295301
219	7.00E-08-8.00E-08	4.001188
220	6.00E-08-7.00E-08	4.877811
221	5.00E-08-6.00E-08	5.957165
222	4.00E-08-5.00E-08	7.227576
223	3.00E-08-4.00E-08	8.329162
224	2.53E-08-3.00E-08	4.143105
225	1.00E-08-2.53E-08	12.41344
226	7.50E-09-1.00E-08	1.471211
227	5.00E-09-7.50E-09	1.158897
228	4.00E-09-5.00E-09	0.35851
229	3.00E-09-4.00E-09	0.290023
230	2.50E-09-3.00E-09	0.11744
231	2.00E-09-2.50E-09	0.097999
232	1.50E-09-2.00E-09	0.077735
233	1.20E-09-1.50E-09	0.036563
234	1.00E-09-1.20E-09	0.020061
235	7.50E-10-1.00E-09	0.020123
236	5.00E-10-7.50E-10	0.014515
237	1.00E-10-5.00E-10	0.011274

Group #	Energy Group (MeV)	Flux (n/cm2-s)
238	1.00E-11-1.00E-10	0.00047

Appendix B – Impurity Compositions

Table 12. Impurity Compositions.

Element	Earth's Crust: CRC Handbook (wt.%)	Ferrous Metal: NIST SP 260-176 (wt.%)	Non-Ferrous Metal: NIST SP 260-176 (wt.%)
H	0.0014	0.000005	0.000211
He	0.000008	0.000001	0.000001
Li	0.0005	0.000001	0.000001
Be	0.0005	0.000001	0.0036
B	0.0005	0.00058	0.0001
C	0.0005	0.0097	0.00266
N	0.0005	0.00442	0.00028
O	0.461	0.01	0.0064
F	0.000585	0.000001	0.00001
Ne	0.000005	0.000001	0.000001
Na	0.0236	0.000001	0.000001
Mg	0.0233	0.0007	0.003822
Al	0.0823	0.0099	0.007917
Si	0.282	0.01	0.0085
P	0.00105	0.00557	0.0026
S	0.0005	0.00329	0.00018
Cl	0.0005	0.000001	0.000001
Ar	0.0005	0.000001	0.000001
K	0.0209	0.000001	0.000001
Ca	0.0415	0.00271	0.00002
Sc	0.0005	0.000001	0.000001
Ti	0.00565	0.0075	0.00959
V	0.0005	0.0045	0.0098
Cr	0.0005	0.00982	0.00504
Mn	0.00095	0.01	0.0064
Fe	0.0563	0.0034	0.0091
Co	0.0005	0.0038	0.0055
Ni	0.0005	0.0098	0.0075
Cu	0.0005	0.0089	0.00976
Zn	0.0005	0.00018	0.0096
Ga	0.0005	0.000001	0.00022
Ge	0.0005	0.0001	0.000002
As	0.0005	0.00092	0.002
Se	0.00005	0.00247	0.002

Element	Earth's Crust: CRC Handbook (wt.%)	Ferrous Metal: NIST SP 260-176 (wt.%)	Non-Ferrous Metal: NIST SP 260-176 (wt.%)
Br	0.0005	0.000001	0.000001
Kr	1E-07	0.000001	0.000001
Rb	0.0005	0.000001	0.000001
Sr	0.0005	0.00001	0.000188
Y	0.0005	0.000001	0.000001
Zr	0.0005	0.002	0.001
Nb	0.0005	0.0065	0.009
Mo	0.0005	0.00996	0.0099
Ru	0.000001	0.000001	0.000006
Rh	0.000001	0.000001	0.000001
Pd	0.000015	0.000001	0.000038
Ag	0.000075	0.002	0.004591
Cd	0.00015	0.000001	0.000155
In	0.00025	0.000001	0.000031
Sn	0.0005	0.0035	0.0096
Sb	0.0002	0.0004	0.0079
Te	0.000001	0.00003	0.004
I	0.00045	0.000001	0.000001
Xe	3E-08	0.000001	0.000001
Cs	0.0005	0.000001	0.000001
Ba	0.0005	0.000001	0.000001
La	0.0005	0.00002	0.000001
Ce	0.0005	0.00016	0.000001
Pr	0.0005	0.000004	0.000001
Nd	0.0005	0.000012	0.000001
Sm	0.0005	0.000001	0.000001
Eu	0.0005	0.000001	0.000001
Gd	0.0005	0.000001	0.000001
Tb	0.0005	0.000001	0.000001
Dy	0.0005	0.000001	0.000001
Ho	0.0005	0.000001	0.000001
Er	0.0005	0.000001	0.000001
Tm	0.0005	0.000001	0.000001
Yb	0.0005	0.000001	0.000001
Lu	0.0005	0.000001	0.000001
Hf	0.0005	0.00006	7.85E-05
Ta	0.0005	0.0053	0.0001

Element	Earth's Crust: CRC Handbook (wt.%)	Ferrous Metal: NIST SP 260-176 (wt.%)	Non-Ferrous Metal: NIST SP 260-176 (wt.%)
W	0.0005	0.01	0.000846
Re	7E-07	0.000001	0.000001
Os	1.5E-06	0.000001	0.000001
Ir	0.000001	0.000001	0.000001
Pt	0.000005	0.000001	0.000001
Au	0.000004	0.000005	0.000072
Hg	0.000085	0.000001	0.000112
Tl	0.0005	0.000001	2.75E-06
Pb	0.0005	0.00024	0.0062
Bi	8.5E-06	0.00009	0.003

Appendix C – MCNP Inputs

12" Bonner Sphere 17.333 – 20.0 MeV

```
Bonner Sphere
c
c
1    6    -4.08       -10                 imp:n=1        $ LiI crystal
2    7    -4.20       -11  10             imp:n=1        $ TiO2
3    8    -2.80       -12  11  13         imp:n=1        $ Al Top
4    9    -2.50       -13                 imp:n=1        $ Glass Top
20   5    -0.97       -30  12             imp:n=1        $ Poly Sphere
98   0                -1   30  12  13     imp:n=1        $ Void
99   0                 1                  imp:n=0        $ Problem Boundary

c -----------------------------SURFACE----------------------------------------------------------------------
c
1   rpp  -100 100 -100 100 -100 100          $ problem boundary
c
c
c
10   rcc 0 0 -0.2   0 0 .4     0.2   $ LiI crystal
11   rcc 0 0 -0.2   0 0 .60983     0.5   $ ti02
12   rcc 0 0  0.5842   0 0 -30.48   0.67437   $ top al
13   rcc 0 0 -0.2   0 0 -29.6958   0.5   $ top glass
14   rcc 0 0 -3.6   0 0 -7.2   0.9   $ mid al
15   rcc 0 0 -3.6   0 0 -7.2   0.6   $ mid glass
16   rcc 0 0 -9.6   0 0 -19.31 2.54  $ bot al
17   rcc 0 0 -10.8  0 0 -17.61 2.14  $ bot pm tube
18   rcc 0 0 -28.91 0 0 -1.6   0.8   $ bot al
30   so  15.24                        $ poly sphere

c -----------------------------DATA-------------------------------------------------------------------------
c
mode n
c
nps 1e9
sdef pos=-50 0 0 axs=1 0 0 ext=1 rad=d1 vec=1 0 0 dir=1 erg=d2
si1 0 15.24
sp1 -21 1
si2 1.7333E+01 2.0000E+01
sp2 0 1
c
f14:n    1
fm14    -1 6 105
sd14     1
stop f14 0.01
c
c Concrete
m1       1001.80c  1.0094E-02  1002.80c  1.1609E-06  8016.80c  4.8220E-02       $ Concrete 8.1070E-02
2.452
        12024.80c  4.1100E-04
        12025.80c  5.2032E-05 12026.80c  5.7287E-05 27059.80c  1.8748E-03
        14028.80c  1.5226E-02 14029.80c  7.7349E-04 14030.80c  5.1049E-04
        16032.80c  2.4972E-04 16033.80c  1.9717E-06 16034.80c  1.1173E-05
```

```
        16036.80c  2.6289E-08 20040.80c  2.5054E-03 20042.80c  1.6722E-05
        20043.80c  3.4891E-06 20044.80c  5.3913E-05 20046.80c  1.0338E-07
        20048.80c  4.8330E-06 26054.80c  5.8614E-05 26056.80c  9.2011E-04
        26057.80c  2.1249E-05 26058.80c  2.8279E-06
mt1     lwtr.20t
c
c Road Concrete
m2      1001.80c  8.9613E-03  1002.80c  1.0307E-06  6000.80c  7.0695E-03        $ Road Concrete
7.9961E-02  2.410
         8016.80c  4.6146E-02
        12024.80c  1.9571E-04 12025.80c  2.4777E-05 12026.80c  2.7279E-05
        27059.80c  4.0175E-04 14028.80c  6.9409E-03 14029.80c  3.5260E-04
        14030.80c  2.3271E-04 16032.80c  1.6053E-04 16033.80c  1.2675E-06
        16034.80c  7.1825E-06 16036.80c  1.6900E-08 20040.80c  8.7106E-03
        20042.80c  5.8136E-05 20043.80c  1.2130E-05 20044.80c  1.8744E-04
        20046.80c  3.5942E-07 20048.80c  1.6803E-05 26054.80c  2.6471E-05
        26056.80c  4.1554E-04 26057.80c  9.5967E-06 26058.80c  1.2771E-06
mt2     lwtr.20t
c
c Sand
m3      1001.80c  7.9549E-03  1002.80c  9.1492E-07  6000.80c  2.8640E-04        $ Sand 5.8756E-02 1.700
         8016.80c  3.4307E-02
        11023.80c  7.5982E-04 27059.80c  1.3053E-03 14028.80c  1.2272E-02
        14029.80c  6.2343E-04 14030.80c  4.1145E-04 19039.80c  2.8379E-04
        19040.80c  3.5604E-08 19041.80c  2.0481E-05 20040.80c  2.7764E-04
        20042.80c  1.8530E-06 20043.80c  3.8664E-07 20044.80c  5.9743E-06
        20046.80c  1.1456E-08 20048.80c  5.3557E-07 26054.80c  1.4239E-05
        26056.80c  2.2352E-04 26057.80c  5.1621E-06 26058.80c  6.8698E-07
mt3     lwtr.20t
c
c Air
m4      1001.80c  5.3678E-07  1002.80c  6.1737E-11  7014.80c  3.8983E-05        $ Air 5.0468E-05
0.001198
         7015.80c  1.4242E-07  8016.80c  1.0806E-05
c
c Polyethylene
m5      1001.80c  2  6000.80c  1        $ Polyethylene 0.97
mt5     poly.20t
c
c LiI Crystal
m6      3006.80c  1.6624E-02  3007.80c  1.8471E-03 53127.80c  1.8471E-02        $ LiI Crystal 3.6942E-
02  4.08
c
c TiO2
m7      8016.80c  6.3328E-02                                  $ TiO2 9.4992E-02  4.2
        22046.80c  2.6123E-03 22047.80c  2.3558E-03 22048.80c  2.3343E-02
        22049.80c  1.7130E-03 22050.80c  1.6402E-03
c
c Aluminum D16
m8      12024.80c  2.7400E-04 12025.80c  3.4688E-05 12026.80c  3.8191E-05        $ Aluminum D16
6.0932E-02  2.8
        13027.80c  5.9370E-02 25055.80c  1.5346E-04 29063.80c  7.3396E-04
        29065.80c  3.2744E-04
mt8     al27.20t
c
c Glass
```

```
m9       8016.80c  4.3305E-02                                    $ Glass 7.2182E-02  2.5
       11023.80c  7.2873E-03 12024.80c  8.8516E-05 12025.80c  1.1206E-05
       12026.80c  1.2338E-05 27059.80c  2.9531E-04 14028.80c  1.6453E-02
       14029.80c  8.3580E-04 14030.80c  5.5161E-04 11023.80c  1.4099E-04
       19039.80c  1.7886E-04 19040.80c  2.2439E-08 19041.80c  1.2908E-05
       20040.80c  2.8629E-03 20042.80c  1.9107E-05 20043.80c  3.9868E-06
       20044.80c  6.1604E-05 20046.80c  1.1813E-07 20048.80c  5.5225E-06
       22046.80c  1.5550E-06 22047.80c  1.4023E-06 22048.80c  1.3895E-05
       22049.80c  1.0197E-06 22050.80c  9.7633E-07 26054.80c  2.2042E-06
       26056.80c  3.4601E-05 26057.80c  7.9910E-07 26058.80c  1.0635E-07
c
c Plexiglas
m10      1001.80c  5.6775E-02  1002.80c  6.5299E-06  6000.80c  3.5489E-02       $ Plexiglas 1.0647E-01
1.18
        8016.80c  1.4196E-02
c
c Cadmium
m11      48106.80c  5.7913E-04 48108.80c  4.1234E-04 48110.80c  5.7866E-03       $ Cadmium 4.6330E-
02   8.648
       48111.80c  5.9302E-03 48112.80c  1.1179E-02 48113.80c  5.6615E-03
       48114.80c  1.3311E-02 48116.80c  3.4701E-03
```

TREAT Hole 11 Open

```
TREAT input Half Slotted Core. Flux Wire, 100k particles/cycle
c 10/15/14 revised fuel chamfer planes 39/40/41/42 for 0.612 in
c increase kcode from 1e4 to 3e4 particles/cycle and from 320 to 640 cycles
c 10/28/14 revised fuel/reflector chamfer planes 173/174/175/176 for 0.605 in
c 10/29/14 added flux wire tallies and write mctal
c 10/30/14 revised north viewing port, cells 1001/1100/1101
c 11/7/14  revised flux wire to L = 60", imp:n=2, 2" segments
c 11/10/14 revised material m9, replaced m2 with m9 (m2 and m9 are duplicates)
c revised material m8 composition and density for consistency with Brittan reference
c
c ***************************************************************************
c *       u=1       Standard Fuel Assembly                        *
c *       u=2       Zircaloy-can Dummy Fuel Assembly              *
c *       u=3       Slotted Assembly WITH NO FUEL                 *
c *       u=4       HALF Assembly full of graphite                *
c *       u=5       HALF Slotted Assembly  WITH NO FUEL           *
c *       u=6       middle slotted assembly                       *
c *       u=21      Transient Control Rods NE                     *
c *       u=22      Transient Control Rods SE                     *
c *       u=23      Transient Control Rods SW                     *
c *       u=24      Transient Control Rods NW                     *
c *       u=31      Control/Shutdown Rods NE                      *
c *       u=32      Control/Shutdown Rods SE                      *
c *       u=33      Control/Shutdown Rods SW                      *
c *       u=34      Control/Shutdown Rods NW                      *
c *       u=41      Compensation/Shutdown Rods NE                 *
c *       u=42      Compensation/Shutdown Rods SE                 *
c *       u=43      Compensation/Shutdown Rods SW                 *
c *       u=44      Compensation/Shutdown Rods NW                 *
c ***************************************************************************
c
```

```
c
c ******************************************************************************
c *****************************Cell Cards*************************************
c ******************************************************************************
c
c ==== Standard Fuel Assembly =====
18 1  8.62668E-02   35 -36 37 -38 39 -40 -41 42          -44 45         u=1   $ fuel  used as source
                 imp:n=1
107 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=21 $ fuel              (fuel part)
                 imp:n=1
147 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=22 $ fuel              (fuel part)
                 imp:n=1
187 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=23 $ fuel              (fuel part)
                 imp:n=1
227 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=24 $ fuel              (fuel part)
                 imp:n=1
307 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=31 $ fuel              (fuel part)
                 imp:n=1
347 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=32 $ fuel              (fuel part)
                 imp:n=1
387 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=33 $ fuel              (fuel part)
                 imp:n=1
427 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=34 $ fuel              (fuel part)
                 imp:n=1
507 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=41 $ fuel              (fuel part)
                 imp:n=1
547 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=42 $ fuel              (fuel part)
                 imp:n=1
587 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=43 $ fuel              (fuel part)
                 imp:n=1
627 1  8.62668E-02  35 -36 37 -38 39 -40 -41 42       -44 45 51        u=44 $ fuel              (fuel part)
                 imp:n=1
9990  0   -2 1  -3 4  -10 9  lat=1 u=90
              fill=0:18 0:18 0:0
c     A  B  C  D  E  F  G  H  I  J  K  L  M  N  O  P  Q  R  S
      2  2  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  2  2              $ 19
      2  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  2              $ 18
      1  1  1  1  1  1  1 32  1  1  1 33  1  1  1  1  1  1  1              $ 17
      1  1  1  1  1 32  1  1  1  1  1  1  1 33  1  1  1  1  1              $ 16
      1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1              $ 15
      1  1  1 22  1  1  1  1  1  1  1  1  1  1  1 23  1  1  1              $ 14
      1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1              $ 13
      1  1 22  1  1 42  1  1  1  1  1  1  1 43  1  1 23  1  1              $ 12
      1  1  1  1  1  1  1  1  1  4  1  1  1  1  1  1  1  1  1              $ 11
      1  1  1  1  1  1  1  1  1  6  1  1  1  1  1  1  1  1  1              $ 10
      1  1  1  1  1  1  1  1  1  5  1  1  1  1  1  1  1  1  1              $ 9
      1  1 21  1  1 41  1  1  1  3  1  1  1 44  1  1 24  1  1              $ 8
      1  1  1  1  1  1  1  1  1  3  1  1  1  1  1  1  1  1  1              $ 7
      1  1  1 21  1  1  1  1  1  3  1  1  1  1  1 24  1  1  1              $ 6
      1  1  1  1  1  1  1  1  1  3  1  1  1  1  1  1  1  1  1              $ 5
      1  1  1  1  1 31  1  1  1  3  1  1  1 34  1  1  1  1  1              $ 4
      1  1  1  1  1  1  1 31  1  3  1 34  1  1  1  1  1  1  1              $ 3
      2  1  1  1  1  1  1  1  1  3  1  1  1  1  1  1  1  1  2              $ 2
      2  2  1  1  1  1  1  1  1  3  1  1  1  1  1  1  1  2  2              $ 1
c     A  B  C  D  E  F  G  H  I  J  K  L  M  N  O  P  Q  R  S
                 imp:n=1
```

```
c
c
9991 0         5 -6   7  -8   9  -10
               78
               (-133:134: 147: -148) fill=90
               fill=90
                imp:n=1
11 4  8.36732E-02  (165 -166 167 -168 173 -174 -175
                176 (153 :154) 163 164)
               :(153 163 -164 169 -170 171 -172)          u=1   $ graphite reflector (up part)
                imp:n=1
12 3  9.69364E-05  43 -153 -154                            u=1   $ out gas tube
                imp:n=1
13 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
               ((63 -64 65 -66 59 -60 -61 62 163):
               (63 -64 65 -66 59 -60 -61 62 -56 -177)):
               (163 -164 165 -166 167 -168 59 -60 -61 62
               (-169: 170: -171: 172):
               (178 -177 165 -166 167 -168 59 -60 -61 62
               (-169: 170: -171: 172)))                    u=1
                imp:n=1
14 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
               19 -22 23 -26 27 -28 -29 30  43):
               (43 -163 153 59 -60 -61 62 63 -64 65 -66)     u=1   $ Al-2 alloy      (up part)
                imp:n=1
15 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30)    43      u=1   $ air gap        (up part)
                imp:n=1
c --
16 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30      -43 44      u=1   $ Zr-alloy        Upper Zr-3 spacer
                imp:n=1
17 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -43 44      u=1   $ air gap         Upper Zr-3 spacer
                imp:n=1
c --
19 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                  19 -22 23 -26 27 -28 -29 30     -44 45      u=1   $ Zr-3 alloy      (fuel part)
                imp:n=1
20 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45      u=1   $ air gap         (fuel part)
                imp:n=1
21 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                20 -21 24 -25 31 -32 -33 34       -44 45      u=1   $ air around fuel
                imp:n=1
c --
22 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30      -45 46      u=1   $ Zr-alloy        Lower Zr-3 spacer
                imp:n=1
23 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45 46      u=1   $ air gap         Lower Zr-3
spacer
                imp:n=1
c --
24 4  8.36732E-02  (165 -166 167 -168 173 -174 -175 176 -178):
               (178 -177 169 -170 171 -172)                u=1   $ graphite reflector (down part)
                imp:n=1
25 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                19 -22 23 -26 27 -28 -29 30 -46):
                (23 -26 -46 177 59 -60 -61 62 63 -64)        u=1   $ Al-2 alloy      (down part)
                imp:n=1
26 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30)    -46      u=1   $ air gap         (down part)
```

```
                 imp:n=1
c ---------------------------------------------------------------------------------------------------
c
c =========================== Transient Control Rod NE ========================
101 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                 (153 :154) 163 164)
                 :(153 163 -164 169 -170 171 -172))       51        u=21 $ graphite reflector (up part)
                 imp:n=1
102 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                ((63 -64 65 -66 59 -60 -61 62 163):
                (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                (163 -164 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172):
                (178 -177 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172)))                          u=21
                 imp:n=1
103 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=21
                 imp:n=1
104 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=21
                 imp:n=1
105 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30  43):
                 (43 -163 51 59 -60 -61 62 63 -64 65 -66)           u=21 $ Al-2 alloy         (up part)
                 imp:n=1
106 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=21 $ air gap           (up part)
                 imp:n=1
c --
108 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                    19 -22 23 -26 27 -28 -29 30      -44 45        u=21 $ Zr-3 alloy         (fuel part)
                 imp:n=1
109 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=21 $ air gap           (fuel part)
                 imp:n=1
110 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                  20 -21 24 -25 31 -32 -33 34        -44 45 51      u=21 $ air around fuel
                 imp:n=1
c --
111 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                 (178 -177 169 -170 171 -172)) 51                   u=21 $ graphite reflector (down part)
                 imp:n=1
112 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                  19 -22 23 -26 27 -28 -29 30 -46):
                  (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=21 $ Al-alloy          (down part)
                 imp:n=1
113 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=21 $ air gap           (down part)
                 imp:n=1
114 3  9.69364E-05  50 -51                                       u=21
                 imp:n=1
115 8  4.3185E-02   49 -50  -44 45                               u=21 $ Zr-2 guide tube
                 imp:n=1
116 5  5.99145E-02  (49 -50 -45):(49 -50 44)                            u=21
                 imp:n=1
117 3  9.69364E-05  48 -49                                       u=21
                 imp:n=1
c - Rod surfaces ---
c
118 7  8.58601E-02  47 -48     115 -113                             u=21 $ carbon steel
```

```
                  trcl=21
                   imp:n=1
119 8  4.3185E-02   47 -48     -116  118                            u=21 $ Zr-2 guide tube
                  trcl=21
                   imp:n=1
120 7  8.58601E-02  47 -48     -118                               u=21
                  trcl=21
                   imp:n=1
121 6  8.71910E-02 -47  52    -113                                u=21 $ poison
                  trcl=21
                   imp:n=1
122 4  8.36732E-02 -47 -116   108                                 u=21 $ graphite follower
                  trcl=21
                   imp:n=1
123 3  9.69364E-05 -48 120                                      u=21
                  trcl=21
                   imp:n=1
124 7  8.58601E-02 -47 -52     115                                u=21 $ carbon steel
                  trcl=21
                   imp:n=1
125 8  4.3185E-02  -115 116 -48 117                                 u=21 $ upper part of Zr follower (with plug)
                  trcl=21
                   imp:n=1
126 7  8.58601E-02 -115 116 -117                                   u=21 $ ss plug
                  trcl=21
                   imp:n=1
127 8  4.3185E-02  -108 118 -47 117                                 u=21
                  trcl=21
                   imp:n=1
128 7  8.58601E-02 -108 118 -117                                   u=21
                  trcl=21
                   imp:n=1
129 7  8.58601E-02 -47 -118  119                                  u=21
                  trcl=21
                   imp:n=1
130 4  8.36732E-02 -47 -118 -119                                  u=21
                  trcl=21
                   imp:n=1
131 7  8.58601E-02 -48  113 -120                                  u=21
                  trcl=21
                   imp:n=1
c
c ---------------------------------------------------------------------------------------------------
c
c =========================== Transient Control Rod SE =======================
141 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                   (153 :154) 163 164)
                   :(153 163 -164 169 -170 171 -172))       51        u=22 $ graphite reflector (up part)
                   imp:n=1
142 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                  ((63 -64 65 -66 59 -60 -61 62 163):
                  (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                  (163 -164 165 -166 167 -168 59 -60 -61 62
                  (-169: 170: -171: 172):
                  (178 -177 165 -166 167 -168 59 -60 -61 62
                  (-169: 170: -171: 172)))                           u=22
```

```
               imp:n=1
143 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=22
               imp:n=1
144 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=22
               imp:n=1
145 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
               19 -22 23 -26 27 -28 -29 30  43):
               (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=22 $ Al-2 alloy        (up part)
               imp:n=1
146 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51         u=22 $ air gap           (up part)
               imp:n=1
c --
148 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                  19 -22 23 -26 27 -28 -29 30      -44 45        u=22 $ Zr-3 alloy         (fuel part)
               imp:n=1
149 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=22 $ air gap           (fuel part)
               imp:n=1
150 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                20 -21 24 -25 31 -32 -33 34        -44 45 51      u=22 $ air around fuel
               imp:n=1
c --
151 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
               (178 -177 169 -170 171 -172)) 51                  u=22 $ graphite reflector (down part)
               imp:n=1
152 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                19 -22 23 -26 27 -28 -29 30 -46):
                (23 -26 -46 177 59 -60 -61 62 63 -64)) 51       u=22 $ Al-alloy          (down part)
               imp:n=1
153 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51       u=22 $ air gap           (down part)
               imp:n=1
154 3  9.69364E-05  50 -51                                    u=22
               imp:n=1
155 8  4.3185E-02   49 -50  -44 45                              u=22 $ Zr-2 guide tube
               imp:n=1
156 5  5.99145E-02  (49 -50 -45):(49 -50 44)                         u=22
               imp:n=1
157 3  9.69364E-05  48 -49                                    u=22
               imp:n=1
c - Rod surfaces ---
c
158 7  8.58601E-02  47 -48     115 -113                             u=22 $ carbon steel
              trcl=22
               imp:n=1
159 8  4.3185E-02   47 -48     -116  118                           u=22 $ Zr-2 guide tube
              trcl=22
               imp:n=1
160 7  8.58601E-02  47 -48     -118                              u=22
              trcl=22
               imp:n=1
161 6  8.71910E-02 -47  52    -113                               u=22 $ poison
              trcl=22
               imp:n=1
162 4  8.36732E-02 -47 -116   108                                u=22 $ graphite follower
              trcl=22
               imp:n=1
163 3  9.69364E-05 -48 120                                     u=22
```

```
                trcl=22
                 imp:n=1
164 7  8.58601E-02 -47 -52     115                              u=22 $ carbon steel
                trcl=22
                 imp:n=1
165 8  4.3185E-02  -115 116 -48 117                             u=22 $ upper part of Zr follower (with plug)
                trcl=22
                 imp:n=1
166 7  8.58601E-02 -115 116 -117                                u=22 $ ss plug
                trcl=22
                 imp:n=1
167 8  4.3185E-02  -108 118 -47 117                             u=22
                trcl=22
                 imp:n=1
168 7  8.58601E-02 -108 118 -117                                u=22
                trcl=22
                 imp:n=1
169 7  8.58601E-02 -47 -118  119                                u=22
                trcl=22
                 imp:n=1
170 4  8.36732E-02 -47 -118 -119                                u=22
                trcl=22
                 imp:n=1
171 7  8.58601E-02 -48  113 -120                                u=22
                trcl=22
                 imp:n=1
c
c ------------------------------------------------------------------------------------------------
c
c =========================== Transient Control Rod SW =======================
181 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                 (153 :154) 163 164)
                 :(153 163 -164 169 -170 171 -172))      51       u=23 $ graphite reflector (up part)
                 imp:n=1
182 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                ((63 -64 65 -66 59 -60 -61 62 163):
                (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                (163 -164 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172):
                (178 -177 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172)))                        u=23
                 imp:n=1
183 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30       -43 44 51      u=23
                 imp:n=1
184 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30       -45 46 51      u=23
                 imp:n=1
185 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30  43):
                 (43 -163 51 59 -60 -61 62 63 -64 65 -66)         u=23 $ Al-2 alloy        (up part)
                 imp:n=1
186 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51         u=23 $ air gap          (up part)
                 imp:n=1
c --
188 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                    19 -22 23 -26 27 -28 -29 30      -44 45       u=23 $ Zr-3 alloy        (fuel part)
                 imp:n=1
```

```
189 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=23 $ air gap           (fuel part)
                    imp:n=1
190 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                     20 -21 24 -25 31 -32 -33 34        -44 45 51      u=23 $ air around fuel
                    imp:n=1
c --
191 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                    (178 -177 169 -170 171 -172)) 51                  u=23 $ graphite reflector (down part)
                    imp:n=1
192 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                      19 -22 23 -26 27 -28 -29 30 -46):
                      (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=23 $ Al-alloy          (down part)
                    imp:n=1
193 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=23 $ air gap           (down part)
                    imp:n=1
194 3  9.69364E-05  50 -51                                          u=23
                    imp:n=1
195 8  4.3185E-02   49 -50  -44 45                                    u=23 $ Zr-2 guide tube
                    imp:n=1
196 5  5.99145E-02  (49 -50 -45):(49 -50 44)                           u=23
                    imp:n=1
197 3  9.69364E-05  48 -49                                          u=23
                    imp:n=1
c - Rod surfaces ---
c
198 7  8.58601E-02  47 -48     115 -113                               u=23 $ carbon steel
                   trcl=23
                    imp:n=1
199 8  4.3185E-02   47 -48     -116  118                              u=23 $ Zr-2 guide tube
                   trcl=23
                    imp:n=1
200 7  8.58601E-02  47 -48     -118                                   u=23
                   trcl=23
                    imp:n=1
201 6  8.71910E-02 -47  52    -113                                    u=23 $ poison
                   trcl=23
                    imp:n=1
202 4  8.36732E-02 -47 -116   108                                     u=23 $ graphite follower
                   trcl=23
                    imp:n=1
203 3  9.69364E-05 -48 120                                          u=23
                   trcl=23
                    imp:n=1
204 7  8.58601E-02 -47 -52     115                                    u=23 $ carbon steel
                   trcl=23
                    imp:n=1
205 8  4.3185E-02  -115 116 -48 117                                   u=23 $ upper part of Zr follower (with plug)
                   trcl=23
                    imp:n=1
206 7  8.58601E-02 -115 116 -117                                      u=23 $ ss plug
                   trcl=23
                    imp:n=1
207 8  4.3185E-02  -108 118 -47 117                                   u=23
                   trcl=23
                    imp:n=1
208 7  8.58601E-02 -108 118 -117                                      u=23
```

```
              trcl=23
               imp:n=1
209 7  8.58601E-02 -47 -118  119                              u=23
              trcl=23
               imp:n=1
210 4  8.36732E-02 -47 -118 -119                              u=23
              trcl=23
               imp:n=1
211 7  8.58601E-02 -48  113 -120                              u=23
              trcl=23
               imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c ========================== Transient Control Rod NW ======================
221 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
               (153 :154) 163 164)
               :(153 163 -164 169 -170 171 -172))       51        u=24 $ graphite reflector (up part)
               imp:n=1
222 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
              ((63 -64 65 -66 59 -60 -61 62 163):
              (63 -64 65 -66 59 -60 -61 62 -56 -177)):
              (163 -164 165 -166 167 -168 59 -60 -61 62
              (-169: 170: -171: 172):
              (178 -177 165 -166 167 -168 59 -60 -61 62
              (-169: 170: -171: 172)))                          u=24
               imp:n=1
223 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=24
               imp:n=1
224 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=24
               imp:n=1
225 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
               19 -22 23 -26 27 -28 -29 30  43):
               (43 -163 51 59 -60 -61 62 63 -64 65 -66)           u=24 $ Al-2 alloy        (up part)
               imp:n=1
226 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=24 $ air gap           (up part)
               imp:n=1
c --
228 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                   19 -22 23 -26 27 -28 -29 30      -44 45        u=24 $ Zr-3 alloy        (fuel part)
               imp:n=1
229 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=24 $ air gap           (fuel part)
               imp:n=1
230 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                20 -21 24 -25 31 -32 -33 34        -44 45 51      u=24 $ air around fuel
               imp:n=1
c --
231 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
               (178 -177 169 -170 171 -172)) 51                  u=24 $ graphite reflector (down part)
               imp:n=1
232 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30 -46):
                 (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=24 $ Al-alloy          (down part)
               imp:n=1
233 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=24 $ air gap           (down part)
               imp:n=1
```

```
234 3  9.69364E-05  50 -51                                u=24
                 imp:n=1
235 8  4.3185E-02   49 -50  -44 45                          u=24 $ Zr-2 guide tube
                 imp:n=1
236 5  5.99145E-02  (49 -50 -45):(49 -50 44)                    u=24
                 imp:n=1
237 3  9.69364E-05  48 -49                                u=24
                 imp:n=1
c - Rod surfaces ---
c
238 7  8.58601E-02  47 -48     115 -113                        u=24 $ carbon steel
                trcl=24
                 imp:n=1
239 8  4.3185E-02   47 -48     -116  118                      u=24 $ Zr-2 guide tube
                trcl=24
                 imp:n=1
240 7  8.58601E-02  47 -48     -118                          u=24
                trcl=24
                 imp:n=1
241 6  8.71910E-02 -47  52    -113                          u=24 $ poison
                trcl=24
                 imp:n=1
242 4  8.36732E-02 -47 -116   108                           u=24 $ graphite follower
                trcl=24
                 imp:n=1
243 3  9.69364E-05 -48 120                                u=24
                trcl=24
                 imp:n=1
244 7  8.58601E-02 -47 -52     115                          u=24 $ carbon steel
                trcl=24
                 imp:n=1
245 8  4.3185E-02  -115 116 -48 117                          u=24 $ upper part of Zr follower (with plug)
                trcl=24
                 imp:n=1
246 7  8.58601E-02 -115 116 -117                            u=24 $ ss plug
                trcl=24
                 imp:n=1
247 8  4.3185E-02  -108 118 -47 117                          u=24
                trcl=24
                 imp:n=1
248 7  8.58601E-02 -108 118 -117                            u=24
                trcl=24
                 imp:n=1
249 7  8.58601E-02 -47 -118  119                            u=24
                trcl=24
                 imp:n=1
250 4  8.36732E-02 -47 -118 -119                            u=24
                trcl=24
                 imp:n=1
251 7  8.58601E-02 -48  113 -120                            u=24
                trcl=24
                 imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c =========================== Control/Shutdown Rod NE =======================
```

```
301 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                    (153 :154) 163 164)
                    :(153 163 -164 169 -170 171 -172))       51        u=31 $ graphite reflector (up part)
                    imp:n=1
302 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                   ((63 -64 65 -66 59 -60 -61 62 163):
                   (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                   (163 -164 165 -166 167 -168 59 -60 -61 62
                   (-169: 170: -171: 172):
                   (178 -177 165 -166 167 -168 59 -60 -61 62
                   (-169: 170: -171: 172)))                          u=31
                    imp:n=1
303 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=31
                    imp:n=1
304 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=31
                    imp:n=1
305 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                    19 -22 23 -26 27 -28 -29 30  43):
                    (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=31 $ Al-2 alloy         (up part)
                    imp:n=1
306 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=31 $ air gap            (up part)
                    imp:n=1
c --
308 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                        19 -22 23 -26 27 -28 -29 30      -44 45        u=31 $ Zr-3 alloy         (fuel part)
                    imp:n=1
309 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=31 $ air gap            (fuel part)
                    imp:n=1
310 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                     20 -21 24 -25 31 -32 -33 34        -44 45 51      u=31 $ air around fuel
                    imp:n=1
c --
311 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                    (178 -177 169 -170 171 -172)) 51                  u=31 $ graphite reflector (down part)
                    imp:n=1
312 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                      19 -22 23 -26 27 -28 -29 30 -46):
                      (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=31 $ Al-alloy           (down part)
                    imp:n=1
313 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=31 $ air gap            (down part)
                    imp:n=1
314 3  9.69364E-05  50 -51                                     u=31
                    imp:n=1
315 8  4.3185E-02   49 -50  -44 45                               u=31 $ Zr-2 guide tube
                    imp:n=1
316 5  5.99145E-02  (49 -50 -45):(49 -50 44)                         u=31
                    imp:n=1
317 3  9.69364E-05  48 -49                                     u=31
                    imp:n=1
c - Rod surfaces ---
c
318 7  8.58601E-02  47 -48     122 -114                           u=31 $ carbon steel
                   trcl=31
                    imp:n=1
319 8  4.3185E-02   47 -48     -123  105                          u=31 $ Zr-2 guide tube
                   trcl=31
```

```
                  imp:n=1
320 7  8.58601E-02  47 -48     -105                              u=31
                 trcl=31
                  imp:n=1
321 6  8.71910E-02 -47  104   -114                               u=31 $ poison
                 trcl=31
                  imp:n=1
322 4  8.36732E-02 -47 -123    125                               u=31 $ graphite follower
                 trcl=31
                  imp:n=1
323 3  9.69364E-05 -48 121                                     u=31
                 trcl=31
                  imp:n=1
324 7  8.58601E-02 -47 -104 122                                  u=31 $ carbon steel
                 trcl=31
                  imp:n=1
325 8  4.3185E-02  -122 123 -48 117                               u=31 $ upper part of Zr follower (with plug)
                 trcl=31
                  imp:n=1
326 7  8.58601E-02 -122 123 -117                                 u=31 $ ss plug
                 trcl=31
                  imp:n=1
327 8  4.3185E-02  105 -125 -47 117                               u=31
                 trcl=31
                  imp:n=1
328 7  8.58601E-02 105 -125 -117                                 u=31
                 trcl=31
                  imp:n=1
329 7  8.58601E-02 -47 -105 126                                  u=31
                 trcl=31
                  imp:n=1
330 4  8.36732E-02 -47 -126                                    u=31
                 trcl=31
                  imp:n=1
331 7  8.58601E-02 -48  114 -121                                 u=31
                 trcl=31
                  imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c =========================== Control/Shutdown Rod SE =======================
341 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                  (153 :154) 163 164)
                  :(153 163 -164 169 -170 171 -172))       51        u=32 $ graphite reflector (up part)
                  imp:n=1
342 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                 ((63 -64 65 -66 59 -60 -61 62 163):
                 (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                 (163 -164 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172):
                 (178 -177 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172)))                       u=32
                  imp:n=1
343 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=32
                  imp:n=1
344 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=32
```

```
                 imp:n=1
345 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30  43):
                 (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=32 $ Al-2 alloy        (up part)
                 imp:n=1
346 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51         u=32 $ air gap           (up part)
                 imp:n=1
c --
348 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                    19 -22 23 -26 27 -28 -29 30      -44 45        u=32 $ Zr-3 alloy        (fuel part)
                 imp:n=1
349 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=32 $ air gap           (fuel part)
                 imp:n=1
350 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                  20 -21 24 -25 31 -32 -33 34        -44 45 51      u=32 $ air around fuel
                 imp:n=1
c --
351 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                 (178 -177 169 -170 171 -172)) 51                  u=32 $ graphite reflector (down part)
                 imp:n=1
352 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                   19 -22 23 -26 27 -28 -29 30 -46):
                   (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=32 $ Al-alloy          (down part)
                 imp:n=1
353 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=32 $ air gap           (down part)
                 imp:n=1
354 3  9.69364E-05  50 -51                                 u=32
                 imp:n=1
355 8  4.3185E-02   49 -50  -44 45                           u=32 $ Zr-2 guide tube
                 imp:n=1
356 5  5.99145E-02  (49 -50 -45):(49 -50 44)                       u=32
                 imp:n=1
357 3  9.69364E-05  48 -49                                 u=32
                 imp:n=1
c - Rod surfaces ---
c
358 7  8.58601E-02  47 -48     122 -114                          u=32 $ carbon steel
                trcl=32
                 imp:n=1
359 8  4.3185E-02   47 -48     -123  105                         u=32 $ Zr-2 guide tube
                trcl=32
                 imp:n=1
360 7  8.58601E-02  47 -48     -105                            u=32
                trcl=32
                 imp:n=1
361 6  8.71910E-02 -47  104   -114                             u=32 $ poison
                trcl=32
                 imp:n=1
362 4  8.36732E-02 -47 -123    125                             u=32 $ graphite follower
                trcl=32
                 imp:n=1
363 3  9.69364E-05 -48 121                                 u=32
                trcl=32
                 imp:n=1
364 7  8.58601E-02 -47 -104 122                              u=32 $ carbon steel
                trcl=32
```

```
              imp:n=1
365 8  4.3185E-02  -122 123 -48 117                    u=32 $ upper part of Zr follower (with plug)
              trcl=32
              imp:n=1
366 7  8.58601E-02 -122 123 -117                       u=32 $ ss plug
              trcl=32
              imp:n=1
367 8  4.3185E-02  105 -125 -47 117                    u=32
              trcl=32
              imp:n=1
368 7  8.58601E-02 105 -125 -117                       u=32
              trcl=32
              imp:n=1
369 7  8.58601E-02 -47 -105 126                        u=32
              trcl=32
              imp:n=1
370 4  8.36732E-02 -47 -126                            u=32
              trcl=32
              imp:n=1
371 7  8.58601E-02 -48  114 -121                       u=32
              trcl=32
              imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c ========================== Control/Shutdown Rod SW ======================
381 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
              (153 :154) 163 164)
              :(153 163 -164 169 -170 171 -172))     51      u=33 $ graphite reflector (up part)
              imp:n=1
382 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
              ((63 -64 65 -66 59 -60 -61 62 163):
              (63 -64 65 -66 59 -60 -61 62 -56 -177)):
              (163 -164 165 -166 167 -168 59 -60 -61 62
              (-169: 170: -171: 172):
              (178 -177 165 -166 167 -168 59 -60 -61 62
              (-169: 170: -171: 172)))                 u=33
              imp:n=1
383 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30      -43 44 51     u=33
              imp:n=1
384 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30      -45 46 51     u=33
              imp:n=1
385 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
              19 -22 23 -26 27 -28 -29 30  43):
              (43 -163 51 59 -60 -61 62 63 -64 65 -66)      u=33 $ Al-2 alloy      (up part)
              imp:n=1
386 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51      u=33 $ air gap       (up part)
              imp:n=1
c --
388 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                  19 -22 23 -26 27 -28 -29 30     -44 45      u=33 $ Zr-3 alloy      (fuel part)
              imp:n=1
389 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51     u=33 $ air gap       (fuel part)
              imp:n=1
390 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
               20 -21 24 -25 31 -32 -33 34      -44 45 51     u=33 $ air around fuel
```

```
                   imp:n=1
c --
391 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                   (178 -177 169 -170 171 -172)) 51                  u=33 $ graphite reflector (down part)
                   imp:n=1
392 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                     19 -22 23 -26 27 -28 -29 30 -46):
                     (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=33 $ Al-alloy          (down part)
                   imp:n=1
393 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=33 $ air gap           (down part)
                   imp:n=1
394 3  9.69364E-05  50 -51                                   u=33
                   imp:n=1
395 8  4.3185E-02   49 -50  -44 45                               u=33 $ Zr-2 guide tube
                   imp:n=1
396 5  5.99145E-02  (49 -50 -45):(49 -50 44)                          u=33
                   imp:n=1
397 3  9.69364E-05  48 -49                                   u=33
                   imp:n=1
c - Rod surfaces ---
c
398 7  8.58601E-02  47 -48     122 -114                            u=33 $ carbon steel
                  trcl=33
                   imp:n=1
399 8  4.3185E-02   47 -48     -123  105                           u=33 $ Zr-2 guide tube
                  trcl=33
                   imp:n=1
400 7  8.58601E-02  47 -48     -105                               u=33
                  trcl=33
                   imp:n=1
401 6  8.71910E-02 -47  104   -114                               u=33 $ poison
                  trcl=33
                   imp:n=1
402 4  8.36732E-02 -47 -123    125                               u=33 $ graphite follower
                  trcl=33
                   imp:n=1
403 3  9.69364E-05 -48 121                                  u=33
                  trcl=33
                   imp:n=1
404 7  8.58601E-02 -47 -104 122                               u=33 $ carbon steel
                  trcl=33
                   imp:n=1
405 8  4.3185E-02  -122 123 -48 117                             u=33 $ upper part of Zr follower (with plug)
                  trcl=33
                   imp:n=1
406 7  8.58601E-02 -122 123 -117                              u=33 $ ss plug
                  trcl=33
                   imp:n=1
407 8  4.3185E-02  105 -125 -47 117                             u=33
                  trcl=33
                   imp:n=1
408 7  8.58601E-02 105 -125 -117                              u=33
                  trcl=33
                   imp:n=1
409 7  8.58601E-02 -47 -105 126                               u=33
                  trcl=33
```

```
                 imp:n=1
410 4  8.36732E-02 -47 -126                                    u=33
                trcl=33
                 imp:n=1
411 7  8.58601E-02 -48  114 -121                                 u=33
                trcl=33
                 imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c =========================== Control/Shutdown Rod NW =======================
421 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                 (153 :154) 163 164)
                 :(153 163 -164 169 -170 171 -172))       51        u=34 $ graphite reflector (up part)
                 imp:n=1
422 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                ((63 -64 65 -66 59 -60 -61 62 163):
                (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                (163 -164 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172):
                (178 -177 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172)))                          u=34
                 imp:n=1
423 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=34
                 imp:n=1
424 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=34
                 imp:n=1
425 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30  43):
                 (43 -163 51 59 -60 -61 62 63 -64 65 -66)           u=34 $ Al-2 alloy        (up part)
                 imp:n=1
426 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=34 $ air gap           (up part)
                 imp:n=1
c --
428 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                    19 -22 23 -26 27 -28 -29 30      -44 45        u=34 $ Zr-3 alloy        (fuel part)
                 imp:n=1
429 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=34 $ air gap           (fuel part)
                 imp:n=1
430 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                  20 -21 24 -25 31 -32 -33 34        -44 45 51      u=34 $ air around fuel
                 imp:n=1
c --
431 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                 (178 -177 169 -170 171 -172)) 51                  u=34 $ graphite reflector (down part)
                 imp:n=1
432 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                   19 -22 23 -26 27 -28 -29 30 -46):
                   (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=34 $ Al-alloy          (down part)
                 imp:n=1
433 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=34 $ air gap           (down part)
                 imp:n=1
434 3  9.69364E-05  50 -51                                      u=34
                 imp:n=1
435 8  4.3185E-02   49 -50  -44 45                                 u=34 $ Zr-2 guide tube
                 imp:n=1
```

```
436 5  5.99145E-02  (49 -50 -45):(49 -50 44)                         u=34
                   imp:n=1
437 3  9.69364E-05  48 -49                                       u=34
                   imp:n=1
c - Rod surfaces ---
c
438 7  8.58601E-02  47 -48     122 -114                           u=34 $ carbon steel
                  trcl=34
                   imp:n=1
439 8  4.3185E-02   47 -48     -123  105                          u=34 $ Zr-2 guide tube
                  trcl=34
                   imp:n=1
440 7  8.58601E-02  47 -48     -105                             u=34
                  trcl=34
                   imp:n=1
441 6  8.71910E-02 -47  104   -114                              u=34 $ poison
                  trcl=34
                   imp:n=1
442 4  8.36732E-02 -47 -123    125                              u=34 $ graphite follower
                  trcl=34
                   imp:n=1
443 3  9.69364E-05 -48 121                                      u=34
                  trcl=34
                   imp:n=1
444 7  8.58601E-02 -47 -104 122                                 u=34 $ carbon steel
                  trcl=34
                   imp:n=1
445 8  4.3185E-02  -122 123 -48 117                              u=34 $ upper part of Zr follower (with plug)
                  trcl=34
                   imp:n=1
446 7  8.58601E-02 -122 123 -117                                u=34 $ ss plug
                  trcl=34
                   imp:n=1
447 8  4.3185E-02  105 -125 -47 117                              u=34
                  trcl=34
                   imp:n=1
448 7  8.58601E-02 105 -125 -117                                u=34
                  trcl=34
                   imp:n=1
449 7  8.58601E-02 -47 -105 126                                 u=34
                  trcl=34
                   imp:n=1
450 4  8.36732E-02 -47 -126                                    u=34
                  trcl=34
                   imp:n=1
451 7  8.58601E-02 -48  114 -121                                u=34
                  trcl=34
                   imp:n=1
c
c ------------------------------------------------------------------------------------------------
c
c ------------------------------------------------------------------------------------------------
c
c =========================== Compensation/Shutdown Rod NE
=====================
501 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
```

```
                 (153 :154) 163 164)
                 :(153 163 -164 169 -170 171 -172))      51        u=41 $ graphite reflector (up part)
                 imp:n=1
502 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                ((63 -64 65 -66 59 -60 -61 62 163):
                (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                (163 -164 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172):
                (178 -177 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172)))                        u=41
                 imp:n=1
503 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=41
                 imp:n=1
504 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=41
                 imp:n=1
505 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                 19 -22 23 -26 27 -28 -29 30  43):
                 (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=41 $ Al-2 alloy        (up part)
                 imp:n=1
506 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=41 $ air gap           (up part)
                 imp:n=1
c --
508 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                    19 -22 23 -26 27 -28 -29 30      -44 45       u=41 $ Zr-3 alloy        (fuel part)
                 imp:n=1
509 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=41 $ air gap           (fuel part)
                 imp:n=1
510 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                  20 -21 24 -25 31 -32 -33 34        -44 45 51      u=41 $ air around fuel
                 imp:n=1
c --
511 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                 (178 -177 169 -170 171 -172)) 51                   u=41 $ graphite reflector (down part)
                 imp:n=1
512 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                   19 -22 23 -26 27 -28 -29 30 -46):
                   (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=41 $ Al-alloy          (down part)
                 imp:n=1
513 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=41 $ air gap           (down part)
                 imp:n=1
514 3  9.69364E-05  50 -51                                       u=41
                 imp:n=1
515 8  4.3185E-02   49 -50  -44 45                                  u=41 $ Zr-2 guide tube
                 imp:n=1
516 5  5.99145E-02  (49 -50 -45):(49 -50 44)                            u=41
                 imp:n=1
517 3  9.69364E-05  48 -49                                       u=41
                 imp:n=1
c - Rod surfaces ---
c
518 7  8.58601E-02  47 -48     122 -114                              u=41 $ carbon steel
                trcl=41
                 imp:n=1
519 8  4.3185E-02   47 -48     -123  105                             u=41 $ Zr-2 guide tube
                trcl=41
                 imp:n=1
```

```
520 7  8.58601E-02  47 -48     -105                              u=41
                 trcl=41
                  imp:n=1
521 6  8.71910E-02 -47  104   -114                               u=41 $ poison
                 trcl=41
                  imp:n=1
522 4  8.36732E-02 -47 -123    125                               u=41 $ graphite follower
                 trcl=41
                  imp:n=1
523 3  9.69364E-05 -48 121                                     u=41
                 trcl=41
                  imp:n=1
524 7  8.58601E-02 -47 -104 122                                  u=41 $ carbon steel
                 trcl=41
                  imp:n=1
525 8  4.3185E-02  -122 123 -48 117                                u=41 $ upper part of Zr follower (with plug)
                 trcl=41
                  imp:n=1
526 7  8.58601E-02 -122 123 -117                                  u=41 $ ss plug
                 trcl=41
                  imp:n=1
527 8  4.3185E-02  105 -125 -47 117                                u=41
                 trcl=41
                  imp:n=1
528 7  8.58601E-02 105 -125 -117                                  u=41
                 trcl=41
                  imp:n=1
529 7  8.58601E-02 -47 -105 126                                  u=41
                 trcl=41
                  imp:n=1
530 4  8.36732E-02 -47 -126                                    u=41
                 trcl=41
                  imp:n=1
531 7  8.58601E-02 -48  114 -121                                 u=41
                 trcl=41
                  imp:n=1
c
c -------------------------------------------------------------------------------------------------
c
c =========================== Compensation/Shutdown Rod SE
======================
541 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                  (153 :154) 163 164)
                  :(153 163 -164 169 -170 171 -172))       51        u=42 $ graphite reflector (up part)
                  imp:n=1
542 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                 ((63 -64 65 -66 59 -60 -61 62 163):
                 (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                 (163 -164 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172):
                 (178 -177 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172)))                     u=42
                  imp:n=1
543 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=42
                  imp:n=1
544 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=42
```

```
                   imp:n=1
545 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                   19 -22 23 -26 27 -28 -29 30  43):
                   (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=42 $ Al-2 alloy        (up part)
                   imp:n=1
546 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=42 $ air gap           (up part)
                   imp:n=1
c --
548 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                      19 -22 23 -26 27 -28 -29 30      -44 45        u=42 $ Zr-3 alloy        (fuel part)
                   imp:n=1
549 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=42 $ air gap           (fuel part)
                   imp:n=1
550 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                    20 -21 24 -25 31 -32 -33 34        -44 45 51      u=42 $ air around fuel
                   imp:n=1
c --
551 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                   (178 -177 169 -170 171 -172)) 51                  u=42 $ graphite reflector (down part)
                   imp:n=1
552 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                     19 -22 23 -26 27 -28 -29 30 -46):
                     (23 -26 -46 177 59 -60 -61 62 63 -64)) 51        u=42 $ Al-alloy          (down part)
                   imp:n=1
553 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51        u=42 $ air gap           (down part)
                   imp:n=1
554 3  9.69364E-05  50 -51                                       u=42
                   imp:n=1
555 8  4.3185E-02   49 -50  -44 45                                 u=42 $ Zr-2 guide tube
                   imp:n=1
556 5  5.99145E-02  (49 -50 -45):(49 -50 44)                           u=42
                   imp:n=1
557 3  9.69364E-05  48 -49                                       u=42
                   imp:n=1
c - Rod surfaces ---
c
558 7  8.58601E-02  47 -48     122 -114                              u=42 $ carbon steel
                  trcl=42
                   imp:n=1
559 8  4.3185E-02   47 -48     -123  105                             u=42 $ Zr-2 guide tube
                  trcl=42
                   imp:n=1
560 7  8.58601E-02  47 -48     -105                                u=42
                  trcl=42
                   imp:n=1
561 6  8.71910E-02 -47  104   -114                                 u=42 $ poison
                  trcl=42
                   imp:n=1
562 4  8.36732E-02 -47 -123    125                                 u=42 $ graphite follower
                  trcl=42
                   imp:n=1
563 3  9.69364E-05 -48 121                                         u=42
                  trcl=42
                   imp:n=1
564 7  8.58601E-02 -47 -104 122                                    u=42 $ carbon steel
                  trcl=42
```

```
                  imp:n=1
565 8  4.3185E-02  -122 123 -48 117                              u=42 $ upper part of Zr follower (with plug)
                 trcl=42
                  imp:n=1
566 7  8.58601E-02 -122 123 -117                                u=42 $ ss plug
                 trcl=42
                  imp:n=1
567 8  4.3185E-02  105 -125 -47 117                              u=42
                 trcl=42
                  imp:n=1
568 7  8.58601E-02 105 -125 -117                                u=42
                 trcl=42
                  imp:n=1
569 7  8.58601E-02 -47 -105 126                                u=42
                 trcl=42
                  imp:n=1
570 4  8.36732E-02 -47 -126                                  u=42
                 trcl=42
                  imp:n=1
571 7  8.58601E-02 -48  114 -121                                u=42
                 trcl=42
                  imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c =========================== Compensation/Shutdown Rod SW
======================
581 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                  (153 :154) 163 164)
                  :(153 163 -164 169 -170 171 -172))       51        u=43 $ graphite reflector (up part)
                  imp:n=1
582 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                 ((63 -64 65 -66 59 -60 -61 62 163):
                 (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                 (163 -164 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172):
                 (178 -177 165 -166 167 -168 59 -60 -61 62
                 (-169: 170: -171: 172)))                          u=43
                  imp:n=1
583 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=43
                  imp:n=1
584 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=43
                  imp:n=1
585 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                  19 -22 23 -26 27 -28 -29 30  43):
                  (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=43 $ Al-2 alloy        (up part)
                  imp:n=1
586 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51          u=43 $ air gap           (up part)
                  imp:n=1
c --
588 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                      19 -22 23 -26 27 -28 -29 30      -44 45        u=43 $ Zr-3 alloy        (fuel part)
                  imp:n=1
589 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=43 $ air gap           (fuel part)
                  imp:n=1
590 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
```

```
                    20 -21 24 -25 31 -32 -33 34        -44 45 51      u=43 $ air around fuel
                   imp:n=1
c --
591 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                   (178 -177 169 -170 171 -172)) 51                  u=43 $ graphite reflector (down part)
                   imp:n=1
592 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                     19 -22 23 -26 27 -28 -29 30 -46):
                     (23 -26 -46 177 59 -60 -61 62 63 -64)) 51       u=43 $ Al-alloy          (down part)
                   imp:n=1
593 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51       u=43 $ air gap           (down part)
                   imp:n=1
594 3  9.69364E-05  50 -51                                    u=43
                   imp:n=1
595 8  4.3185E-02   49 -50  -44 45                              u=43 $ Zr-2 guide tube
                   imp:n=1
596 5  5.99145E-02  (49 -50 -45):(49 -50 44)                          u=43
                   imp:n=1
597 3  9.69364E-05  48 -49                                    u=43
                   imp:n=1
c - Rod surfaces ---
c
598 7  8.58601E-02  47 -48     122 -114                          u=43 $ carbon steel
                  trcl=43
                   imp:n=1
599 8  4.3185E-02   47 -48     -123  105                         u=43 $ Zr-2 guide tube
                  trcl=43
                   imp:n=1
600 7  8.58601E-02  47 -48     -105                            u=43
                  trcl=43
                   imp:n=1
601 6  8.71910E-02 -47  104   -114                              u=43 $ poison
                  trcl=43
                   imp:n=1
602 4  8.36732E-02 -47 -123    125                              u=43 $ graphite follower
                  trcl=43
                   imp:n=1
603 3  9.69364E-05 -48 121                                     u=43
                  trcl=43
                   imp:n=1
604 7  8.58601E-02 -47 -104 122                                u=43 $ carbon steel
                  trcl=43
                   imp:n=1
605 8  4.3185E-02  -122 123 -48 117                             u=43 $ upper part of Zr follower (with plug)
                  trcl=43
                   imp:n=1
606 7  8.58601E-02 -122 123 -117                               u=43 $ ss plug
                  trcl=43
                   imp:n=1
607 8  4.3185E-02  105 -125 -47 117                             u=43
                  trcl=43
                   imp:n=1
608 7  8.58601E-02 105 -125 -117                               u=43
                  trcl=43
                   imp:n=1
609 7  8.58601E-02 -47 -105 126                                u=43
```

```
                  trcl=43
                   imp:n=1
610 4  8.36732E-02 -47 -126                              u=43
                  trcl=43
                   imp:n=1
611 7  8.58601E-02 -48  114 -121                           u=43
                  trcl=43
                   imp:n=1
c
c -----------------------------------------------------------------------------------------------
c
c =========================== Compensation/Shutdown Rod NW
=======================
621 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176
                   (153 :154) 163 164)
                   :(153 163 -164 169 -170 171 -172))      51       u=44 $ graphite reflector (up part)
                   imp:n=1
622 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                  ((63 -64 65 -66 59 -60 -61 62 163):
                  (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                  (163 -164 165 -166 167 -168 59 -60 -61 62
                  (-169: 170: -171: 172):
                  (178 -177 165 -166 167 -168 59 -60 -61 62
                  (-169: 170: -171: 172)))                     u=44
                   imp:n=1
623 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44 51      u=44
                   imp:n=1
624 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46 51      u=44
                   imp:n=1
625 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                   19 -22 23 -26 27 -28 -29 30  43):
                   (43 -163 51 59 -60 -61 62 63 -64 65 -66)          u=44 $ Al-2 alloy        (up part)
                   imp:n=1
626 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) 44 51         u=44 $ air gap           (up part)
                   imp:n=1
c --
628 9  4.31626E-02 (-20 :21 :-24 :25 :-31 :32 :33 :-34)
                       19 -22 23 -26 27 -28 -29 30      -44 45       u=44 $ Zr-3 alloy        (fuel part)
                   imp:n=1
629 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -44 45 51      u=44 $ air gap           (fuel part)
                   imp:n=1
630 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42)
                    20 -21 24 -25 31 -32 -33 34        -44 45 51      u=44 $ air around fuel
                   imp:n=1
c --
631 4  8.36732E-02  ((165 -166 167 -168 173 -174 -175 176 -178):
                   (178 -177 169 -170 171 -172)) 51                  u=44 $ graphite reflector (down part)
                   imp:n=1
632 5  5.99145E-02  (((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                     19 -22 23 -26 27 -28 -29 30 -46):
                     (23 -26 -46 177 59 -60 -61 62 63 -64)) 51       u=44 $ Al-alloy          (down part)
                   imp:n=1
633 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  51       u=44 $ air gap           (down part)
                   imp:n=1
634 3  9.69364E-05  50 -51                                  u=44
                   imp:n=1
```

```
635 8  4.3185E-02   49 -50  -44 45                              u=44 $ Zr-2 guide tube
                 imp:n=1
636 5  5.99145E-02  (49 -50 -45):(49 -50 44)                         u=44
                 imp:n=1
637 3  9.69364E-05  48 -49                                     u=44
                 imp:n=1
c - Rod surfaces ---
c
638 7  8.58601E-02  47 -48     122 -114                         u=44 $ carbon steel
                trcl=44
                 imp:n=1
639 8  4.3185E-02   47 -48     -123  105                        u=44 $ Zr-2 guide tube
                trcl=44
                 imp:n=1
640 7  8.58601E-02  47 -48     -105                             u=44
                trcl=44
                 imp:n=1
641 6  8.71910E-02 -47  104   -114                              u=44 $ poison
                trcl=44
                 imp:n=1
642 4  8.36732E-02 -47 -123    125                              u=44 $ graphite follower
                trcl=44
                 imp:n=1
643 3  9.69364E-05 -48 121                                     u=44
                trcl=44
                 imp:n=1
644 7  8.58601E-02 -47 -104 122                                 u=44 $ carbon steel
                trcl=44
                 imp:n=1
645 8  4.3185E-02  -122 123 -48 117                             u=44 $ upper part of Zr follower (with plug)
                trcl=44
                 imp:n=1
646 7  8.58601E-02 -122 123 -117                                u=44 $ ss plug
                trcl=44
                 imp:n=1
647 8  4.3185E-02  105 -125 -47 117                             u=44
                trcl=44
                 imp:n=1
648 7  8.58601E-02 105 -125 -117                                u=44
                trcl=44
                 imp:n=1
649 7  8.58601E-02 -47 -105 126                                 u=44
                trcl=44
                 imp:n=1
650 4  8.36732E-02 -47 -126                                    u=44
                trcl=44
                 imp:n=1
651 7  8.58601E-02 -48  114 -121                                u=44
                trcl=44
                 imp:n=1
c
c ------------------------------------------------------------------------------------------------------
c
c ==== Zircaloy-can Dummy Fuel Assembly with Air gap between clad and graphite =====
701 4  8.36732E-02  165 -166 167 -168 -174 173 -175 176              u=2     $ graphite reflector
                 imp:n=1
```

```
702 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                (59 -60 62 63 -61 -64 65 -66)                  u=2
                imp:n=1
703 9  4.31626E-02  (-63 :64 :-65 :66 :-59 :60 :61 :-62)
               19 -22 23 -26 27 -28 -29 30                     u=2     $ Zr-alloy
                imp:n=1
704 3  9.69364E-05  -19 :22 :-23 :26 :-27 :28 :29 :-30              u=2     $ air gap
                imp:n=1
c
c ------------------------------------------------------------------------------
c
c ======== Slotted Assembly WITH NO FUEL ===========
711 4  8.36732E-02  (165 -166 167 -168 173 -174 -175
                 176 (153 :154) 163 164)
                :(153 163 -164 169 -170 171 -172)              u=3   $ graphite reflector (up part)
                imp:n=1
712 3  9.69364E-05  43 -153 -154                               u=3 $ out gas tube
                imp:n=1
713 3  9.69364E-05  (-165 :166 :-167 :168 :-173 :174 :175 :-176)
                ((63 -64 65 -66 59 -60 -61 62 163):
                (63 -64 65 -66 59 -60 -61 62 -56 -177)):
                (163 -164 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172):
                (178 -177 165 -166 167 -168 59 -60 -61 62
                (-169: 170: -171: 172)))                       u=3
                imp:n=1
714 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                19 -22 23 -26 27 -28 -29 30  43):
                (43 -163 153 59 -60 -61 62 63 -64 65 -66)         u=3 $ Al-2 alloy        (up part)
                imp:n=1
715 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30)     43        u=3 $ air gap          (up part)
                imp:n=1
c --
716 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -43 44        u=3 $ Zr-alloy          Upper Zr-3 spacer
                imp:n=1
717 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -43 44        u=3 $ air gap           Upper Zr-3 spacer
                imp:n=1
c -- Slot --
718 9  4.31626E-02  ((-20 :-31 :32) 19 27 -28 -44 45 -57):
                ((21 :33 :-34) -22 -29 30 -44 45 58)             u=3 $ Zr-3 alloy around slot
                imp:n=1
719 3  9.69364E-05  ((20 31 -32 -57):(-21 -33 34 58):
                (23 -26 27 -28 -29 30 57 -58 ))      -44 45       u=3 $ air inside slot
                imp:n=1
c --
720 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30)  -44 45       u=3 $ air gap
                imp:n=1
c --
721 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30        -45 46        u=3 $ Zr-alloy          Lower Zr-3 spacer
                imp:n=1
722 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30) -45 46        u=3 $ air gap           Lower Zr-3 spacer
                imp:n=1
 c --
723 4  8.36732E-02  (165 -166 167 -168 173 -174 -175 176 -178):
                (178 -177 169 -170 171 -172)                   u=3 $ graphite reflector (down part)
                imp:n=1
```

```
724 5  5.99145E-02  ((-63 :64 :-65 :66 :-59 :60 :61 :-62)
                     19 -22 23 -26 27 -28 -29 30 -46):
                     (23 -26 -46 177 59 -60 -61 62 63 -64)           u=3 $ Al-2 alloy        (down part)
                   imp:n=1
725 3  9.69364E-05  (-19 :22 :-23 :26 :-27 :28 :29 :-30)    -46        u=3 $ air gap           (down part)
                   imp:n=1
c
c -----------------------------------------------------------------------------------------
c
c =================== HALF Assembly full of graphite ================================
731 9  4.31626E-02  (-20 :21 :-24 :66 :-31 :60 :61 :-34 :71)
                  19 -22 23 -26 27 -28 -29 30            -68        u=4 $ Zr-3 alloy        (up part)
                   imp:n=1
732 3  9.69364E-05  ((-19 :22 :-23 :26 :-27 :28 :29 :-30)  -67)
                    :(19 -22 -67 68 )                           u=4 $ air gap           (up part)
                   imp:n=1
733 4  8.36732E-02  -71 20 31 24 34 -21                              u=4
                   imp:n=1
734 10  8.76286E-02 (-73 :-76 :-77 :64 :-63) 19 67 74 75  -22           u=4
                   imp:n=1
735 3   9.69364E-05  (63 -64 73 76 77):(67 (-19 :22 :-74 :-75))        u=4
                   imp:n=1
c
c -----------------------------------------------------------------------------------------
c
c =================== HALF Slotted Assembly  WITH NO
FUEL===================================
741 4  8.36732E-02  35 -36 37 -38 39 -40 -41 42           43 -70       u=5 $ graphite reflector (up part)
                   imp:n=1
                  trcl=1
742 3  9.69364E-05  (-35 :36 :-37 :38 :-39 :40 :41 :-42 :70)
                  ((63 -64 65 -66 59 -60 -61 62 43):
                   (63 -64 65 -66 59 -60 -61 62 -56 -46))    -69      u=5 $ air around graphite
                   imp:n=1
                  trcl=1
743 5  5.99145E-02  (-63 :64 :-65 :66 :-59 :60 :61 :-62 :69)
                  19 -22 23 -26 27 -28 -29 30            43 -68      u=5 $ Al-2 alloy        (up part)
                   imp:n=1
                  trcl=1
744 3  9.69364E-05  ((-19 :22 :-23 :26 :-27 :28 :29 :-30)  43 -67)
                    :(19 -22 -67 68 43)                         u=5 $ air gap           (up part)
                   imp:n=1
                  trcl=1
c --
745 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30   -68  -43 44        u=5 $ Zr-alloy          Upper Zr-3
spacer
                   imp:n=1
                  trcl=1
746 3  9.69364E-05  ((-19 :22 :-23 :26 :-27 :28 :29 :-30) -43 44 -67):
                    (19 -22 -67 68  -43 44)                       u=5 $ air gap           Upper Zr-3 spacer
                   imp:n=1
                  trcl=1
c -- Slot --
747 9  4.31626E-02  (((-20 :-31 :32) 19 27 -28 -44 45 -57):
                  ((21 :33 :-34) -22 -29 30 -44 45 58):
                   (19 20 -44 45 -57 -68 71):
```

```
                (-22 20 -44 45  58 -68 71))    -68              u=5 $ Zr-3 alloy around slot
                imp:n=1
               trcl=1
748 3  9.69364E-05  ((20 31 -32 -57):(-21 -33 34 58):
                (23 -26 27 -28 -29 30 57 -58 )) (-44 45 -71)
                :(-44 45 57 -58 -67 71)                    u=5 $ air inside slot
                imp:n=1
               trcl=1
c --
749 3  9.69364E-05  ((-19 :22 :-23 :26 :-27 :28 :29 :-30)
               :(-22 58 -67 68)
               :(19 -57 -67 68))   -44 45 -67  u=5                 $ air gap
                imp:n=1
               trcl=1
c --
750 9  4.31626E-02    19 -22 23 -26 27 -28 -29 30       -45  46 -68    u=5 $ Zr-alloy          Lower Zr-3
spacer
                imp:n=1
               trcl=1
751 3  9.69364E-05  ((-19 :22 :-23 :26 :-27 :28 :29 :-30) -45  46 -67)
                :(19 -22 -67 68  -45 46)                    u=5 $ air gap          Lower Zr-3 spacer
                imp:n=1
               trcl=1
c --
752 4  8.36732E-02  35 -36 37 -38 39 -40 -41 42            -46 -70    u=5 $ graphite reflector (down part)
                imp:n=1
               trcl=1
753 5  5.99145E-02  (-63 :64 :-65 :66 :-59 :60 :61 :-62 :69)
                19 -22 23 -26 27 -28 -29 30            -46 -68   u=5 $ Al-2 alloy        (down part)
                imp:n=1
               trcl=1
754 3   9.69364E-05 (-19 :22 :-23 :26 :-27 :28 :29 :-30 :68) -46 -67    u=5 $ air gap          (down part)
                imp:n=1
               trcl=1
755 10  8.76286E-02 (-73 :-76 :-77 :64 :-63) 19 67 74 75  -22         u=5
                imp:n=1
               trcl=1
756 3   9.69364E-05  (63 -64 73 76 77):(67 (-19 :22 :-74 :-75))        u=5
                imp:n=1
               trcl=1
c
c ------------------------------------------------------------------------------------------
c
c ---------- middle slotted assembly -------------------
761 3   9.69364E-05 -19: (63 -64) :22                          u=6
                imp:n=1
762 10  8.76286E-02 (19 -63):(-22 64)                          u=6
                imp:n=1
c
c Experiment
c
c =============> Irradiation Wire in the core center < ========================
2001 16 -8.16167542 -132 203 -204
               imp:n=1
c
2002 10  8.76286E-02 -201 202 9 -10                                   $ 10  8.76286E-02
```

```
            imp:n=1
2003 10  8.76286E-02 (-10 204 -200):(9 -203 -200)                        $ 10  8.76286E-02
            imp:n=1
2004  3  9.69364E-05 (-10 204 200 -202):(203 -204  132 -202):(9 -203 200 -202)
            imp:n=1
c ======================> Steel Pump <
==========================================
2005 3   9.69364E-05 9 -10 -135
            imp:n=1
2006 17 -8.18676     9 -10  135 -136
            imp:n=1
2007 3   9.69364E-05 136 -137 9 -10
            imp:n=1
2008 17 -8.18676     (137 -138 141 -142 140 -139):(141 -142 139 -134 -144 145):
            (141 -142 133 -140 -143 146)
            imp:n=1
2009 3  9.69364E-05  (-10 137 142 133 -134 -147 148):
            (9 133 -134 137 -141 -147 148)
            imp:n=1
2010 3  9.69364E-05  (133 141 -142 143 -147):(-134 141 -142 144 -147):
            (133 141 -142 -146 148):(-134 141 -142 -145 148):
            (-139 140 141 -142 -143 -144 138 -147 148)
            imp:n=1
c
c ==================== viewing holes <=================================
1001 3  9.69364E-05  (-18 14 149 -150 -151 152)  #1100 #1101                 $ north viewing cavity w=
14.25"
            imp:n=1
1002 3  9.69364E-05  15 -11 156 -155 158 -157
             (1040:-1050:1051:-1020:1060)
            (-1040:(1105 -1106 1107 -1108))    $ west  viewing slot
              imp:n=1
1003 4  8.36732E-02  (-13 17 -159 160 -157 158)                          $ south viewing slot
            imp:n=1
1004 8  4.3185E-02  ((-149 :150 :151 :-152) (560 -559 -179 180)) -18 14        $ North Zr-3 liner
            imp:n=1
1005 8  4.3185E-02  ((-160 :159 :157 :-158) (181 -182 -183 184)) -13 17
            imp:n=1
1100 4  8.36732E-02  (-553 14 149 -150 -151 152) (-549:550)                 $ north slot insert w= 4.125"
            imp:n=1
1101 4  8.36732E-02  (553 -554 149 -150 -151 152) (-551:552)                 $ north slot insert w= 5.8125"
            imp:n=1
c ===============> Measurement Holes north, south, east<===============
1006 3  9.69364E-05 (-189 -18 14)                                 $ north measurement hole
            imp:n=1
1007 3  9.69364E-05 (-190 -18 14)                                 $ north measurement hole
            imp:n=1
1008 3  9.69364E-05 (-185 -13 17)                                 $ south measurement hole
            imp:n=1
1009 3  9.69364E-05 (-186 -13 17)                                 $ south measurement hole
            imp:n=1
1010 3  9.69364E-05 (-187 -11 15)                                 $ west measurement hole
            imp:n=1
1011 3  9.69364E-05 (-188 -11 15)                                 $ west measurement hole
            imp:n=1
c
```

```
c ==================== Access Hole E ========================
1020 7  8.58601E-02  (-2001 2002):(-2003 2004):(-2001 2003 2005) imp:n=1  $ South Lower Access Hole
E
1021 7  8.58601E-02  (-2006 2007):(-2008 2009):(-2006 2008 2005) imp:n=1  $ South Upper Access Hole
E
1022 3   9.69364E-05  (-2007 -2005):-2009                    imp:n=1  $ South Upper Access Hole E
c
c ==================== Access Hole E ========================
1023  4  8.36732E-02 -2020:-2021                          imp:n=1  $ graphite wall on east side
1024  115 -3.53  (-2023 2037):(-2024 2038)                      imp:n=1  $ shield door
c
c ---------- Center Irradiation cylinder ---------------
2021 3   9.69364E-05   -78 79 9 -10                              $ dummy cell separating the lattice from
irradiation cells
                imp:n=1
2022 10  8.76286E-02   -79 80 9 -10                              $ 1st
                imp:n=1
2023 10  8.76286E-02   (-80 83 9 -210):(-80 83 -10 209)                    $ 2nd
                imp:n=1
2024 11 -8.55 (-81 82 -10  92 -206)                             $ 3nd
                imp:n=1
2025 10  8.76286E-02   (92 -206 -80 81):(-92 205 -80 82):(-80 83 -205 207):
                 (91 -207 -80 82):(-91 208 -80 81)                    $ 3nd
                imp:n=1
2026 11 -8.55 -81 82 9 -10 -91 208                              $ 3nd
                imp:n=1
2027 11 -8.55 (-82 83 -209 205):(-82 83 210 -207):(206 -209 -80 83):
                 (-80 82 -208 210)                             $ 4th
                imp:n=1
2028 10  8.76286E-02   -83 84 9 -10                              $ 5th
                imp:n=1
2029  5  5.99145E-02   -84 85 9 -10                              $ 6th
                imp:n=1
2030  3  9.69364E-05   -85 86 9 -10                              $ 7th
                imp:n=1
2031 10  8.76286E-02   -86 87 9 -10                              $ 8th
                imp:n=1
2032  3  9.69364E-05   -87 88 9 -10                              $ 9th
                imp:n=1
2033 10  8.76286E-02   -88 89 9 -10                              $ 10th
                imp:n=1
c ------- twin irradiation tubes m8cal -------
2034 3   9.69364E-05  -95 92 -93                               $ upper cap      13  2.53448E-02
                imp:n=1
2035 3   9.69364E-05   97 -98 90 -93                             $ left 1st       10  8.76286E-02
                imp:n=1
2036  3  9.69364E-05   96 -97 90 -93                             $ left 2nd
                imp:n=1
2037 3   9.69364E-05   95 -96 90 -93                             $ left 3nd       14 -7.8885
                imp:n=1
2038 3   9.69364E-05   94 -95 91 -92                             $ left 4nd       13  2.53448E-02
                imp:n=1
2039 3   9.69364E-05  -94     91 -92                             $ left 5nd       12 -14.9891
                imp:n=1
2040 3   9.69364E-05  -95     90 -91                             $ left lower cap  10  8.76286E-02
                imp:n=1
```

```
2041  3  9.69364E-05 (201 98 103 90 -93 -89):(201 9 -10 -89 93):
                  (201 9 -10 -89 -90)                                   $
                  imp:n=1
2042 3   9.69364E-05 -100 92 -93                                      $ upper cap       13  2.53448E-02
                  imp:n=1
2043 3   9.69364E-05 102 -103 90 -93                                   $ right 1st       10  8.76286E-02
                  imp:n=1
2044  3  9.69364E-05 101 -102 90 -93                                   $ right 2nd
                  imp:n=1
2045 3   9.69364E-05 100 -101 90 -93                                   $ right 3nd       14 -7.8885
                  imp:n=1
2046 3   9.69364E-05  99 -100 91 -92                                   $ right 4nd       13  2.53448E-02
                  imp:n=1
2047 3   9.69364E-05 -99      91 -92                                  $ right 5nd       15 -1.49415E+1
                  imp:n=1
2048 3   9.69364E-05 -100     90 -91                                  $ right lower cap 10  8.76286E-02
                  imp:n=1
c
c --- core surrounding air ------
9988 3  9.69364E-05 (-5 :6 :-7 :8) 11 -12 13 -14 9 -10
                  imp:n=1
c ----- reflector around core ------
9989 4  8.36732E-02 ((-11 :12 :-13 :14 ) 15 -16 17 -18 9 -10)
c                  (-160:159:179:-180:-14:18)                        $ north viewing port -> w = 4"
                  (-560:559:179:-180:-14:18)                        $ north viewing port
                  (155:-156:157:-158:-15:1040)
                  (-1105:1106:-1107:1108:11)                           $ west viewing port
                  (-181:182:183:-184:13:-17)                        $ south viewing port
                  (189:18:-14)                             $ north measurement hole
                  (190:18:-14)                             $ north measurement hole
                  (185:13:-17)                             $ south measurement hole
                  (186:13:-17)                             $ south measurement hole
                  (187:11:-15)                             $ west measurement hole
                  (188:11:-15)                             $ west measurement hole
                  imp:n=1
c
20000 115 -3.53 #1020 #1021 #1022 #1023 2025 2028 2029 2030 2031 2032
        2033 2034 2035
        1003 -1004 1007 -1008 1016 -1017 -1010 -1011 -1012 -1013
       (-1001:1002:-1005:1006:-1014:1015)
       (-1027:1028:-1029:1030:15)
       (-1032:1033:-1034:1035:1031)     imp:n=1   $ a
20006 4  8.36732E-02 -2037:-2038  imp:n=1
20001 7  8.58601E-02 1003 -1001 1032 -1033 1034 -1035
        ((1027 -1028 1029 -1030):-1031)
       (-1018:1019:-1020:1021)
       (-1023:1024:-1025:1026:1022)   imp:n=1   $ a
20002 7  8.58601E-02 1041 -1040 1042 -1043 -1044 -1045
        (-1046:1047:1048:-1049)  imp:n=1   $ a
20003 7  8.58601E-02  1057 -1040 1050 -1051 1020 -1060
           (-1056:1055:-1052:1053:-1061:1062)
           (-1042:1043:1044:1045)          imp:n=1   $
20004 1005 -1.0 1056 -1055 1052 -1053 1061 -1062
        (-1042:1043:1044:1045)  imp:n=1   $ poly
20005 7  8.58601E-02  #1020 #1021 #1022
     (2012 -1007 -2017 -2018 99999 -2014 -3006):
```

```
     (2012 -2011 1013 -2018 99999 -2014 -3006):
     (-2011 1004 -2018 -2016 99999 -2014 2022 -3006):
     (-2013 -2011 1011 -2016 99999 -2014 -3006):
     (-2013 1008 -2015 -2016 99999 -2014 -3006):
     (-2013 2010 -2015 1010 99999 -2014 -3006):
     (2010 -1003 -2015 1024 99999 -2014 -3006):
     (2010 -1003 -1023 -2017 99999 -2014 -3006):
     (2010 -1003 99999 -1025 1023 -1024 -3006):
     (2010 -1003 1026 -2014 1023 -1024 99999 -3006):
     (2010 2012 -2017 1012 99999 -3006)                    imp:n=1  $ steel lining on bioshield
c ============ Core Map =======================
c
c
9992   3  9.69364E-05 3001  -3002 3003 -3004 99999 -3006 2027 #9998
       2030 2031 2032 2033 2034 2036 2037 2038 (-15 :16 :-17 :18 :-9 :10)
       #20000 #20001 #20002 #20003 #20004 99998
       #4000 #4001 #4002 #4003 #4004 #4005 #4006
       #4007 #4008 #4009 #4010
       #64000 #64001  #164001 #64002 #64003 #64004
       #1020 #1021 #1022 #1023 #1024 #20005 imp:n=1   $ air outside reflector
9996   3  9.69364E-05 -99998 imp:n=1
9997   3  9.69364E-05 -2027 imp:n=1
9999   3  9.69364E-05 -2030 imp:n=1
10000  3  9.69364E-05 -2031 imp:n=1
10001  3  9.69364E-05 -2032 imp:n=1
10002  3  9.69364E-05 -2033 imp:n=1
10003  3  9.69364E-05 -2034 imp:n=1
10004  1006 -0.465   -2036  imp:n=1
9998   10 8.76286E-02  -2028 2025 imp:n=1
9995   115 -3.53 3001  -3002 3003 -3004 3005 -99999
            (-15 :16 :-17 :18 :-9 :10)
       #20000 #20001 #20002 #20003 #20004
       #4000 #4001 #4002 #4003 #4004 #4005 #4006
       #4007 #4008 #4009 #4010 imp:n=1   $ floor
9993 0  (-3001:3002:-3003:3004:-3005:3006) imp:n=0   $ outside world
9994   3  9.69364E-05 15 -1040 -1048 1049 1046 -1047  imp:n=1   $ air inside coll
c
4000 7 8.59E-02 11002 -11000 12000 -12003 13000 -13001
       -14000 -14001 ( -11001 : -12001 : 12002 )  imp:n=1
4001 7 8.59E-02 11101 -11100 12100 -12103 13001 -13100
       ( -12101 : 12102 )  imp:n=1
4002 7 8.59E-02 11200 -11000 12200 -12100 13001 -13100 imp:n=1
4003 7 8.59E-02 11200 -11000 12103 -12201 13001 -13100 imp:n=1
4004 7 8.59E-02 11300 -11301 12300 -12301 13001 -13100 14703 imp:n=1
4005 7 8.59E-02 14400 -14401 14500 -14501 13001 -13100 imp:n=1
4006 7 8.59E-02 14402 -14403 14502 -14503 13001 -13100 imp:n=1
4007 7 8.59E-02 11601 -11600 12600 -12601 13001 -13100 14701 imp:n=1
4008 7 8.59E-02 11601 -11100 12101 -12600 13001 -13100 imp:n=1
4009 7 8.59E-02 11601 -11100 12601 -12102 13001 -13100 imp:n=1
4010 7 8.59E-02 11700 -11600 14700 -14703
       ( 11701 : 14702 )
       ( -11702 : -14701 )  imp:n=1
c
64000 82 -5.0 11301 -11101 12100 -12103 13001 -13100 14701 -14400 -14402
       (-11601:-12101:12102)
       (14703:11702) imp:n=1
```

```
64001  1005 -1.0 #20005 21301 -1003 22204 -22201 99999 -23101
       (-21303:-22203:22200:23100) imp:n=1
164001  1006 -0.93 21303 -21300 22203 -22200 99999 -23100
       imp:n=1
64002  7 8.59E-02 #20005 21302 -1003 22205 -22202 99999 -23102
       (-21301:-22204:22201:23101) imp:n=1
64003 82 -5.0 21702 -21703 -14702
       (-11701:-14700) imp:n=1
64004 3  9.69364E-05 11600 -11101 12600 -12601 23102 -23103
          imp:n=1

c ********************************************************************************
c ******************************Surface Cards************************************
c ********************************************************************************
c
c --- lattice ---
  1   px    0
  2   px    10.16
  3   py    10.16
  4   py    0
c ------- Lattice Window -------
  5   px    0.001
  6   px    193.04
  7   py    0.001
  8   py    193.04
  9   pz   -121.999375                            $ -58.57875 from 177 pz (old value ->-123.825)
  10  pz    121.999375                            $ +62.70625 from 163 pz (old value ->123.825)
c ------- Core surrounding gap (+5.08 from core) ------
  11  px   -5.08
  12  px    198.12
  13  py   -5.08
  14  py    198.12
c ------- Core surrounding reflector (+60.96 from core gap) ------
  15  px   -66.04                                 $ -60.96 from surface 11
  16  px    259.08
  17  py   -66.04
  18  py    259.08
c ------- Zircaloy-can Dummy Fuel Assembly surfaces-------
  19  px    0.0508
  20  px    0.1143
  21  px   10.0457
  22  px   10.1092
  23  py    0.0508
  24  py    0.1143
  25  py   10.0457
  26  py   10.1092
  27  p    1 1 0  1.224132015                     $ outer down left
  28  p   -1 1 0  8.935867985                     $ outer up left
  29  p    1 1 0 19.09586798                      $ outer up right
  30  p   -1 1 0 -8.93586798                      $ outer down right
c --> 0.0635 thickness
  31  p    1 1 0  1.313934576                     $ inner down left
  32  p   -1 1 0  8.846065424                     $ inner up left
  33  p    1 1 0 19.006065419                     $ inner up right
  34  p   -1 1 0 -8.846065419                     $ inner down right
c ------- Standard Fuel Assembly-------
```

```
  35  px   0.254                                          $
  36  px   9.906
  37  py   0.254
  38  py   9.906
c  39  p    1 1 0  1.511500211                            $ inner down left fuel
c  40  p   -1 1 0  8.648499789                            $ inner up left   fuel
c  41  p    1 1 0 18.808499784                            $ inner up right  fuel
c  42  p   -1 1 0 -8.648499784                            $ inner down right fuel
c revised for chamfer l = 0.612 in., keep fuel w = 3.8 in
  39  p    1 1 0  1.607183349 $ inner down left fuel
  40  p   -1 1 0  8.552816651 $ inner up left   fuel
  41  p    1 1 0 18.71281665  $ inner up right  fuel
  42  p   -1 1 0 -8.552816651 $ inner down right fuel
  43  pz   59.055                                       $ Zr spacer +0.635 from 44 pz
  44  pz   58.42                                        $ upper boundary of fuel (fuel length 120.9675cm)
  45  pz  -62.5475                                      $ lower boundary of fuel
  46  pz  -63.1825                                      $ Zr spacer -0.635  from 45 pz
c ------- Transient Control Rod Assembly surfaces ------
  47  c/z  5.08 5.08  1.90500
  48  c/z  5.08 5.08  2.22250
  49  c/z  5.08 5.08  2.54000
  50  c/z  5.08 5.08  2.85750
  51  c/z  5.08 5.08  2.95910
c ------- Slotted Fuel Assembly (aluminum canned) ------
c  53  pz   25.71115                                    $ -32.70885 from 44 pz
c  54  pz   25.55875                                    $ -0.1524  from 53 pz
c  55  pz  -29.68625                                    $ -55.245   from 54 pz
  56  pz  -29.83865                                     $ -0.1524  from 55 pz
  57  px    0.635                                       $ side surfaces for hole
  58  px    9.525                                       $ side surfaces for hole
c --> 0.127 thickness
  59  p    1 1 0  1.403737137                           $ inner outer down left
  60  p   -1 1 0  8.756262863                           $ inner outer up left
  61  p    1 1 0 18.91626286                            $ inner outer up right
  62  p   -1 1 0 -8.756262858                           $ inner outer down right
  63  px   0.1778
  64  px   9.9822
  65  py   0.1778
  66  py   9.9822
c --> HALF Slotted NO FUEL assembly <--
  67  py   5.1308
  68  py   5.0292
  69  py   4.9022
  70  py   4.826
  71  py   4.9657                                       $ -0.0635 from 68 py
c  72  py   5.08
  73  py   5.1943                                       $ +0.0635 from 67 py (check this value; it should
be +0.127?)
  74  p    1 1 0  6.304132015                           $ outer down left
  75  p   -1 1 0 -3.85586798                            $ outer outer down right
  76  p    1 1 0  6.483737137                           $ inner down left
  77  p   -1 1 0 -3.676262858                           $ inner outer down right
c ----- Central Irradiation Surfaces core center at 0 on z axis ----
  78  c/z  96.52 101.6   3.1                            $ dummy suface as lattice boundary
  79  c/z  96.52 101.6   3.030220                       $ outside ss surface
  80  c/z  96.52 101.6   2.913380                       $ ss dummy heaters IR +0.0508  from 83
```

```
 81  c/z  96.52 101.6   2.90068                                  $ Dy layers    +0.0381  from 83
 82  c/z  96.52 101.6   2.86766                                  $ Dy layers    +0.00508 from 83
 83  c/z  96.52 101.6   2.862580                                 $ Dy collar IR
c
 84  c/z  96.52 101.6   2.705100                                 $ ss sleeve IR
 85  c/z  96.52 101.6   2.578100                                 $ Al sleeve IR
 86  c/z  96.52 101.6   2.569210                                 $ ss calibration loop OR
 87  c/z  96.52 101.6   1.637030                                 $ ss calibration loop IR
 88  c/z  96.52 101.6   1.587500                                 $ ss calibration test tarin OR
 89  c/z  96.52 101.6   1.422400                                 $ ss calibration test tarin IR
 90  pz  -21.11629                                        $ fuel pin
 93  pz   15.71625                                        $ fuel pin
c
 210  pz  -78.27375                                       $ Dy collar (lower)
 208  pz  -32.55375                                       $ Dy collar
 91  pz  -19.21875                                        $ fuel pin
 207  pz  -10.96375                                       $ Dy collar
 205  pz    8.08625                                       $ Dy collar
 92  pz   15.07125                                        $ Dy collar
 206  pz   28.40625                                       $ Dy collar
 209  pz   72.85625                                       $ Dy collar (upper)
c ------- twin irradiation tubes m8cal -------
 94  c/z  95.72625 101.6    0.21971                             $ fuel            left
 95  c/z  95.72625 101.6    0.254                               $ Na bond         left
 96  c/z  95.72625 101.6    0.2921                              $ jacket wall      left
 97  c/z  95.72625 101.6    0.32893                             $ tube NA          left
 98  c/z  95.72625 101.6    0.47625                             $ shield/flow tube left
c --
 99  c/z  97.31375 101.6    0.2195                              $ fuel            right
 100  c/z  97.31375 101.6    0.2538                             $ Na bond          right
 101  c/z  97.31375 101.6    0.2919                             $ jacket wall      right
 102  c/z  97.31375 101.6    0.3289                             $ tube NA          right
 103  c/z  97.31375 101.6    0.4762                             $ shield/flow tube right
c ========================== ROD POSITION ===============================
c ---------- Transient Rod_set 1 u=3 --------
 120  pz  110.4900
 113  pz  104.4575                                        $
 52  pz  -38.1000                                         $
 108  pz -188.2775                                        $
 115  pz  -41.9100                                        $
 116  pz  -47.9425                                        $
 117  c/z  5.08 5.08  1.5875                                 $ ss plug diameter
 118  pz -194.3100                                        $ graphite part in zr follower
 119  pz -212.0900
c ---------- Control Rod / Compensation Rod_set_1  u=4 --------
 121  pz   76.2000
 114  pz   70.1675                                        $ +142.5575 from 104 pz
 104  pz  -72.3900                                        $ from -73.3425 plane of origin
 125  pz -222.5675                                        $ -152.4 from 104 pz
 122  pz  -76.2000
 123  pz  -82.2325
 105  pz -228.6000
 126  pz -246.3800
c ---------- Transient Rod_set_2       u=12 ---------
c 106  pz  63.4365                                        $ additional surface for transient out of core (-
38.1635 plane of origin)
```

```
c 109  pz -88.9635                                        $ -152.4 from 106 pz
c 112  pz  205.994                                        $ +142.5575 from 106
c --------- Control Rod / Compensation Rod_set_2 u=13 --------
c 127  pz  222.5675
c 111  pz  216.5350                                        $ +142.5575 from 107
c 107  pz   73.9775                                       $ from -73.3425 plane of origin
 110  pz  -76.2000                                       $ -152.4 from 107 pz
 128  pz   70.1675
c 129  pz   64.1350
 130  pz  -82.2325
c 131  pz -100.0125
c ====================== END OF ROD POSITION ==========================
c 132 rcc 96.52 101.595 -12.22375  0 0 20.32   0.0508
  132 c/z 96.52 101.595  0.0508
c ========************** PUMP SURFACES *************=========
 133 px 91.757594
 134 px 101.282406
 135 c/z 96.52 92.0750875  1.03505
 136 c/z 96.52 92.0750875  1.67055
 137 c/z 96.52 92.0750875  1.864324
 138 c/z 96.52 92.0750875  3.809925
 139 px 98.424963
 140 px 94.615037
 141 pz 66.494
 142 pz 70.1274
 143 p  -0.59914 1 0 38.68694
 144 p   0.59914 1 0 154.3449
 145 p  -0.59913 1 0 29.80603
 146 p   0.59913 1 0 145.4625
 147 py  96
 148 py  88
c ------> NORTH viewing Hole 4x32 in. (1/8 sides, 3/32in. up/down) <-----
c 149 px  91.44
c 150 px 101.6
 149 px  78.4225   $ w = 14.25"
 150 px 114.6175   $ w = 14.25"
 151 pz  40.64
 152 pz -40.64
 179 pz  40.878125
 180 pz -40.878125
 549 px  91.28     $ w = 4.125"
 550 px 101.76     $ w = 4.125"
 551 px  89.14     $ w = 5.8125"
 552 px 103.90     $ w = 5.8125"
 553 py 218.12     $ l = 7.875"
 554 py 238.13     $ l = 15.75"
 560 px  78.105    $ liner for w = 14.25"
 559 px 114.935    $ liner for w = 14.25"
c -----------------> Fuel outgas tube <------------
 153 c/z 5.08 5.08   0.9525
 154 pz  81.359375                                        $ +22.06625 from 163 pz
c ------------> (4.25x24in) west viewing slot <----------
 155 py 101.9175
 156 py  91.1225
 157 pz  30.48
 158 pz -30.48
```

```
c ------------> (4.25x24in) south viewing slot <----------
 159 px 101.9175
 160 px  91.1225
 181 px  90.805
 182 px 102.235
 183 pz  30.718125
 184 pz -30.718125
c -------------> additional viewing Holes 4x32 in. <-----
 161 px  78.105
 162 px 114.935
c ------> additional surfaces for upper and lower Graphite reflector <-------
 163 pz 59.293125                                    $ aluminum part above Zr spacer +0.238125 from
43 pz old value 59.182
 164 pz 68.183125                                    $ +8.89 from 163 pz old value 68.072
c
 165 px 0.2794                                       $ +0.1016 from 63
 166 px 9.8806                                       $ -0.1016 from 64
 167 py 0.2794                                       $ +0.1016 from 65
 168 py 9.8806                                       $ -0.1016 from 66
c --- upper reflector surfaces ----
 169 px 0.9144                                       $ +0.635  from 165
 170 px 9.2456                                       $ +0.635  from 166
 171 py 0.9144                                       $ +0.635  from 167
 172 py 9.2456                                       $ -0.635  from 168
c 173 p    1 1 0  1.547421235                           $ inner down left fuel
c 174 p   -1 1 0  8.612578765                           $ inner up left   fuel
c 175 p    1 1 0 18.77257876                            $ inner outer up right
c 176 p   -1 1 0 -8.612578761                           $ inner outer down right
c revised for chamfer l = 0.605 in., w = 3.78 in
 173 p    1 1 0   1.645410991 $ inner down left
 174 p   -1 1 0   8.514589009 $ inner up left
 175 p    1 1 0  18.674589009 $ inner up right
 176 p   -1 1 0  -8.514589009 $ inner down right
c --- lower reflector surface -----
 177 pz -63.420625                                   $ -0.238125 from 46 pz (old value ->-63.3095)
 178 pz -72.310625                                   $ -8.89 from 177 pz (old value -> -72.1995)
c --->Horizontal holes in north, south and west faces <----
 185 c/y  35.56  30.48  7.62
 186 c/y  35.56 -30.48  7.62
 187 c/x 157.48  30.48  7.62
 188 c/x 157.48 -30.48  7.62
 189 c/y 157.48  30.48  7.62
 190 c/y 157.48 -30.48  7.62
c ------------- Tally Segmenting Surfaces ----------------
c 191 pz -10.19175
c 192 pz  -8.15975
c 193 pz  -6.12775
c 194 pz  -4.09575
c 195 pz  -2.06375
c 196 pz  -0.03175
c 197 pz   2.00025
c 198 pz   4.03225
c 199 pz   6.06425
c -------- Flux Wire additional surfaces  ----------------
 200 c/z 96.52 101.595  0.0635
 201 c/z 96.52 101.595  0.12065
```

```
 202 c/z 96.52 101.595  0.09017
c 203 pz  -12.22375            $ 8" wire
c 204 pz    8.09625            $ 8" wire
 203 pz  -78.26375             $ 60" wire
 204 pz   74.13625             $ 60" wire
c ------------- 60" Wire Tally 2" Segmenting Surfaces ----------------
900 pz  -63.02375
901 pz  -57.94375
902 pz  -52.86375
903 pz  -47.78375
904 pz  -42.70375
905 pz  -37.62375
906 pz  -32.54375
907 pz  -27.46375
908 pz  -22.38375
909 pz  -17.30375
910 pz  -12.22375
911 pz  -7.14375
912 pz  -2.06375
913 pz   3.01625
914 pz   8.09625
915 pz   13.17625
916 pz   18.25625
917 pz   23.33625
918 pz   28.41625
919 pz   33.49625
920 pz   38.57625
921 pz   43.65625
922 pz   48.73625
923 pz   53.81625
924 pz   58.89625
c
1001 px -71.12      $ Inner "Heavy" Concrete Shield Edge (West) IPE-720-4-SR5
1002 px 264.16      $ Inner "Heavy" Concrete Shield Edge (East) IPE-720-4-SR5
1003 px -223.52      $ Outer "Heavy" Concrete Shield Edge (West) IPE-720-4-SR2
1004 px 416.56      $ Outer "Heavy" Concrete Shield Edge (East) IPE-720-4-SR2
c
1005 py -71.12      $ Inner "Heavy" Concrete Shield Edge (South) IPE-720-4-SR5
1006 py 264.16      $ Inner "Heavy" Concrete Shield Edge (North) IPE-720-4-SR5
1007 py -223.52      $ Outer "Heavy" Concrete Shield Edge (South) IPE-720-4-SR2
1008 py 416.56      $ Outer "Heavy" Concrete Shield Edge (North) IPE-720-4-SR2
c
1010 p -131.9213876 416.56 0 -223.52 324.9613876 0 -131.9213876 416.56 100      $ Outer "Heavy"
Concrete Shield Edge (North-West) IPE-720-4-SR1
1011 p 324.9613876 416.56 0 416.56 324.9613876 0 324.9613876 416.56 100      $ Outer "Heavy"
Concrete Shield Edge (North-East) IPE-720-4-SR1
1012 p -131.9213876 -223.52 0 -223.52 -131.9213876 0 -131.9213876 -223.52 100      $ Outer "Heavy"
Concrete Shield Edge (South-West) IPE-720-4-SR1
1013 p 324.9613876 -223.52 0 416.56 -131.9213876 0 324.9613876 -223.52 100      $ Outer "Heavy"
Concrete Shield Edge (South-East) IPE-720-4-SR1
c
1014 pz -124.46      $ Inner "Heavy" Concrete Shield Edge (Bottom) Z0720-0167 use surface 9 from
origional deck
1015 pz 170.18      $ Inner "Heavy" Concrete Shield Edge (Top) Z0720-0167
1016 pz -243.84      $ Outer "Heavy" Concrete Shield Edge (Bottom) Z0720-0167
1017 pz 365.76      $ Outer "Heavy" Concrete Shield Edge (Top) Z0720-0167
```

```
c
2010 px -224.155    $ steel lining
2011 px  417.195
2012 py -224.155
2013 py  417.195
2014 pz  149.86     $ 8' height
2015 p -132.370  417.009 0 -223.969  325.410 0 -132.370  417.009 100  $ NW
2016 p  325.410  417.009 0  417.009  325.410 0  325.410  417.009 100  $ NE
2017 p -132.370 -223.969 0 -223.969 -132.370 0 -132.370 -223.969 100  $ SW
2018 p  325.410 -223.969 0  417.009 -132.370 0  325.410 -223.969 100  $ SE
c
1018 py 91.44      $ Inner portion if Radiography port IPE-720-4-SR3
1019 py 101.6      $ Inner portion if Radiography port IPE-720-4-SR5
1020 pz -30.48      $ Inner portion if Radiography port IPE-720-4-SR3
1021 pz 30.48      $ Inner portion if Radiography port IPE-720-4-SR3
1022 px -147.32      $ Inner/Outer  IPE-720-4-SR5
1023 py 35.56      $ 3' outer portion if Radiography port IPE-720-4-SR5
1024 py 137.16      $ 3' outer portion if Radiography port IPE-720-4-SR5
1025 pz -45.72      $ 3' outer portion if Radiography port IPE-720-4-SR5
1026 pz 45.72      $ 3' outer portion if Radiography port IPE-720-4-SR5
c
1027 py 90.805      $ Inner portion if Radiography port IPE-720-4-SR3
1028 py 102.235      $ Inner portion if Radiography port IPE-720-4-SR5
1029 pz -31.115      $ Inner portion if Radiography port IPE-720-4-SR3
1030 pz 31.115      $ Inner portion if Radiography port IPE-720-4-SR3
1031 px -146.685      $ Inner/Outer  IPE-720-4-SR5
1032 py 34.925      $ 3' outer portion if Radiography port IPE-720-4-SR5
1033 py 137.795      $ 3' outer portion if Radiography port IPE-720-4-SR5
1034 pz -46.355      $ 3' outer portion if Radiography port IPE-720-4-SR5
1035 pz 46.355      $ 3' outer portion if Radiography port IPE-720-4-SR5
c
1040 px -42.8625
1041 px -152.7175
1042 p -42.8625 93.98 5.08 -42.8625 93.98 -6.35 -152.7175 91.7575 17.4625 $ aluminum neg Y outside
1043 p -42.8625 99.06 5.08 -42.8625 99.06 -6.35 -152.7175 101.2825 17.4625 $ aluminum pos Y outside
c
1044 p -42.8625 99.06 -6.35 -42.8625 93.98 -6.35 -152.7175 101.2825 -18.7325 $ aluminum neg Z outside
1045 p -42.8625 99.06 5.08 -42.8625 93.98 5.08 -152.7175 101.2825 17.4625 $ aluminum pos Z outside
c
1046 p -42.8753442 94.61487009 5.08
     -42.8753442 94.61487009 -6.35 -152.7303442 92.39237009 17.4625 $ aluminum neg Y inside
1047 p -42.8753442 98.42512991 5.08
     -42.8753442 98.42512991 -6.35 -152.7303442 100.6476299 17.4625 $ aluminum pos Y inside
c
1048 p -42.9336247 99.06 -5.718995824
     -42.9336247 93.98 -5.718995824 -152.7886247 101.2825 -18.10149582 $ aluminum neg Z inside
1049 p -42.9336247 99.06 4.448995824
     -42.9336247 93.98 4.448995824 -152.7886247 101.2825 16.83149582 $ aluminum pos Z inside
c
1050  py  91.7575  $  Z0720-400
1051  py  101.2825  $  Z0720-400
1052  py  92.3925  $  Z0720-400
1053  py  100.6475  $  Z0720-400
1055  px  -43.4975  $  Z0720-400
1056  px  -147.0025  $  Z0720-400
1057  px  -147.6375  $  Z0720-400
```

```
1060  pz  29.21  $  Z0720-400
1061  pz  -29.845  $  Z0720-400
1062  pz  28.575  $  Z0720-400
c
c 1101  px  -25.24125  $ RE-1-23101
c 1102  py  89.05875  $ RE-1-23101
c 1103  py  103.98125  $ RE-1-23101
c
1105 py 93.0275 $ Radiography Sketch
1106 py 100.0125 $ Radiography Sketch
1107 pz -5.715 $ Radiography Sketch
1108 pz 4.445 $ Radiography Sketch
c
c Access Hole E
2001 rcc  35.72  -224.16 -30.48     0 78.105 0    10.955
2002 rcc  35.72  -224.16 -30.48     0 78.105 0    10.137
2003 rcc  35.72  -147.055 -30.48    0 76.025 0    8.415
2004 rcc  35.72  -147.055 -30.48    0 76.025 0    7.704
2005 py -147.055
2006 rcc  35.72  -224.16 30.48     0 78.105 0    10.955
2007 rcc  35.72  -224.16 30.48     0 78.105 0    10.137
2008 rcc  35.72  -147.055 30.48    0 76.025 0    8.415
2009 rcc  35.72  -147.055 30.48    0 76.025 0    7.704
c
c Access Hole C    graphite wall on east side
2020 rpp  264.16 339.725  19.82 172.22  -76.2 76.2
2021 rpp  339.725 416.56  9.66 182.38  -86.36 86.36
2022 rpp  416.56 417.195 9.66 182.38  -86.36 86.36
c Access Hole C Door
2023 rpp  417.195 460.375 -25.9 217.94  -93.98   119.38
2024 arb 460.375 -25.9   -93.98    460.375 -25.9    119.38
         460.375  217.94  119.38   460.375  217.94 -93.98
         499.745  13.47  -93.98    499.745  13.47   80.01
         499.745  178.57  80.01    499.745  178.57 -93.98
         1234 5678 1584 2673 1256 7384
2037 rpp 417.195 460.375  80.78 111.26 -22.225 8.255
2038 rpp 460.375 499.745 70.62 121.42 -32.385 18.415
c
c top hole
2025 rcc 96.52 96.52 170.18   0 0 195.58   10.16
2026 rcc 96.52 96.52 365.76   0 0 -5 10 $ -0.01677 0.635
2027 rcc 96.52 96.52 272.74   0 0  5 10 $ -0.01677 0.635
2030 rcc 96.52 66.04 272.74   0 0  5 10
2031 rcc 96.52 35.56 272.74   0 0  5 10
2032 rcc 96.52 5.08 272.74   0 0  5 10
2033 rcc 96.52 -25.4 272.74   0 0  5 10
2034 rcc 96.52 -55.88 272.74   0 0  5 10
c
c rotating shield plug
2028 rcc 96.52 96.52 272.7325 0 0 -30.48 167.64
2029 rpp -53.34 246.38 -53.34 246.38 142.2525 242.2525
2035 rpp 43.18 149.86 -123.825 111.76 272.7325 289.3575
2036 rpp 35.56 157.48 35.56 157.48 365.76 426.72
c
3001 px -1000
3002 px  1000
```

```
3003 py -1000
3004 py  1000
3005 pz -1000
3006 pz  1000
c
11000 px -254 $ Base plate Z0012-0012-DJ
11001 px -330.835 $ Base plate Z0012-0012-DJ
11002 px -368.6048 $ Base plate Z0012-0012-DJ
c
12000 py 44.7675 $ Base plate Z0012-0012-DJ
12001 py 80.01 $ Base plate Z0012-0012-DJ
12002 py 113.03 $ Base plate Z0012-0012-DJ
12003 py 148.2725 $ Base plate Z0012-0012-DJ
c
13000 pz -70.485 $ Base plate Z0012-0012-DJ
13001 pz -68.8975 $ Base plate Z0012-0012-DJ
c
14000 p -340.6648 44.7675 -70.485 -340.6648 44.7675 -20.485
        -368.6048 72.7075 -70.485 $ Base plate Z0012-0012-DJ
14001 p -340.6648 148.2725 -70.485 -340.6648 148.2725 -20.485
       -368.6048 120.3325 -70.485 $ Base plate Z0012-0012-DJ
11100 px -253.365 $ Back Z0012-0012
11101 px -254.3175 $ Back Z0012-0012
c back side
12100 py 46.6725 $ Back Z0012-0012
12101 py 78.4225 $ Back Z0012-0012
12102 py 114.6175 $ Back Z0012-0012
12103 py 146.3675 $ Back Z0012-0012
c back side
13100 pz 40.005 $ Back Z0012-0012
c sides
11200 px -340.36 $ sides Z0012-0012
c
12200 py 45.72 $ sides Z0012-0012
12201 py 147.32 $ sides Z0012-0012
c front
11300 px -363.22 $ front Z0012-0012
11301 px -362.2675 $ front Z0012-0012
12300 py 73.66 $ front Z0012-0012
12301 py 119.38 $ front Z0012-0012
c slant
14400 p -340.36 46.6725 0 -340.36 46.6725 100
       -362.2675 73.66 0
14401 p -341.0995146 46.07218812 0 -341.0995146 46.07218812 100
       -363.0070146 73.05968812 0
14500 p -340.36 46.6725 0 -340.36 46.6725 100
       -341.10 46.07218812 0
14501 p -362.2675 73.66 0 -362.2675 73.66 100
       -363.0070 73.05968812 0
14402 p -340.36 146.3675 0 -340.36 146.3675 100
       -362.2675 119.38 0
14403 p -341.0995146 146.9678119 0 -341.0995146 146.9678119 100
       -363.0070146 119.9803119 0
14502 p -340.36 146.3675 0 -340.36 146.3675 100
       -341.0995146 146.9678119 0
14503 p -362.2675 119.38 0 -362.2675 119.38 100
```

```
      -363.0070146 119.9803119 0
c inner sides
11600 px -332.74
11601 px -333.6925
12600 py 79.375
12601 py 113.665
 c forward hole
11700 px -362.585
11701 px -350.2406
11702 px -349.2881
c
14700 c/x 96.52 0 12.573
14701 c/x 96.52 0 13.208
14702 c/x 96.52 0 15.24
14703 c/x 96.52 0 15.875
c
21300 px -370.8400 $ poly inside
21301 px -401.3200 $ poly outside
21302 px -406.4000 $ steel outside
21303 px -386.08 $ polybreak
c
22200 py 154.94 $ poly inside
22201 py 185.42 $ poly outside
22202 py 190.50 $ steel outside
c
22203 py 30.48 $ poly inside
22204 py 0.00 $ poly outside
22205 py -5.08 $ steel outside
c
23100 pz 47.625 $ poly inside
23101 pz 78.105 $ poly outside
23102 pz 83.185 $ steel outside
c
21702 px -362.9406 $ ID-1C-12656
21703 px -337.5406 $ ID-1C-12656
c
23103 pz 84.185
c
99998 rpp 5.24 66.2 -559.395 -498.435 -2.54 58.42
99999 pz -93.98 $ APPROX FLOOR MUST FIX

c ********************************************************************************
c ******************************Data Cards*************************************
c ********************************************************************************
c
c       Material cards (Brittan composition)
c
c       Fuel (Brittan's memo)  boron 7.6 ppm (as calculated
m1      92235.70c   8.6849E-6
        92238.70c   6.2967E-7
         6000.70c   8.6227E-2
        26054.70c   6.5286E-7
        26056.70c   1.0239E-5
        26057.70c   2.3659E-7
        26058.70c   3.1248E-8
         8016.70c   1.8623E-5
```

```
         5010.70c   1.4495E-7
         5011.70c   5.8343E-7
mt1      grph.10t
c
c        Zr-3 alloy  (Brittan's memo)
c m2       40000.66c   4.2865E-2      50000.42c   9.2780E-5
c         26054.70c   1.1659E-5      26056.70c   1.8285E-4
c         26057.70c   4.2252E-6      26058.70c   5.5804E-7
c         28058.70c   2.2803E-7      28060.70c   8.7821E-8
c         28061.70c   3.8183E-9      28062.70c   2.2207E-8
c         28064.70c   3.1149E-9
c         24050.70c   9.8706E-8      24052.70c   1.9013E-6
c         24053.70c   2.1556E-7      24054.70c   5.3551E-8
c         48000.50c   6.9974E-9      72000.60c   2.2034E-6
c          5010.70c   1.3751E-7       5011.70c   5.9006E-7
c
c        Air (Brittan's memo)
m3       18000.35c   2.5122E-7
         8016.70c   1.2678E-5
         7014.70c   8.3688E-5      7015.70c    3.1919E-7
c
c        Graphite (Brittan's memo)
m4       26054.70c   1.0536E-6      26056.70c   1.6524E-5
        26057.70c   3.8181E-7      26058.70c   5.0428E-8
         5010.70c   3.5167E-8      5011.70c   1.5090E-7
         6000.70c   8.3655E-2
mt4      grph.10t
c
c        Al-2 alloy (Brittan's memo)
m5       13027.70c   5.9477E-2
        26054.70c   2.5591E-5      26056.70c   4.0136E-4
        26057.70c   9.2739E-6      26058.70c   1.2249E-6
c
c        B4C (my calculation)
m6       5010.70c   1.38808E-2       5011.70c   5.58720E-2
        6000.70c   1.74382E-2
mt6      grph.10t
c
c        Carbon-steel (taiwo's calculation)
m7       26054.70c   5.08189E-3   26056.70c   7.68600E-2
        26057.70c   1.74474E-3   26058.70c   2.26468E-4
        42000.66c   5.47000E-4    6000.70c   1.40000E-3
c
c        Zr-2 alloy (Brittan's memo)
c m8       40000.66c   4.2498E-2   50000.42c   4.7529E-5
c         26054.70c   5.3721E-6   26056.70c   8.4254E-5
c         26057.70c   1.9468E-6   26058.70c   2.5712E-7
c         28058.70c   2.2872E-5   28060.70c   8.8091E-6
c         28061.70c   3.8301E-7   28062.70c   2.2275E-6
c         28064.70c   3.1245E-7
c         24050.70c   3.6634E-6   24052.70c   7.0565E-5
c         24053.70c   8.0005E-6   24054.70c   1.9875E-6
c          5010.70c   1.3793E-7    5011.70c   5.9187E-7
c         48000.50c   1.0528E-8   72000.60c   2.2102E-6
c
c Zircaloy-2 revised B-10, B-11, added isotopes for endf7
```

```
m8    40090.70c   2.1864E-02
      40091.70c   4.7680E-03
      40092.70c   7.2880E-03
      40094.70c   7.3858E-03
      40096.70c   1.1899E-03
      50112.70c   4.6096E-06
      50114.70c   3.0889E-06
      50115.70c   1.7108E-06
      50116.70c   6.9048E-05
      50117.70c   3.6496E-05
      50118.70c   1.1510E-04
      50119.70c   4.0773E-05
      50120.70c   1.5487E-04
      50122.70c   2.2002E-05
      50124.70c   2.7515E-05
      26054.70c   5.4180E-06
      26056.70c   8.4226E-05
      26057.70c   1.9284E-06
      26058.70c   2.5712E-07
      24050.70c   3.6592E-06
      24052.70c   7.0564E-05
      24053.70c   8.0005E-06
      24054.70c   1.9917E-06
      28058.70c   2.2948E-05
      28060.70c   8.7732E-06
      28061.70c   3.7984E-07
      28062.70c   1.2067E-06
      28064.70c   3.0589E-07
       5010.70c   1.4523E-08
       5011.70c   5.8457E-08
      48106.70c   1.3160E-10
      48108.70c   9.3701E-11
      48110.70c   1.3150E-09
      48111.70c   1.3476E-09
      48112.70c   2.5405E-09
      48113.70c   1.2866E-09
      48114.70c   3.0248E-09
      48116.70c   7.8857E-10
      72174.70c   3.5805E-09
      72176.70c   1.1506E-07
      72177.70c   4.1122E-07
      72178.70c   6.0331E-07
      72179.70c   3.0122E-07
      72180.70c   7.7577E-07
c
c        Zr-assumed Zr-3 (Brittan's memo)
c m9       40000.66c   4.2865E-2    50000.42c   9.2780E-5
c         26054.70c   1.1659E-5    26056.70c   1.8285E-4
c         26057.70c   4.2252E-6    26058.70c   5.5804E-7
c         28058.70c   2.2803E-7    28060.70c   8.7821E-8
c         28061.70c   3.8183E-9    28062.70c   2.2207E-8
c         28064.70c   3.1149E-9
c         24050.70c   9.8706E-8    24052.70c   1.9013E-6
c         24053.70c   2.1556E-7    24054.70c   5.3551E-8
c         48000.50c   6.9974E-9    72000.60c   2.2034E-6
c          5010.70c   1.3751E-7     5011.70c   5.9006E-7
```

```
c
c Zircaloy-3 revised B-10, B-11, added isotopes for endf7
m9    40090.70c   2.2053E-02
      40091.70c   4.8093E-03
      40092.70c   7.3511E-03
      40094.70c   7.4497E-03
      40096.70c   1.2002E-03
      50112.70c   8.9982E-07
      50114.70c   6.0297E-07
      50115.70c   3.3395E-07
      50116.70c   1.3479E-05
      50117.70c   7.1243E-06
      50118.70c   2.2468E-05
      50119.70c   7.9592E-06
      50120.70c   3.0232E-05
      50122.70c   4.2950E-06
      50124.70c   5.3711E-06
      26054.70c   1.1759E-05
      26056.70c   1.8280E-04
      26057.70c   4.1852E-06
      26058.70c   5.5803E-07
      24050.70c   9.8595E-08
      24052.70c   1.9013E-06
      24053.70c   2.1557E-07
      24054.70c   5.3665E-08
      28058.70c   2.2878E-07
      28060.70c   8.7465E-08
      28061.70c   3.7868E-09
      28062.70c   1.2031E-08
      28064.70c   3.0495E-09
       5010.70c   1.4479E-08
       5011.70c   5.8279E-08
      48106.70c   8.7467E-11
      48108.70c   6.2277E-11
      48110.70c   8.7398E-10
      48111.70c   8.9567E-10
      48112.70c   1.6885E-09
      48113.70c   8.5508E-10
      48114.70c   2.0104E-09
      48116.70c   5.2411E-10
      72174.70c   3.5695E-09
      72176.70c   1.1471E-07
      72177.70c   4.0997E-07
      72178.70c   6.0147E-07
      72179.70c   3.0030E-07
      72180.70c   7.7340E-07
c
c      SS304 stainless steel 304 (8.76286E-02)
m10        6000.70c 3.18633E-04   14000.60c 1.70334E-03
         15031.70c 6.95028E-05   16000.66c 4.47591E-05
         24050.70c 7.60426E-04   24052.70c 1.46474E-02
         24053.70c 1.66070E-03   24054.70c 4.12553E-04
         25055.70c 1.74157E-03   26054.70c 3.38249E-03
         26056.70c 5.33527E-02   26057.70c 1.22049E-03
         26058.70c 1.62731E-04   28058.70c 5.56500E-03
         28060.70c 2.12753E-03   28061.70c 9.21111E-05
```

```
     28062.70c 2.92637E-04   28064.70c 7.41781E-05
c --- My Dysprosium 8.55 gr/cm3 ---
m11      66156.70c  -0.06
     66158.70c  -0.10
     66160.70c  -2.34
     66161.70c -18.91
     66162.70c -25.51
     66163.70c -24.90
     66164.70c -28.18
c -------------------------------------
c      Fuel Pin T-462 d=-14.97 gr/cm3
c m12      92234.70c -0.40
c        92235.70c -40.40
c        92236.70c  -0.23
c        92238.70c -30.00
c        94239.70c -17.98
c        94240.70c  -1.12
c        94241.70c  -0.05
c        94242.70c  -0.01
c        40000.66c  -9.82
c
c      Sodium Bond
c m13      11023.70c 2.53448E-02
c
c      cladding  (g/cm**3)
c m14      26054.70c -3.89892E-01  26056.70c -6.16568E+00
c        26057.70c -1.47890E-01  26058.70c -1.88224E-02
c        24050.70c -4.18448E-02  24052.70c -8.06018E-01
c        24053.70c -9.13853E-02  24054.70c -2.27020E-02
c        28058.70c -2.76801E-02  28060.70c -1.05822E-02
c        28061.70c -4.58159E-04  28062.70c -1.45557E-03
c        28064.70c -3.68960E-04  74182.70c -9.41240E-03
c        74183.70c -5.10867E-03  74184.70c -1.09615E-02
c        74186.70c -1.02460E-02  42000.66c -8.26800E-02
c        25055.70c -4.53150E-02
c      Fuel Pin T-433 (wt%) d=-14.91 gr/cm3
c m15      92234.70c -0.57
c        92235.70c -61.82
c        92236.70c -0.34
c        92238.70c -27.52
c        40000.66c -9.86
c ------ Irradiation Wire --- d (gr/cm3)= 8.16167542----------
m16    92233.70c  -0.000030
    92234.70c  -0.006684
    92235.70c  -1.189980
    92236.70c  -0.008274
    92238.70c  -4.795080
    40000.66c -94.000000
c ------   Inconel x-750 ----- d= 8.18676 gr/cm3 -------
m17     6000.70c -3.32120E-03  24050.70c -5.24920E-02
    24052.70c -1.05149E+00  24053.70c -1.21511E-01
    24054.70c -3.07551E-02  26054.70c -3.22316E-02
    26056.70c -5.24199E-01  26057.70c -1.23290E-02
    26058.70c -1.65691E-03  28058.70c -3.92116E+00
    28060.70c -1.56217E+00  28061.70c -6.90537E-02
    28062.70c -4.08186E-01  28064.70c -5.91036E-02
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     25055.70c -3.73635E-02  14000.60c -2.07575E-02
     22000.66c -2.17539E-01  13027.70c -6.14422E-02
c
c    Tanner Concrete 2.25 g/cc
m1002 6000.70c 1.600e-3  8016.70c 4.350e-2 11023.50c 5.500e-4
     13027.70c 1.600e-3 14000.60c 1.520e-2 16032.50c 5.000e-5
     20000.50c 3.100e-3 26000.55c 3.800e-4  1001.70c 7.606e-3
c
c  Polyethylene,  Borated   -1.00 (PNNL-15870 Rev. 1)
m1005   1001.70c -0.125355  5010.70c -0.1 6000.70c -0.774645
c
c  Polyethylene,  Borated   -0.93 (PNNL-15870 Rev. 1)
m1006   1001.70c -0.143716 6000.70c -0.856284
c Lead
m82    82000 1                        $ Pb
c
c PNNL-Concrete,Magnetite 3.53
m115      1001.80c -3.1122E-03  1002.80c -7.1533E-07  8016.80c -3.2962E-01
          12024.80c -7.2788E-03
        12025.80c -9.5994E-04 12026.80c -1.0991E-03 13027.80c -2.3486E-02
        14028.80c -2.3656E-02 14029.80c -1.2447E-03 14030.80c -8.4974E-04
        16032.80c -1.3401E-03 16033.80c -1.0912E-05 16034.80c -6.3701E-05
        16036.80c -1.5871E-07 20040.80c -6.8653E-02 20042.80c -4.8109E-04
        20043.80c -1.0277E-04 20044.80c -1.6249E-03 20046.80c -3.2575E-06
        20048.80c -1.5891E-04 22046.80c -4.3029E-03 22047.80c -3.9648E-03
        22048.80c -4.0119E-02 22049.80c -3.0056E-03 22050.80c -2.9364E-03
        23050.80c -7.6306E-06 23051.80c -3.1054E-03 24050.80c -7.0869E-05
        24052.80c -1.4212E-03 24053.80c -1.6426E-04 24054.80c -4.1658E-05
        25055.80c -1.9810E-03 26054.80c -2.6774E-02 26056.80c -4.3584E-01
        26057.80c -1.0246E-02 26058.80c -1.3874E-03
mt115     lwtr.20t
c
*tr1 10.16 10.16 0  180 270 90  90 180 90  90 90 0
c
c Transient Bank Position - Max 40" (101.6 cm) travel (ANL-IFR-232)
TR21    0 0 101.6                                   $ NE transient rod position
TR22    0 0 101.6                                   $ SE transient rod position
TR23    0 0 101.6                                   $ SW transient rod position
TR24    0 0 101.6                                   $ SW transient rod position
c
c Control Bank Position - Max 58" (147.32 cm) travel (ANL-IFR-232)
TR31    0 0  55.88                                  $ NE control rod position
TR32    0 0  55.88                                  $ SE control rod position
TR33    0 0  55.88                                  $ SW control rod position
TR34    0 0  55.88                                  $ SW control rod position
c
c Compensation Bank Position - Max 58" (147.32 cm) travel (ANL-IFR-232)
TR41    0 0 147.32                                  $ NE compensation rod position
TR42    0 0 147.32                                  $ SE compensation rod position
TR43    0 0 147.32                                  $ SW compensation rod position
TR44    0 0 147.32                                  $ SW compensation rod position
c 18<9990[4 1 0]<9991 18<9990[5 1 0]<9991 18<9990[6 1 0]<9991 18<9990[7 1 0]<9991
mode  n
c
c ******************** Begin Definition of Source ******************************
sdef  erg=d2 pos=d1 ext=fpos d4
```

```
     axs=0 0 1    $
     rad=d5
ds4  s         101   316i    418            $ distribution numbers
sc1   source positions
si1  l       25.4 5.08 0   35.56 5.08 0
      45.72 5.08 0   55.88 5.08 0
      66.04 5.08 0   76.2 5.08 0
      86.36 5.08 0   96.52 5.08 0
      106.68 5.08 0   116.84 5.08 0
      127 5.08 0   137.16 5.08 0
      147.32 5.08 0   157.48 5.08 0
      167.64 5.08 0   15.24 15.24 0
      25.4 15.24 0   35.56 15.24 0
      45.72 15.24 0   55.88 15.24 0
      66.04 15.24 0   76.2 15.24 0
      86.36 15.24 0   96.52 15.24 0
      106.68 15.24 0   116.84 15.24 0
      127 15.24 0   137.16 15.24 0
      147.32 15.24 0   157.48 15.24 0
      167.64 15.24 0   177.8 15.24 0
      5.08 25.4 0   15.24 25.4 0
      25.4 25.4 0   35.56 25.4 0
      45.72 25.4 0   55.88 25.4 0
      66.04 25.4 0   86.36 25.4 0
      96.52 25.4 0   106.68 25.4 0
      127 25.4 0   137.16 25.4 0
      147.32 25.4 0   157.48 25.4 0
      167.64 25.4 0   177.8 25.4 0
      187.96 25.4 0   5.08 35.56 0
      15.24 35.56 0   25.4 35.56 0
      35.56 35.56 0   45.72 35.56 0
      66.04 35.56 0   76.2 35.56 0
      86.36 35.56 0   96.52 35.56 0
      106.68 35.56 0   116.84 35.56 0
      127 35.56 0   147.32 35.56 0
      157.48 35.56 0   167.64 35.56 0
      177.8 35.56 0   187.96 35.56 0
      5.08 45.72 0   15.24 45.72 0
      25.4 45.72 0   35.56 45.72 0
      45.72 45.72 0   55.88 45.72 0
      66.04 45.72 0   76.2 45.72 0
      86.36 45.72 0   96.52 45.72 0
      106.68 45.72 0   116.84 45.72 0
      127 45.72 0   137.16 45.72 0
      147.32 45.72 0   157.48 45.72 0
      167.64 45.72 0   177.8 45.72 0
      187.96 45.72 0   5.08 55.88 0
      15.24 55.88 0   25.4 55.88 0
      45.72 55.88 0   55.88 55.88 0
      66.04 55.88 0   76.2 55.88 0
      86.36 55.88 0   96.52 55.88 0
      106.68 55.88 0   116.84 55.88 0
      127 55.88 0   137.16 55.88 0
      147.32 55.88 0   167.64 55.88 0
      177.8 55.88 0   187.96 55.88 0
      5.08 66.04 0   15.24 66.04 0
```

25.4 66.04 0   35.56 66.04 0
45.72 66.04 0   55.88 66.04 0
66.04 66.04 0   76.2 66.04 0
86.36 66.04 0   96.52 66.04 0
106.68 66.04 0   116.84 66.04 0
127 66.04 0   137.16 66.04 0
147.32 66.04 0   157.48 66.04 0
167.64 66.04 0   177.8 66.04 0
187.96 66.04 0   5.08 76.2 0
15.24 76.2 0   35.56 76.2 0
45.72 76.2 0   66.04 76.2 0
76.2 76.2 0   86.36 76.2 0
96.52 76.2 0   106.68 76.2 0
116.84 76.2 0   127 76.2 0
147.32 76.2 0   157.48 76.2 0
177.8 76.2 0   187.96 76.2 0
5.08 86.36 0   15.24 86.36 0
25.4 86.36 0   35.56 86.36 0
45.72 86.36 0   55.88 86.36 0
66.04 86.36 0   76.2 86.36 0
86.36 86.36 0   106.68 86.36 0
116.84 86.36 0   127 86.36 0
137.16 86.36 0   147.32 86.36 0
157.48 86.36 0   167.64 86.36 0
177.8 86.36 0   187.96 86.36 0
5.08 96.52 0   15.24 96.52 0
25.4 96.52 0   35.56 96.52 0
45.72 96.52 0   55.88 96.52 0
66.04 96.52 0   76.2 96.52 0
86.36 96.52 0   106.68 96.52 0
116.84 96.52 0   127 96.52 0
137.16 96.52 0   147.32 96.52 0
157.48 96.52 0   167.64 96.52 0
177.8 96.52 0   187.96 96.52 0
5.08 106.68 0   15.24 106.68 0
25.4 106.68 0   35.56 106.68 0
45.72 106.68 0   55.88 106.68 0
66.04 106.68 0   76.2 106.68 0
86.36 106.68 0   106.68 106.68 0
116.84 106.68 0   127 106.68 0
137.16 106.68 0   147.32 106.68 0
157.48 106.68 0   167.64 106.68 0
177.8 106.68 0   187.96 106.68 0
5.08 116.84 0   15.24 116.84 0
35.56 116.84 0   45.72 116.84 0
66.04 116.84 0   76.2 116.84 0
86.36 116.84 0   106.68 116.84 0
116.84 116.84 0   127 116.84 0
147.32 116.84 0   157.48 116.84 0
177.8 116.84 0   187.96 116.84 0
5.08 127 0   15.24 127 0
25.4 127 0   35.56 127 0
45.72 127 0   55.88 127 0
66.04 127 0   76.2 127 0
86.36 127 0   106.68 127 0
116.84 127 0   127 127 0

```
      137.16 127 0   147.32 127 0
      157.48 127 0   167.64 127 0
      177.8 127 0   187.96 127 0
      5.08 137.16 0   15.24 137.16 0
      25.4 137.16 0   45.72 137.16 0
      55.88 137.16 0   66.04 137.16 0
      76.2 137.16 0   86.36 137.16 0
      106.68 137.16 0   116.84 137.16 0
      127 137.16 0   137.16 137.16 0
      147.32 137.16 0   167.64 137.16 0
      177.8 137.16 0   187.96 137.16 0
      5.08 147.32 0   15.24 147.32 0
      25.4 147.32 0   35.56 147.32 0
      45.72 147.32 0   55.88 147.32 0
      66.04 147.32 0   76.2 147.32 0
      86.36 147.32 0   106.68 147.32 0
      116.84 147.32 0   127 147.32 0
      137.16 147.32 0   147.32 147.32 0
      157.48 147.32 0   167.64 147.32 0
      177.8 147.32 0   187.96 147.32 0
      5.08 157.48 0   15.24 157.48 0
      25.4 157.48 0   35.56 157.48 0
      45.72 157.48 0   66.04 157.48 0
      76.2 157.48 0   86.36 157.48 0
      106.68 157.48 0   116.84 157.48 0
      127 157.48 0   147.32 157.48 0
      157.48 157.48 0   167.64 157.48 0
      177.8 157.48 0   187.96 157.48 0
      5.08 167.64 0   15.24 167.64 0
      25.4 167.64 0   35.56 167.64 0
      45.72 167.64 0   55.88 167.64 0
      66.04 167.64 0   86.36 167.64 0
      106.68 167.64 0   127 167.64 0
      137.16 167.64 0   147.32 167.64 0
      157.48 167.64 0   167.64 167.64 0
      177.8 167.64 0   187.96 167.64 0
      15.24 177.8 0   25.4 177.8 0
      35.56 177.8 0   45.72 177.8 0
      55.88 177.8 0   66.04 177.8 0
      76.2 177.8 0   86.36 177.8 0
      106.68 177.8 0   116.84 177.8 0
      127 177.8 0   137.16 177.8 0
      147.32 177.8 0   157.48 177.8 0
      167.64 177.8 0   177.8 177.8 0
      25.4 187.96 0   35.56 187.96 0
      45.72 187.96 0   55.88 187.96 0
      66.04 187.96 0   76.2 187.96 0
      86.36 187.96 0   106.68 187.96 0
      116.84 187.96 0   127 187.96 0
      137.16 187.96 0   147.32 187.96 0
      157.48 187.96 0   167.64 187.96 0
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     2.510E-03 2.338E-03 2.387E-03 2.465E-03 2.522E-03 2.551E-03
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1.773E-03 1.896E-03 1.900E-03 1.783E-03 1.866E-03 1.973E-03
2.057E-03 2.120E-03 2.171E-03 2.292E-03 2.108E-03 2.063E-03
2.051E-03 2.022E-03 1.978E-03 1.942E-03 1.949E-03 1.952E-03
1.950E-03 1.982E-03 2.021E-03 2.042E-03 2.062E-03 2.133E-03
si101 H -62.5475 14i 58.42
sp101 D 0 6.380E-02 6.626E-02 6.933E-02 7.198E-02 7.421E-02
7.566E-02 7.645E-02 7.585E-02 7.347E-02 6.990E-02
6.552E-02 6.082E-02 5.655E-02 5.215E-02 4.807E-02
si102 H -62.5475 14i 58.42
sp102 D 0 6.596E-02 6.798E-02 7.066E-02 7.258E-02 7.445E-02
7.627E-02 7.682E-02 7.573E-02 7.311E-02 6.922E-02
6.425E-02 5.937E-02 5.521E-02 5.116E-02 4.723E-02

si103 H -62.5475 14i 58.42
sp103 D 0 6.749E-02 6.970E-02 7.218E-02 7.422E-02 7.567E-02
7.677E-02 7.684E-02 7.512E-02 7.229E-02 6.821E-02
6.353E-02 5.853E-02 5.401E-02 4.969E-02 4.575E-02
si104 H -62.5475 14i 58.42
sp104 D 0 6.915E-02 7.141E-02 7.419E-02 7.619E-02 7.738E-02
7.745E-02 7.629E-02 7.408E-02 7.093E-02 6.700E-02
6.273E-02 5.777E-02 5.299E-02 4.817E-02 4.429E-02
si105 H -62.5475 14i 58.42
sp105 D 0 7.053E-02 7.289E-02 7.582E-02 7.802E-02 7.858E-02
7.767E-02 7.598E-02 7.325E-02 6.988E-02 6.607E-02
6.196E-02 5.683E-02 5.203E-02 4.725E-02 4.325E-02
si106 H -62.5475 14i 58.42
sp106 D 0 7.138E-02 7.350E-02 7.650E-02 7.873E-02 7.891E-02
7.787E-02 7.582E-02 7.297E-02 6.944E-02 6.575E-02
6.140E-02 5.644E-02 5.168E-02 4.691E-02 4.267E-02
si107 H -62.5475 14i 58.42
sp107 D 0 7.073E-02 7.297E-02 7.599E-02 7.810E-02 7.858E-02
7.786E-02 7.604E-02 7.330E-02 7.001E-02 6.608E-02
6.173E-02 5.680E-02 5.187E-02 4.705E-02 4.288E-02
si108 H -62.5475 14i 58.42
sp108 D 0 7.026E-02 7.246E-02 7.552E-02 7.773E-02 7.847E-02
7.791E-02 7.611E-02 7.354E-02 7.023E-02 6.629E-02
6.200E-02 5.712E-02 5.212E-02 4.715E-02 4.309E-02
si109 H -62.5475 14i 58.42
sp109 D 0 7.095E-02 7.315E-02 7.599E-02 7.801E-02 7.876E-02
7.800E-02 7.607E-02 7.312E-02 6.980E-02 6.618E-02
6.177E-02 5.678E-02 5.170E-02 4.692E-02 4.279E-02
si110 H -62.5475 14i 58.42
sp110 D 0 7.119E-02 7.364E-02 7.638E-02 7.864E-02 7.902E-02
7.805E-02 7.556E-02 7.303E-02 6.967E-02 6.564E-02
6.138E-02 5.668E-02 5.165E-02 4.682E-02 4.264E-02
si111 H -62.5475 14i 58.42
sp111 D 0 7.028E-02 7.272E-02 7.592E-02 7.779E-02 7.861E-02
7.789E-02 7.598E-02 7.315E-02 7.000E-02 6.627E-02
6.199E-02 5.702E-02 5.208E-02 4.716E-02 4.314E-02
si112 H -62.5475 14i 58.42
sp112 D 0 6.858E-02 7.105E-02 7.418E-02 7.651E-02 7.757E-02
7.739E-02 7.625E-02 7.391E-02 7.094E-02 6.729E-02
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si113 H -62.5475 14i 58.42
sp113 D 0 6.637E-02 6.876E-02 7.207E-02 7.492E-02 7.679E-02
7.710E-02 7.643E-02 7.469E-02 7.195E-02 6.843E-02
6.406E-02 5.942E-02 5.444E-02 4.933E-02 4.522E-02
si114 H -62.5475 14i 58.42
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si115 H -62.5475 14i 58.42
sp115 D 0 6.272E-02 6.568E-02 6.911E-02 7.243E-02 7.472E-02
7.627E-02 7.657E-02 7.554E-02 7.311E-02 7.022E-02
6.630E-02 6.164E-02 5.666E-02 5.164E-02 4.738E-02
si116 H -62.5475 14i 58.42
sp116 D 0 6.204E-02 6.446E-02 6.826E-02 7.194E-02 7.468E-02
7.630E-02 7.662E-02 7.594E-02 7.399E-02 7.069E-02
6.662E-02 6.201E-02 5.703E-02 5.174E-02 4.768E-02

si117 H -62.5475 14i 58.42
sp117 D 0 6.397E-02 6.585E-02 6.940E-02 7.291E-02 7.572E-02
7.705E-02 7.714E-02 7.588E-02 7.366E-02 7.017E-02
6.552E-02 6.074E-02 5.543E-02 5.018E-02 4.638E-02
si118 H -62.5475 14i 58.42
sp118 D 0 6.650E-02 6.822E-02 7.143E-02 7.464E-02 7.691E-02
7.768E-02 7.738E-02 7.568E-02 7.288E-02 6.890E-02
6.422E-02 5.885E-02 5.349E-02 4.843E-02 4.479E-02
si119 H -62.5475 14i 58.42
sp119 D 0 6.994E-02 7.181E-02 7.496E-02 7.747E-02 7.872E-02
7.837E-02 7.690E-02 7.421E-02 7.089E-02 6.706E-02
6.228E-02 5.682E-02 5.143E-02 4.647E-02 4.265E-02
si120 H -62.5475 14i 58.42
sp120 D 0 7.382E-02 7.564E-02 7.867E-02 8.080E-02 8.104E-02
7.893E-02 7.605E-02 7.252E-02 6.873E-02 6.462E-02
5.980E-02 5.471E-02 4.947E-02 4.441E-02 4.077E-02
si121 H -62.5475 14i 58.42
sp121 D 0 7.805E-02 7.990E-02 8.301E-02 8.463E-02 8.350E-02
7.938E-02 7.454E-02 7.014E-02 6.603E-02 6.194E-02
5.751E-02 5.259E-02 4.733E-02 4.249E-02 3.896E-02
si122 H -62.5475 14i 58.42
sp122 D 0 8.083E-02 8.294E-02 8.629E-02 8.773E-02 8.512E-02
7.903E-02 7.276E-02 6.830E-02 6.428E-02 6.033E-02
5.580E-02 5.101E-02 4.610E-02 4.136E-02 3.810E-02
si123 H -62.5475 14i 58.42
sp123 D 0 7.616E-02 7.808E-02 8.124E-02 8.339E-02 8.257E-02
7.922E-02 7.521E-02 7.123E-02 6.739E-02 6.329E-02
5.835E-02 5.330E-02 4.807E-02 4.311E-02 3.940E-02
si124 H -62.5475 14i 58.42
sp124 D 0 7.337E-02 7.513E-02 7.837E-02 8.100E-02 8.119E-02
7.942E-02 7.643E-02 7.297E-02 6.914E-02 6.492E-02
5.994E-02 5.468E-02 4.925E-02 4.404E-02 4.014E-02
si125 H -62.5475 14i 58.42
sp125 D 0 7.611E-02 7.798E-02 8.106E-02 8.319E-02 8.266E-02
7.952E-02 7.530E-02 7.120E-02 6.738E-02 6.319E-02
5.853E-02 5.331E-02 4.812E-02 4.303E-02 3.943E-02
si126 H -62.5475 14i 58.42
sp126 D 0 8.101E-02 8.287E-02 8.587E-02 8.752E-02 8.513E-02
7.909E-02 7.296E-02 6.831E-02 6.437E-02 6.042E-02
5.591E-02 5.109E-02 4.601E-02 4.132E-02 3.813E-02
si127 H -62.5475 14i 58.42
sp127 D 0 7.767E-02 7.982E-02 8.307E-02 8.473E-02 8.339E-02
7.936E-02 7.447E-02 7.021E-02 6.613E-02 6.210E-02
5.747E-02 5.255E-02 4.739E-02 4.249E-02 3.916E-02
si128 H -62.5475 14i 58.42
sp128 D 0 7.329E-02 7.525E-02 7.877E-02 8.102E-02 8.102E-02
7.911E-02 7.583E-02 7.242E-02 6.876E-02 6.464E-02
6.019E-02 5.488E-02 4.942E-02 4.451E-02 4.087E-02
si129 H -62.5475 14i 58.42
sp129 D 0 6.911E-02 7.128E-02 7.473E-02 7.751E-02 7.903E-02
7.852E-02 7.685E-02 7.427E-02 7.090E-02 6.718E-02
6.239E-02 5.718E-02 5.161E-02 4.666E-02 4.279E-02
si130 H -62.5475 14i 58.42
sp130 D 0 6.588E-02 6.769E-02 7.133E-02 7.479E-02 7.719E-02
7.785E-02 7.703E-02 7.550E-02 7.277E-02 6.913E-02
6.459E-02 5.935E-02 5.381E-02 4.858E-02 4.452E-02

si131 H -62.5475 14i 58.42
sp131 D 0 6.331E-02 6.563E-02 6.927E-02 7.275E-02 7.553E-02
7.727E-02 7.726E-02 7.610E-02 7.380E-02 7.017E-02
6.595E-02 6.100E-02 5.556E-02 5.015E-02 4.625E-02
si132 H -62.5475 14i 58.42
sp132 D 0 6.152E-02 6.424E-02 6.795E-02 7.158E-02 7.468E-02
7.639E-02 7.695E-02 7.612E-02 7.404E-02 7.105E-02
6.697E-02 6.208E-02 5.694E-02 5.185E-02 4.762E-02
si133 H -62.5475 14i 58.42
sp133 D 0 6.028E-02 6.364E-02 6.729E-02 7.108E-02 7.395E-02
7.583E-02 7.642E-02 7.603E-02 7.444E-02 7.134E-02
6.763E-02 6.308E-02 5.800E-02 5.274E-02 4.826E-02
si134 H -62.5475 14i 58.42
sp134 D 0 6.191E-02 6.413E-02 6.787E-02 7.192E-02 7.496E-02
7.684E-02 7.733E-02 7.671E-02 7.454E-02 7.119E-02
6.706E-02 6.177E-02 5.634E-02 5.082E-02 4.662E-02
si135 H -62.5475 14i 58.42
sp135 D 0 6.360E-02 6.570E-02 6.969E-02 7.357E-02 7.626E-02
7.793E-02 7.794E-02 7.635E-02 7.397E-02 7.032E-02
6.587E-02 6.058E-02 5.472E-02 4.885E-02 4.465E-02
si136 H -62.5475 14i 58.42
sp136 D 0 6.649E-02 6.892E-02 7.278E-02 7.636E-02 7.840E-02
7.888E-02 7.781E-02 7.555E-02 7.255E-02 6.871E-02
6.387E-02 5.835E-02 5.236E-02 4.674E-02 4.224E-02
si137 H -62.5475 14i 58.42
sp137 D 0 7.290E-02 7.544E-02 7.911E-02 8.204E-02 8.212E-02
7.944E-02 7.602E-02 7.254E-02 6.892E-02 6.483E-02
6.012E-02 5.471E-02 4.885E-02 4.360E-02 3.937E-02
si138 H -62.5475 14i 58.42
sp138 D 0 8.108E-02 8.382E-02 8.746E-02 8.939E-02 8.662E-02
7.973E-02 7.280E-02 6.812E-02 6.413E-02 5.998E-02
5.500E-02 5.019E-02 4.500E-02 4.021E-02 3.647E-02
si139 H -62.5475 14i 58.42
sp139 D 0 8.518E-02 8.784E-02 9.161E-02 9.268E-02 8.871E-02
7.982E-02 7.140E-02 6.600E-02 6.172E-02 5.752E-02
5.311E-02 4.809E-02 4.305E-02 3.832E-02 3.495E-02
si140 H -62.5475 14i 58.42
sp140 D 0 7.790E-02 8.043E-02 8.420E-02 8.648E-02 8.492E-02
7.996E-02 7.446E-02 7.010E-02 6.612E-02 6.199E-02
5.723E-02 5.186E-02 4.627E-02 4.107E-02 3.700E-02
si141 H -62.5475 14i 58.42
sp141 D 0 7.269E-02 7.511E-02 7.889E-02 8.191E-02 8.228E-02
8.008E-02 7.701E-02 7.331E-02 6.950E-02 6.501E-02
5.983E-02 5.428E-02 4.849E-02 4.292E-02 3.868E-02
si142 H -62.5475 14i 58.42
sp142 D 0 7.784E-02 8.036E-02 8.432E-02 8.650E-02 8.523E-02
7.998E-02 7.453E-02 7.024E-02 6.618E-02 6.181E-02
5.702E-02 5.174E-02 4.615E-02 4.096E-02 3.713E-02
si143 H -62.5475 14i 58.42
sp143 D 0 8.480E-02 8.761E-02 9.127E-02 9.264E-02 8.861E-02
8.001E-02 7.159E-02 6.614E-02 6.171E-02 5.759E-02
5.327E-02 4.821E-02 4.315E-02 3.832E-02 3.506E-02
si144 H -62.5475 14i 58.42
sp144 D 0 8.057E-02 8.326E-02 8.742E-02 8.916E-02 8.660E-02
7.978E-02 7.299E-02 6.833E-02 6.403E-02 5.996E-02
5.555E-02 5.038E-02 4.520E-02 4.011E-02 3.665E-02

si145 H -62.5475 14i 58.42
sp145 D 0 7.236E-02 7.473E-02 7.901E-02 8.185E-02 8.209E-02
7.963E-02 7.586E-02 7.264E-02 6.906E-02 6.503E-02
6.020E-02 5.491E-02 4.927E-02 4.385E-02 3.953E-02
si146 H -62.5475 14i 58.42
sp146 D 0 6.617E-02 6.842E-02 7.246E-02 7.621E-02 7.842E-02
7.882E-02 7.765E-02 7.571E-02 7.277E-02 6.890E-02
6.407E-02 5.867E-02 5.265E-02 4.683E-02 4.226E-02
si147 H -62.5475 14i 58.42
sp147 D 0 6.318E-02 6.540E-02 6.958E-02 7.334E-02 7.620E-02
7.786E-02 7.780E-02 7.663E-02 7.430E-02 7.074E-02
6.609E-02 6.071E-02 5.475E-02 4.885E-02 4.457E-02
si148 H -62.5475 14i 58.42
sp148 D 0 6.172E-02 6.386E-02 6.794E-02 7.166E-02 7.488E-02
7.681E-02 7.728E-02 7.671E-02 7.470E-02 7.154E-02
6.722E-02 6.178E-02 5.635E-02 5.089E-02 4.667E-02
si149 H -62.5475 14i 58.42
sp149 D 0 6.013E-02 6.343E-02 6.724E-02 7.088E-02 7.376E-02
7.575E-02 7.659E-02 7.613E-02 7.457E-02 7.167E-02
6.783E-02 6.296E-02 5.801E-02 5.275E-02 4.830E-02
si150 H -62.5475 14i 58.42
sp150 D 0 6.001E-02 6.315E-02 6.710E-02 7.105E-02 7.417E-02
7.621E-02 7.684E-02 7.641E-02 7.479E-02 7.171E-02
6.787E-02 6.292E-02 5.778E-02 5.232E-02 4.766E-02
si151 H -62.5475 14i 58.42
sp151 D 0 6.106E-02 6.363E-02 6.778E-02 7.192E-02 7.521E-02
7.739E-02 7.805E-02 7.733E-02 7.530E-02 7.170E-02
6.734E-02 6.190E-02 5.606E-02 4.999E-02 4.534E-02
si152 H -62.5475 14i 58.42
sp152 D 0 6.225E-02 6.491E-02 6.933E-02 7.371E-02 7.676E-02
7.845E-02 7.865E-02 7.737E-02 7.510E-02 7.122E-02
6.646E-02 6.076E-02 5.438E-02 4.783E-02 4.282E-02
si153 H -62.5475 14i 58.42
sp153 D 0 6.521E-02 6.818E-02 7.270E-02 7.663E-02 7.893E-02
7.939E-02 7.862E-02 7.641E-02 7.341E-02 6.943E-02
6.436E-02 5.870E-02 5.225E-02 4.557E-02 4.021E-02
si154 H -62.5475 14i 58.42
sp154 D 0 7.321E-02 7.689E-02 8.123E-02 8.427E-02 8.370E-02
7.984E-02 7.538E-02 7.196E-02 6.847E-02 6.439E-02
5.964E-02 5.405E-02 4.807E-02 4.191E-02 3.699E-02
si155 H -62.5475 14i 58.42
sp155 D 0 7.988E-02 8.339E-02 8.787E-02 9.002E-02 8.743E-02
8.042E-02 7.315E-02 6.846E-02 6.445E-02 6.024E-02
5.558E-02 5.033E-02 4.449E-02 3.918E-02 3.511E-02
si156 H -62.5475 14i 58.42
sp156 D 0 7.581E-02 7.903E-02 8.335E-02 8.607E-02 8.514E-02
8.043E-02 7.508E-02 7.102E-02 6.708E-02 6.272E-02
5.787E-02 5.245E-02 4.660E-02 4.083E-02 3.653E-02
si157 H -62.5475 14i 58.42
sp157 D 0 7.060E-02 7.368E-02 7.808E-02 8.141E-02 8.227E-02
8.048E-02 7.738E-02 7.408E-02 7.020E-02 6.579E-02
6.074E-02 5.502E-02 4.891E-02 4.301E-02 3.835E-02
si158 H -62.5475 14i 58.42
sp158 D 0 6.828E-02 7.137E-02 7.560E-02 7.917E-02 8.088E-02
8.046E-02 7.836E-02 7.533E-02 7.167E-02 6.737E-02
6.207E-02 5.606E-02 5.001E-02 4.402E-02 3.936E-02

si159 H -62.5475 14i 58.42
sp159 D 0 7.050E-02 7.380E-02 7.813E-02 8.149E-02 8.223E-02
8.029E-02 7.735E-02 7.397E-02 7.022E-02 6.595E-02
6.071E-02 5.495E-02 4.893E-02 4.307E-02 3.840E-02
si160 H -62.5475 14i 58.42
sp160 D 0 7.589E-02 7.893E-02 8.339E-02 8.618E-02 8.517E-02
8.042E-02 7.515E-02 7.095E-02 6.701E-02 6.278E-02
5.793E-02 5.235E-02 4.644E-02 4.088E-02 3.654E-02
si161 H -62.5475 14i 58.42
sp161 D 0 8.003E-02 8.327E-02 8.785E-02 9.011E-02 8.751E-02
8.029E-02 7.315E-02 6.839E-02 6.428E-02 6.027E-02
5.557E-02 5.019E-02 4.470E-02 3.928E-02 3.511E-02
si162 H -62.5475 14i 58.42
sp162 D 0 7.279E-02 7.613E-02 8.108E-02 8.422E-02 8.398E-02
7.976E-02 7.527E-02 7.193E-02 6.858E-02 6.439E-02
5.981E-02 5.435E-02 4.829E-02 4.231E-02 3.711E-02
si163 H -62.5475 14i 58.42
sp163 D 0 6.489E-02 6.789E-02 7.254E-02 7.664E-02 7.902E-02
7.943E-02 7.839E-02 7.627E-02 7.357E-02 6.951E-02
6.460E-02 5.876E-02 5.226E-02 4.588E-02 4.034E-02
si164 H -62.5475 14i 58.42
sp164 D 0 6.209E-02 6.482E-02 6.927E-02 7.362E-02 7.676E-02
7.843E-02 7.844E-02 7.724E-02 7.524E-02 7.140E-02
6.649E-02 6.085E-02 5.441E-02 4.815E-02 4.281E-02
si165 H -62.5475 14i 58.42
sp165 D 0 6.078E-02 6.338E-02 6.764E-02 7.188E-02 7.530E-02
7.733E-02 7.790E-02 7.722E-02 7.536E-02 7.193E-02
6.751E-02 6.211E-02 5.615E-02 5.007E-02 4.544E-02
si166 H -62.5475 14i 58.42
sp166 D 0 5.977E-02 6.305E-02 6.704E-02 7.095E-02 7.407E-02
7.608E-02 7.692E-02 7.647E-02 7.484E-02 7.195E-02
6.798E-02 6.314E-02 5.767E-02 5.238E-02 4.771E-02
si167 H -62.5475 14i 58.42
sp167 D 0 5.936E-02 6.271E-02 6.695E-02 7.104E-02 7.413E-02
7.647E-02 7.720E-02 7.697E-02 7.525E-02 7.210E-02
6.813E-02 6.316E-02 5.753E-02 5.203E-02 4.697E-02
si168 H -62.5475 14i 58.42
sp168 D 0 5.998E-02 6.286E-02 6.754E-02 7.187E-02 7.541E-02
7.777E-02 7.851E-02 7.794E-02 7.600E-02 7.238E-02
6.791E-02 6.226E-02 5.590E-02 4.952E-02 4.415E-02
si169 H -62.5475 14i 58.42
sp169 D 0 6.064E-02 6.383E-02 6.877E-02 7.336E-02 7.675E-02
7.877E-02 7.919E-02 7.847E-02 7.610E-02 7.233E-02
6.746E-02 6.144E-02 5.475E-02 4.742E-02 4.072E-02
si170 H -62.5475 14i 58.42
sp170 D 0 6.234E-02 6.586E-02 7.102E-02 7.554E-02 7.846E-02
7.974E-02 7.953E-02 7.807E-02 7.519E-02 7.136E-02
6.624E-02 5.998E-02 5.313E-02 4.548E-02 3.807E-02
si171 H -62.5475 14i 58.42
sp171 D 0 6.619E-02 6.995E-02 7.527E-02 7.932E-02 8.082E-02
8.032E-02 7.831E-02 7.578E-02 7.268E-02 6.871E-02
6.356E-02 5.759E-02 5.081E-02 4.363E-02 3.706E-02
si172 H -62.5475 14i 58.42
sp172 D 0 7.031E-02 7.431E-02 7.928E-02 8.302E-02 8.319E-02
8.037E-02 7.652E-02 7.336E-02 7.001E-02 6.583E-02
6.094E-02 5.520E-02 4.878E-02 4.217E-02 3.672E-02

si173 H -62.5475 14i 58.42
sp173 D 0 6.840E-02 7.240E-02 7.701E-02 8.065E-02 8.192E-02
8.050E-02 7.779E-02 7.474E-02 7.127E-02 6.683E-02
6.187E-02 5.608E-02 4.949E-02 4.312E-02 3.792E-02
si174 H -62.5475 14i 58.42
sp174 D 0 6.583E-02 6.940E-02 7.431E-02 7.831E-02 8.045E-02
8.038E-02 7.869E-02 7.635E-02 7.274E-02 6.836E-02
6.336E-02 5.738E-02 5.089E-02 4.434E-02 3.919E-02
si175 H -62.5475 14i 58.42
sp175 D 0 6.412E-02 6.757E-02 7.225E-02 7.672E-02 7.934E-02
8.011E-02 7.924E-02 7.721E-02 7.389E-02 6.949E-02
6.441E-02 5.836E-02 5.189E-02 4.534E-02 4.008E-02
si176 H -62.5475 14i 58.42
sp176 D 0 6.340E-02 6.687E-02 7.169E-02 7.600E-02 7.905E-02
8.009E-02 7.940E-02 7.755E-02 7.429E-02 7.000E-02
6.478E-02 5.873E-02 5.209E-02 4.560E-02 4.046E-02
si177 H -62.5475 14i 58.42
sp177 D 0 6.399E-02 6.754E-02 7.260E-02 7.682E-02 7.941E-02
8.009E-02 7.929E-02 7.691E-02 7.385E-02 6.952E-02
6.423E-02 5.826E-02 5.179E-02 4.544E-02 4.027E-02
si178 H -62.5475 14i 58.42
sp178 D 0 6.573E-02 6.917E-02 7.428E-02 7.837E-02 8.043E-02
8.037E-02 7.876E-02 7.611E-02 7.281E-02 6.867E-02
6.333E-02 5.733E-02 5.082E-02 4.455E-02 3.926E-02
si179 H -62.5475 14i 58.42
sp179 D 0 6.837E-02 7.225E-02 7.717E-02 8.070E-02 8.175E-02
8.052E-02 7.764E-02 7.463E-02 7.115E-02 6.704E-02
6.193E-02 5.589E-02 4.972E-02 4.326E-02 3.799E-02
si180 H -62.5475 14i 58.42
sp180 D 0 7.017E-02 7.426E-02 7.932E-02 8.293E-02 8.322E-02
8.020E-02 7.642E-02 7.332E-02 6.999E-02 6.602E-02
6.104E-02 5.517E-02 4.883E-02 4.236E-02 3.676E-02
si181 H -62.5475 14i 58.42
sp181 D 0 6.581E-02 7.001E-02 7.507E-02 7.914E-02 8.094E-02
8.014E-02 7.821E-02 7.588E-02 7.271E-02 6.872E-02
6.372E-02 5.781E-02 5.093E-02 4.388E-02 3.701E-02
si182 H -62.5475 14i 58.42
sp182 D 0 6.215E-02 6.591E-02 7.099E-02 7.547E-02 7.847E-02
7.981E-02 7.949E-02 7.791E-02 7.514E-02 7.134E-02
6.623E-02 6.022E-02 5.312E-02 4.561E-02 3.816E-02
si183 H -62.5475 14i 58.42
sp183 D 0 6.061E-02 6.370E-02 6.860E-02 7.317E-02 7.687E-02
7.879E-02 7.925E-02 7.844E-02 7.617E-02 7.251E-02
6.739E-02 6.152E-02 5.476E-02 4.740E-02 4.083E-02
si184 H -62.5475 14i 58.42
sp184 D 0 5.982E-02 6.285E-02 6.729E-02 7.180E-02 7.541E-02
7.782E-02 7.874E-02 7.785E-02 7.589E-02 7.261E-02
6.782E-02 6.241E-02 5.612E-02 4.950E-02 4.406E-02
si185 H -62.5475 14i 58.42
sp185 D 0 5.916E-02 6.268E-02 6.676E-02 7.091E-02 7.415E-02
7.626E-02 7.732E-02 7.696E-02 7.519E-02 7.228E-02
6.824E-02 6.348E-02 5.774E-02 5.192E-02 4.695E-02
si186 H -62.5475 14i 58.42
sp186 D 0 5.896E-02 6.259E-02 6.677E-02 7.096E-02 7.420E-02
7.649E-02 7.748E-02 7.710E-02 7.542E-02 7.256E-02
6.845E-02 6.337E-02 5.763E-02 5.172E-02 4.631E-02

si187 H -62.5475 14i 58.42
sp187 D 0 5.908E-02 6.219E-02 6.705E-02 7.173E-02 7.530E-02
7.805E-02 7.896E-02 7.863E-02 7.654E-02 7.309E-02
6.850E-02 6.266E-02 5.608E-02 4.910E-02 4.304E-02
si188 H -62.5475 14i 58.42
sp188 D 0 5.905E-02 6.277E-02 6.791E-02 7.291E-02 7.672E-02
7.919E-02 8.002E-02 7.933E-02 7.710E-02 7.326E-02
6.828E-02 6.207E-02 5.499E-02 4.712E-02 3.929E-02
si189 H -62.5475 14i 58.42
sp189 D 0 6.053E-02 6.485E-02 7.038E-02 7.521E-02 7.850E-02
8.026E-02 8.019E-02 7.866E-02 7.607E-02 7.208E-02
6.683E-02 6.041E-02 5.321E-02 4.535E-02 3.746E-02
si190 H -62.5475 14i 58.42
sp190 D 0 6.136E-02 6.563E-02 7.121E-02 7.587E-02 7.903E-02
8.027E-02 7.990E-02 7.804E-02 7.522E-02 7.099E-02
6.589E-02 5.958E-02 5.277E-02 4.539E-02 3.886E-02
si191 H -62.5475 14i 58.42
sp191 D 0 6.140E-02 6.558E-02 7.091E-02 7.559E-02 7.873E-02
8.004E-02 7.973E-02 7.805E-02 7.514E-02 7.095E-02
6.569E-02 5.960E-02 5.277E-02 4.591E-02 3.992E-02
si192 H -62.5475 14i 58.42
sp192 D 0 6.071E-02 6.475E-02 7.007E-02 7.472E-02 7.829E-02
8.017E-02 7.993E-02 7.838E-02 7.532E-02 7.126E-02
6.612E-02 5.990E-02 5.316E-02 4.639E-02 4.083E-02
si193 H -62.5475 14i 58.42
sp193 D 0 6.018E-02 6.411E-02 6.941E-02 7.432E-02 7.786E-02
7.988E-02 8.004E-02 7.853E-02 7.566E-02 7.152E-02
6.639E-02 6.029E-02 5.356E-02 4.686E-02 4.139E-02
si194 H -62.5475 14i 58.42
sp194 D 0 6.003E-02 6.381E-02 6.907E-02 7.406E-02 7.774E-02
7.968E-02 8.007E-02 7.864E-02 7.591E-02 7.167E-02
6.653E-02 6.034E-02 5.370E-02 4.708E-02 4.168E-02
si195 H -62.5475 14i 58.42
sp195 D 0 6.009E-02 6.406E-02 6.940E-02 7.423E-02 7.767E-02
7.967E-02 7.998E-02 7.856E-02 7.583E-02 7.151E-02
6.643E-02 6.038E-02 5.361E-02 4.701E-02 4.157E-02
si196 H -62.5475 14i 58.42
sp196 D 0 6.063E-02 6.461E-02 6.987E-02 7.483E-02 7.816E-02
7.995E-02 7.972E-02 7.833E-02 7.545E-02 7.144E-02
6.624E-02 6.002E-02 5.321E-02 4.662E-02 4.092E-02
si197 H -62.5475 14i 58.42
sp197 D 0 6.114E-02 6.543E-02 7.074E-02 7.549E-02 7.863E-02
8.010E-02 7.969E-02 7.816E-02 7.517E-02 7.117E-02
6.589E-02 5.952E-02 5.295E-02 4.591E-02 4.000E-02
si198 H -62.5475 14i 58.42
sp198 D 0 6.124E-02 6.569E-02 7.114E-02 7.598E-02 7.887E-02
8.007E-02 7.977E-02 7.807E-02 7.514E-02 7.114E-02
6.595E-02 5.970E-02 5.285E-02 4.546E-02 3.893E-02
si199 H -62.5475 14i 58.42
sp199 D 0 6.036E-02 6.481E-02 7.037E-02 7.502E-02 7.854E-02
8.002E-02 8.002E-02 7.886E-02 7.614E-02 7.224E-02
6.686E-02 6.050E-02 5.333E-02 4.543E-02 3.749E-02
si200 H -62.5475 14i 58.42
sp200 D 0 5.886E-02 6.269E-02 6.770E-02 7.276E-02 7.667E-02
7.910E-02 8.000E-02 7.928E-02 7.709E-02 7.348E-02
6.855E-02 6.219E-02 5.507E-02 4.721E-02 3.933E-02

si201 H -62.5475 14i 58.42
sp201 D 0 5.883E-02 6.211E-02 6.684E-02 7.168E-02 7.543E-02
7.786E-02 7.887E-02 7.844E-02 7.657E-02 7.332E-02
6.865E-02 6.293E-02 5.629E-02 4.917E-02 4.302E-02
si202 H -62.5475 14i 58.42
sp202 D 0 5.860E-02 6.226E-02 6.657E-02 7.075E-02 7.427E-02
7.647E-02 7.752E-02 7.722E-02 7.572E-02 7.269E-02
6.861E-02 6.362E-02 5.765E-02 5.175E-02 4.628E-02
si203 H -62.5475 14i 58.42
sp203 D 0 5.862E-02 6.225E-02 6.665E-02 7.091E-02 7.439E-02
7.661E-02 7.762E-02 7.732E-02 7.570E-02 7.266E-02
6.863E-02 6.364E-02 5.760E-02 5.151E-02 4.590E-02
si204 H -62.5475 14i 58.42
sp204 D 0 5.834E-02 6.176E-02 6.666E-02 7.148E-02 7.545E-02
7.809E-02 7.938E-02 7.895E-02 7.714E-02 7.350E-02
6.909E-02 6.309E-02 5.606E-02 4.894E-02 4.207E-02
si205 H -62.5475 14i 58.42
sp205 D 0 5.773E-02 6.182E-02 6.711E-02 7.241E-02 7.643E-02
7.922E-02 8.023E-02 7.998E-02 7.785E-02 7.410E-02
6.908E-02 6.279E-02 5.539E-02 4.727E-02 3.860E-02
si206 H -62.5475 14i 58.42
sp206 D 0 5.746E-02 6.187E-02 6.758E-02 7.295E-02 7.716E-02
7.980E-02 8.080E-02 8.018E-02 7.792E-02 7.412E-02
6.880E-02 6.231E-02 5.480E-02 4.653E-02 3.772E-02
si207 H -62.5475 14i 58.42
sp207 D 0 5.725E-02 6.202E-02 6.788E-02 7.323E-02 7.731E-02
8.002E-02 8.090E-02 8.007E-02 7.758E-02 7.359E-02
6.839E-02 6.200E-02 5.450E-02 4.655E-02 3.873E-02
si208 H -62.5475 14i 58.42
sp208 D 0 5.754E-02 6.230E-02 6.808E-02 7.333E-02 7.764E-02
7.993E-02 8.061E-02 7.959E-02 7.720E-02 7.316E-02
6.789E-02 6.158E-02 5.440E-02 4.690E-02 3.984E-02
si209 H -62.5475 14i 58.42
sp209 D 0 5.773E-02 6.237E-02 6.797E-02 7.339E-02 7.738E-02
7.966E-02 8.036E-02 7.939E-02 7.679E-02 7.295E-02
6.770E-02 6.144E-02 5.447E-02 4.743E-02 4.098E-02
si210 H -62.5475 14i 58.42
sp210 D 0 5.778E-02 6.215E-02 6.758E-02 7.301E-02 7.710E-02
7.961E-02 8.045E-02 7.939E-02 7.678E-02 7.290E-02
6.777E-02 6.143E-02 5.453E-02 4.770E-02 4.183E-02
si211 H -62.5475 14i 58.42
sp211 D 0 5.773E-02 6.187E-02 6.738E-02 7.263E-02 7.686E-02
7.943E-02 8.030E-02 7.954E-02 7.682E-02 7.294E-02
6.770E-02 6.162E-02 5.482E-02 4.805E-02 4.234E-02
si212 H -62.5475 14i 58.42
sp212 D 0 5.771E-02 6.176E-02 6.734E-02 7.258E-02 7.690E-02
7.942E-02 8.033E-02 7.949E-02 7.702E-02 7.282E-02
6.769E-02 6.149E-02 5.474E-02 4.813E-02 4.260E-02
si213 H -62.5475 14i 58.42
sp213 D 0 5.775E-02 6.194E-02 6.745E-02 7.256E-02 7.681E-02
7.938E-02 8.035E-02 7.946E-02 7.687E-02 7.282E-02
6.771E-02 6.165E-02 5.477E-02 4.809E-02 4.239E-02
si214 H -62.5475 14i 58.42
sp214 D 0 5.778E-02 6.210E-02 6.759E-02 7.285E-02 7.698E-02
7.951E-02 8.033E-02 7.932E-02 7.693E-02 7.303E-02
6.775E-02 6.154E-02 5.468E-02 4.774E-02 4.186E-02

si215 H -62.5475 14i 58.42
sp215 D 0 5.757E-02 6.215E-02 6.792E-02 7.319E-02 7.723E-02
7.964E-02 8.036E-02 7.943E-02 7.702E-02 7.322E-02
6.790E-02 6.160E-02 5.462E-02 4.730E-02 4.084E-02
si216 H -62.5475 14i 58.42
sp216 D 0 5.742E-02 6.222E-02 6.805E-02 7.348E-02 7.738E-02
7.986E-02 8.060E-02 7.962E-02 7.705E-02 7.326E-02
6.806E-02 6.177E-02 5.450E-02 4.694E-02 3.978E-02
si217 H -62.5475 14i 58.42
sp217 D 0 5.729E-02 6.199E-02 6.789E-02 7.322E-02 7.737E-02
7.981E-02 8.076E-02 7.981E-02 7.760E-02 7.382E-02
6.846E-02 6.205E-02 5.464E-02 4.659E-02 3.871E-02
si218 H -62.5475 14i 58.42
sp218 D 0 5.740E-02 6.181E-02 6.748E-02 7.286E-02 7.701E-02
7.984E-02 8.077E-02 8.012E-02 7.791E-02 7.411E-02
6.899E-02 6.253E-02 5.502E-02 4.647E-02 3.766E-02
si219 H -62.5475 14i 58.42
sp219 D 0 5.751E-02 6.160E-02 6.710E-02 7.236E-02 7.639E-02
7.922E-02 8.039E-02 7.993E-02 7.783E-02 7.421E-02
6.923E-02 6.275E-02 5.542E-02 4.733E-02 3.871E-02
si220 H -62.5475 14i 58.42
sp220 D 0 5.797E-02 6.155E-02 6.669E-02 7.142E-02 7.534E-02
7.805E-02 7.922E-02 7.902E-02 7.709E-02 7.377E-02
6.914E-02 6.317E-02 5.641E-02 4.902E-02 4.215E-02
si221 H -62.5475 14i 58.42
sp221 D 0 5.817E-02 6.187E-02 6.640E-02 7.074E-02 7.430E-02
7.676E-02 7.781E-02 7.750E-02 7.598E-02 7.301E-02
6.895E-02 6.371E-02 5.755E-02 5.139E-02 4.584E-02
si222 H -62.5475 14i 58.42
sp222 D 0 5.840E-02 6.204E-02 6.659E-02 7.079E-02 7.420E-02
7.652E-02 7.748E-02 7.729E-02 7.570E-02 7.268E-02
6.893E-02 6.368E-02 5.793E-02 5.175E-02 4.603E-02
si223 H -62.5475 14i 58.42
sp223 D 0 5.772E-02 6.139E-02 6.640E-02 7.142E-02 7.534E-02
7.814E-02 7.947E-02 7.918E-02 7.731E-02 7.390E-02
6.923E-02 6.340E-02 5.650E-02 4.898E-02 4.159E-02
si224 H -62.5475 14i 58.42
sp224 D 0 5.617E-02 6.071E-02 6.659E-02 7.217E-02 7.668E-02
7.952E-02 8.074E-02 8.046E-02 7.840E-02 7.468E-02
6.935E-02 6.304E-02 5.540E-02 4.722E-02 3.887E-02
si225 H -62.5475 14i 58.42
sp225 D 0 5.573E-02 6.061E-02 6.656E-02 7.225E-02 7.676E-02
7.969E-02 8.080E-02 8.047E-02 7.806E-02 7.436E-02
6.924E-02 6.270E-02 5.535E-02 4.755E-02 3.987E-02
si226 H -62.5475 14i 58.42
sp226 D 0 5.562E-02 6.061E-02 6.660E-02 7.220E-02 7.670E-02
7.952E-02 8.057E-02 7.990E-02 7.783E-02 7.390E-02
6.882E-02 6.257E-02 5.547E-02 4.821E-02 4.149E-02
si227 H -62.5475 14i 58.42
sp227 D 0 5.606E-02 6.057E-02 6.633E-02 7.188E-02 7.638E-02
7.937E-02 8.065E-02 8.001E-02 7.768E-02 7.396E-02
6.856E-02 6.234E-02 5.548E-02 4.835E-02 4.238E-02
si228 H -62.5475 14i 58.42
sp228 D 0 5.635E-02 6.059E-02 6.616E-02 7.166E-02 7.622E-02
7.916E-02 8.051E-02 8.013E-02 7.776E-02 7.386E-02
6.842E-02 6.226E-02 5.543E-02 4.859E-02 4.289E-02

si229 H -62.5475 14i 58.42
sp229 D 0 5.637E-02 6.045E-02 6.606E-02 7.154E-02 7.601E-02
7.919E-02 8.046E-02 8.008E-02 7.797E-02 7.384E-02
6.848E-02 6.221E-02 5.549E-02 4.866E-02 4.319E-02
si230 H -62.5475 14i 58.42
sp230 D 0 5.619E-02 6.049E-02 6.611E-02 7.170E-02 7.607E-02
7.918E-02 8.055E-02 8.007E-02 7.773E-02 7.370E-02
6.855E-02 6.240E-02 5.551E-02 4.875E-02 4.300E-02
si231 H -62.5475 14i 58.42
sp231 D 0 5.599E-02 6.057E-02 6.636E-02 7.192E-02 7.629E-02
7.936E-02 8.046E-02 8.004E-02 7.766E-02 7.386E-02
6.868E-02 6.245E-02 5.560E-02 4.841E-02 4.237E-02
si232 H -62.5475 14i 58.42
sp232 D 0 5.575E-02 6.063E-02 6.643E-02 7.208E-02 7.658E-02
7.943E-02 8.062E-02 8.008E-02 7.769E-02 7.405E-02
6.885E-02 6.261E-02 5.558E-02 4.819E-02 4.143E-02
si233 H -62.5475 14i 58.42
sp233 D 0 5.572E-02 6.063E-02 6.662E-02 7.220E-02 7.656E-02
7.964E-02 8.083E-02 8.041E-02 7.824E-02 7.445E-02
6.916E-02 6.280E-02 5.541E-02 4.749E-02 3.982E-02
si234 H -62.5475 14i 58.42
sp234 D 0 5.604E-02 6.063E-02 6.651E-02 7.200E-02 7.661E-02
7.966E-02 8.095E-02 8.060E-02 7.847E-02 7.462E-02
6.943E-02 6.310E-02 5.549E-02 4.719E-02 3.872E-02
si235 H -62.5475 14i 58.42
sp235 D 0 5.742E-02 6.095E-02 6.632E-02 7.117E-02 7.543E-02
7.818E-02 7.940E-02 7.928E-02 7.752E-02 7.412E-02
6.945E-02 6.346E-02 5.657E-02 4.909E-02 4.164E-02
si236 H -62.5475 14i 58.42
sp236 D 0 5.771E-02 6.162E-02 6.615E-02 7.048E-02 7.428E-02
7.675E-02 7.793E-02 7.773E-02 7.624E-02 7.312E-02
6.906E-02 6.381E-02 5.777E-02 5.161E-02 4.572E-02
si237 H -62.5475 14i 58.42
sp237 D 0 5.835E-02 6.201E-02 6.660E-02 7.073E-02 7.425E-02
7.631E-02 7.717E-02 7.681E-02 7.547E-02 7.291E-02
6.903E-02 6.390E-02 5.816E-02 5.195E-02 4.636E-02
si238 H -62.5475 14i 58.42
sp238 D 0 5.738E-02 6.111E-02 6.612E-02 7.112E-02 7.527E-02
7.794E-02 7.912E-02 7.878E-02 7.713E-02 7.388E-02
6.948E-02 6.359E-02 5.675E-02 4.952E-02 4.281E-02
si239 H -62.5475 14i 58.42
sp239 D 0 5.631E-02 6.053E-02 6.600E-02 7.142E-02 7.585E-02
7.877E-02 8.035E-02 7.991E-02 7.822E-02 7.469E-02
6.980E-02 6.350E-02 5.611E-02 4.816E-02 4.038E-02
si240 H -62.5475 14i 58.42
sp240 D 0 5.558E-02 6.003E-02 6.585E-02 7.163E-02 7.620E-02
7.925E-02 8.057E-02 8.031E-02 7.836E-02 7.487E-02
6.972E-02 6.328E-02 5.593E-02 4.804E-02 4.039E-02
si241 H -62.5475 14i 58.42
sp241 D 0 5.505E-02 6.004E-02 6.587E-02 7.173E-02 7.628E-02
7.944E-02 8.072E-02 8.030E-02 7.834E-02 7.482E-02
6.939E-02 6.305E-02 5.589E-02 4.819E-02 4.088E-02
si242 H -62.5475 14i 58.42
sp242 D 0 5.488E-02 5.981E-02 6.593E-02 7.154E-02 7.622E-02
7.930E-02 8.073E-02 8.051E-02 7.830E-02 7.461E-02
6.936E-02 6.304E-02 5.592E-02 4.845E-02 4.141E-02

si243 H -62.5475 14i 58.42
sp243 D 0 5.483E-02 5.977E-02 6.572E-02 7.143E-02 7.612E-02
7.910E-02 8.063E-02 8.030E-02 7.809E-02 7.451E-02
6.937E-02 6.303E-02 5.611E-02 4.879E-02 4.219E-02
si244 H -62.5475 14i 58.42
sp244 D 0 5.519E-02 5.960E-02 6.556E-02 7.131E-02 7.585E-02
7.908E-02 8.065E-02 8.036E-02 7.826E-02 7.432E-02
6.925E-02 6.282E-02 5.604E-02 4.894E-02 4.277E-02
si245 H -62.5475 14i 58.42
sp245 D 0 5.538E-02 5.963E-02 6.529E-02 7.081E-02 7.554E-02
7.907E-02 8.097E-02 8.084E-02 7.876E-02 7.444E-02
6.876E-02 6.259E-02 5.573E-02 4.896E-02 4.323E-02
si246 H -62.5475 14i 58.42
sp246 D 0 5.527E-02 5.957E-02 6.520E-02 7.083E-02 7.545E-02
7.905E-02 8.116E-02 8.084E-02 7.867E-02 7.442E-02
6.884E-02 6.257E-02 5.578E-02 4.908E-02 4.327E-02
si247 H -62.5475 14i 58.42
sp247 D 0 5.506E-02 5.968E-02 6.546E-02 7.121E-02 7.590E-02
7.907E-02 8.054E-02 8.043E-02 7.829E-02 7.440E-02
6.903E-02 6.301E-02 5.611E-02 4.900E-02 4.281E-02
si248 H -62.5475 14i 58.42
sp248 D 0 5.490E-02 5.976E-02 6.574E-02 7.135E-02 7.611E-02
7.925E-02 8.055E-02 8.035E-02 7.820E-02 7.451E-02
6.932E-02 6.308E-02 5.612E-02 4.870E-02 4.207E-02
si249 H -62.5475 14i 58.42
sp249 D 0 5.492E-02 5.977E-02 6.578E-02 7.152E-02 7.629E-02
7.933E-02 8.073E-02 8.043E-02 7.824E-02 7.458E-02
6.945E-02 6.325E-02 5.593E-02 4.834E-02 4.145E-02
si250 H -62.5475 14i 58.42
sp250 D 0 5.509E-02 5.973E-02 6.581E-02 7.166E-02 7.635E-02
7.945E-02 8.073E-02 8.047E-02 7.837E-02 7.471E-02
6.949E-02 6.322E-02 5.584E-02 4.812E-02 4.096E-02
si251 H -62.5475 14i 58.42
sp251 D 0 5.553E-02 5.999E-02 6.592E-02 7.152E-02 7.621E-02
7.927E-02 8.068E-02 8.043E-02 7.840E-02 7.490E-02
6.966E-02 6.320E-02 5.596E-02 4.794E-02 4.039E-02
si252 H -62.5475 14i 58.42
sp252 D 0 5.633E-02 6.030E-02 6.587E-02 7.138E-02 7.575E-02
7.904E-02 8.031E-02 8.011E-02 7.824E-02 7.465E-02
6.976E-02 6.357E-02 5.613E-02 4.823E-02 4.034E-02
si253 H -62.5475 14i 58.42
sp253 D 0 5.717E-02 6.076E-02 6.578E-02 7.090E-02 7.502E-02
7.797E-02 7.937E-02 7.902E-02 7.749E-02 7.417E-02
6.953E-02 6.366E-02 5.685E-02 4.952E-02 4.280E-02
si254 H -62.5475 14i 58.42
sp254 D 0 5.747E-02 6.126E-02 6.581E-02 7.041E-02 7.408E-02
7.669E-02 7.802E-02 7.784E-02 7.621E-02 7.332E-02
6.922E-02 6.398E-02 5.800E-02 5.182E-02 4.587E-02
si255 H -62.5475 14i 58.42
sp255 D 0 5.829E-02 6.210E-02 6.663E-02 7.088E-02 7.431E-02
7.640E-02 7.698E-02 7.638E-02 7.521E-02 7.284E-02
6.898E-02 6.398E-02 5.831E-02 5.222E-02 4.651E-02
si256 H -62.5475 14i 58.42
sp256 D 0 5.719E-02 6.088E-02 6.612E-02 7.103E-02 7.518E-02
7.795E-02 7.895E-02 7.856E-02 7.704E-02 7.398E-02
6.946E-02 6.354E-02 5.679E-02 4.977E-02 4.356E-02

si257 H -62.5475 14i 58.42
sp257 D 0 5.616E-02 6.028E-02 6.574E-02 7.116E-02 7.563E-02
7.860E-02 8.018E-02 7.989E-02 7.803E-02 7.459E-02
6.972E-02 6.343E-02 5.621E-02 4.866E-02 4.171E-02
si258 H -62.5475 14i 58.42
sp258 D 0 5.544E-02 5.975E-02 6.561E-02 7.132E-02 7.596E-02
7.917E-02 8.045E-02 8.037E-02 7.832E-02 7.484E-02
6.972E-02 6.342E-02 5.604E-02 4.839E-02 4.121E-02
si259 H -62.5475 14i 58.42
sp259 D 0 5.481E-02 5.961E-02 6.564E-02 7.148E-02 7.602E-02
7.928E-02 8.065E-02 8.030E-02 7.833E-02 7.476E-02
6.986E-02 6.342E-02 5.608E-02 4.835E-02 4.141E-02
si260 H -62.5475 14i 58.42
sp260 D 0 5.477E-02 5.952E-02 6.555E-02 7.139E-02 7.580E-02
7.909E-02 8.061E-02 8.037E-02 7.820E-02 7.468E-02
6.967E-02 6.328E-02 5.632E-02 4.870E-02 4.204E-02
si261 H -62.5475 14i 58.42
sp261 D 0 5.483E-02 5.977E-02 6.545E-02 7.115E-02 7.573E-02
7.907E-02 8.043E-02 8.018E-02 7.816E-02 7.452E-02
6.945E-02 6.320E-02 5.625E-02 4.914E-02 4.266E-02
si262 H -62.5475 14i 58.42
sp262 D 0 5.502E-02 5.947E-02 6.512E-02 7.080E-02 7.550E-02
7.893E-02 8.064E-02 8.051E-02 7.842E-02 7.439E-02
6.930E-02 6.298E-02 5.622E-02 4.943E-02 4.328E-02
si263 H -62.5475 14i 58.42
sp263 D 0 5.518E-02 5.916E-02 6.451E-02 6.969E-02 7.462E-02
7.907E-02 8.191E-02 8.235E-02 7.981E-02 7.473E-02
6.848E-02 6.200E-02 5.570E-02 4.921E-02 4.359E-02
si264 H -62.5475 14i 58.42
sp264 D 0 5.515E-02 5.921E-02 6.450E-02 6.979E-02 7.469E-02
7.896E-02 8.178E-02 8.213E-02 7.979E-02 7.483E-02
6.862E-02 6.215E-02 5.561E-02 4.920E-02 4.360E-02
si265 H -62.5475 14i 58.42
sp265 D 0 5.489E-02 5.957E-02 6.521E-02 7.086E-02 7.542E-02
7.864E-02 8.053E-02 8.045E-02 7.841E-02 7.452E-02
6.933E-02 6.317E-02 5.625E-02 4.934E-02 4.340E-02
si266 H -62.5475 14i 58.42
sp266 D 0 5.467E-02 5.943E-02 6.541E-02 7.112E-02 7.574E-02
7.889E-02 8.057E-02 8.035E-02 7.833E-02 7.450E-02
6.936E-02 6.336E-02 5.639E-02 4.915E-02 4.274E-02
si267 H -62.5475 14i 58.42
sp267 D 0 5.460E-02 5.950E-02 6.558E-02 7.127E-02 7.590E-02
7.916E-02 8.058E-02 8.042E-02 7.839E-02 7.477E-02
6.952E-02 6.335E-02 5.620E-02 4.876E-02 4.201E-02
si268 H -62.5475 14i 58.42
sp268 D 0 5.489E-02 5.956E-02 6.552E-02 7.142E-02 7.596E-02
7.924E-02 8.062E-02 8.042E-02 7.836E-02 7.473E-02
6.962E-02 6.341E-02 5.616E-02 4.848E-02 4.160E-02
si269 H -62.5475 14i 58.42
sp269 D 0 5.520E-02 5.986E-02 6.566E-02 7.120E-02 7.590E-02
7.908E-02 8.061E-02 8.027E-02 7.841E-02 7.490E-02
6.968E-02 6.339E-02 5.613E-02 4.841E-02 4.130E-02
si270 H -62.5475 14i 58.42
sp270 D 0 5.604E-02 5.999E-02 6.555E-02 7.103E-02 7.562E-02
7.873E-02 8.015E-02 7.998E-02 7.809E-02 7.465E-02
6.975E-02 6.357E-02 5.627E-02 4.877E-02 4.180E-02

si271 H -62.5475 14i 58.42
sp271 D 0 5.680E-02 6.028E-02 6.551E-02 7.076E-02 7.496E-02
7.788E-02 7.937E-02 7.906E-02 7.746E-02 7.418E-02
6.942E-02 6.373E-02 5.704E-02 4.996E-02 4.360E-02
si272 H -62.5475 14i 58.42
sp272 D 0 5.721E-02 6.120E-02 6.583E-02 7.026E-02 7.401E-02
7.665E-02 7.790E-02 7.772E-02 7.641E-02 7.347E-02
6.918E-02 6.404E-02 5.807E-02 5.182E-02 4.624E-02
si273 H -62.5475 14i 58.42
sp273 D 0 5.826E-02 6.192E-02 6.652E-02 7.077E-02 7.414E-02
7.654E-02 7.717E-02 7.683E-02 7.539E-02 7.288E-02
6.890E-02 6.408E-02 5.826E-02 5.201E-02 4.634E-02
si274 H -62.5475 14i 58.42
sp274 D 0 5.732E-02 6.101E-02 6.608E-02 7.104E-02 7.502E-02
7.792E-02 7.908E-02 7.874E-02 7.704E-02 7.393E-02
6.947E-02 6.371E-02 5.693E-02 4.968E-02 4.301E-02
si275 H -62.5475 14i 58.42
sp275 D 0 5.644E-02 6.056E-02 6.602E-02 7.137E-02 7.568E-02
7.878E-02 8.013E-02 7.982E-02 7.802E-02 7.451E-02
6.965E-02 6.359E-02 5.631E-02 4.853E-02 4.059E-02
si276 H -62.5475 14i 58.42
sp276 D 0 5.567E-02 6.022E-02 6.591E-02 7.150E-02 7.609E-02
7.903E-02 8.037E-02 8.026E-02 7.835E-02 7.473E-02
6.974E-02 6.345E-02 5.605E-02 4.811E-02 4.052E-02
si277 H -62.5475 14i 58.42
sp277 D 0 5.512E-02 5.978E-02 6.570E-02 7.154E-02 7.608E-02
7.912E-02 8.059E-02 8.026E-02 7.837E-02 7.478E-02
6.973E-02 6.331E-02 5.607E-02 4.838E-02 4.117E-02
si278 H -62.5475 14i 58.42
sp278 D 0 5.506E-02 5.972E-02 6.573E-02 7.141E-02 7.580E-02
7.887E-02 8.060E-02 8.016E-02 7.821E-02 7.456E-02
6.967E-02 6.327E-02 5.619E-02 4.883E-02 4.193E-02
si279 H -62.5475 14i 58.42
sp279 D 0 5.543E-02 6.001E-02 6.562E-02 7.111E-02 7.570E-02
7.874E-02 8.018E-02 7.988E-02 7.781E-02 7.431E-02
6.934E-02 6.323E-02 5.642E-02 4.938E-02 4.283E-02
si280 H -62.5475 14i 58.42
sp280 D 0 5.599E-02 6.011E-02 6.541E-02 7.073E-02 7.531E-02
7.847E-02 8.002E-02 7.982E-02 7.772E-02 7.400E-02
6.896E-02 6.302E-02 5.654E-02 4.987E-02 4.402E-02
si281 H -62.5475 14i 58.42
sp281 D 0 5.700E-02 6.042E-02 6.497E-02 6.978E-02 7.418E-02
7.811E-02 8.068E-02 8.068E-02 7.839E-02 7.368E-02
6.785E-02 6.200E-02 5.632E-02 5.045E-02 4.549E-02
si282 H -62.5475 14i 58.42
sp282 D 0 5.708E-02 6.048E-02 6.517E-02 6.983E-02 7.400E-02
7.806E-02 8.061E-02 8.071E-02 7.827E-02 7.371E-02
6.796E-02 6.208E-02 5.611E-02 5.038E-02 4.555E-02
si283 H -62.5475 14i 58.42
sp283 D 0 5.585E-02 6.000E-02 6.548E-02 7.091E-02 7.534E-02
7.832E-02 7.991E-02 7.973E-02 7.775E-02 7.398E-02
6.897E-02 6.321E-02 5.649E-02 4.992E-02 4.412E-02
si284 H -62.5475 14i 58.42
sp284 D 0 5.532E-02 5.990E-02 6.573E-02 7.125E-02 7.563E-02
7.861E-02 8.010E-02 7.984E-02 7.802E-02 7.433E-02
6.929E-02 6.331E-02 5.638E-02 4.930E-02 4.300E-02

si285 H -62.5475 14i 58.42
sp285 D 0 5.492E-02 5.970E-02 6.573E-02 7.140E-02 7.588E-02
7.903E-02 8.043E-02 8.012E-02 7.819E-02 7.474E-02
6.954E-02 6.339E-02 5.621E-02 4.882E-02 4.191E-02
si286 H -62.5475 14i 58.42
sp286 D 0 5.494E-02 5.967E-02 6.567E-02 7.151E-02 7.593E-02
7.905E-02 8.057E-02 8.047E-02 7.846E-02 7.487E-02
6.979E-02 6.338E-02 5.602E-02 4.840E-02 4.127E-02
si287 H -62.5475 14i 58.42
sp287 D 0 5.534E-02 5.987E-02 6.572E-02 7.133E-02 7.602E-02
7.905E-02 8.071E-02 8.032E-02 7.842E-02 7.491E-02
6.985E-02 6.346E-02 5.600E-02 4.830E-02 4.069E-02
si288 H -62.5475 14i 58.42
sp288 D 0 5.616E-02 6.020E-02 6.586E-02 7.122E-02 7.560E-02
7.866E-02 8.027E-02 8.002E-02 7.824E-02 7.475E-02
6.974E-02 6.369E-02 5.635E-02 4.853E-02 4.071E-02
si289 H -62.5475 14i 58.42
sp289 D 0 5.678E-02 6.045E-02 6.563E-02 7.083E-02 7.507E-02
7.796E-02 7.933E-02 7.910E-02 7.742E-02 7.421E-02
6.966E-02 6.375E-02 5.701E-02 4.979E-02 4.298E-02
si290 H -62.5475 14i 58.42
sp290 D 0 5.724E-02 6.119E-02 6.589E-02 7.044E-02 7.410E-02
7.676E-02 7.792E-02 7.765E-02 7.627E-02 7.335E-02
6.914E-02 6.391E-02 5.804E-02 5.194E-02 4.617E-02
si291 H -62.5475 14i 58.42
sp291 D 0 5.838E-02 6.197E-02 6.658E-02 7.077E-02 7.415E-02
7.652E-02 7.749E-02 7.712E-02 7.568E-02 7.282E-02
6.872E-02 6.374E-02 5.805E-02 5.194E-02 4.606E-02
si292 H -62.5475 14i 58.42
sp292 D 0 5.765E-02 6.123E-02 6.636E-02 7.119E-02 7.527E-02
7.804E-02 7.948E-02 7.905E-02 7.727E-02 7.378E-02
6.929E-02 6.348E-02 5.675E-02 4.931E-02 4.185E-02
si293 H -62.5475 14i 58.42
sp293 D 0 5.635E-02 6.076E-02 6.653E-02 7.191E-02 7.634E-02
7.930E-02 8.052E-02 8.010E-02 7.825E-02 7.465E-02
6.948E-02 6.325E-02 5.584E-02 4.758E-02 3.913E-02
si294 H -62.5475 14i 58.42
sp294 D 0 5.581E-02 6.047E-02 6.637E-02 7.192E-02 7.635E-02
7.927E-02 8.056E-02 8.007E-02 7.821E-02 7.445E-02
6.936E-02 6.306E-02 5.571E-02 4.799E-02 4.041E-02
si295 H -62.5475 14i 58.42
sp295 D 0 5.659E-02 6.093E-02 6.651E-02 7.162E-02 7.578E-02
7.856E-02 7.984E-02 7.939E-02 7.726E-02 7.368E-02
6.886E-02 6.291E-02 5.618E-02 4.913E-02 4.278E-02
si296 H -62.5475 14i 58.42
sp296 D 0 5.793E-02 6.150E-02 6.637E-02 7.123E-02 7.515E-02
7.790E-02 7.899E-02 7.866E-02 7.656E-02 7.307E-02
6.835E-02 6.267E-02 5.662E-02 5.016E-02 4.483E-02
si297 H -62.5475 14i 58.42
sp297 D 0 6.051E-02 6.283E-02 6.655E-02 7.054E-02 7.398E-02
7.661E-02 7.805E-02 7.753E-02 7.545E-02 7.203E-02
6.739E-02 6.216E-02 5.683E-02 5.169E-02 4.785E-02
si298 H -62.5475 14i 58.42
sp298 D 0 6.039E-02 6.280E-02 6.664E-02 7.067E-02 7.397E-02
7.659E-02 7.794E-02 7.753E-02 7.558E-02 7.196E-02
6.739E-02 6.222E-02 5.679E-02 5.175E-02 4.776E-02

si299 H -62.5475 14i 58.42
sp299 D 0 5.763E-02 6.124E-02 6.636E-02 7.142E-02 7.541E-02
7.799E-02 7.908E-02 7.862E-02 7.660E-02 7.307E-02
6.845E-02 6.269E-02 5.653E-02 5.015E-02 4.477E-02
si300 H -62.5475 14i 58.42
sp300 D 0 5.649E-02 6.080E-02 6.641E-02 7.162E-02 7.590E-02
7.860E-02 7.985E-02 7.923E-02 7.714E-02 7.373E-02
6.888E-02 6.301E-02 5.634E-02 4.922E-02 4.278E-02
si301 H -62.5475 14i 58.42
sp301 D 0 5.559E-02 6.038E-02 6.633E-02 7.188E-02 7.624E-02
7.916E-02 8.054E-02 8.022E-02 7.809E-02 7.450E-02
6.946E-02 6.329E-02 5.583E-02 4.805E-02 4.044E-02
si302 H -62.5475 14i 58.42
sp302 D 0 5.605E-02 6.058E-02 6.627E-02 7.164E-02 7.620E-02
7.932E-02 8.084E-02 8.029E-02 7.836E-02 7.470E-02
6.976E-02 6.335E-02 5.584E-02 4.761E-02 3.919E-02
si303 H -62.5475 14i 58.42
sp303 D 0 5.729E-02 6.079E-02 6.614E-02 7.107E-02 7.536E-02
7.822E-02 7.925E-02 7.912E-02 7.720E-02 7.417E-02
6.948E-02 6.365E-02 5.682E-02 4.945E-02 4.198E-02
si304 H -62.5475 14i 58.42
sp304 D 0 5.750E-02 6.120E-02 6.600E-02 7.040E-02 7.413E-02
7.681E-02 7.792E-02 7.773E-02 7.598E-02 7.336E-02
6.899E-02 6.394E-02 5.808E-02 5.195E-02 4.601E-02
si305 H -62.5475 14i 58.42
sp305 D 0 5.876E-02 6.219E-02 6.656E-02 7.056E-02 7.399E-02
7.626E-02 7.756E-02 7.738E-02 7.576E-02 7.262E-02
6.870E-02 6.349E-02 5.774E-02 5.201E-02 4.643E-02
si306 H -62.5475 14i 58.42
sp306 D 0 5.826E-02 6.168E-02 6.643E-02 7.115E-02 7.524E-02
7.786E-02 7.909E-02 7.900E-02 7.712E-02 7.374E-02
6.904E-02 6.319E-02 5.638E-02 4.927E-02 4.256E-02
si307 H -62.5475 14i 58.42
sp307 D 0 5.774E-02 6.159E-02 6.693E-02 7.193E-02 7.623E-02
7.887E-02 8.017E-02 7.989E-02 7.791E-02 7.426E-02
6.936E-02 6.313E-02 5.557E-02 4.749E-02 3.893E-02
si308 H -62.5475 14i 58.42
sp308 D 0 5.750E-02 6.177E-02 6.717E-02 7.254E-02 7.676E-02
7.947E-02 8.045E-02 7.984E-02 7.798E-02 7.421E-02
6.918E-02 6.270E-02 5.531E-02 4.695E-02 3.815E-02
si309 H -62.5475 14i 58.42
sp309 D 0 5.745E-02 6.190E-02 6.735E-02 7.289E-02 7.689E-02
7.941E-02 8.040E-02 7.971E-02 7.754E-02 7.382E-02
6.858E-02 6.227E-02 5.504E-02 4.725E-02 3.949E-02
si310 H -62.5475 14i 58.42
sp310 D 0 5.796E-02 6.221E-02 6.762E-02 7.273E-02 7.683E-02
7.920E-02 7.994E-02 7.904E-02 7.695E-02 7.325E-02
6.810E-02 6.207E-02 5.522E-02 4.786E-02 4.101E-02
si311 H -62.5475 14i 58.42
sp311 D 0 5.872E-02 6.266E-02 6.774E-02 7.253E-02 7.613E-02
7.850E-02 7.939E-02 7.834E-02 7.625E-02 7.260E-02
6.789E-02 6.208E-02 5.553E-02 4.884E-02 4.280E-02
si312 H -62.5475 14i 58.42
sp312 D 0 6.033E-02 6.335E-02 6.774E-02 7.217E-02 7.535E-02
7.746E-02 7.825E-02 7.738E-02 7.527E-02 7.184E-02
6.739E-02 6.198E-02 5.603E-02 5.016E-02 4.531E-02

si313 H -62.5475 14i 58.42
sp313 D 0 6.329E-02 6.494E-02 6.803E-02 7.144E-02 7.402E-02
7.592E-02 7.639E-02 7.564E-02 7.368E-02 7.068E-02
6.642E-02 6.162E-02 5.674E-02 5.224E-02 4.896E-02
si314 H -62.5475 14i 58.42
sp314 D 0 6.327E-02 6.499E-02 6.812E-02 7.143E-02 7.402E-02
7.579E-02 7.639E-02 7.580E-02 7.384E-02 7.049E-02
6.639E-02 6.168E-02 5.679E-02 5.215E-02 4.884E-02
si315 H -62.5475 14i 58.42
sp315 D 0 6.016E-02 6.321E-02 6.770E-02 7.208E-02 7.560E-02
7.750E-02 7.822E-02 7.746E-02 7.538E-02 7.193E-02
6.740E-02 6.208E-02 5.612E-02 5.004E-02 4.510E-02
si316 H -62.5475 14i 58.42
sp316 D 0 5.861E-02 6.251E-02 6.772E-02 7.266E-02 7.632E-02
7.844E-02 7.926E-02 7.838E-02 7.621E-02 7.259E-02
6.780E-02 6.213E-02 5.569E-02 4.883E-02 4.284E-02
si317 H -62.5475 14i 58.42
sp317 D 0 5.775E-02 6.212E-02 6.772E-02 7.273E-02 7.675E-02
7.908E-02 7.983E-02 7.923E-02 7.687E-02 7.311E-02
6.834E-02 6.224E-02 5.533E-02 4.786E-02 4.104E-02
si318 H -62.5475 14i 58.42
sp318 D 0 5.728E-02 6.186E-02 6.750E-02 7.275E-02 7.680E-02
7.933E-02 8.034E-02 7.979E-02 7.740E-02 7.365E-02
6.875E-02 6.249E-02 5.524E-02 4.735E-02 3.949E-02
si319 H -62.5475 14i 58.42
sp319 D 0 5.722E-02 6.156E-02 6.724E-02 7.247E-02 7.664E-02
7.938E-02 8.069E-02 7.993E-02 7.778E-02 7.433E-02
6.924E-02 6.290E-02 5.534E-02 4.697E-02 3.831E-02
si320 H -62.5475 14i 58.42
sp320 D 0 5.737E-02 6.148E-02 6.689E-02 7.208E-02 7.612E-02
7.901E-02 8.011E-02 7.978E-02 7.779E-02 7.431E-02
6.940E-02 6.321E-02 5.585E-02 4.755E-02 3.905E-02
si321 H -62.5475 14i 58.42
sp321 D 0 5.777E-02 6.129E-02 6.623E-02 7.121E-02 7.524E-02
7.795E-02 7.911E-02 7.885E-02 7.706E-02 7.397E-02
6.926E-02 6.360E-02 5.666E-02 4.925E-02 4.255E-02
si322 H -62.5475 14i 58.42
sp322 D 0 5.790E-02 6.153E-02 6.618E-02 7.041E-02 7.421E-02
7.671E-02 7.776E-02 7.750E-02 7.589E-02 7.305E-02
6.901E-02 6.383E-02 5.793E-02 5.187E-02 4.622E-02
si323 H -62.5475 14i 58.42
sp323 D 0 5.934E-02 6.245E-02 6.635E-02 7.032E-02 7.359E-02
7.614E-02 7.757E-02 7.734E-02 7.558E-02 7.266E-02
6.833E-02 6.323E-02 5.776E-02 5.225E-02 4.710E-02
si324 H -62.5475 14i 58.42
sp324 D 0 5.909E-02 6.206E-02 6.652E-02 7.123E-02 7.502E-02
7.778E-02 7.896E-02 7.850E-02 7.665E-02 7.329E-02
6.861E-02 6.281E-02 5.630E-02 4.951E-02 4.365E-02
si325 H -62.5475 14i 58.42
sp325 D 0 5.898E-02 6.251E-02 6.744E-02 7.246E-02 7.617E-02
7.884E-02 7.990E-02 7.939E-02 7.729E-02 7.342E-02
6.853E-02 6.228E-02 5.531E-02 4.762E-02 3.986E-02
si326 H -62.5475 14i 58.42
sp326 D 0 6.056E-02 6.469E-02 6.984E-02 7.473E-02 7.793E-02
7.940E-02 7.968E-02 7.848E-02 7.590E-02 7.221E-02
6.711E-02 6.090E-02 5.385E-02 4.621E-02 3.850E-02

si327 H -62.5475 14i 58.42
sp327 D 0 6.179E-02 6.571E-02 7.071E-02 7.516E-02 7.794E-02
7.928E-02 7.910E-02 7.740E-02 7.476E-02 7.113E-02
6.614E-02 6.021E-02 5.353E-02 4.667E-02 4.046E-02
si328 H -62.5475 14i 58.42
sp328 D 0 6.263E-02 6.578E-02 7.055E-02 7.461E-02 7.737E-02
7.867E-02 7.834E-02 7.688E-02 7.425E-02 7.057E-02
6.576E-02 6.028E-02 5.403E-02 4.777E-02 4.253E-02
si329 H -62.5475 14i 58.42
sp329 D 0 6.377E-02 6.621E-02 7.010E-02 7.358E-02 7.606E-02
7.737E-02 7.733E-02 7.604E-02 7.362E-02 7.007E-02
6.578E-02 6.057E-02 5.487E-02 4.941E-02 4.521E-02
si330 H -62.5475 14i 58.42
sp330 D 0 6.624E-02 6.753E-02 7.018E-02 7.277E-02 7.453E-02
7.537E-02 7.530E-02 7.418E-02 7.193E-02 6.890E-02
6.514E-02 6.068E-02 5.630E-02 5.191E-02 4.903E-02
si331 H -62.5475 14i 58.42
sp331 D 0 6.637E-02 6.748E-02 6.984E-02 7.264E-02 7.460E-02
7.537E-02 7.518E-02 7.427E-02 7.203E-02 6.903E-02
6.513E-02 6.063E-02 5.632E-02 5.205E-02 4.906E-02
si332 H -62.5475 14i 58.42
sp332 D 0 6.365E-02 6.620E-02 7.006E-02 7.361E-02 7.618E-02
7.730E-02 7.717E-02 7.596E-02 7.369E-02 7.031E-02
6.589E-02 6.055E-02 5.490E-02 4.947E-02 4.507E-02
si333 H -62.5475 14i 58.42
sp333 D 0 6.255E-02 6.603E-02 7.053E-02 7.461E-02 7.733E-02
7.854E-02 7.832E-02 7.655E-02 7.423E-02 7.065E-02
6.593E-02 6.024E-02 5.408E-02 4.795E-02 4.248E-02
si334 H -62.5475 14i 58.42
sp334 D 0 6.165E-02 6.554E-02 7.060E-02 7.508E-02 7.801E-02
7.914E-02 7.896E-02 7.754E-02 7.486E-02 7.102E-02
6.634E-02 6.039E-02 5.367E-02 4.675E-02 4.045E-02
si335 H -62.5475 14i 58.42
sp335 D 0 6.025E-02 6.426E-02 6.978E-02 7.455E-02 7.779E-02
7.951E-02 7.971E-02 7.859E-02 7.596E-02 7.217E-02
6.723E-02 6.124E-02 5.404E-02 4.631E-02 3.860E-02
si336 H -62.5475 14i 58.42
sp336 D 0 5.873E-02 6.232E-02 6.744E-02 7.238E-02 7.654E-02
7.905E-02 7.976E-02 7.912E-02 7.714E-02 7.340E-02
6.876E-02 6.252E-02 5.539E-02 4.767E-02 3.978E-02
si337 H -62.5475 14i 58.42
sp337 D 0 5.862E-02 6.173E-02 6.652E-02 7.124E-02 7.516E-02
7.768E-02 7.895E-02 7.840E-02 7.663E-02 7.334E-02
6.879E-02 6.319E-02 5.656E-02 4.960E-02 4.360E-02
si338 H -62.5475 14i 58.42
sp338 D 0 5.821E-02 6.185E-02 6.623E-02 7.055E-02 7.421E-02
7.649E-02 7.753E-02 7.734E-02 7.569E-02 7.279E-02
6.888E-02 6.368E-02 5.796E-02 5.198E-02 4.659E-02
si339 H -62.5475 14i 58.42
sp339 D 0 6.027E-02 6.314E-02 6.668E-02 6.984E-02 7.300E-02
7.595E-02 7.755E-02 7.721E-02 7.540E-02 7.231E-02
6.775E-02 6.263E-02 5.772E-02 5.261E-02 4.793E-02
si340 H -62.5475 14i 58.42
sp340 D 0 6.020E-02 6.269E-02 6.712E-02 7.140E-02 7.485E-02
7.730E-02 7.858E-02 7.805E-02 7.611E-02 7.260E-02
6.782E-02 6.232E-02 5.614E-02 4.995E-02 4.487E-02

si341 H -62.5475 14i 58.42
sp341 D 0 6.071E-02 6.355E-02 6.822E-02 7.290E-02 7.639E-02
7.845E-02 7.922E-02 7.858E-02 7.611E-02 7.237E-02
6.766E-02 6.160E-02 5.479E-02 4.792E-02 4.152E-02
si342 H -62.5475 14i 58.42
sp342 D 0 6.235E-02 6.569E-02 7.045E-02 7.485E-02 7.794E-02
7.930E-02 7.923E-02 7.784E-02 7.526E-02 7.146E-02
6.649E-02 6.044E-02 5.360E-02 4.622E-02 3.889E-02
si343 H -62.5475 14i 58.42
sp343 D 0 6.608E-02 6.963E-02 7.460E-02 7.823E-02 7.993E-02
7.961E-02 7.786E-02 7.575E-02 7.266E-02 6.893E-02
6.408E-02 5.821E-02 5.161E-02 4.468E-02 3.815E-02
si344 H -62.5475 14i 58.42
sp344 D 0 7.054E-02 7.414E-02 7.878E-02 8.182E-02 8.201E-02
7.920E-02 7.585E-02 7.284E-02 6.964E-02 6.586E-02
6.130E-02 5.594E-02 4.989E-02 4.371E-02 3.846E-02
si345 H -62.5475 14i 58.42
sp345 D 0 7.027E-02 7.291E-02 7.706E-02 8.000E-02 8.041E-02
7.866E-02 7.586E-02 7.313E-02 6.997E-02 6.613E-02
6.155E-02 5.663E-02 5.108E-02 4.536E-02 4.098E-02
si346 H -62.5475 14i 58.42
sp346 D 0 6.935E-02 7.131E-02 7.457E-02 7.699E-02 7.783E-02
7.736E-02 7.574E-02 7.336E-02 7.051E-02 6.702E-02
6.277E-02 5.809E-02 5.289E-02 4.798E-02 4.423E-02
si347 H -62.5475 14i 58.42
sp347 D 0 7.035E-02 7.108E-02 7.313E-02 7.467E-02 7.549E-02
7.534E-02 7.429E-02 7.228E-02 6.960E-02 6.672E-02
6.320E-02 5.928E-02 5.497E-02 5.117E-02 4.845E-02
si348 H -62.5475 14i 58.42
sp348 D 0 7.024E-02 7.099E-02 7.280E-02 7.466E-02 7.566E-02
7.537E-02 7.420E-02 7.243E-02 6.974E-02 6.673E-02
6.322E-02 5.919E-02 5.507E-02 5.129E-02 4.841E-02
si349 H -62.5475 14i 58.42
sp349 D 0 6.922E-02 7.114E-02 7.437E-02 7.682E-02 7.784E-02
7.741E-02 7.578E-02 7.330E-02 7.059E-02 6.706E-02
6.296E-02 5.821E-02 5.299E-02 4.820E-02 4.409E-02
si350 H -62.5475 14i 58.42
sp350 D 0 6.994E-02 7.295E-02 7.678E-02 7.971E-02 8.031E-02
7.862E-02 7.580E-02 7.292E-02 7.011E-02 6.643E-02
6.197E-02 5.665E-02 5.108E-02 4.569E-02 4.102E-02
si351 H -62.5475 14i 58.42
sp351 D 0 7.044E-02 7.400E-02 7.855E-02 8.190E-02 8.197E-02
7.906E-02 7.561E-02 7.288E-02 6.985E-02 6.606E-02
6.150E-02 5.596E-02 4.994E-02 4.380E-02 3.848E-02
si352 H -62.5475 14i 58.42
sp352 D 0 6.573E-02 6.951E-02 7.434E-02 7.835E-02 7.989E-02
7.944E-02 7.793E-02 7.568E-02 7.288E-02 6.897E-02
6.411E-02 5.832E-02 5.178E-02 4.474E-02 3.832E-02
si353 H -62.5475 14i 58.42
sp353 D 0 6.187E-02 6.532E-02 7.016E-02 7.479E-02 7.798E-02
7.932E-02 7.942E-02 7.813E-02 7.525E-02 7.146E-02
6.660E-02 6.066E-02 5.376E-02 4.632E-02 3.896E-02
si354 H -62.5475 14i 58.42
sp354 D 0 6.013E-02 6.333E-02 6.796E-02 7.288E-02 7.656E-02
7.869E-02 7.921E-02 7.846E-02 7.603E-02 7.255E-02
6.781E-02 6.183E-02 5.515E-02 4.787E-02 4.154E-02

si355 H -62.5475 14i 58.42
sp355 D 0 5.958E-02 6.228E-02 6.683E-02 7.149E-02 7.514E-02
7.768E-02 7.836E-02 7.793E-02 7.591E-02 7.276E-02
6.830E-02 6.258E-02 5.634E-02 5.003E-02 4.479E-02
si356 H -62.5475 14i 58.42
sp356 D 0 5.870E-02 6.220E-02 6.653E-02 7.059E-02 7.397E-02
7.619E-02 7.717E-02 7.689E-02 7.536E-02 7.252E-02
6.859E-02 6.365E-02 5.800E-02 5.229E-02 4.734E-02
si357 H -62.5475 14i 58.42
sp357 D 0 6.115E-02 6.385E-02 6.704E-02 6.962E-02 7.237E-02
7.543E-02 7.718E-02 7.712E-02 7.522E-02 7.175E-02
6.709E-02 6.220E-02 5.783E-02 5.324E-02 4.891E-02
si358 H -62.5475 14i 58.42
sp358 D 0 6.129E-02 6.354E-02 6.745E-02 7.133E-02 7.455E-02
7.702E-02 7.801E-02 7.736E-02 7.517E-02 7.195E-02
6.727E-02 6.189E-02 5.614E-02 5.059E-02 4.642E-02
si359 H -62.5475 14i 58.42
sp359 D 0 6.210E-02 6.462E-02 6.890E-02 7.319E-02 7.626E-02
7.817E-02 7.849E-02 7.746E-02 7.492E-02 7.134E-02
6.673E-02 6.101E-02 5.485E-02 4.848E-02 4.347E-02
si360 H -62.5475 14i 58.42
sp360 D 0 6.481E-02 6.770E-02 7.201E-02 7.595E-02 7.839E-02
7.910E-02 7.815E-02 7.641E-02 7.348E-02 6.955E-02
6.484E-02 5.909E-02 5.284E-02 4.652E-02 4.117E-02
si361 H -62.5475 14i 58.42
sp361 D 0 7.309E-02 7.600E-02 8.049E-02 8.330E-02 8.288E-02
7.923E-02 7.481E-02 7.153E-02 6.856E-02 6.477E-02
6.022E-02 5.488E-02 4.885E-02 4.308E-02 3.832E-02
si362 H -62.5475 14i 58.42
sp362 D 0 8.237E-02 8.454E-02 8.798E-02 8.911E-02 8.572E-02
7.834E-02 7.111E-02 6.657E-02 6.300E-02 5.933E-02
5.522E-02 5.084E-02 4.617E-02 4.143E-02 3.828E-02
si363 H -62.5475 14i 58.42
sp363 D 0 7.987E-02 8.132E-02 8.348E-02 8.453E-02 8.231E-02
7.708E-02 7.174E-02 6.809E-02 6.482E-02 6.128E-02
5.746E-02 5.313E-02 4.873E-02 4.459E-02 4.158E-02
si364 H -62.5475 14i 58.42
sp364 D 0 7.652E-02 7.675E-02 7.799E-02 7.869E-02 7.773E-02
7.510E-02 7.220E-02 6.943E-02 6.650E-02 6.355E-02
6.011E-02 5.640E-02 5.260E-02 4.942E-02 4.700E-02
si365 H -62.5475 14i 58.42
sp365 D 0 7.653E-02 7.669E-02 7.805E-02 7.880E-02 7.769E-02
7.512E-02 7.222E-02 6.927E-02 6.628E-02 6.340E-02
6.014E-02 5.661E-02 5.285E-02 4.948E-02 4.686E-02
si366 H -62.5475 14i 58.42
sp366 D 0 7.960E-02 8.113E-02 8.337E-02 8.449E-02 8.213E-02
7.719E-02 7.218E-02 6.833E-02 6.483E-02 6.109E-02
5.751E-02 5.324E-02 4.887E-02 4.457E-02 4.148E-02
si367 H -62.5475 14i 58.42
sp367 D 0 8.202E-02 8.438E-02 8.763E-02 8.892E-02 8.556E-02
7.825E-02 7.135E-02 6.670E-02 6.326E-02 5.965E-02
5.545E-02 5.096E-02 4.616E-02 4.154E-02 3.816E-02
si368 H -62.5475 14i 58.42
sp368 D 0 7.274E-02 7.566E-02 8.028E-02 8.332E-02 8.265E-02
7.910E-02 7.512E-02 7.194E-02 6.857E-02 6.473E-02
6.029E-02 5.509E-02 4.911E-02 4.305E-02 3.835E-02

si369 H -62.5475 14i 58.42
sp369 D 0 6.462E-02 6.730E-02 7.177E-02 7.569E-02 7.821E-02
7.891E-02 7.833E-02 7.635E-02 7.354E-02 6.977E-02
6.508E-02 5.952E-02 5.320E-02 4.661E-02 4.111E-02
si370 H -62.5475 14i 58.42
sp370 D 0 6.170E-02 6.423E-02 6.866E-02 7.313E-02 7.646E-02
7.804E-02 7.859E-02 7.765E-02 7.495E-02 7.141E-02
6.700E-02 6.121E-02 5.497E-02 4.861E-02 4.338E-02
si371 H -62.5475 14i 58.42
sp371 D 0 6.050E-02 6.291E-02 6.707E-02 7.151E-02 7.482E-02
7.719E-02 7.792E-02 7.738E-02 7.532E-02 7.204E-02
6.780E-02 6.248E-02 5.642E-02 5.063E-02 4.600E-02
si372 H -62.5475 14i 58.42
sp372 D 0 5.945E-02 6.278E-02 6.673E-02 7.054E-02 7.360E-02
7.587E-02 7.696E-02 7.657E-02 7.496E-02 7.178E-02
6.818E-02 6.351E-02 5.817E-02 5.280E-02 4.810E-02
si373 H -62.5475 14i 58.42
sp373 D 0 6.100E-02 6.381E-02 6.735E-02 7.017E-02 7.310E-02
7.517E-02 7.630E-02 7.595E-02 7.433E-02 7.153E-02
6.722E-02 6.274E-02 5.836E-02 5.348E-02 4.949E-02
si374 H -62.5475 14i 58.42
sp374 D 0 6.200E-02 6.401E-02 6.760E-02 7.138E-02 7.446E-02
7.636E-02 7.709E-02 7.655E-02 7.458E-02 7.129E-02
6.699E-02 6.208E-02 5.666E-02 5.140E-02 4.755E-02
si375 H -62.5475 14i 58.42
sp375 D 0 6.318E-02 6.511E-02 6.904E-02 7.284E-02 7.602E-02
7.759E-02 7.768E-02 7.655E-02 7.420E-02 7.071E-02
6.627E-02 6.086E-02 5.502E-02 4.954E-02 4.540E-02
si376 H -62.5475 14i 58.42
sp376 D 0 6.622E-02 6.817E-02 7.201E-02 7.563E-02 7.783E-02
7.835E-02 7.732E-02 7.556E-02 7.282E-02 6.894E-02
6.434E-02 5.896E-02 5.307E-02 4.746E-02 4.332E-02
si377 H -62.5475 14i 58.42
sp377 D 0 7.274E-02 7.464E-02 7.837E-02 8.110E-02 8.108E-02
7.880E-02 7.537E-02 7.229E-02 6.890E-02 6.531E-02
6.050E-02 5.544E-02 4.996E-02 4.474E-02 4.077E-02
si378 H -62.5475 14i 58.42
sp378 D 0 8.186E-02 8.363E-02 8.689E-02 8.830E-02 8.524E-02
7.864E-02 7.197E-02 6.757E-02 6.356E-02 5.978E-02
5.556E-02 5.086E-02 4.616E-02 4.152E-02 3.847E-02
si379 H -62.5475 14i 58.42
sp379 D 0 8.715E-02 8.859E-02 9.120E-02 9.105E-02 8.660E-02
7.785E-02 6.972E-02 6.470E-02 6.068E-02 5.694E-02
5.301E-02 4.897E-02 4.489E-02 4.061E-02 3.805E-02
si380 H -62.5475 14i 58.42
sp380 D 0 8.274E-02 8.262E-02 8.319E-02 8.281E-02 7.988E-02
7.441E-02 6.936E-02 6.596E-02 6.312E-02 6.012E-02
5.714E-02 5.391E-02 5.085E-02 4.790E-02 4.597E-02
si381 H -62.5475 14i 58.42
sp381 D 0 8.279E-02 8.271E-02 8.341E-02 8.294E-02 7.997E-02
7.446E-02 6.935E-02 6.584E-02 6.283E-02 6.003E-02
5.713E-02 5.394E-02 5.077E-02 4.785E-02 4.598E-02
si382 H -62.5475 14i 58.42
sp382 D 0 8.685E-02 8.828E-02 9.082E-02 9.124E-02 8.662E-02
7.791E-02 6.987E-02 6.469E-02 6.077E-02 5.715E-02
5.329E-02 4.897E-02 4.473E-02 4.075E-02 3.804E-02

si383 H -62.5475 14i 58.42
sp383 D 0 8.173E-02 8.354E-02 8.691E-02 8.805E-02 8.525E-02
7.857E-02 7.188E-02 6.720E-02 6.363E-02 5.991E-02
5.574E-02 5.112E-02 4.613E-02 4.177E-02 3.857E-02
si384 H -62.5475 14i 58.42
sp384 D 0 7.252E-02 7.468E-02 7.815E-02 8.079E-02 8.089E-02
7.878E-02 7.554E-02 7.238E-02 6.909E-02 6.526E-02
6.068E-02 5.546E-02 5.000E-02 4.485E-02 4.093E-02
si385 H -62.5475 14i 58.42
sp385 D 0 6.611E-02 6.815E-02 7.186E-02 7.538E-02 7.768E-02
7.807E-02 7.747E-02 7.565E-02 7.275E-02 6.894E-02
6.441E-02 5.919E-02 5.337E-02 4.761E-02 4.336E-02
si386 H -62.5475 14i 58.42
sp386 D 0 6.301E-02 6.504E-02 6.892E-02 7.281E-02 7.571E-02
7.735E-02 7.775E-02 7.671E-02 7.426E-02 7.063E-02
6.636E-02 6.106E-02 5.529E-02 4.968E-02 4.543E-02
si387 H -62.5475 14i 58.42
sp387 D 0 6.136E-02 6.346E-02 6.744E-02 7.141E-02 7.448E-02
7.644E-02 7.740E-02 7.653E-02 7.459E-02 7.153E-02
6.732E-02 6.220E-02 5.697E-02 5.146E-02 4.741E-02
si388 H -62.5475 14i 58.42
sp388 D 0 6.002E-02 6.320E-02 6.685E-02 7.074E-02 7.356E-02
7.558E-02 7.638E-02 7.603E-02 7.432E-02 7.159E-02
6.786E-02 6.342E-02 5.833E-02 5.326E-02 4.887E-02
si389 H -62.5475 14i 58.42
sp389 D 0 6.180E-02 6.426E-02 6.772E-02 7.132E-02 7.435E-02
7.586E-02 7.631E-02 7.564E-02 7.409E-02 7.091E-02
6.712E-02 6.240E-02 5.738E-02 5.240E-02 4.844E-02
si390 H -62.5475 14i 58.42
sp390 D 0 6.350E-02 6.526E-02 6.886E-02 7.235E-02 7.524E-02
7.654E-02 7.675E-02 7.567E-02 7.358E-02 7.055E-02
6.629E-02 6.141E-02 5.594E-02 5.085E-02 4.720E-02
si391 H -62.5475 14i 58.42
sp391 D 0 6.595E-02 6.750E-02 7.106E-02 7.417E-02 7.648E-02
7.738E-02 7.672E-02 7.514E-02 7.272E-02 6.912E-02
6.473E-02 5.953E-02 5.439E-02 4.924E-02 4.586E-02
si392 H -62.5475 14i 58.42
sp392 D 0 6.959E-02 7.105E-02 7.444E-02 7.689E-02 7.822E-02
7.798E-02 7.608E-02 7.379E-02 7.059E-02 6.701E-02
6.257E-02 5.762E-02 5.255E-02 4.755E-02 4.407E-02
si393 H -62.5475 14i 58.42
sp393 D 0 7.408E-02 7.529E-02 7.815E-02 7.994E-02 7.986E-02
7.781E-02 7.474E-02 7.143E-02 6.827E-02 6.453E-02
6.027E-02 5.566E-02 5.083E-02 4.628E-02 4.285E-02
si394 H -62.5475 14i 58.42
sp394 D 0 7.951E-02 8.043E-02 8.239E-02 8.319E-02 8.136E-02
7.725E-02 7.250E-02 6.851E-02 6.500E-02 6.139E-02
5.774E-02 5.367E-02 4.940E-02 4.522E-02 4.246E-02
si395 H -62.5475 14i 58.42
sp395 D 0 8.419E-02 8.410E-02 8.544E-02 8.544E-02 8.194E-02
7.578E-02 6.981E-02 6.589E-02 6.249E-02 5.911E-02
5.589E-02 5.235E-02 4.882E-02 4.540E-02 4.336E-02
si396 H -62.5475 14i 58.42
sp396 D 0 7.998E-02 7.981E-02 8.015E-02 7.975E-02 7.765E-02
7.425E-02 7.037E-02 6.717E-02 6.427E-02 6.134E-02
5.880E-02 5.561E-02 5.276E-02 5.008E-02 4.801E-02

si397 H -62.5475 14i 58.42
sp397 D 0 8.020E-02 7.982E-02 8.053E-02 7.988E-02 7.759E-02
7.379E-02 7.011E-02 6.692E-02 6.422E-02 6.146E-02
5.880E-02 5.585E-02 5.265E-02 5.011E-02 4.809E-02
si398 H -62.5475 14i 58.42
sp398 D 0 8.390E-02 8.424E-02 8.567E-02 8.558E-02 8.204E-02
7.554E-02 6.974E-02 6.554E-02 6.239E-02 5.911E-02
5.608E-02 5.243E-02 4.879E-02 4.554E-02 4.341E-02
si399 H -62.5475 14i 58.42
sp399 D 0 7.945E-02 8.026E-02 8.247E-02 8.321E-02 8.142E-02
7.718E-02 7.252E-02 6.851E-02 6.497E-02 6.150E-02
5.768E-02 5.367E-02 4.930E-02 4.521E-02 4.266E-02
si400 H -62.5475 14i 58.42
sp400 D 0 7.418E-02 7.557E-02 7.794E-02 7.974E-02 7.977E-02
7.780E-02 7.469E-02 7.150E-02 6.804E-02 6.446E-02
6.026E-02 5.575E-02 5.087E-02 4.633E-02 4.311E-02
si401 H -62.5475 14i 58.42
sp401 D 0 7.000E-02 7.134E-02 7.427E-02 7.661E-02 7.779E-02
7.752E-02 7.603E-02 7.371E-02 7.081E-02 6.682E-02
6.236E-02 5.759E-02 5.265E-02 4.798E-02 4.452E-02
si402 H -62.5475 14i 58.42
sp402 D 0 6.626E-02 6.771E-02 7.096E-02 7.401E-02 7.607E-02
7.703E-02 7.675E-02 7.535E-02 7.274E-02 6.889E-02
6.465E-02 5.942E-02 5.450E-02 4.956E-02 4.610E-02
si403 H -62.5475 14i 58.42
sp403 D 0 6.352E-02 6.536E-02 6.894E-02 7.219E-02 7.485E-02
7.631E-02 7.669E-02 7.589E-02 7.361E-02 7.036E-02
6.611E-02 6.118E-02 5.612E-02 5.126E-02 4.762E-02
si404 H -62.5475 14i 58.42
sp404 D 0 6.144E-02 6.404E-02 6.778E-02 7.134E-02 7.415E-02
7.571E-02 7.636E-02 7.591E-02 7.417E-02 7.113E-02
6.698E-02 6.237E-02 5.744E-02 5.256E-02 4.862E-02
si405 H -62.5475 14i 58.42
sp405 D 0 6.280E-02 6.524E-02 6.859E-02 7.189E-02 7.438E-02
7.575E-02 7.601E-02 7.508E-02 7.298E-02 7.018E-02
6.646E-02 6.206E-02 5.743E-02 5.267E-02 4.848E-02
si406 H -62.5475 14i 58.42
sp406 D 0 6.456E-02 6.672E-02 6.982E-02 7.270E-02 7.490E-02
7.616E-02 7.582E-02 7.458E-02 7.236E-02 6.950E-02
6.560E-02 6.121E-02 5.663E-02 5.165E-02 4.780E-02
si407 H -62.5475 14i 58.42
sp407 D 0 6.676E-02 6.866E-02 7.170E-02 7.444E-02 7.580E-02
7.628E-02 7.546E-02 7.377E-02 7.155E-02 6.826E-02
6.440E-02 6.020E-02 5.535E-02 5.062E-02 4.674E-02
si408 H -62.5475 14i 58.42
sp408 D 0 6.902E-02 7.100E-02 7.343E-02 7.561E-02 7.647E-02
7.624E-02 7.489E-02 7.281E-02 7.028E-02 6.699E-02
6.314E-02 5.909E-02 5.459E-02 5.010E-02 4.632E-02
si409 H -62.5475 14i 58.42
sp409 D 0 7.190E-02 7.321E-02 7.538E-02 7.675E-02 7.674E-02
7.552E-02 7.377E-02 7.136E-02 6.859E-02 6.551E-02
6.216E-02 5.829E-02 5.423E-02 5.008E-02 4.652E-02
si410 H -62.5475 14i 58.42
sp410 D 0 7.418E-02 7.501E-02 7.648E-02 7.681E-02 7.629E-02
7.463E-02 7.245E-02 6.993E-02 6.736E-02 6.452E-02
6.133E-02 5.790E-02 5.433E-02 5.090E-02 4.787E-02

```
si411 H -62.5475 14i 58.42
sp411 D 0 7.541E-02 7.566E-02 7.603E-02 7.568E-02 7.477E-02
     7.306E-02 7.122E-02 6.877E-02 6.649E-02 6.400E-02
     6.129E-02 5.849E-02 5.558E-02 5.296E-02 5.058E-02
si412 H -62.5475 14i 58.42
sp412 D 0 7.525E-02 7.564E-02 7.603E-02 7.573E-02 7.461E-02
     7.303E-02 7.103E-02 6.873E-02 6.645E-02 6.376E-02
     6.130E-02 5.864E-02 5.581E-02 5.316E-02 5.084E-02
si413 H -62.5475 14i 58.42
sp413 D 0 7.413E-02 7.492E-02 7.627E-02 7.673E-02 7.640E-02
     7.439E-02 7.233E-02 6.995E-02 6.728E-02 6.433E-02
     6.143E-02 5.802E-02 5.443E-02 5.107E-02 4.830E-02
si414 H -62.5475 14i 58.42
sp414 D 0 7.204E-02 7.325E-02 7.553E-02 7.656E-02 7.670E-02
     7.549E-02 7.346E-02 7.130E-02 6.860E-02 6.546E-02
     6.196E-02 5.821E-02 5.417E-02 5.019E-02 4.708E-02
si415 H -62.5475 14i 58.42
sp415 D 0 6.951E-02 7.118E-02 7.348E-02 7.529E-02 7.620E-02
     7.597E-02 7.483E-02 7.268E-02 7.030E-02 6.691E-02
     6.294E-02 5.870E-02 5.475E-02 5.034E-02 4.692E-02
si416 H -62.5475 14i 58.42
sp416 D 0 6.756E-02 6.925E-02 7.151E-02 7.333E-02 7.454E-02
     7.578E-02 7.577E-02 7.435E-02 7.200E-02 6.821E-02
     6.390E-02 5.954E-02 5.543E-02 5.124E-02 4.761E-02
si417 H -62.5475 14i 58.42
sp417 D 0 6.565E-02 6.750E-02 6.989E-02 7.163E-02 7.356E-02
     7.567E-02 7.620E-02 7.532E-02 7.307E-02 6.945E-02
     6.469E-02 6.033E-02 5.617E-02 5.222E-02 4.865E-02
si418 H -62.5475 14i 58.42
sp418 D 0 6.341E-02 6.584E-02 6.868E-02 7.133E-02 7.351E-02
     7.528E-02 7.596E-02 7.535E-02 7.331E-02 7.026E-02
     6.602E-02 6.151E-02 5.725E-02 5.309E-02 4.921E-02
c U235 prompt neutron dist (using Histogram so energy biasing can be utilized)
si2 H  0.0000 0.038975 0.06225 0.081975 0.09975 0.11625 0.1318
     0.146625 0.16085 0.1746 0.18795 0.200925 0.213625 0.22605
     0.238225 0.2502 0.262 0.2736 0.28505 0.296375 0.30755
     0.3186 0.32955 0.3404 0.35115 0.361825 0.3724 0.3829
     0.39335 0.403725 0.414025 0.424275 0.434475 0.4446 0.4547
     0.46475 0.474775 0.484725 0.494675 0.504575 0.514425 0.524275
     0.534075 0.543875 0.553625 0.563375 0.573075 0.582775 0.59245
     0.602125 0.611775 0.6214 0.631025 0.640625 0.650225 0.6598
     0.6694 0.678975 0.688525 0.6981 0.70765 0.7172 0.726775
     0.736325 0.745875 0.755425 0.764975 0.774525 0.784075 0.79365
     0.8032 0.812775 0.82235 0.83195 0.841525 0.851125 0.860725
     0.87035 0.879975 0.8896 0.89925 0.9089 0.918575 0.92825
     0.93795 0.94765 0.957375 0.9671 0.976875 0.986625 0.996425
     1.006225 1.01605 1.0259 1.03575 1.045625 1.055525 1.06545
     1.0754 1.08535 1.09535 1.10535 1.115375 1.12545 1.135525
     1.145625 1.155775 1.165925 1.1761 1.186325 1.196575 1.20685
     1.21715 1.227475 1.237825 1.248225 1.25865 1.2691 1.2796
     1.290125 1.300675 1.31125 1.321875 1.33255 1.34325 1.353975
     1.36475 1.375575 1.386425 1.397325 1.40825 1.419225 1.430225
     1.4413 1.4524 1.463525 1.474725 1.48595 1.49725 1.508575
     1.51995 1.531375 1.54285 1.554375 1.56595 1.577575 1.58925
     1.600975 1.612775 1.6246 1.6365 1.64845 1.660475 1.67255
     1.684675 1.69685 1.709125 1.721425 1.7338 1.74625 1.758775
```

```
      1.77135 1.783975 1.7967 1.809475 1.82235 1.835275 1.848275
      1.86135 1.8745 1.887725 1.90105 1.914425 1.9279 1.94145
      1.9551 1.968825 1.98265 1.99655 2.010525 2.024625 2.0388
      2.053075 2.06745 2.081925 2.0965 2.111175 2.12595 2.140825
      2.155825 2.170925 2.18615 2.201475 2.216925 2.2325 2.2482
      2.264 2.27995 2.296025 2.312225 2.328575 2.34505 2.361675
      2.378425 2.395325 2.412375 2.4296 2.44695 2.464475 2.482175
      2.500025 2.51805 2.53625 2.554625 2.573175 2.591925 2.610875
      2.63 2.649325 2.668875 2.688625 2.7086 2.728775 2.7492
      2.76985 2.790725 2.811875 2.83325 2.8549 2.876825 2.899
      2.921475 2.94425 2.9673 2.990675 3.01435 3.038375 3.062725
      3.087425 3.112475 3.137925 3.163725 3.18995 3.216575 3.2436
      3.2711 3.29905 3.32745 3.356375 3.385775 3.415725 3.446225
      3.4773 3.508975 3.541275 3.5742 3.607825 3.64215 3.677225
      3.713075 3.74975 3.787275 3.8257 3.865075 3.905425 3.946875
      3.9894 4.033125 4.0781 4.1244 4.172125 4.221375 4.272225
      4.3248 4.37925 4.4357 4.494325 4.555275 4.6188 4.685125
      4.7545 4.827225 4.9037 4.9843 5.069575 5.16005 5.2565
      5.35975 5.470925 5.591325 5.722725 5.867425 6.0285 6.2103
      6.419125 6.664775 6.96355 7.34595 7.88005 8.7816 8.8478
      8.9175 8.9911 9.0691 9.152 9.24055 9.3355 9.43795
      9.549125 9.670725 9.8049 9.954625 10.124025 10.3191 10.54925
      10.83005 11.1907 11.69655 12.5549 20
SP2 D 0.0 20.0 298R 1.0 19R
si5   0 4.8259999
sp5   -21 1
nonu   0 1 508r
nps 1e9
c
f4:n 9996
e4   1.00E-11 1.00E-10 5.00E-10 7.50E-10 1.00E-09 1.20E-09 1.50E-09 2.00E-09
     2.50E-09 3.00E-09 4.00E-09 5.00E-09 7.50E-09 1.00E-08 2.53E-08 3.00E-08
     4.00E-08 5.00E-08 6.00E-08 7.00E-08 8.00E-08 9.00E-08 1.00E-07 1.25E-07
     1.50E-07 1.75E-07 2.00E-07 2.25E-07 2.50E-07 2.75E-07 3.00E-07 3.25E-07
     3.50E-07 3.75E-07 4.00E-07 4.50E-07 5.00E-07 5.50E-07 6.00E-07 6.25E-07
     6.50E-07 7.00E-07 7.50E-07 8.00E-07 8.50E-07 9.00E-07 9.25E-07 9.50E-07
     9.75E-07 1.00E-06 1.01E-06 1.02E-06 1.03E-06 1.04E-06 1.05E-06 1.06E-06
     1.07E-06 1.08E-06 1.09E-06 1.10E-06 1.11E-06 1.12E-06 1.13E-06 1.14E-06
     1.15E-06 1.18E-06 1.20E-06 1.23E-06 1.25E-06 1.30E-06 1.35E-06 1.40E-06
     1.45E-06 1.50E-06 1.59E-06 1.68E-06 1.77E-06 1.86E-06 1.94E-06 2.00E-06
     2.12E-06 2.21E-06 2.30E-06 2.38E-06 2.47E-06 2.57E-06 2.67E-06 2.77E-06
     2.87E-06 2.97E-06 3.00E-06 3.05E-06 3.15E-06 3.50E-06 3.73E-06 4.00E-06
     4.75E-06 5.00E-06 5.40E-06 6.00E-06 6.25E-06 6.50E-06 6.75E-06 7.00E-06
     7.15E-06 8.10E-06 9.10E-06 1.00E-05 1.15E-05 1.19E-05 1.29E-05 1.38E-05
     1.44E-05 1.51E-05 1.60E-05 1.70E-05 1.85E-05 1.90E-05 2.00E-05 2.10E-05
     2.25E-05 2.50E-05 2.75E-05 3.00E-05 3.13E-05 3.18E-05 3.33E-05 3.38E-05
     3.46E-05 3.55E-05 3.70E-05 3.80E-05 3.91E-05 3.96E-05 4.10E-05 4.24E-05
     4.40E-05 4.52E-05 4.70E-05 4.83E-05 4.92E-05 5.06E-05 5.20E-05 5.34E-05
     5.90E-05 6.10E-05 6.50E-05 6.75E-05 7.20E-05 7.60E-05 8.00E-05 8.20E-05
     9.00E-05 1.00E-04 1.08E-04 1.15E-04 1.19E-04 1.22E-04 1.86E-04 1.93E-04
     2.08E-04 2.10E-04 2.40E-04 2.85E-04 3.05E-04 5.50E-04 6.70E-04 6.83E-04
     9.50E-04 1.15E-03 1.50E-03 1.55E-03 1.80E-03 2.20E-03 2.29E-03 2.58E-03
     3.00E-03 3.74E-03 3.90E-03 6.00E-03 8.03E-03 9.50E-03 1.30E-02 1.70E-02
     2.50E-02 3.00E-02 4.50E-02 5.00E-02 5.20E-02 6.00E-02 7.30E-02 7.50E-02
     8.20E-02 8.50E-02 1.00E-01 1.28E-01 1.50E-01 2.00E-01 2.70E-01 3.30E-01
     4.00E-01 4.20E-01 4.40E-01 4.70E-01 5.00E-01 5.50E-01 5.73E-01 6.00E-01
```

6.70E-01 6.79E-01 7.50E-01 8.20E-01 8.61E-01 8.75E-01 9.00E-01 9.20E-01
1.01E+00 1.10E+00 1.20E+00 1.25E+00 1.32E+00 1.36E+00 1.40E+00 1.50E+00
1.85E+00 2.35E+00 2.48E+00 3.00E+00 4.30E+00 4.80E+00 6.43E+00 8.19E+00
1.00E+01 1.28E+01 1.38E+01 1.46E+01 1.57E+01 1.73E+01 2.00E+01

Appendix D - ORIGEN Inputs

1 Week Hydrogen Activation

```
'----------------------------------------------------------------
'
'1) Create ORIGEN activation library.
'
'----------------------------------------------------------------

'${DATA}/origen_filenames:
'                    *=usable in COUPLE 0$$ a3
'                    Reaction Resource (currently
'                    based on JEFF-3.0/A activation
'                    multigroup library)
'17   yields         17
'27   decay          27
'21   end7dec        21
'22   jeff47g        22   *
'74   jeff252g       74   *
'75   jeff56g        75   *
'76   jeff999g       76   *
'77   jeff49g        77   *
'78   jeff200g       78   *
'79   jeff44g        79   *
'80   jeff238g       80   *
'81   xn238v7        88
'82   xn27g19v7      88
'83   xn44           88
'84   xn238          88
'86   xg18           88
'87   xn200g19v7     88
'88   xn27g19v7      88

=couple
*********************************************************************************
*           cross sections from 200-group JEFF-3.1/A                 *
*                                    *

'0$$ a3 is Reaction Resource (AMPX library) from origen_filenames above
0$$ a3 80 e
'1$$ a18 is number of energy groups (must agree with 0$$ a3)
1$$ a18 238 e t
'9** is 238-group flux (must agree with 1$$ a18)
9**
0.000103282
0.000339399
0.000702528
0.000913094
0.002605801
0.041044224
0.140845048
0.512756954
1.581170808
0.942135592
4.491534817
```

3.002976087
0.854918978
4.039863221
3.409259246
1.07000146
0.484373949
0.436245621
0.76455088
0.582966939
1.197341817
1.11307116
1.146077102
0.259154671
0.326195696
0.182447919
0.543961044
0.941906333
0.975617369
0.125192596
0.985471927
0.386188493
0.331804268
0.737984354
0.438641043
0.451839948
0.305075997
0.308514473
1.112080008
1.012639645
1.301870908
1.086340869
0.547880353
0.828865356
0.523274068
0.114580298
0.282797759
0.085343742
0.613860642
0.447059762
0.122791906
0.330060085
1.266487917
0.588461227
1.263683346
0.916393835
1.104697852
0.613399106
1.087368225
1.664235406
0.169713783
0.903847865
0.634549994
0.510715214
0.173685739
0.879255961
0.671061613

0.149176718
1.223474772
0.908664995
1.610605475
0.096936501
1.00547962
3.064604891
0.380044285
0.975336285
0.773609314
0.070151319
0.441721026
0.203711286
2.530339568
0.156386758
0.215559737
0.398268217
0.492328002
0.681510898
0.609936142
0.163134433
0.340447565
0.36126038
0.43443696
0.255773568
0.433110607
0.228798171
0.689665903
0.18537685
0.19108899
0.19714263
0.130109366
0.192833062
0.277139804
0.191778761
0.265064565
0.241356523
0.250827974
0.092022849
0.207192021
0.194311503
0.302820484
0.188718979
0.183386625
0.110327592
0.342484138
0.118254574
0.305174441
0.655398557
0.726169451
0.812888203
0.538572953
0.383819835
0.406077115
0.212215862
0.677218516

0.490213006
0.471689001
0.389373626
0.381164451
0.530179825
0.676430271
0.288886918
1.191826982
0.817158515
1.021774831
1.111687439
0.19098454
0.328764066
0.342781038
0.357970145
0.374481374
0.974639744
0.720600399
0.48435905
1.641577524
0.67957499
0.624216987
1.043783747
0.322731953
0.165882594
0.101034161
0.345242555
0.359072791
0.373987101
0.390115183
0.40760803
0.383085941
0.354494956
0.415791201
0.435324649
0.613886641
0.322794588
0.448307135
0.531046724
0.562378814
0.597392158
0.636759751
0.372734978
0.387509029
0.403428472
0.420628788
0.439267438
0.227149948
0.232435893
0.23795887
0.24373484
0.099175124
0.100160577
0.101164673
0.102187936
0.103230908

0.104294153
0.105378255
0.106483821
0.107611483
0.108761894
0.109935738
0.111133721
0.112356581
0.113605085
0.114880031
0.292943335
0.301533873
0.310612521
0.320221168
0.67146341
0.717506698
0.769893993
0.829999251
0.899618344
0.479742845
0.501870809
1.077827727
1.194214556
1.336835824
1.515448782
0.840955703
0.906781535
0.983267625
1.073417936
1.181734123
1.315438482
1.486985062
1.719289262
2.056557691
2.586093166
3.479648147
5.063081262
2.731776376
3.29530077
4.001188016
4.877810645
5.957165281
7.227576162
8.32916185
4.143105216
12.41343636
1.471211029
1.158896541
0.358510442
0.290023473
0.117440222
0.097999073
0.077734789
0.036562903
0.020060659
0.020122507

```
0.014514562
0.011274491
0.000470223  e
t
done
end


=shell
cp ft33f001 hole11-10ft.f33
end

'-----------------------------------------------------------------
'
'2) Perform activation.
'
'-----------------------------------------------------------------

=origen
solver{ type=CRAM opt{ substeps=10 } }
case(hole11-10ft){
   mat{ iso=[ H=1 ] units=grams }
   lib{ file="hole11-10ft.f33" pos=1 }
'  flux is n/cm2-   value over 1 second
   flux=[3.5868e1 0 0 0 0 ]
   time{ units=days t=[7 7.5 8 14 37] }
   print{ cutoffs[curies=1e-20] rel_cutoff=no
         nuc{ total=yes units=[curies]  }
   }

}


end
```