

## ABSTRACT

Title of Document: MODELING AND VALIDATION OF  
DOSIMETRY MEASUREMENT  
ASSUMPTIONS WITHIN THE ARMED  
FORCES RADIOBIOLOGY RESEARCH  
INSTITUTE TRIGA MARK-F REACTOR  
AND ASSOCIATED EXPOSURE FACILITIES  
USING MONTE CARLO TECHNIQUES.

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The TRIGA Mark F reactor at the Armed Forces Radiobiology Research Institute in Bethesda Maryland is a 1 megawatt steady state reactor which can also be operated in pulse mode at a power of up to 2500 megawatts. It is characterized by a moveable core and two large exposure rooms, rather than a thermal column or beam ports, as found in most research reactors. A detailed model of the reactor and the associated exposure facilities was developed using the Monte Carlo N-Particle (MCNP) and Monte Carlo N-Particle Extended (MCNPX) software programs.

The model was benchmarked against operational data from the reactor, to include total core excess reactivity, control rod worths, and nominal fuel element worths. The model was then used to model burnup within individual fuel elements

within the core to determine the effect of core movement within the reactor pool on individual element burnup. Movement of the core with respect to the two exposure rooms was modeled to determine the effect of movement of the core on the radiation fields and gamma and neutron fluxes within the exposure rooms. Additionally, the model was used to demonstrate the effectiveness of gadolinium paint used within the exposure rooms to reduce thermal neutron production and subsequent  $\text{Ar}^{41}$  production within the exposure rooms.

The model showed a good approximation to measured benchmark data across all applied metrics, and additionally provided confirmation of data on dose rates within the exposure rooms. It also showed that, while there was some variation of burnup within individual fuel elements based on core position within the reactor pool, the overall effect was negligible for effective fuel management within the core. Finally, the model demonstrated explicitly that the use of gadolinium paint within the exposure rooms was, and remains, an effective way of reducing the thermal flux, and subsequent  $\text{Ar}^{41}$  production within the exposure rooms. It also demonstrated that the gadolinium paint also resulted in a much steeper neutron flux gradient within the exposure rooms than would have been obtained had neutrons been allowed to thermalize within the wood walls lining the rooms and then reenter the exposure facilities.

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# Dedication

For Ann,

Because she thinks atomic scientists are fascinating

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## Chapter 1: Background and Definition of the Problem

The Armed Forces Radiobiology Research Institute, and its TRIGA Mark F nuclear reactor, has been conducting research into the effects of radiation on biological systems for nearly 50 years.

Of particular concern to a defense lab is research into the effects of nuclear weapons, and in particular the mixed gamma and neutron radiation field which is produced in the first minute following a nuclear detonation.[1] An ideal tool for replicating those fields is the TRIGA Mark F reactor, due to the high neutron leakage and large exposure rooms.

The biological effects of radiation on living tissue is very dependent on the type of radiation and its energy spectrum.[2] At the extremely high doses required to determine incapacitation curves conducted by AFRRRI in the early years of its history, such spectrum calculations were of little import. As the Institute's research has shifted from incapacitation to determining the effects of radiation on cellular processes at the molecular level, the radiation spectrum to which samples are subjected has become of much more significance.

### TRIGA Reactors

The TRIGA reactor was originally conceived and designed by the General Atomics Corporation in 1956, and the design team had the first reactor constructed by 1958.[3] The reactor was designed to be inherently safe, with a large prompt negative temperature coefficient of reactivity. This design feature made the system inherently

safe and forgiving, and over 70 TRIGA reactors have been installed worldwide, with 65 of them still in service.[4]

The TRIGA reactor fuel is an alloy of zirconium hydride ( $ZrH_{1.x}$ , with  $x$  generally varying between .2 and .8) and uranium metal. The uranium is enriched to 20%  $U^{235}$ , and in the AFRRRI TRIGA reactor the uranium concentration of the fuel is approximately 8.5% by weight in the fuel elements and 12% by weight in the fuel followed control rods. The fuel is over moderated by the hydrogen present in the fuel itself, giving it a high negative temperature coefficient of reactivity. As the reactor fuel heats, Doppler broadening in the resonance region of the fuel causes increased neutron capture, which rapidly causes the reaction to shut down, in turn shutting down the reactor. It is this forgiving feature of the fuel which allows the reactor to be operated in pulse mode, and also makes it safe for operation by inexperienced operators, or students learning the fundamentals of reactor operations.[5-8]

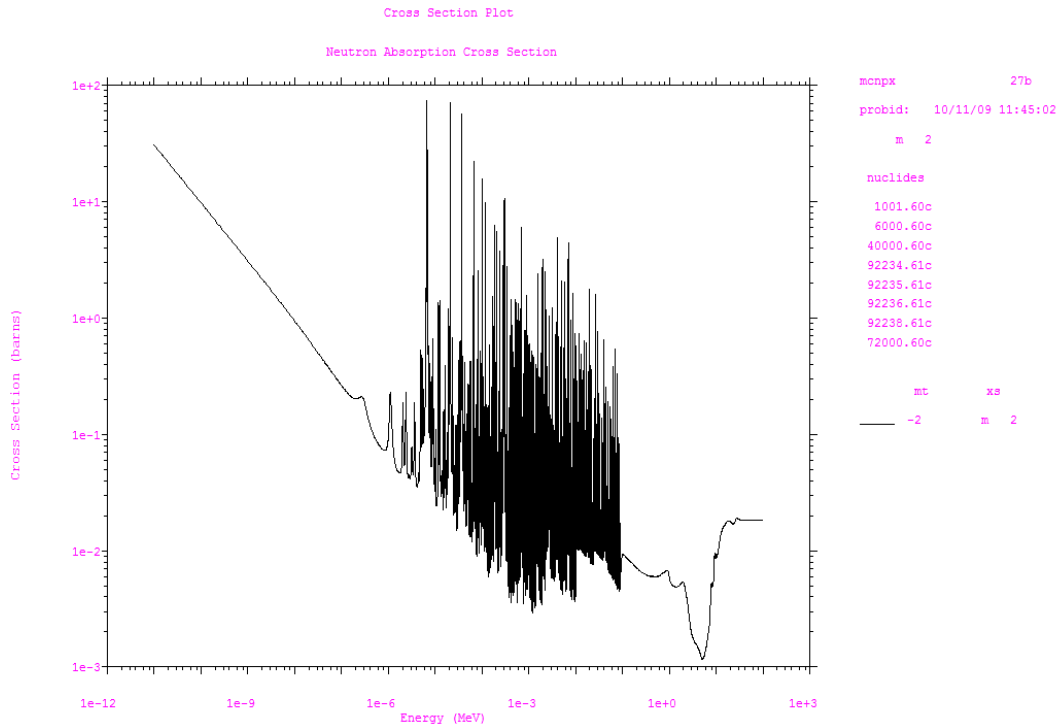


Figure 1. MCNPX generated total composite absorption cross section of zirconium hydride fuel in the AFRR TRIGA reactor.

There are four primary types of the TRIGA reactor. The first developed, the Mark I, is characterized by a graphite reflected core installed at the bottom of a small, below-ground pool. The second model developed, the Mark F, was characterized by its primary operation in a pulse mode and its use of a water reflector for the core. The TRIGA Mark II differs from the Mark I in that, while its core is identical to that of the Mark I, the pool is surrounded by a concrete biological shield located above the reactor room floor. The last model developed, the Mark III, features a movable core supporting both steady state and pulsing operations. The movable core greatly enhances operations, with an exposure room available at one end of the pool and thermal columns at the other end of the pool. In addition to the four models of TRIGA reactor developed by General Atomics, the company also retrofitted a number

of reactors built by other organizations to allow them to utilize the General Atomics TRIGA fuel elements in place of their original plate-shaped fuel elements, generally as part of a conversion from high enrichment fuel to low enrichment fuel.[9] These differences, coupled with differences in power levels, exposure facilities, and changes to the facilities during their operational life essentially mean that each TRIGA reactor facility is of a unique design.

### *The AFRRRI TRIGA Reactor*

The AFRRRI TRIGA Mark F reactor can trace its origins to a request from the Navy Surgeon General's Office to the Armed Forces Special Weapons Project in August 1958, recommending that a "bio-nuclear facility" be established at the National Naval Medical Center in Bethesda, Maryland.[10] In October 1959 the Director of Defense Research and Engineering recommended support of that proposal, and construction of the reactor facility began on 29 November 1960.[11] The building was made available for limited occupancy in January 1962, the Atomic Energy Commission issued an operating license for the reactor on 26 June 1962, and the reactor itself first achieved criticality on 28 June 1962.[12, 13] Of the 4 TRIGA Mark F reactors built by General Atomics, it is the only one which remains in operation.[14, 15] It is also the only TRIGA which has an identified focus on radiobiology research.[16]

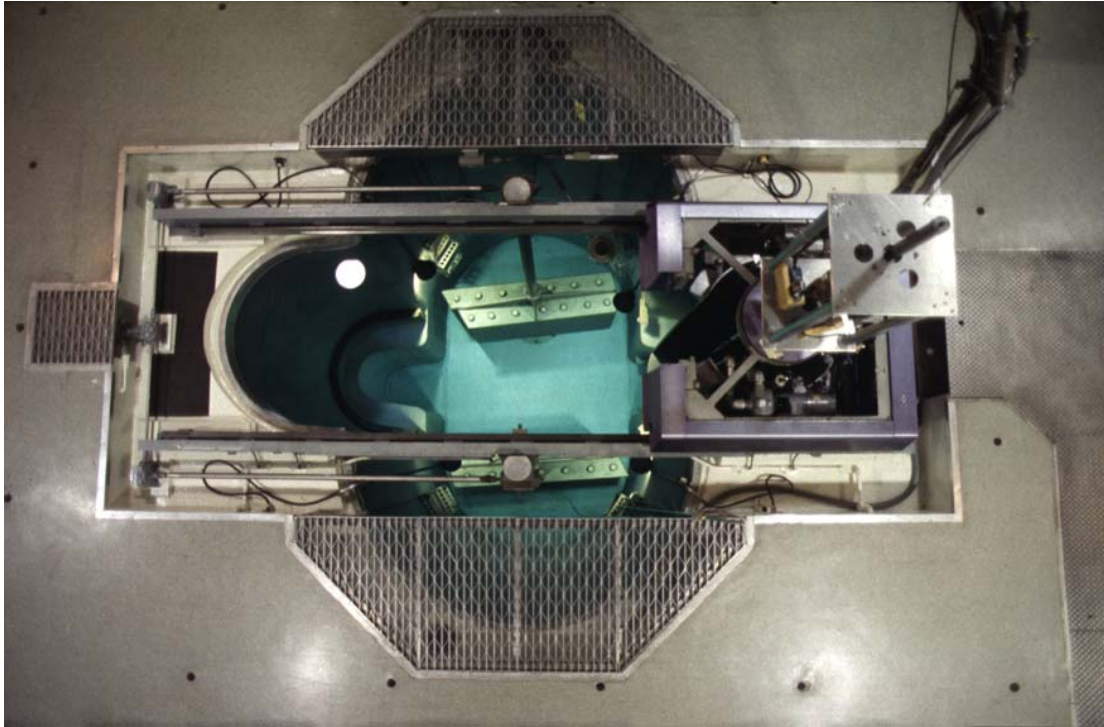


Figure 2. Overhead view of the AFRRI TRIGA Mark F reactor pool. Core in position 750 and shield doors open. Note carriage and tracks, which allow the core to be repositioned within the reactor pool. AFRRI photo.

#### Reactor Core

The AFRRI TRIGA reactor core is a cylindrical core composed of up to 87 standard TRIGA cylindrical fuel elements arrayed within five concentric rings within the core. The reactor is controlled through the use of four control rods. Three of the control rods, located in core positions D-1, D-7, and D-13 (the safe, shim, and regulating rods, respectively) are controlled by mechanical drive mechanisms. The 4<sup>th</sup> rod, located at core position A-1, is known as the transient rod, and is the control rod used to control the reactor when it is operated in pulse mode. It can be rapidly ejected from the core using an air powered pneumatic control system [17].

The central core position, which contains the transient control rod, is designated as core position A-1 and is located at the core centerline. The innermost

fuel ring, designated as B-ring, is centered 4.05 cm from the core center. The six element positions are numbered in a clockwise direction as B-1 thru B-6, with position B-1 closest to exposure room 1, and position B-6 immediately adjacent to position B-1. The 12 elements of C-ring are centered 7.98 cm from the core centerline. The element positions are numbered in a clockwise direction as C-1 thru C-12, with position C-1 closest to exposure room 1, and position C-12 immediately adjacent to position C-1. D-ring contains 18 positions, numbered D-1 thru D-18 and centered 11.94 cm from the core centerline. Position D-1 is located closest to exposure room 1, and the core positions are numbered in a clockwise direction with position D-18 immediately adjacent to position D-1. Three of the positions in this ring, positions D-1, D-7, and D-13, contain fuel followed control rods. The 24 elements of E-ring are located 15.92 cm from the core centerline. They are numbered in a clockwise direction as E-1 thru E-24, with element E-1 located in the position closest to exposure room 1 and element E-24 immediately adjacent to element E-1. Core position E-23 contains a dry core exposure tube. The outermost ring of the core, F-ring, is centered 19.89 cm from the core centerline. The 30 elements of F-ring are numbered counterclockwise as F-1 thru F-30, with element F-1 located in the position closest to exposure room 1, and element position F-30 immediately adjacent to it. Core position F-9 has not contained a fuel element and has been empty since shortly after the 1991 installation of the fuel followed control rods in order to keep total excess reactivity within the core below the reactor's license limits.[18]

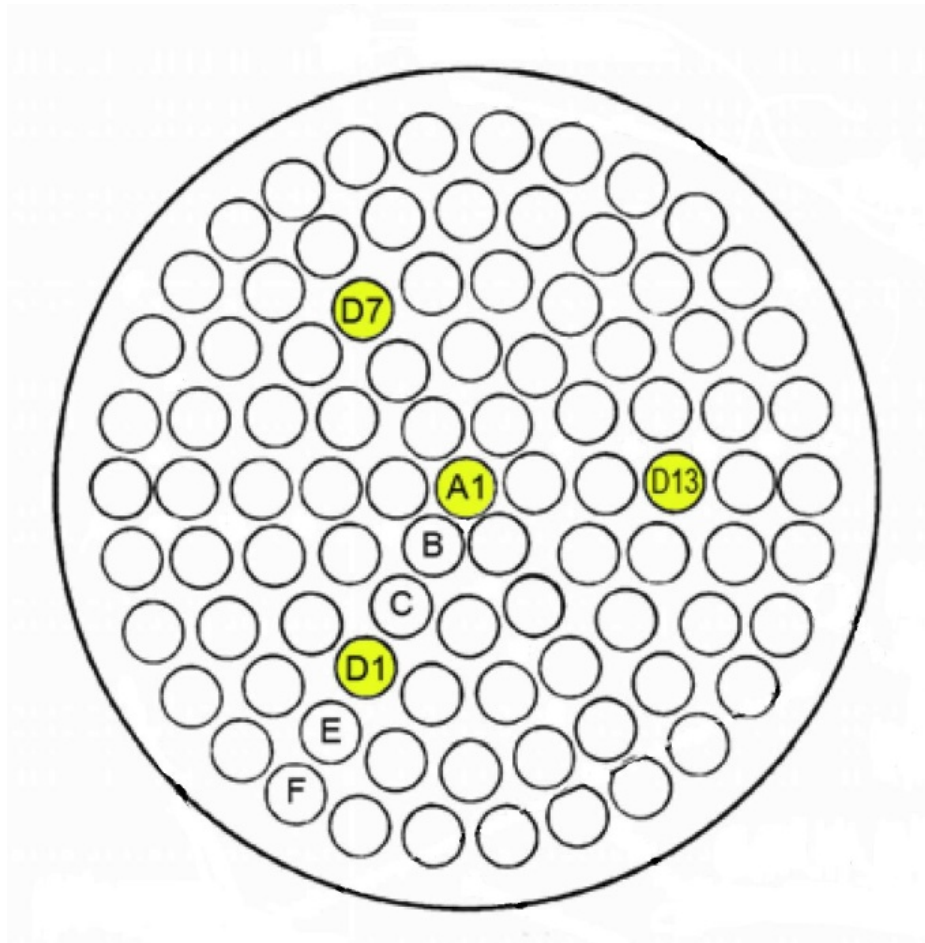


Figure 3. Core map of the AFRR I TRIGA core. AFRR I diagram, from[19].

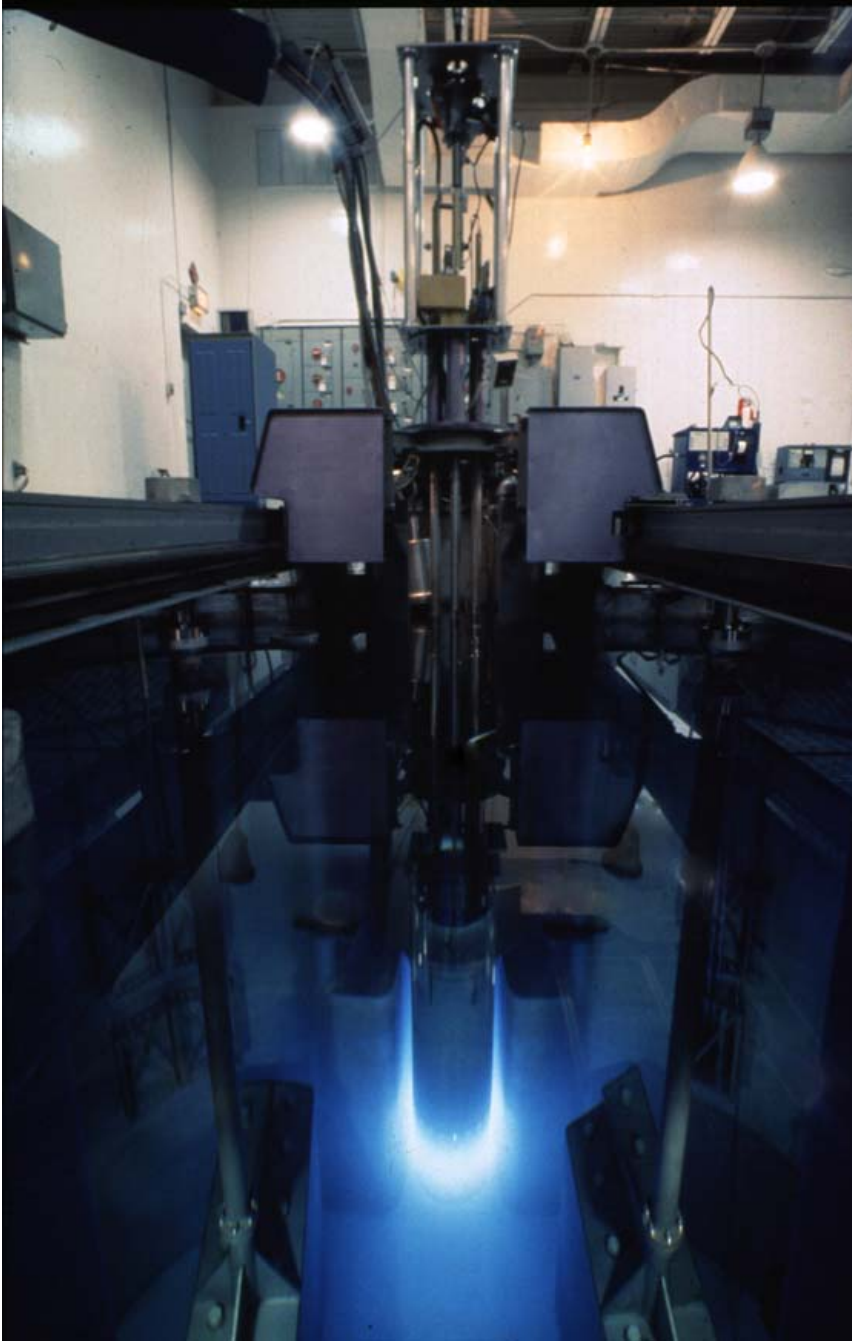


Figure 4. AFRRRI TRIGA reactor in operation at core position 750 with shield doors open. AFRRRI photo.

#### Associated Exposure Facilities

The primary exposure facilities for the AFRRRI TRIGA reactor are the two exposure rooms. Exposure room one measures approximately 6.1 m by 6.1 m by 2.68 m

inches feet in height. Exposure room two is essentially identical to exposure room one except for the size of the room, with exposure room two measuring approximately 3.048 m by 3.048 m by 2.44 m in height.

As originally conceived, exposure room 1 was designed as a fast neutron exposure room, and exposure room 2 as a thermal neutron exposure room [20], and in early operational documents they are referred to as the fast neutron and thermal neutron exposure rooms, respectively [21]. At some point prior to 1980, the heavy water moderating tank was removed from the thermal neutron exposure room, the facilities were renamed exposure rooms 1 and 2, and they are now used essentially interchangeably.

In addition to the exposure rooms, the reactor has a number of other exposure capabilities. A dry core exposure tube can be used to place objects requiring irradiation within the core itself. The core exposure tube replaces one of the fuel elements within the core, and is typically located in core position E-23. A pneumatic tube system which allowed samples to be moved from the hot labs within the facility to the core and back has been removed from service and partially disassembled, but may be reinstalled in the near future. Penetrations in the top grid plate allow small samples to be placed directly into the core between the fuel elements. Finally, the reactor possesses a portable beam port which can be installed within the reactor pool—although it has never been used within the memory of any of the members of the current reactor staff, a period covering the last 29 years.

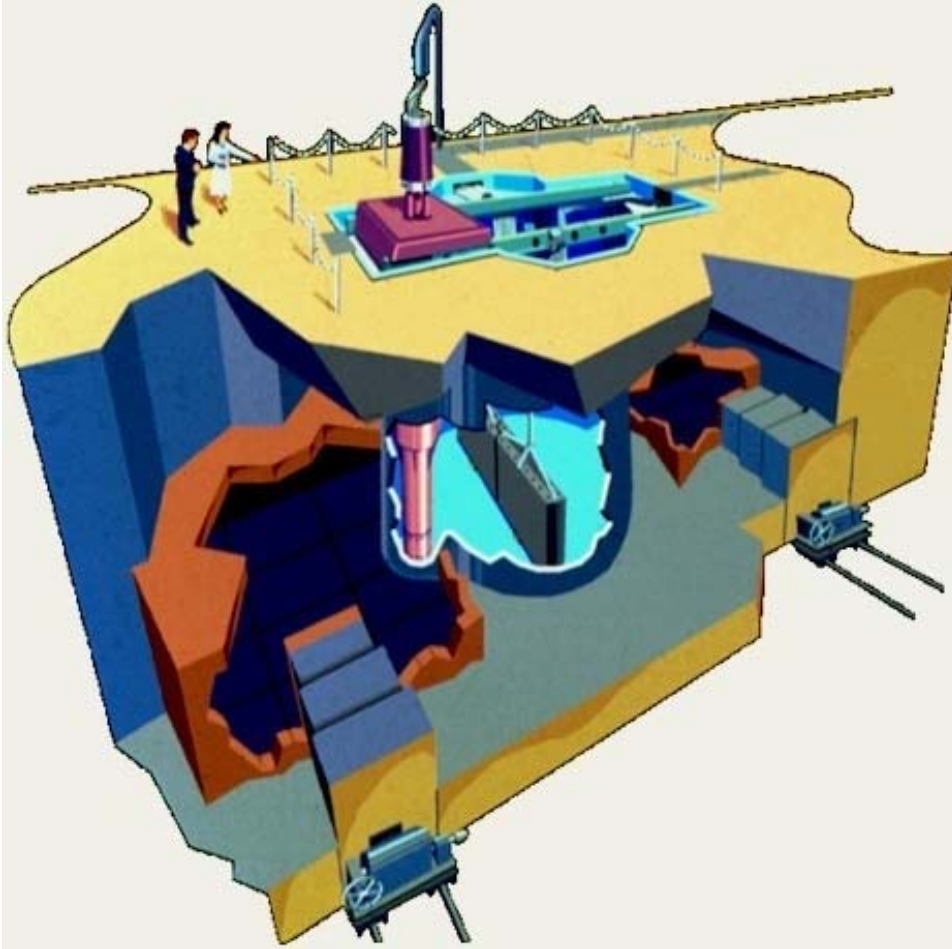


Figure 5. Cutaway drawing of AFRRI TRIGA Mark F reactor and associated exposure facilities. AFRRI drawing. Exposure room 1 on the left; exposure room 2 on the right.

#### The Reactor Environment

The reactor itself sits at the bottom of a 15,000 gallon tank of demineralized water which serves as both coolant and moderator for the reactor and as a biological shield for personnel working on the reactor deck.[22] The core is suspended from a carriage which houses the control rod drive mechanisms and which also allows the reactor core to be positioned at any position along the track between the two exposure rooms upon which the carriage is mounted. This ability to move the core gives researchers a great deal of flexibility in varying the radiation field within the two exposure rooms.

### Fuel History

The original AFRRI TRIGA core consisted of aluminum clad fuel elements. Early operations of the reactor were plagued by fuel element elongation problems caused by a fuel phase transition within the fuel elements. Additionally, fuel cladding melting temperatures limited the amount of time the reactor could operate at 1 megawatt steady-state power. Because of this, in February 1965 the original core's fuel elements were removed from the reactor and transferred to other facilities. Fifty-two of the elements were transferred to the University of Illinois, 56 to the North Carolina State University, and 6 to Cornell University, to include elements within the core and on-hand spare fuel elements. [23] This fuel was replaced with stainless steel clad fuel elements in March 1965, and the reactor was brought to initial criticality with the new core on 19 March 1965. [21]

The fuel was removed from the core in November 1991 as part of a project to replace the void-followed Shim, Regulating, and Safety control rods with fuel followed control rods [24]. In 1994 it was observed that a small number of fuel elements would get stuck during insertion or removal from the core. These elements were found to be slightly shorter than other elements within the core, and they were moved from outside rings of the reactor closer to the center of the core, where they could be more easily manipulated [25]. Since that time, while some individual elements may be removed from the core from time to time, they are always returned to their original position within the core, and the loading may be considered essentially unchanged since they were reloaded in 1991. A comparison of the reactor

logs shows that there was no attempt to systematically move elements from outer rings to inner rings in order to balance burnup during the 1991 reload [21].

Burnup within the AFRRI TRIGA core is complicated by the movement of the core within the reactor pool. Neutron leakage into the exposure rooms when the core is adjacent to one or the other room skews the thermal flux within the reactor core [17]. In order to develop a true and accurate picture of burnup within the core, it is necessary to know the core position within the reactor pool, power level, and duration of each reactor run. Unfortunately, short of manually inspecting each volume of the reactor logs (currently numbering 133 volumes), it is impossible to determine the true core exposure history. Overall exposure to the core from its installation in 1965 to December of 2008 is just over 1000 megawatt hours, the equivalent of approximately 43 megawatt days.

Annual usage of the reactor can vary significantly based on the requirements of ongoing research protocols, in turn driven by available funding. Additionally, changes in science result in changes in usage. During the early 1960s, for example, much of AFRRI's research was focused on determining lethal doses of radiation and radiation's incapacitating effects, requiring high power runs.[26] Recent research has moved its focus to the disruptions of sub-cellular processes caused by radiation, necessitating short, low power runs on the reactor. Reactor usage in 2009 spiked due to one specific project focusing on biological agent defeat requiring long high power runs and likely represents a data anomaly. A review of annual reports of the reactor facility provided annual usage figures in megawatt hours and those data are presented in figure 2. Reliable data prior to 1 October 1967 was not available and thus is not

included; additionally, AFRRI changed its reporting basis from an annual cycle of October to September to an annual reporting cycle of January to December in 1984; data provided in figure 5 represents the 15 month reporting period of October 1983 to December 1984 for the year 1984.[27, 28] While annual power output of the reactor can serve as a valuable metric, particularly in determining fuel burnup, it is not a complete picture of reactor usage. A complete picture of reactor usage would include the number of reactor runs and reactor usage requests submitted by AFRRI primary investigators, which would account for decreased power levels and shorter duration runs in the recent past as the objectives of ongoing research has shifted.[29]

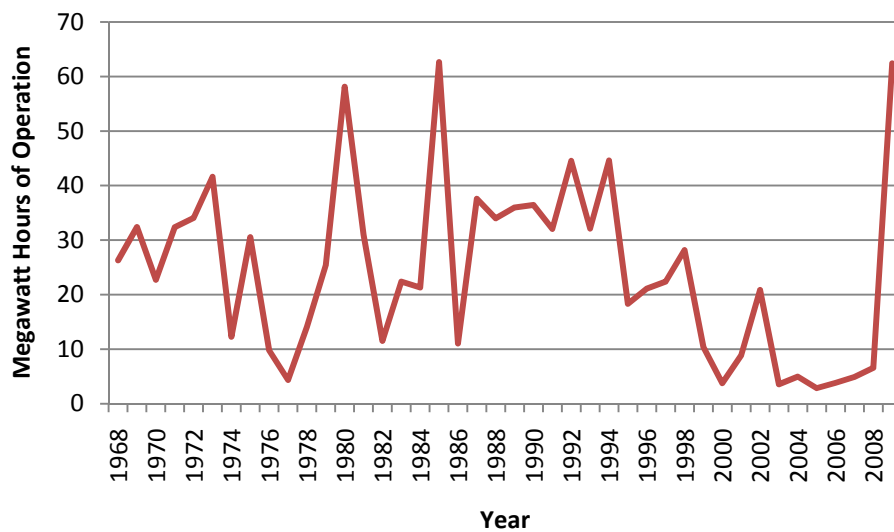


Figure 6. AFRRI TRIGA reactor core operating history, megawatt hours thermal per year, 1 October 1967 thru 1 June 2009.[27-68]

Research Question

Develop a mathematical model of the AFRRI TRIGA core and exposure rooms and model dosimetry readings within the exposure rooms and expand to uncharacterized reactor/shielding/detector geometries. Address the following questions: What are the effects of core movement on radiation spectrum and doses

within targets placed in the exposure rooms? What are the effects of core position within the reactor pool on flux profiles and fuel depletion? Can the effects of the gadolinium paint lining the surfaces of the exposure rooms be adequately modeled using MCNP?

### Methodology

Development of the model of the AFRRRI TRIGA reactor and associated exposure facilities began in September 2008. The model was developed sequentially, starting with a single fuel element, adding additional structure in turn until the core, support structure, biological shielding, and exposure rooms were completed. The model was checked for proper function after each addition to ensure that there were no errors in the geometry modeling approximations.

Dimensions were taken, wherever possible, from the original, General Atomics supplied construction and technical drawings maintained by the AFRRRI reactor staff. Material compositions and densities were taken from standard references or General Atomics supplied data.[69, 70] In order to account for the moving core of the AFRRRI TRIGA, the point of origin for the coordinate system in the model was placed at the center of the core itself, and the core was moved within the reactor tank by, in effect, moving the rest of the system around it.

Burn-up was modeled using MCNPX. Because of distortions in the thermal flux when the core is positioned against the exposure room walls or moved within the reactor pool, the burn-up modeling is inexact, but allows a general assessment of the potential effect of burn-up on the core. Burnup is not expected to have a significant impact on the calculations, based on the changes observed in excess reactivity over

time and the core's relatively low usage, averaging just under one megawatt day per year each year over the life of the core.

The arrays modeled for this dissertation were standard Lucite phantoms used by the center to approximate tissue, although the model could be expanded to more deliberately modeled animal targets in future research. This allows comparison of results from the model to data collected by the AFRRI dosimetrists when taking measurements prior to experimental exposures within the exposure facilities.

Finally, the core position was varied over a range of configurations, and the radiation field modeled in each configuration. Using this data, calibration curves were developed to allow extrapolation of the radiation fields for configurations other than those considered standard at the AFRRI.

### *Contributions to Knowledge*

This research takes an innovative approach to the modeling of the AFRRI exposure facilities by combining a highly detailed model of the core, including explicit modeling of core movement within the pool, with an additional detailed model of the exposure facilities to develop a highly accurate representation of the energy spectrum within the exposure facilities. This approach will provide the AFRRI's dosimetrists and biologists with an extremely valuable tool which will inform their research by allowing them to understand the exposure their samples are receiving in fine detail. Specifically, the research:

- Models a complex reactor system, with its associated exposure facilities, in an innovative manner.

- Develops neutron and gamma dose curves for the reactor's associated exposure facilities for multiple core positions within the pool and multiple positions within each exposure room, providing dosimetrists a tool to more efficiently determine expected doses for targets within the exposure rooms.
- Demonstrates the effect of core position, and associated flux shaping, on fuel depletion within the core, and the effect of that depletion on the neutron flux within the core.
- Verified through modeling the effect of gadolinium paint on the thermal neutron flux within each exposure room, validating the assumptions and experimental results from the studies which originally led to the paint application in 1968.

## Chapter 2: Literature Review

An extensive literature exists on both TRIGA reactors and MCNP modeling. Indeed, the popularity of the TRIGA reactor in university settings has led to a great deal of material in the literature on the modeling of TRIGA reactors using MCNP, which was quite useful in informing this research.

There is, however, a paucity of published literature on the TRIGA Mark F reactor, and virtually all published literature on the Mark F has been published by researchers at AFRRI, likely due to the AFRRI TRIGA Mark F's longevity compared to the other three TRIGA Mark Fs constructed, and its status as the only Mark F still in operation. In addition to the published literature, AFRRI staff members have prepared an extensive collection of internal publications on the properties and operation of the reactor, all of which were made available in support of this research.

### *The Monte Carlo Method*

In March of 1942, Albert Einstein stated in a letter to Cornel Lanczos that “It is hard to sneak a look at God’s cards. But that he would choose to play dice with the world . . . is something I cannot believe for a single moment.”[71] Although it was not the first time he would state such a thought (more famously quoted as “God does not play dice”), it is perhaps the most significant, for shortly after he stated it a group of scientists at what would become the Los Alamos National Laboratory began to develop numerical modeling techniques which would become known as the Monte Carlo Method, named for the casino where the uncle of one of them, Stanislas Ulam, was known to gamble.[72]

The concept behind Monte Carlo is, on the surface, fairly simple—use statistical methods to model complex systems for which a solution cannot be readily reached deterministically—literally “rolling the dice” in order to understand the nature of that complex system.[73] Because of the complexity of nuclear systems and the statistical behavior of neutrons, Monte Carlo lends itself particularly well to modeling of such systems.[74] Although Enrico Fermi is believed to have used a crude version of Monte Carlo as early as 1934 in solving neutron transport calculations, it was not until the availability of sufficient computing power to readily perform the necessary calculations in a reasonable period of time that Monte Carlo techniques came into their own.[75] The process proved very valuable in studying the effectiveness of complex shielding geometries.[76] With increased computing power models became more sophisticated, moving first from one dimensional models to two and then three dimensional ones, and with more sophisticated modeling as that same increase in computing power (and cheaply available memory) allowed models to become more and more detailed over time. Indeed, the developers of MCNP now warn to avoid adding details which are not necessary for the modeling in order to maintain sufficient accuracy without using undue computational power or time.[77]

In Monte Carlo techniques as applied to nuclear transport processes, particles are tracked through their lifetimes. At each event in that lifetime, such as crossing a material boundary or experiencing a collision, probabilities are combined with randomly generated numbers to determine the type of interaction. Probabilities are then again applied based on the type of interaction to determine scattering angle and direction, energy transfer, secondary particle production, etc. The process is then

repeated for each subsequent interaction of the particle until it reaches the end of its life. The process is then repeated again and again until sufficient particle histories have been tracked to provide a good approximation of actual activity within the system being studied.[78]

The standard Monte Carlo program used for nuclear studies within the United States is the Monte Carlo N-Particle (MCNP) software program, developed over several decades by the Los Alamos National Lab. It currently exists in two versions, MCNP 5.x and MCNPX 2.x. Current plans from Los Alamos are to combine MCNP and MCNPX into a single program, MCNPX 6, over the period 2010 to 2012.[79, 80]

Although Monte Carlo techniques provide powerful tools to the researcher, they are considered to be cumbersome to use, require laborious input, can be slow to yield answers, and require expert users to ensure valid results.[81] Indeed, MCNP and MCNPX are said to exchange user efficiency for computational efficiency, and a few hours of user time invested in model development has been said to reduce computational time by a factor of 10 to 1000.[80] Additionally, Monte Carlo techniques are extremely sensitive to geometry and material compositions, and great care must be taken to ensure that errors are not introduced during the problem setup. While MCNP can produce very precise answers based on the input provided, subtle errors can lead to those answers being precisely wrong, emphasizing the importance of careful benchmarking of problems against measured experimental data wherever possible.[82]

### MCNP Modeling of TRIGA Reactors

Due to the popularity of both MCNP and of TRIGA reactors within the research community, it should not be surprising that an extensive body of literature exists on the modeling of TRIGA reactors with MCNP. Over time these models became more sophisticated as both the MCNP code and available computing power improved.

In 1998 and 1999, the Musashi Institute of Technology in Kawasaki, Japan reported on their efforts to model the 100 kwth TRIGA Mark II reactor at the Institute using MCNP 4. Their model did not include top and bottom end fixtures on the fuel elements, modeled the grid plates as solid pieces of aluminum, and only modeled 20 cm beyond the core in the vertical direction, and 20 cm beyond the reactor's graphite reflector in the horizontal direction. Their results provided good approximations to experimentally derived data for control rod worths, nominal fuel element worth, and total reactivity.[83, 84]

Beginning in 2003, the Bangladesh Institute of Energy and Technology developed an MCNP 4 model of their 3 MWth TRIGA Mark II reactor. The reactor core has its fuel elements arranged in an overall circular arrangement but with the individual elements arranged in a hexagonal array within the core. Their model explicitly modeled the fuel elements and control rods individually, but only modeled enough of the reactor tank, support structures, and biological shielding to account for neutron reflection back into the core. They found that the model provided good approximations for flux distribution, control rod worths, and excess reactivity within the core.[85] The model was also used to compare the sensitivity of the results to

different cross section sources, again with good results.[86] Following completion of the model and its benchmarking against operational data from the reactor, the model was then used to develop axial power distributions within individual fuel elements in the core to allow the Institute to use the NCTRIGA thermohydraulic code to model heat transfer within the core, specifically to model natural convection cooling within the core when it is operating at power levels of 500 kwth or less. They found that the combination of MCNP and NCTRIGA provided a good approximation of the reactor's behavior under conditions of natural convection which allowed them to analyze safety assumptions when the reactor was operating under those conditions.[87] The Bangladesh Atomic Energy Agency also modeled their reactor using the SRAC code in addition to MCNP. Their modeling, however, followed similar techniques to those made by others using MCNP, including modeling their top and bottom grid plates as single, solid disks.[88]

In 2005, the University of Wisconsin reported on their MCNP modeling of the school's 1 mwth TRIGA reactor and the benchmarking of it against existing operational data. No details were provided on the modeling assumptions used. When calculating their differential control rod worths, they found that MCNP calculated values differed from the experimentally derived values by from 0.44% to 5.8% depending on which of their three control rods they were measuring. [89]

The Pennsylvania State University conducted MCNP modeling of their Breazeale Nuclear Reactor in order to optimize the thermal neutron flux from their beam port, which originates within a D<sub>2</sub>O tank adjacent to the reactor. The study compared the results of an MCNP modeling of the facility with the results of a

deterministic calculation using the TORT program. TORT is different from MCNP in that it is designed to track particles incident on a surface of the defined system through their lives within the system.[90] Comparison of both models to experimentally derived data showed that both models provided a good fit to the experimental data and also gave predictive results that were further confirmed by experimentation.[91]

Oak Ridge National Laboratory developed a model of the Organization of Atomic Energy for Peace in Thailand's TRIGA Mark III reactor using MCNP 4. Although a much simplified model of the reactor core, which did not model the associated exposure facilities, it still provided a good approximation to experimental data.[92]

The General Atomics Corporation has developed a model that approximates the AFRRRI TRIGA Mark F core. Greatly simplified, it makes no attempt to model the support structure of the core other than the core shroud and solid top and bottom plates, and placed the core in what was essentially an infinite water reactor.[70]

Studies have been conducted to determine how sensitive MCNP models are to geometry and material compositions. These studies show that while geometry is important, material composition is the more important factor in modeling and can have the greatest effect on output. Indeed, while some care must be taken in setting up the model input geometry, fine details in the geometry are generally seen to have little effect on the output, particularly in regions outside of the active fuel region of the core.[93, 94]

### Modeling of TRIGA Reactor Fuel Depletion

Fuel depletion within TRIGA reactors has been modeled using a variety of different software packages. The current version of MCNPX has incorporated the CINDER code as part of its package, allowing burnup calculations to be conducted from within MCNPX.[95] Before the incorporation of CINDER into MCNP, a variety of codes for burnup calculations were available, often coupled with MCNP to produce their final outputs. MONTEBURNS, for example, uses an MCNP input file as its source code for burnup calculations. While these couplings provide useful results, they are subject to interpretation of their results and, as with all calculations involving MCNP, are subject to errors induced by improperly developed material compositions or geometries.[96]

Argonne National Lab conducted a modeling of fuel depletion in a number of different research reactors in support of the Reduced Enrichment for Research and Test Reactors program to show that depletion could be successfully modeled with MCNP, in their case by developing lumped fission product cross sections, which have since been integrated into the MCNP cross section data libraries.[97]

### The Verbinski Reports

In 1980, the AFRRRI conducted extensive field characterization studies within their exposure rooms. These studies were conducted to update the reactor field characterization studies originally prepared in the early 1960s, shortly after the reactor was placed in operation. The configurations used in the study were those most commonly used in the institute at the time. Additionally, one and three dimensional computer modeling was performed to model the core using numerical techniques

which were not readily available when the original characterizations were done. The measurements and numerical modeling provided good correlation against the original studies, and have proved to be a useful tool to researchers and dosimetrists in the facility over the years. [98, 99] The Verbinski reports, even 18 years after their publication, still serve as the primary resource for dose planning by the AFRRRI dosimetrists when determining potential exposures using the AFRRRI TRIGA reactor.

The Verbinski reports characterized the AFRRRI TRIGA Mark F radiation fields In a 2 inch lead cave behind a 6 inch lead shield in exposure room 1; a free field (no shielding) in exposure room 1; in an exercise wheel in exposure room 1; in a phantom behind a 6 inch lead wall; and in a free field (no shielding) in exposure room 2.

#### *Dosimetry in the AFRRRI TRIGA Reactor*

The AFRRRI TRIGA reactor has been used for a wide variety of experiments over the nearly 50 years of its operation. After early studies to determine lethal dose limits for radiation, research expanded into determining the effects of sub-lethal, but incapacitating, doses of radiation on living organisms.[26] This research demonstrated that a given dose of fission neutron radiation was more damaging to radiosensitive tissue than an equal dose of gamma radiation.[100] Additionally, studies were conducted into the use of potential radioprotectant drugs.[101, 102] More work was also performed to determine effective post-exposure treatment regimes for use following a radiation accident or weapon use.[103]

One area of particular interest to AFRRRI's sponsors is that of combined injury. While not always an area of high interest, it does experience cyclic periods of high

interest, and is currently undergoing one such high. These combined injuries on the nuclear battlefield can be from one of two types. The first type, and of most immediate concern following a nuclear detonation, are those which combine a radiation exposure with a traumatic injury, as might be experienced due to translation, crushing, or from flying debris.[104-106] In addition to the trauma inflicted by a nuclear detonation, survivors would likely face collapsed public health systems, and so research is also conducted on radiation exposure combined with infection, to determine expected disease modalities and potential treatment regimes.[107-109]

Additionally, the reactor has been used to support development of biodosimetry, the use of tests on blood, tissue, and other bodily fluids to determine individual exposure histories of individuals. Because much of the research at the Institute focuses on the effects of a nuclear detonation, the use of mixed neutron and gamma radiation fields is important to the research, as are nearly pure neutron fields, and correlations between the cellular damage induced in cells have been developed for the reactor in comparison to the other radiation sources within the AFRRI.[110, 111] Additionally, the effects on DNA of various forms of photon radiation (gamma and x-rays) has been compared to neutrons, in terms of both cell survival and relative linear energy transfer of the radiation.[112, 113]

In all cases, dosimetry results were reported as a total dose rate, and as a ratio of neutron dose to total (neutron plus gamma) dose. Through the use of lead shielding around the reactor tank protrusion, lead caves around the samples being irradiated, and borated low-z materials (plywood, paraffin, polyethylene, bismuth, and Masonite among others), the dose rate was varied from a nearly pure gamma spectrum to a

nearly pure (ratio of neutron dose to total dose in excess of 0.95) neutron dose. In addition to the Verbinski reports, several other studies of radiation fields within the exposure rooms have been completed.[114, 115]

### **Gadolinium Paint in Exposure Rooms**

Legend amongst the AFRRI reactor staff has long held that the gadolinium paint used within the two exposure rooms was added to the walls of the rooms as part of an ad-hoc process—this despite the fact that the gadolinium paint composition and the reasons for it were described in detail in the reactor’s Safety Analysis Report.[22] While this ad-hoc application process may have been true of the 1991 repair, relining, and repainting of the exposure rooms, this was not the case when the rooms were originally painted. When originally installed in 1962, the rooms were lined with wood to reduce potential neutron activation of the concrete biological shielding surrounding the rooms, and this lining is documented in the patent application for the TRIGA Mark F reactor. [20] Photos of the exposure rooms from the period shortly after the initial operation of the reactor also show the wood linings of the rooms without the gadolinium painted masonry linings, while later photographs show the lining that was described in current documentation. [19]



Figure 7. Interior of exposure room 2 prior to installation of gadolinium painted Masonite lining. AFRRRI photo.



Figure 8. Installing the Masonite lining in exposure room 1. AFRRRI photo.



Figure 9. Application of gadolinium paint in exposure room 2. Although the literature describes a controlled application, this photo would tend to indicate that control measures were less thorough than described. AFRI photo.

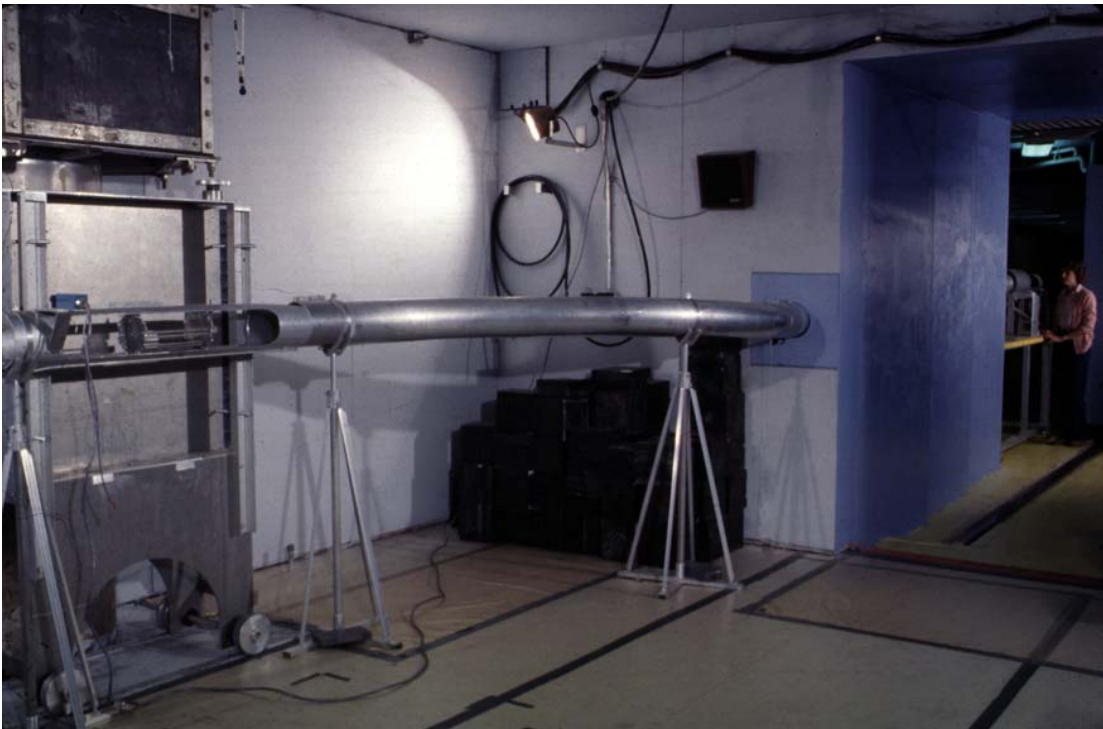


Figure 10. exposure room 1 showing gadolinium painted Masonite lining, extraction tube system and open shield door. AFRI photo.

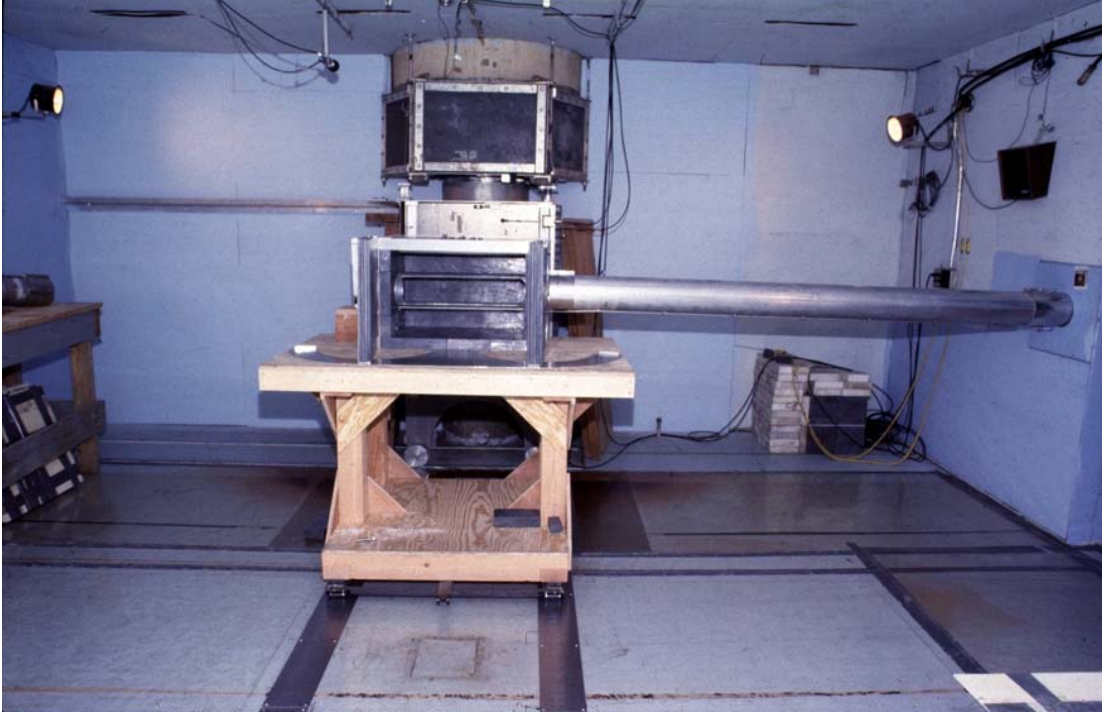


Figure 11. Interior of exposure room 1, showing gadolinium painted Masonite lining and extraction tube system. AFRRRI photo.

Studies conducted in 1967 by the AFRRRI reactor staff showed that there was significant  $^{41}\text{Ar}$  production within the exposure rooms, and by using various sample locations and shielding configurations within exposure room 2 showed that 99% of the  $^{41}\text{Ar}$  production within the facility was caused by thermal neutrons. By shielding the tank protrusion and exposure room walls with cadmium, they were able to reduce the  $^{41}\text{Ar}$  production within the room by two orders of magnitude. Since their calculations indicated that the reactor was producing 1.0 mCi of  $\text{Ar}^{41}$  per megawatt second of reactor operation, this was considered to be a significant reduction of both occupational exposure to the staff and environmental release from the reactor exhaust stack. They further determined that, while unscattered thermal neutrons decreased exponentially as one moved further from the core, they found that there was much less attenuation of thermal neutrons, indicating that a significant number of thermal

neutrons were encountered throughout the exposure room, many likely backscattered into the room from the wood linings of the exposure rooms themselves. While solving one problem—the activation of the surrounding concrete by fast neutrons—the wood lining was creating another problem, that of  $^{41}\text{Ar}$  production. [116] Similar studies of  $^{41}\text{Ar}$  production in exposure room 1 showed that there was significantly more neutron absorption within the volume of the room than in exposure room 2; this was attributed to the larger size of the room and its geometry.[117]

Following the documentation of  $^{41}\text{Ar}$  production within the exposure rooms, AFRRI conducted experimentation to determine the best way to reduce the thermal flux within the exposure rooms. To that end, four materials were considered based on their neutron absorption characteristics. These materials were cadmium, gadolinium, lithium and boron. Cadmium, lithium, and boron were eliminated through AFRRI's testing process due to residual radiation from activation products.[118]

Paint was methodically applied to 0.63 cm Masonite boards which had been installed over the walls of the exposure rooms, obtaining a gadolinium oxide concentration of approximately  $11 \text{ mg/cm}^2$  on the surfaces of the room. Additionally, the tank protrusion of exposure room 1 was covered with a 0.04 cm sheet of aluminum coated with enough coats of paint to yield a concentration of  $22 \text{ mg/cm}^2$  of gadolinium. Due to excessive beta production from the activated gadolinium, specifically the isotope  $^{154}\text{Gd}$ , a further 0.10 cm sheet of cadmium was installed over the gadolinium coated aluminum sheet to both absorb the betas produced and to further attenuate the thermal neutron flux in the room. This configuration was found to reduce the thermal neutron flux within the room by a factor of 30, and the residual

activity within exposure room 1 by a factor of 10.[119] Cadmium shielding and gadolinium paint were not installed on the surfaces of the tank protrusion in exposure room 2 as it was used at the time primarily as a thermal neutron exposure room; such an installation would have been self defeating.

#### Wood Lining of the Exposure Rooms

The exposure rooms of the AFRRRI TRIGA reactor were a design component of the system from the beginning. Indeed, they are noted on the patent application for the TRIGA Mark F as provided “in order to minimize the effects of induced secondary radiation in the concrete shielding.” [20] The wood used to line the walls of the rooms was Douglas Fir. Studies conducted at AFRRRI in the late 1960s confirmed that the wood lining of the exposure rooms were very effective at thermalizing neutrons.[116, 117]

While there is no published literature, other than the AFRRRI internal studies, that describe the use of wood in TRIGA reactor exposure rooms, recent research also supports the use of wood to prevent neutron activation of concrete, where it is used to shield high energy linier accelerators providing medical radiation exposure to patients. [120, 121]

Monte Carlo modeling of medical treatment facility exposure rooms has been completed, to determine the effect of secondary neutron production from medical radiation treatment devices. That research is not directly applicable to this research, but does support the long held belief that wood is an effective material for reducing the neutron fluence within exposure rooms similar to that associated with the TRIGA Mark F, and that lining the room with a neutron absorbing material (in the case of this

particular study, borated polystyrene) was more effective at reducing the neutron fluence than was wood alone. [122]

### Summary

In conclusion, there is an extensive body of literature covering the performance of the General Atomics TRIGA reactor and its modeling. This literature provides a solid theoretical and practical background for the development of a model of the AFRRRI TRIGA reactor and its associated exposure facilities.

## Chapter 3: Building the Model

The construction of the MCNP model proceeded in an orderly manner, albeit with some occasional significant detours and retracing of steps. The end result, however, was a detailed model of the AFRRRI TRIGA Mark F reactor and its associated exposure facilities which provided good correlation to experimental data on the reactor's operation. The development of the model itself is described in subsequent paragraphs.

### Coordinate System and Dimensions

The AFRRRI TRIGA reactor is a complex system, due to the movement of the core within the reactor pool. Because of this, selection of a proper coordinate system was critical to ease of use of the model, particularly if it was to be of value over the long term. For this reason, it was decided to locate the center of the coordinate system at the center of the reactor core itself. The positive x-axis was chosen to be in the direction of exposure room 2, which coincided with an axis through core positions B-4 through F-16. By establishing the coordinate system in this manner, it became possible to easily move the core by changing the x coordinates of the supporting core structure—in effect moving the reactor pool and exposure rooms around the core, rather than moving the core within the pool.

Despite the fact that movement of the core was simplified by centering the model's coordinate system, great care was required in moving the core to ensure that errors were not introduced into the model during the movement. Such errors were generally reflected as geometry errors when the geometry was plotted in the MCNP

Visual Editor, but sometimes were more subtle, requiring a good understanding of expected results in order to catch such errors when they arose, often by producing unexpected results when the model was run.

Dimensioning of the model was also an extremely important consideration. The primary source for all dimensions were the “as built” construction and fabrication drawings for the reactor and its supporting infrastructure from the archival holdings of the Armed Forces Radiobiology Research Institute. These drawings were supplemented by other publications of the Center, including the reactor safety analysis report [22], technical descriptions [19], and operator training documents. Discrepancies between different data sources were resolved, when necessary, by visual inspection of the reactor and its supporting structures. Because of the age of the reactor and its construction drawings, all dimensions were converted from English standard units to metric units before being placed into the model, as MCNP normally operates using metric units.

### Material Compositions

The MCNP code is very sensitive to material densities and compositions. Material composition of some materials and their densities were provided by General Atomics,[70, 123] and these figures were used for the composition of the uranium/zirconium hydride fuel (both in the fuel elements and the fuel followers, which have different compositions), the stainless steel cladding and aluminum structural components, the boron carbide and air in the control rods, and the graphite reflector elements and zirconium rods in the fuel elements. Compositions and densities for other materials were, with one exception, taken from a handbook of

standard material compositions for use with MCNP published by the Pacific Northwest National Lab [69].

The one material composition not derived from these two sources was the composition of the samarium-aluminum burnable poison wafers at the ends of the fuel region of each fuel element. This information was not available in lists of standard materials, and an extensive literature search produced only one publication which described the composition—a 1961 translation of a Soviet publication—and this was used as the source for modeling the wafers as a composition of 1% by weight of samarium oxide ( $\text{Sm}_2\text{O}_3$ ) within an aluminum alloy matrix [124]

#### MCNP Visual Editor

Current versions of MCNP5 and MCNPX come equipped with an additional software interface program named the MCNP Visual Editor (VISED). VISED is a powerful tool, allowing a skilled user to easily define geometries for use with MCNP. It can, however, lull an operator into a false sense of security when defining geometries. Indeed, some instructors recommend not using it for initial construction of MCNP models to ensure proper understanding of the geometry in some detail. To ensure that the AFRRRI TRIGA was properly modeled, all construction of the model was done by hand using Windows Notepad.

That said, VISED provides a much simpler method of executing the MCNP program than the use of the DOS command prompt, and all execution of the program was performed using VISED as the user interface. Additionally, VISED provides useful tools for examining the completed MCNP model, and these features were utilized liberally to ensure that there were no errors in the model geometry, as well as

to produce graphics of the model as well as a graphic representation of some of the data produced by the model.

### Fuel Elements

The first attempt to model the fuel elements involved modeling the complete fuel element involved modeling each element in its entirety. The bottom assembly of the fuel element would rest within an appropriate hole within the bottom grid plate, and the top assembly of the fuel element would pass through a water filled hole in the top grid plate, where it would then protrude into the water of the pool above the plate. As the fuel element was replicated within the system, the model very quickly encountered the constraints on individual cell complexity within MCNP, and an alternative approach needed to be developed in order to ensure that a working model was produced.

In this alternate approach, each element was broken into three pieces. The primary piece of the element ran from the top to the bottom of the cladding can. The other two pieces were the top and bottom elements on the fuel element; their modeling will be discussed in the sections on the top and bottom grid plates, below. This separation of the fuel elements allowed the model to be simplified enough for MCNP to run properly. Once a single fuel element was running properly in the model, it was translated to core position B-1 and replicated throughout the core, as described below in the section titled “building the core.”

The fuel element itself was constructed by creating a cell defined by the outside of the cladding can and then filling it with a universe defined as a series of cells containing the interior contents of the fuel element. This methodology simplifies

the modeling of the elements but makes it difficult to modify the content or composition of any individual fuel element.

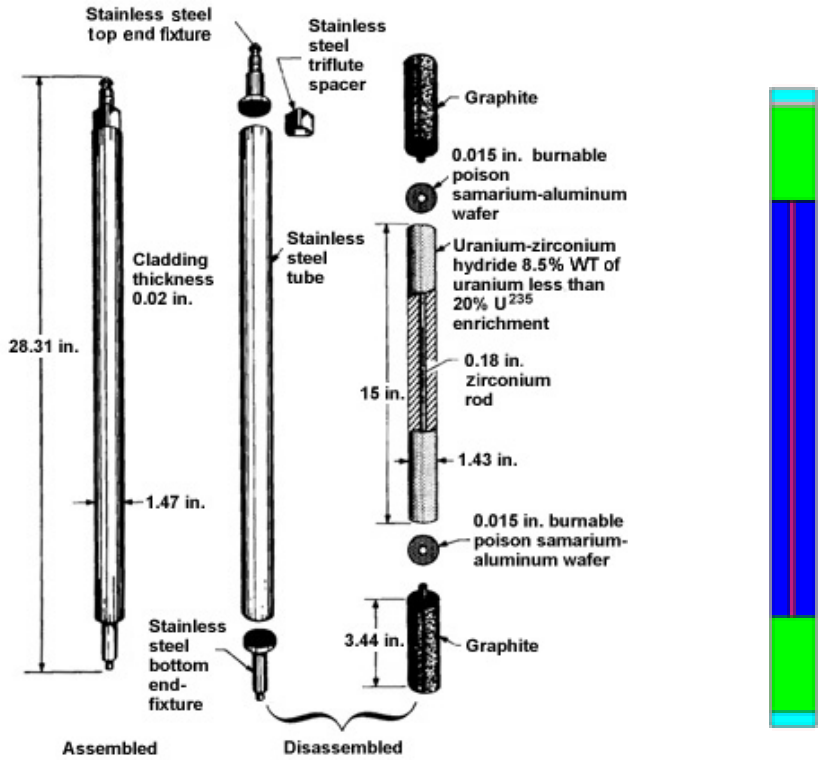


Figure 12. Comparison of fuel element drawing and MCNP model of TRIGA fuel element. Top and bottom end fixtures added in a later step in model development as separate elements.[19]

### Top Grid Plate

The top grid plate was originally modeled as a single element, through which the top assemblies of the fuel elements passed. It, in turn, was surrounded by the reactor pool. This was too complex a model for MCNP to run, so an alternative was developed. In the new model, a water filled cell was placed atop the top grid plate, with this cell including the water in the penetrations through the plate. Within this cell, separate stainless steel cells representing the top assemblies of the individual fuel

elements were added. The triangular spacer assembly at the top of each the fuel elements was not modeled. Additionally, the top of the fuel elements protrude approximately 1-2 mm into the channels through the plate. While an initial attempt was made to model this protrusion, it again made the cells too complex and added little to the model as it was within the acceptable error in tolerances during manufacture of the fuel elements, so all fuel elements were terminated at the plane that demarcated the bottom of the top grid plate. Additionally, the small penetrations through the top plate used to insert detectors into the core were eliminated in the model. Water filled cells separate from the main water filled cell were created where each control rod passed through the top plate and were later replaced with the water filled cells in which the control rods rested.

A literature review showed that top plates in TRIGA reactors were typically modeled as a single solid piece of aluminum, and often the top elements of the fuel elements were entirely eliminated from the models. Based on this, and the negligible change in  $k_{\text{eff}}$  as the top plate and fuel element tops were added to the model, it was determined that the approach used to model the fuel elements in this modeling of the AFRRRI TRIGA reactor was an acceptable approximation of the core.[70, 83, 88, 92]

### Bottom Grid Plate

The bottom grid plate was modeled in a manner similar to that of the top grid plate. A water filled cell was placed on top of the aluminum cell representing the bottom grid plate. Stainless steel cylinders representing the bottoms of the individual fuel elements were placed within the two cells, extending completely through both the water filled cell and the aluminum plate.

A review of the original reactor construction plans showed that each penetration through the bottom plate did not penetrate completely, with a shelf-like projection at the bottom of each penetration holding the fuel element in place. At the bottom of each fuel element was a stainless steel nipple which rested within a penetration of the shelf, helping to stabilize the fuel element and hold it in place. To reduce the complexity of the cells involved in modeling the bottom grid plate, this shelf was not modeled, instead being represented by a single cylinder of stainless steel penetrating completely through the grid plate. Similarly, several penetrations of the bottom grid plate designed to allow cooling water flow were not modeled. As with the top grid plate, water filled cells separate from the main water filled cell were created where each control rod passed through the top plate and were later replaced with the water filled cells in which the control rods rested.

Like the top plate, bottom grid plates in TRIGA reactors are typically modeled as single sheets of aluminum within MCNP, so the approximations within this model were held to be reasonable approximations of the geometry within the bottom grid plate. [70, 83, 88, 92]

### *Transient Control Rod*

There are three different types of transient control rods which can be inserted in the AFRRR TRIGA core. In the poison followed control rod, the boron carbide poison section of the rod sits atop an aluminum cylinder which has a smaller diameter rod of boron carbide at its center. In the aluminum followed control rod, a solid section of aluminum is located below the B<sub>4</sub>C poison section. Finally, in the air

followed control rod, the poison section of the rod sits atop an air filled void. All three of the elements are clad in aluminum.

In modeling the transient control rods, a poison followed control rod was modeled, with the aluminum section of the follower section modeled as being located within a separate cell from the aluminum cladding. This allowed easy conversion of the control rod from one type to another by changing the material composition within the rod. For example, in the poison followed control rod, the central cell of the follower was composed of  $B_4C$ , surrounded by a cell of aluminum, in turn located within a cell representing the aluminum cladding. To convert the model rod to an aluminum followed control rod, it was simply necessary to change the material of the central rod from  $B_4C$  to aluminum, and to convert it to an air followed control rod, the two center cells of the follower section were changed from  $B_4C$  and aluminum to air.

To avoid issues with cell complexity, a water filled cylinder was created within the core and pool which contained the control rod. When the control rod was moved within the core, it moved within this water filled cell, which in turn remained stationary in relation to the rest of the core and surrounding reactor pool.

Although the model was developed to allow the use of any of the three versions of the transient control rod, only the air followed control rod is routinely used at this time by AFRRI. A review of reactor operation records shows the time period that the air followed or poison followed transient rods were used, allowing the model to be modified when benchmarking against specific historical data, ensuring that the core control rods are in the proper configuration [25, 125, 126].

### Shim, Safety, and Regulating Control Rods

The modeling of the safety, shim, and control rods was similar to that of the transient rod. First to be modeled were the fuel follower control rods which were installed in the reactor in November 1991. In a fuel follower control rod, a section of uranium and zirconium hydride fuel is located beneath the poison section of the control rod. As the control rod is withdrawn from the core this fuel follower section is, in turn, inserted into the core. Thus when a control rod is fully withdrawn, it is the equivalent of placing an additional fuel element within the core.

Although the control rod fuel follower section is smaller in diameter than a regular fuel element, the amount of uranium is greater within the fuel follower section (12% by weight in the fuel follower versus 8.5% by weight in a regular fuel element, both enriched to 20%  $U^{235}$ ) and thus the total amount of uranium contained within the elements are roughly equivalent.

As with the transient control rod, a water filled cylinder was created within the core and pool which contained the control rod. This reduced cell complexity within the model, avoiding potential problems in the execution of MCNP. When the control rod was moved within the core, it moved within this water filled cell, which in turn remained stationary in relation to the rest of the core and surrounding reactor pool.

Unlike the transient rod, the design and dimensions of the fuel followed control rod are completely different from that of the air and aluminum followed control rods which were used as shim, safety, or regulating rods prior to the installation of the fuel followed control rods in 1991.

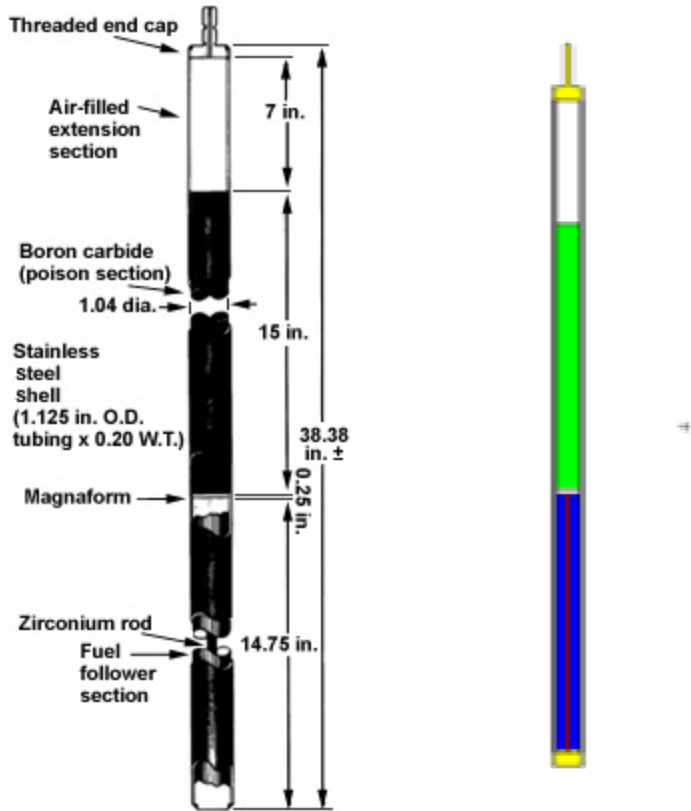


Figure 13. Comparison of drawing of fuel followed control rod to MCNP produced model.[19]

### Control Rod Guide Tubes

Once the model was running with control rods in place, the control rod guide tubes were added to the model. These thin walled tubes extend from a position in the reactor pool some distance above the core to a short distance below the bottom grid plate, and ensure the free and unobstructed travel of the control rods. At this time, the top assembly of the control rods was also extended to the top of the pool surface, to simulate the control rod drive mechanisms. Comparison of the  $k_{\text{eff}}$  of the model before and after addition of the guide tubes showed very minimal change in the excess reactivity of the reactor, so this was assessed to be a reasonable approximation—additional detail in the support structure being likely to have

minimal additional effect on the neutronics of the core. Further, no attempt was made to model the control rod drive mechanisms and associated support structure above the pool surface, as it was assessed that the structure would have no additional effect on the core.

### Core Exposure Tube

Plans for the core exposure tube were not located. Therefore the model of the tube had to be approximated. Using the dimensions of a typical fuel assembly with its bottom projection as a base, an air filled aluminum cylinder was created. To position it within the core, an aluminum projection was added to the bottom of the exposure tube. As in the case of the fuel elements, this projection was modeled separately from the exposure tube itself and was placed within the bottom grid assembly cells.

The core exposure tube serpentine to the surface of the reactor pool to prevent radiation streaming from the core. Because the primary concern in this model deals with radiation within the exposure rooms, it was decided to simplify the modeling of the exposure tube. Therefore, rather than attempting to replicate the serpentine structure of the core exposure tube, it was elected to model it as a straight, air filled aluminum tube terminating approximately 100cm above the top of the core. This reduced the complexity of the model to some extent while still providing for the effect of the air filled void of the core exposure tube within the core and its immediate environs.

Although the reactor plans and other references reflect a series of pneumatic delivery tubes in the vicinity of the core, that system is not currently in service and has been partly disassembled and the tubes removed from the reactor pool. Therefore

no attempt was made to model the pneumatic sample tubes or their support structure. Should the pneumatic tube system be repaired and reinstalled in the future, the tubes could readily be added to the model.

### Assembling the Core

Once an individual fuel element body was created, it was replicated throughout the core using the “LIKE . . . BUT” command in MCNP. The original fuel element was placed in core position B-1, and elements were added individually in sequence. Because of the lack of symmetry within the core of a type which could be replicated using the lattice/matrix features of MCNP, those commands could not be utilized. Thus, the location of each of the additional 86 elements added was developed in relation to core position B-1. After each individual element was added, MCNP was run and a new  $k_{\text{eff}}$  was computed. This ensured that no errors had been propagated in the model when the new elements were added. Problems were encountered when the cell containing the elements exceeded the complexity allowed by MCNP, and in order to avoid these limitations, a water filled cylinder the height of the fuel element body was created to contain the elements and control rods in rings A through D, and separate water filled toruses were created to hold the elements of E and F rings, respectively. Water filled cylinders were also placed in the location of each of the control rods, and in which the control rods were later placed, as discussed above.

The water filled cylinder containing the fuel elements was, in turn, placed into a 50 cm diameter, 100 cm tall water cylinder which mimicked the effects of an infinite water reflector when conducting preliminary criticality calculations.

### Core Shroud

Once the model of the core itself was running within a water cylinder, the core shroud was added to the model. The 1.27 cm thickness cylinder was added, and the water outside the core was divided into a region outside of the shroud and a region inside the shroud in order to reduce cell complexity as other structural elements were added. The core, to include its own water filled cells, was then placed within the inner cell. The water filled cells which would hold the control rods were also extended into the new cells.

There are 20 small holes in the shroud which help to allow convective flow of cooling water into the core region, 10 near the top of the shroud and ten near the bottom of the shroud. These penetrations were not modeled, nor were the mounting brackets which hold the core in position within the shroud. As was the case with the grid plates, a literature review showed this to be a reasonable approximation of actual geometry within MCNP, as most MCNP models did not carry their model beyond 50 cm from the core.

### Core Support Structure

Because of the movable core, the AFRRRI TRIGA reactor's support structure is more complex than that of a typical TRIGA reactor. The core shroud is suspended from a shroud support, made of aluminum and of the same outside diameter as the core shroud. The shroud support is, in turn, suspended from a 0.96 m diameter support assembly. The support assembly is attached to a carriage which allows the entire core assembly to be moved within the reactor pool. Control rod guide tubes, the

control rod drive mechanisms, access to the core exposure tube, and reactor instrumentation all pass through the center of the support assembly.

No attempt was made to model the carriage assembly which moves the support structure of the reactor, or any features above the top of the reactor tank. Additionally, penetrations of the support structure and a large access opening in the core support structure were not modeled, nor were the brackets and supporting assemblies which are used to fasten the support assembly to the shroud support. This, again, is consistent with other models of TRIGA cores.

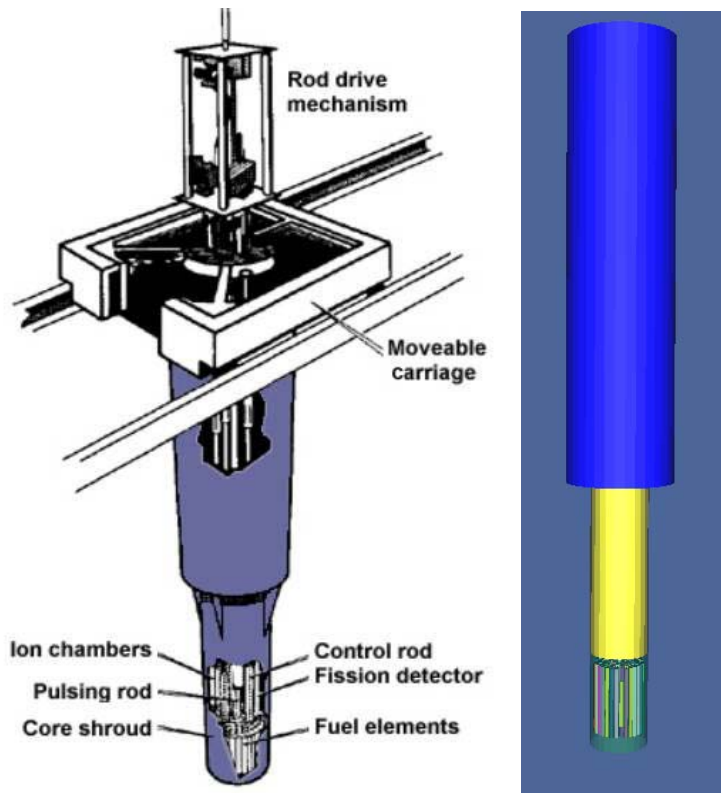


Figure 14. Core support structure, allowing movement of the core within the reactor pool, compared to MCNP model. AFRRRI drawing.

### Reactor Tank

In addition to the complexity of the tank itself, the dimensioned drawings of the tank had been lost by the AFRRRI. Therefore, to obtain dimensions for the tank, a

scaled but non-dimensioned plan was used to determine all appropriate dimensions. After dimensions were measured off of the drawing, they were then converted from English to metric units for input into MCNP. Some approximations in the model were made, such as eliminating rounded corners, which were in areas far enough away from the track of the core within the pool as to have negligible impact on the neutronics behavior of the model. After construction of the model, a digital copy of the missing drawing was obtained from General Atomics, and this drawing was used to confirm the previous measurements, modifying them where necessary. [127]

The reactor tank was modeled as a separate water and air filled structure and once it was functioning properly within MCNP it was merged with the model of the core and associated support structure itself. After completion of the merge, MCNP was again run, and a new  $k_{\text{eff}}$  was determined in order to ensure that the model remained functional.

### Exposure Rooms

The exposure rooms were modeled individually in their own files. Dimensions for the rooms themselves were taken off of the construction diagrams for the reactor facility, and dimensions of the wood lining of the room, and the Masonite inner lining of the room, were taken from other descriptive publications. The Masonite lining is itself painted with a paint containing gadolinium, but no attempt was made to model the paint as a separate cell within MCNP. Instead, the gadolinium, which is described in the technical publications in a concentration per square centimeter of room surface, was assumed to be homogeneously distributed throughout the Masonite. As the Masonite was only 0.3175 cm thick, this was believed to be a valid approximation.

Once the exposure rooms were running individually within MCNP, their files were each merged with that of the core and surrounding pool and tank. After resolving boundary issues between the tank, the individual exposure rooms and the outside world, MCNP was again run and a new  $k_{\text{eff}}$  determined following the addition of each room to ensure that no errors had been introduced into the model.

No attempt was made at this time to model the lead or cadmium shields within each exposure room, or any experimental apparatus or other support structure within the rooms.

### Concrete Shielding

The effectiveness of the concrete shielding was not one of the purposes of this study. Additionally, portions of the shielding, particularly near the exposure rooms, may be concrete, earth, or a combination of both. Further, the shape of the shielding can vary from floor to floor of the reactor facility. Finally, no exact composition of the concrete composing the shielding was available. For this reason, the concrete shielding surrounding the reactor is in many places a reasonable approximation of the shape of the shielding—with particular attention paid to accurately represent the thickness of the shielding surrounding the exposure rooms, and less attention paid to the thickness of concrete surrounding the remainder of the reactor pool.

Because of the lack of specific data on the composition of the concrete itself, a standard composition was used to represent the concrete, in this case “Oak Ridge National Lab composition” concrete. [69] Further, no attempt was made to model any of the steel reinforcing bars within the concrete.

The exposure room doors are multi-ton plugs of concrete which can be moved to create large openings in the exposure rooms through which experiments can be placed in the exposure rooms. The edges of the plugs are shaped in a stepwise fashion to prevent radiation streaming from the rooms into the sample preparation area beyond the plug doors. Because of the reactor interlock systems, the AFRRI TRIGA cannot be operated with the exposure room doors open, and therefore no attempt was made to separately model the exposure room doors, and the walls of the exposure rooms were treated as solid concrete walls. This was considered to be a good approximation of the facility, given allowable operating parameters.

### Cadmium Shield

The cadmium shield in exposure room 1 is a square measuring 61 cm on each side. The shield covers a thin sheet of aluminum which itself is painted with gadolinium oxide.[22] The studies which resulted in the gadolinium paint being placed on interior surfaces of the exposure rooms also found that placing the gadolinium painted shield behind the cadmium shield would reduce exposure of personnel working in the exposure rooms to high energy  $\beta$  particles produced by the decay of activated gadolinium.[119]

As with the gadolinium painted Masonite, the gadolinium paint on the cadmium shielding was approximated by modeling the shield as containing a homogeneous mixture of 99.8% by weight of cadmium and 0.2% by weight of gadolinium. The cadmium shield was centered on the core center directly adjacent to the reactor tank protrusion wall in exposure room 1.

### Fuel Depletion

Fuel depletion is modeled within MCNPX through the incorporation of a previous standalone program known as CINDER90. This subroutine calculates burnup by material, and gives results of depletion calculations for the total mass of a specified material within the system under examination. Given these constraints, it was necessary to redesign the model for use in the burnup calculations.

In order to determine the spatial effects of fuel depletion when the core moves, it was necessary to create a separate material for each fuel element within the core—albeit all identical prior to the start of the burnup process. This, in turn, required that the replicated fuel elements using the LIKE . . . BUT command within MCNPX be replaced by individual fuel elements. This allowed fuel depletion to be computed readily for each individual element in each of the three core positions studied.

## Chapter 4: Benchmarking

In order to determine if the model was functioning properly, a number of benchmarking calculations were made against existing historical data in order to determine if the model was, in fact, accurately depicting the core.

### Core Loading/Approach to Criticality

An approach to criticality is conducted by gradually building up a fuel-moderator system, with an independent neutron source, until critical mass for the system is approached. The reciprocal of the multiplication factor ( $1/M$ ) for the system, as experimentally determined, is plotted as fuel is added. After each addition of fuel or moderator, the plot is extrapolated until the value of  $1/M$  reaches zero, at which point the system has achieved criticality.[128]

In 1991, the AFRRI TRIGA reactor's control rods were replaced with fuel followed rods. As part of this process, all fuel elements were removed from the core, and a  $1/M$  calculation was performed as the core was reloaded. This was the last time the core was reloaded, and the last time that other than individual fuel elements were removed from the core [24]. Therefore, this data serves as an important reproducible benchmark for the model.

In order to replicate the experiment, the fuel elements were placed in the core model in the order and positions in which they were in the 1991 reloading experiment. From a modeling perspective, the full core model was used as a starting point, and individual fuel element bodies were removed from the model. The top and bottom assemblies of the elements, which were modeled separately, were converted

within the model from stainless steel to water—effectively removing them from the core, while reducing the work, and subsequent possibility of introducing errors within the model—and the model was run consecutively for each configuration in the fuel loading sequence in turn. The  $k_{\text{eff}}$  for each loading was used to compute the value of  $1/M$ , and the modeled value was then plotted against the experimentally measured values from 1991.

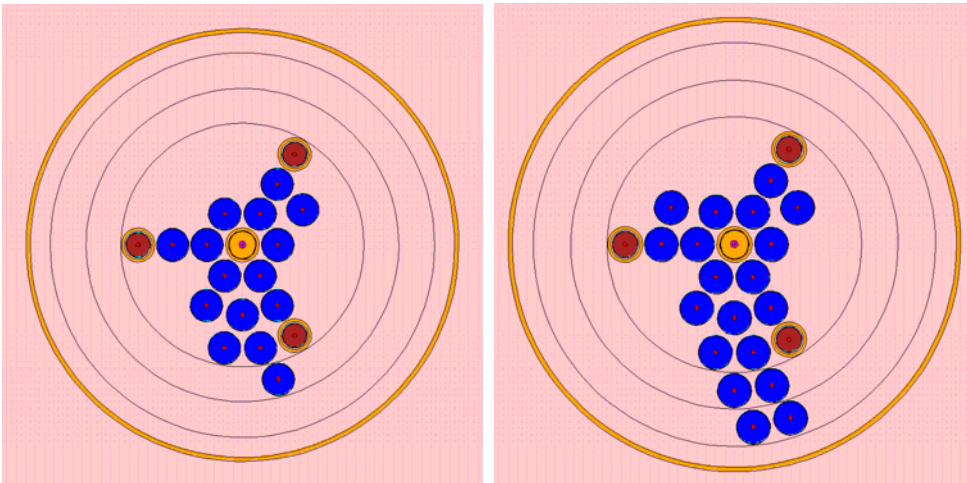


Figure 15. Fuel loading. In addition to fuel followed control rods: 15 elements, 19 elements.

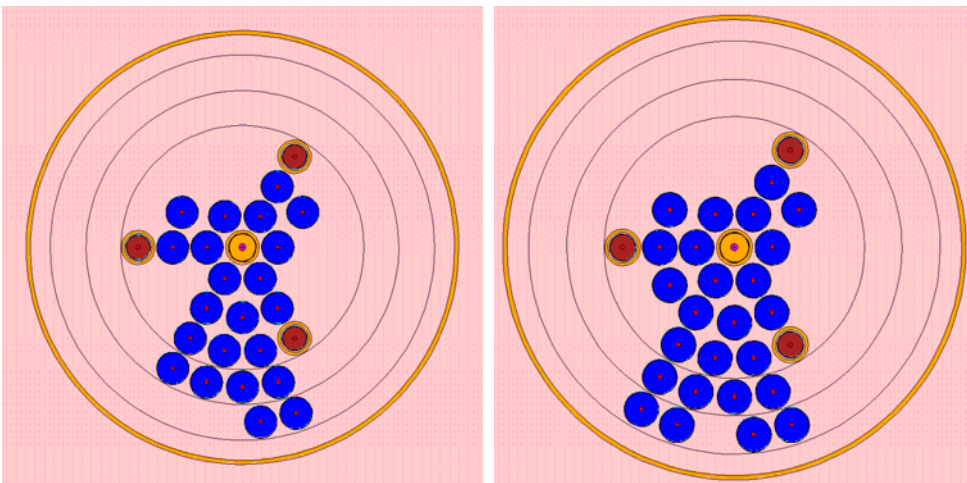


Figure 16. Fuel loading. In addition to fuel followed control rods: 22 elements, 25 elements.

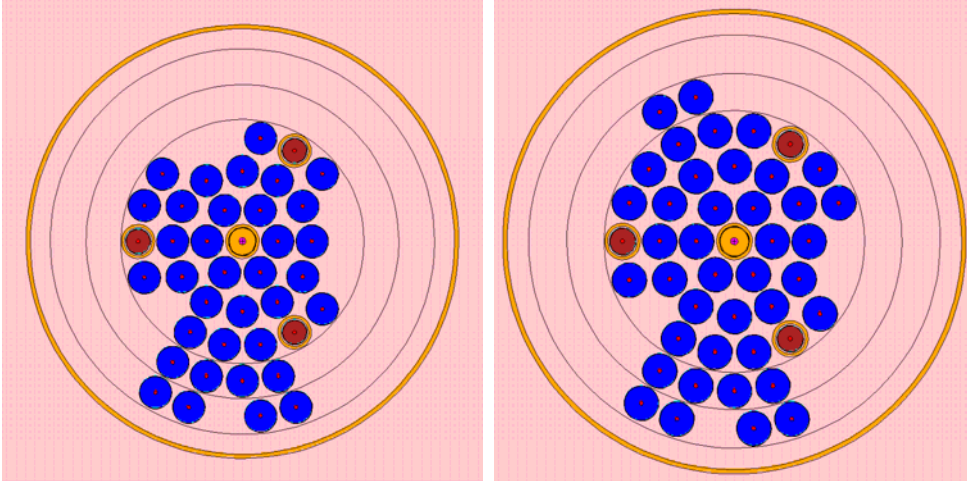


Figure 17. Fuel loading. In addition to fuel followed control rods: 35 elements, 40 elements.

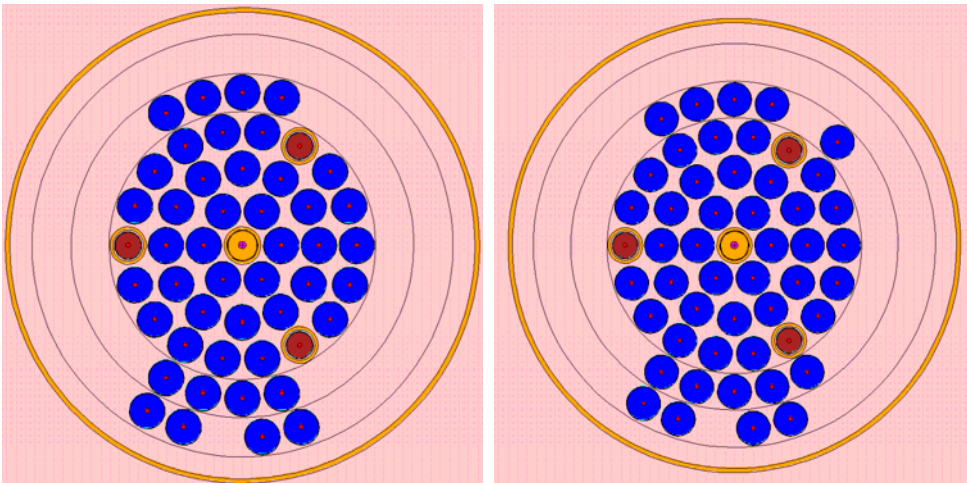


Figure 18. Fuel loading. In addition to fuel followed control rods: 45 elements, 47 elements.

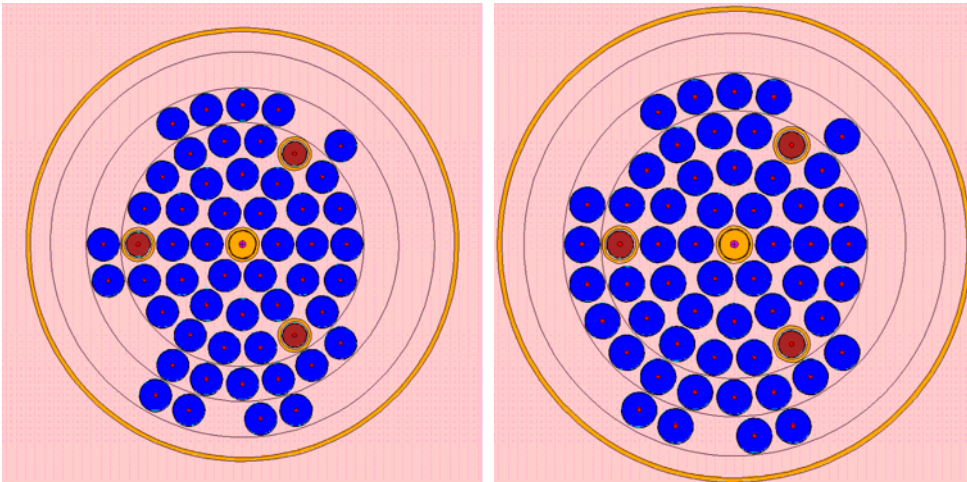


Figure 19. Fuel loading. In addition to fuel followed control rods: 50 elements, 53 elements.

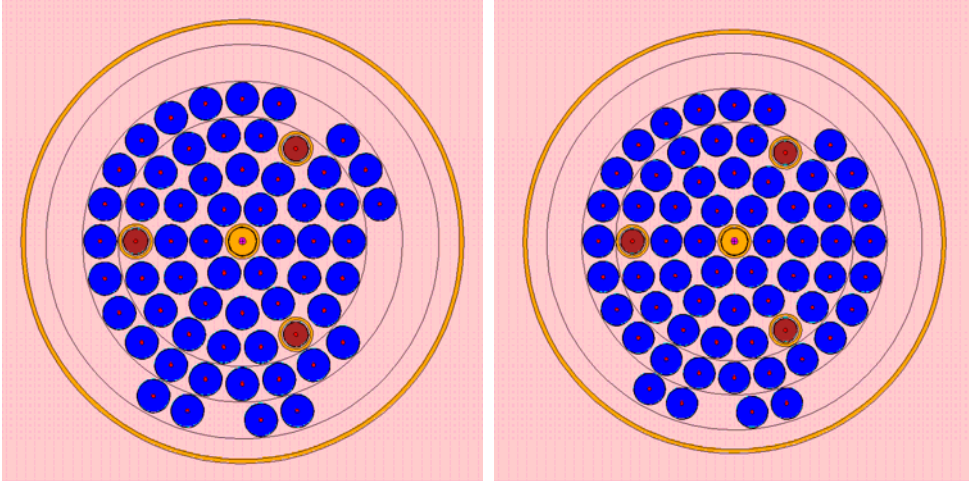


Figure 20. Fuel loading. In addition to fuel followed control rods: 57 elements, 60 elements.

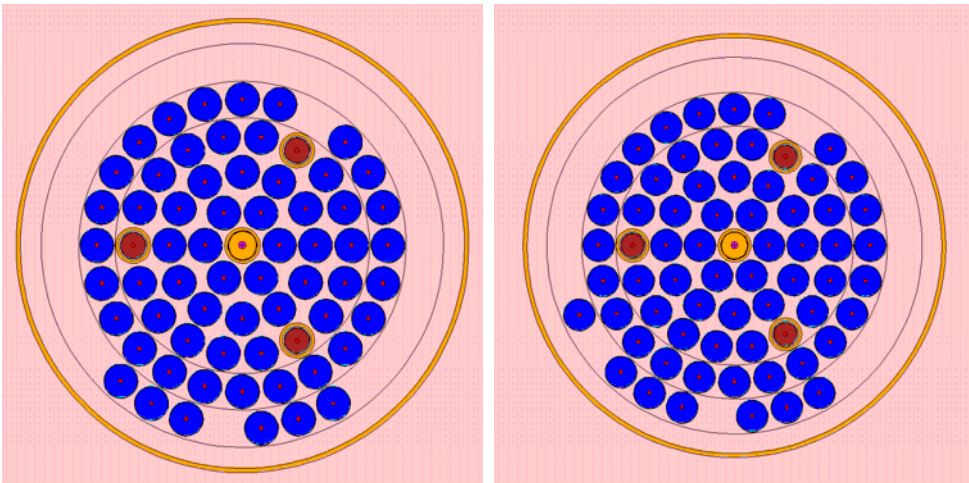


Figure 21. Fuel loading. In addition to fuel followed control rods: 62 elements, 63 elements.

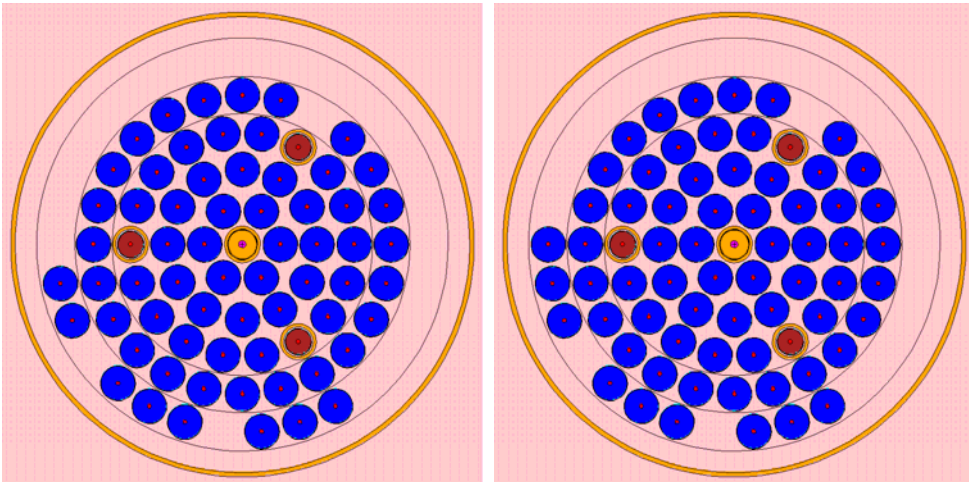


Figure 22. Fuel loading. In addition to fuel followed control rods: 64 elements, 65 elements.

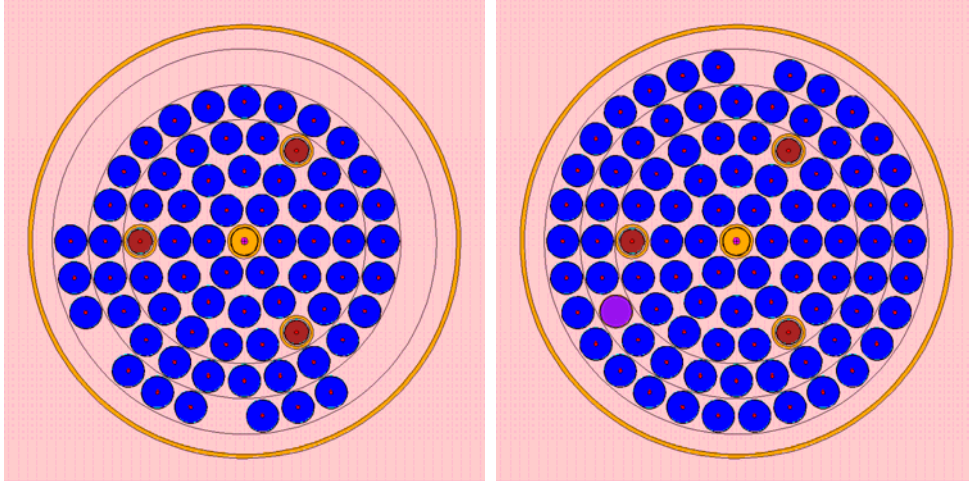


Figure 23. Fuel loading. In addition to fuel followed control rods: 66 elements, fully loaded core with empty element at F-9 and Core Exposure Tube at E-23.

In the 1991 experimental approach to criticality, the subcritical multiplication factor  $M$  was determined by measuring doubling times for count rates in the detectors measuring reactor power. In order to determine the calculated values of  $1/M$  based on the 1991 experimentally measured  $M$ , a search of reactor records was made for the original calculations. While the reactor log books for the runs involved were available for inspection, the calculations and values of  $M$  obtained were not, requiring the values of  $1/M$  to be read manually from a graph in AFRRI's report on the installation of the fuel followed control rods. This graph did not contain data points for experimentally calculated values of  $1/M$  below 43 elements (40 regular fuel elements plus the three fuel followed control rods).[24]

MCNP does not provide the multiplication factor as part of its output. Instead, it reports a value for  $k_{\text{eff}}$ .  $M$  can be calculated, however, using the relationship  $M=1/(1-k_{\text{eff}})$ , in turn allowing the calculation of  $1/M=1-k_{\text{eff}}$ . For subcritical systems, however, the value of  $k_{\text{eff}}$  diverges from the actual subcritical multiplication factor, and this was observed in the calculations performed for this analysis. Of note,

however, was the convergence of the experimentally measured multiplication factor and the MCNP derived multiplication factor as the system approached criticality, with the calculated criticality point and the experimentally measured criticality both showing the system reaching criticality at 69 elements in the core (66 fuel elements plus the three fuel followed control rods).

Number of Elements	Specific Elements Added	MCNP Calculated $k_{\text{eff}}$	MCNP Calculated 1/M	Experimentally Measured 1/M
18 (15+3)	B-1, B-2, B-3, B-4, B-5, B-6, C-1, C-5, C-6, C-9, C-10, C-11, D-14, D-15, E-18	0.66079±0.00033	0.33921±0.00033	N/A
22 (19+3)	C-2, E-19, F-22, F-23	0.69782±0.00034	0.30218±0.00034	N/A
25 (22+3)	D-16, E-20, E-21	0.74152±0.00036	0.25848±0.00036	N/A
28 (25+3)	C-12, F-25, F-26	0.77687±0.00035	0.22313±0.00035	N/A
38 (35+3)	C-3, C-4, C-7, C-8, D-2, D-3, D-6, D-8, D-12, D-18	0.85846±0.00037	0.14154±0.00037	N/A
43 (40+3)	D-4, D-5, D-9, E-5, E-6	0.88398±0.00036	0.11602±0.00036	0.32
48 (45+3)	D-10, D-11, D-17, E-7, E-8	0.91566±0.00036	0.08434±0.00036	0.18
50 (47+3)	E-10, E-17	0.92476±0.00038	0.07542±0.00038	0.15
53 (50+3)	E-1, E-16, E-24	0.93767±0.00034	0.06233±0.00034	0.12
56 (53+3)	E-2, E-22, E-23	0.95362±0.00034	0.04638±0.00034	0.08
60 (57+3)	E-3, E-4, E-11, E-12	0.96775±0.00036	0.03225±0.00036	0.065
63 (60+3)	E-13, E-14, E-15	0.97817±0.00036	0.02183±0.00036	0.03

65 (62+3)	F-21, F-27	0.98413±0.00036	0.01587±0.00036	N/A
66 (63+3)	F-29	0.98744±0.00035	0.01256±0.00035	0.025
67 (64+3)	F-30	0.98815±0.00037	0.01185±0.00037	0.02
68 (65+3)	F-1	0.99172±0.00036	0.00828±0.00036	0.015
69 (66+3)	E-9	0.99417±0.00035	0.00583±0.00035	≤0.00

Table 1. Fuel elements added to core, calculated keff and 1/M, and experimentally calculated 1/M from [11]. N/A indicates data points not plotted on the graph of experimentally calculated 1/M.

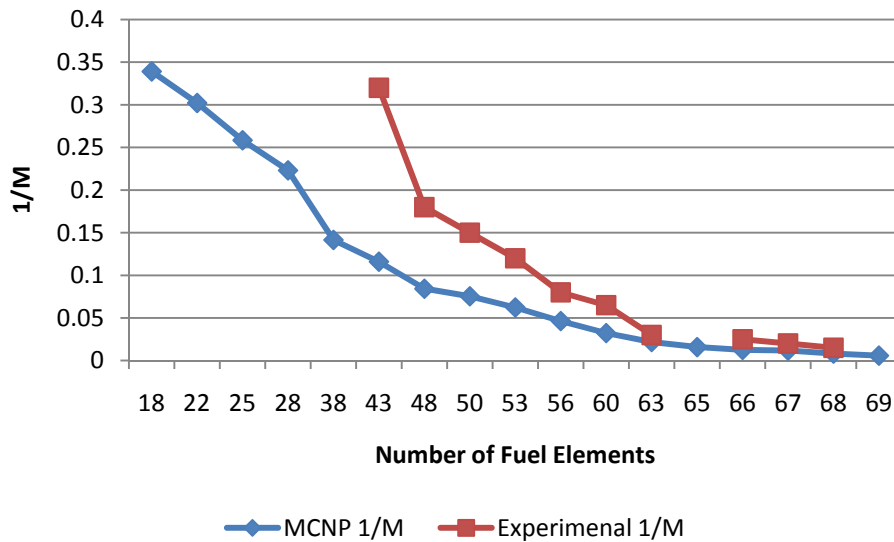


Figure 24. Graph of MCNP calculated 1/M versus experimentally calculated 1/M from [24].

### Nominal Fuel Element Worth

During the AFRRRI TRIGA's annual maintenance outages, the reactor staff computes the relative worth of fuel elements in each ring of the core. They do this by removing an individual fuel element and computing the change in reactivity in the core due to the absence of that element. This procedure was replicated using the model of the core, and the resultant nominal fuel element worths were compared to the measured values for the past five outages. As with the core loading

benchmarking, this was done by deleting the body of the fuel element in question from the model and changing the composition of the top and bottom assemblies of the fuel element from stainless steel to water. While these values can vary from year to year, there was good overall correlation between computed and measured values of the nominal element worths when compared to measured data from 1981 to 2001 [25, 125].

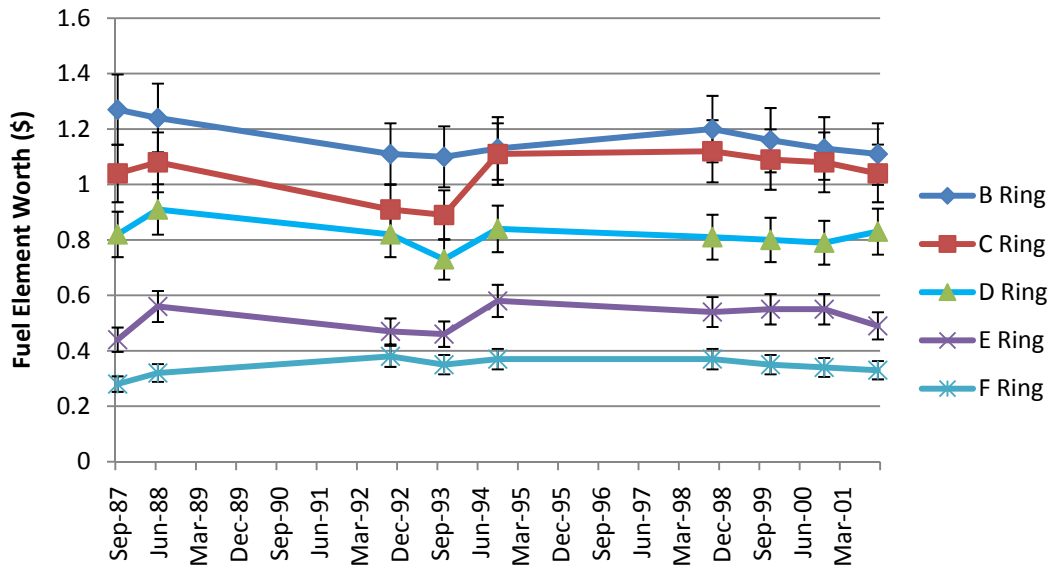


Figure 25. Nominal fuel element reactivity worth in dollars by ring, 1987-2001.[25, 125]

It was noted during the computations that there was considerable sensitivity in the calculations to the position of the subject element relative to control rods, the core exposure tube, and any water filled (missing element) positions in the core. Table 1, below presents a comparison between MCNP computed incremental rod worth and measured rod worth.

Ring position	MCNP Calculated Value	2006 Measured	2000 Measured	1993 Measured	1987 Measured

B Ring	1.278±0.048 B-2	1.04 B-1	1.13 B-1	1.10 B-2	1.27 B-2
C Ring	0.999±0.048 C-12	0.95 C-12	1.08 C-12	0.89 C-3	1.04 C-3
D Ring	0.652±0.047 D-17	0.63 D-2	0.79 D-17	0.73 D-3	0.82 D-17
E Ring	0.351±0.047 E-22	0.34 E-2	0.55 E-22	0.46 E-4	0.44 E-22
F Ring	0.273±0.047 F-27	0.20 F-30	0.34 F-27	0.35 F-28	0.28 F-30

Table 2. MCNP calculated versus measured nominal fuel element reactivity worth, in dollars.

### Control Rod Worths

Calculation of control rod worths using MCNP can be challenging due to approximations made in the MCNP code which can break down in regions of high neutron absorption.[129] Additionally, the movable core of the AFRRI TRIGA reactor complicates the computation of control rod worths. As the core approaches the wall of either exposure room, the distribution of thermal neutrons within the core shifts from a symmetrical distribution to an asymmetrical distribution due to the void formed by the exposure room itself. This in turn causes the relative control rod worth to shift, with those control rods closest to the exposure room against which the reactor is placed decreasing in relative worth. Because of this, rod worth curves are generated annually with the core in three positions—pool center (called “position 500”), against the wall of exposure room 1 (called “core position 250”), and against the wall of exposure room 2 (called “core position 750”). To validate the model, control rod worth curves for each of the four control rods were generated using MCNP with the core in each of the three positions. This data was then compared against measured values of rod worth for each of the three most recent maintenance outages (2006, 2007, and 2008).

Control rod worths in the AFRRRI TRIGA reactor are currently normally computed using a dynamic reactivity computer. In this methodology, rod worths are computed for two control rods simultaneously. One of the two rods being measured is inserted fully into the core, while the other is completely withdrawn. The two rods are then alternately incrementally inserted or withdrawn, and the reactivity computed at each step. In order to avoid saturation of the detectors measuring reactor power, the rod movements are limited to an increase or withdrawal of approximately \$0.80 per rod movement [130]. Prior to the installation of the dynamic reactivity computer, control rod worths were computed using the rod drop method, at first manually using a stopwatch and later using a reactivity computer. These measurements are considered to be accurate to within 10% of the actual value.

This method of coupled measurement of control rod worths is very difficult to replicate using MCNP. For this reason, control rod worths were calculated by simulating the rod drop method of computing reactivity. In this method, the control rod of interest was pulled from the core until it was at a position corresponding to the bottom of the poison section of the control rod positioned at the top of the fuel region of the fuel elements. The reactivity at that point was computed, and equated to a value of zero net reactivity. From that point, the rod was then inserted into the core incrementally and a new  $k_{\text{eff}}$  was computed following each insertion. At each step the reactivity of the core was then computed, and the net reactivity computed in turn. This data then yielded an integral rod worth curve for each of the four control rods in each of the three core positions.

The MCNP model slightly overestimated control rod worth, with the divergence from experimental values increasing as the rods were inserted further into the core—in other words, with increasing insertion of negative reactivity into the core. In order to determine if this reflected the effect of burnup on the control rods, or an increase in relative worth as the surrounding fuel was depleted, annual control rod worth measurements from the reactor were examined from the time of the installation of the fuel followed control rods to the present, a total of 18 years of data. These records showed little measurable change of the rod worth values over the life of the fuel followed control rods outside of the expected deviations due to measurement inaccuracies. While more challenging, a similar comparison of the calculated rod worth of the transient rod to actual measured values showed similar stability in measured rod worth values over time [25, 126]. The computational error in the MCNP computation of  $k_{\text{eff}}$  averaged 0.035 percent, which resulted in an error of  $\pm 0.05$  dollars of reactivity in each of the rod worth calculations. This was much more precise than the estimated 10% error of measurements taken during reactor operation, and when that measurement error is accounted for, the calculated control rod worths can be said to match the measured worths over time.

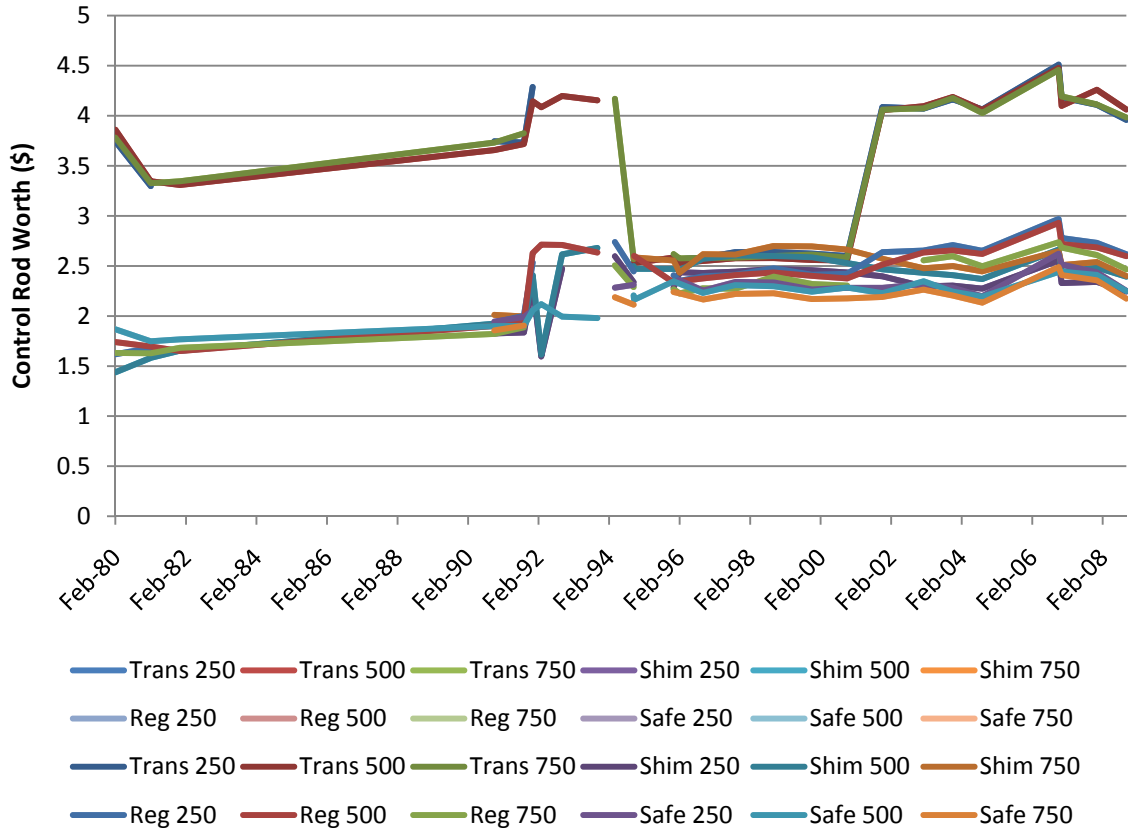


Figure 26. Control rod worths over time and by core position. The transient rod was poison followed from 1994 to 2002, resulting in the large dip in control rod worth for that rod.

While very little literature exists documenting the use of MCNP to measure control rod worths, the literature which is available is intriguing, showing both a similar divergence between experimental and computed values, and also showing the increasing divergence with increasing control rod insertion, with some calculations showing discrepancies between measured and calculated rod worths on the order of 10% at maximum control rod insertion. [84, 85, 89] All MCNP control rod worth studies used a methodology similar to that used on the AFRRI TRIGA MCNP model to compute control rod worths.

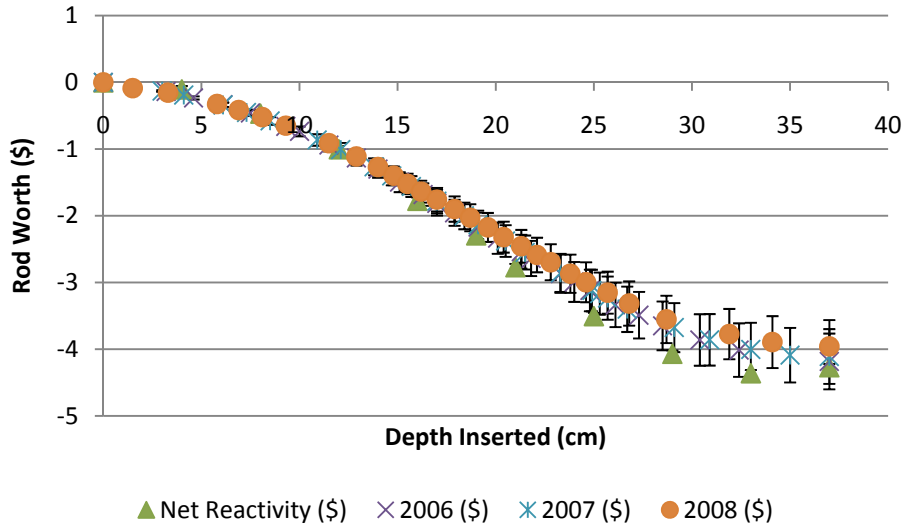


Figure 27. Integral control rod worth curve, core position 250, control rod A-1 (transient).

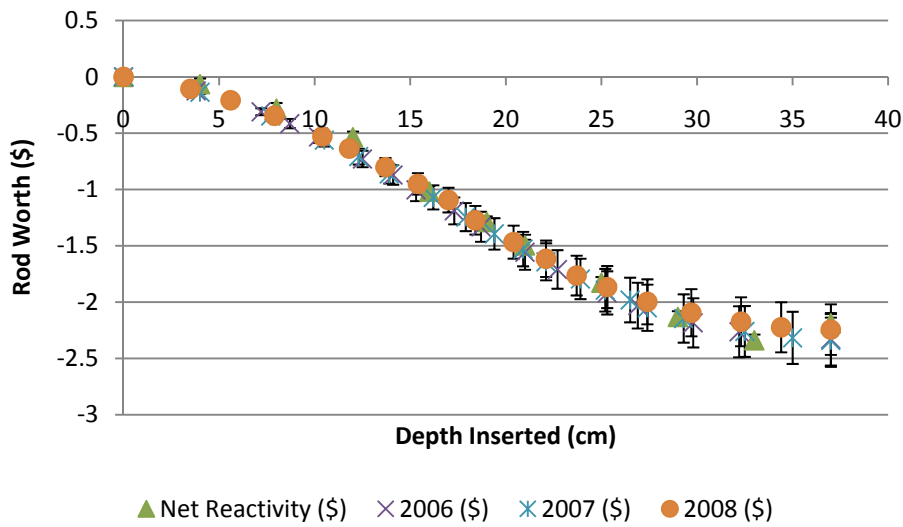


Figure 28. Integral control rod worth curve, core position 250, control rod D-1 (shim).

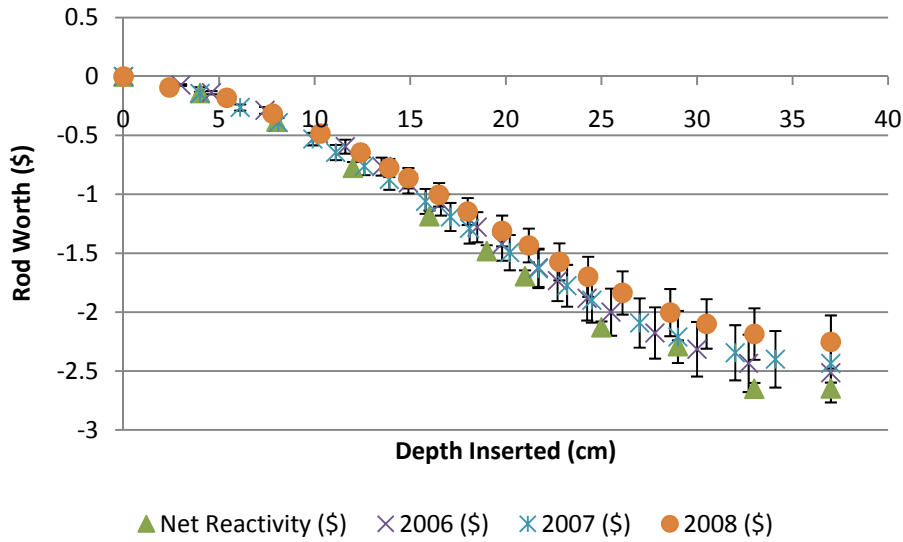


Figure 29. Integral control rod worth curve, core position 250, control rod D-7 (safety).

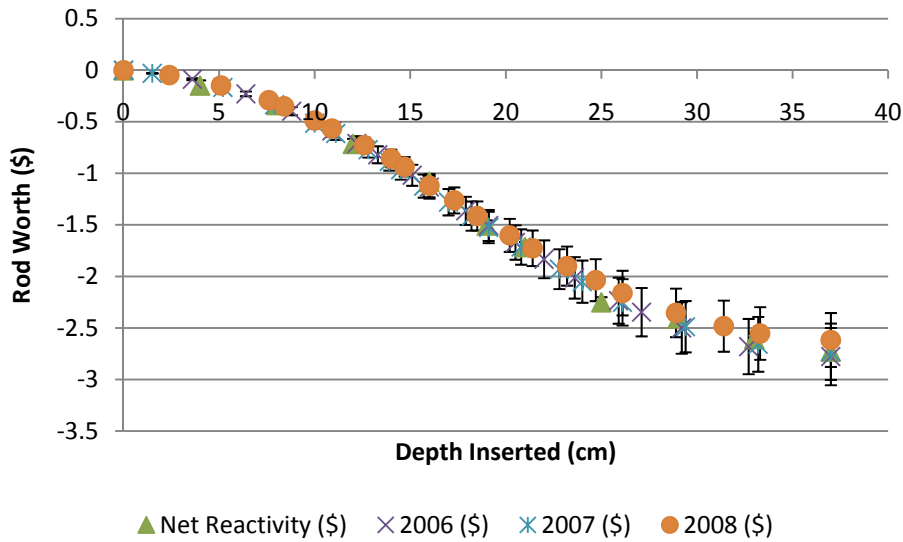


Figure 30. Integral control rod worth curve, core position 250, control rod D-13 (regulating).

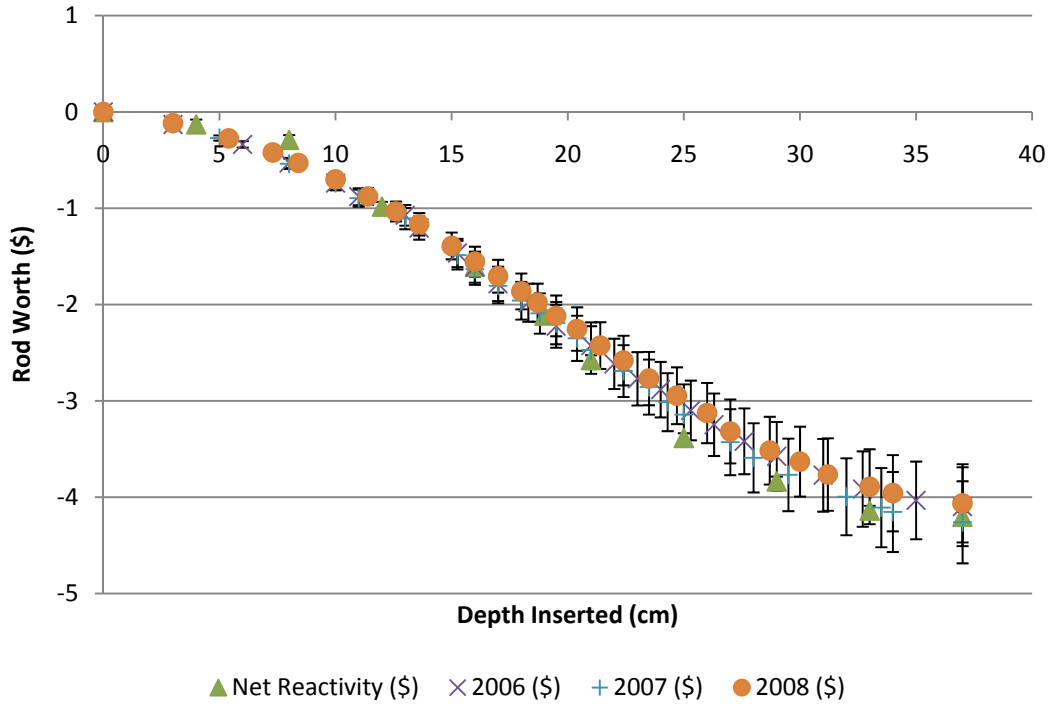


Figure 31. Integral control rod worth curve, core position 500, control rod A-1 (transient).

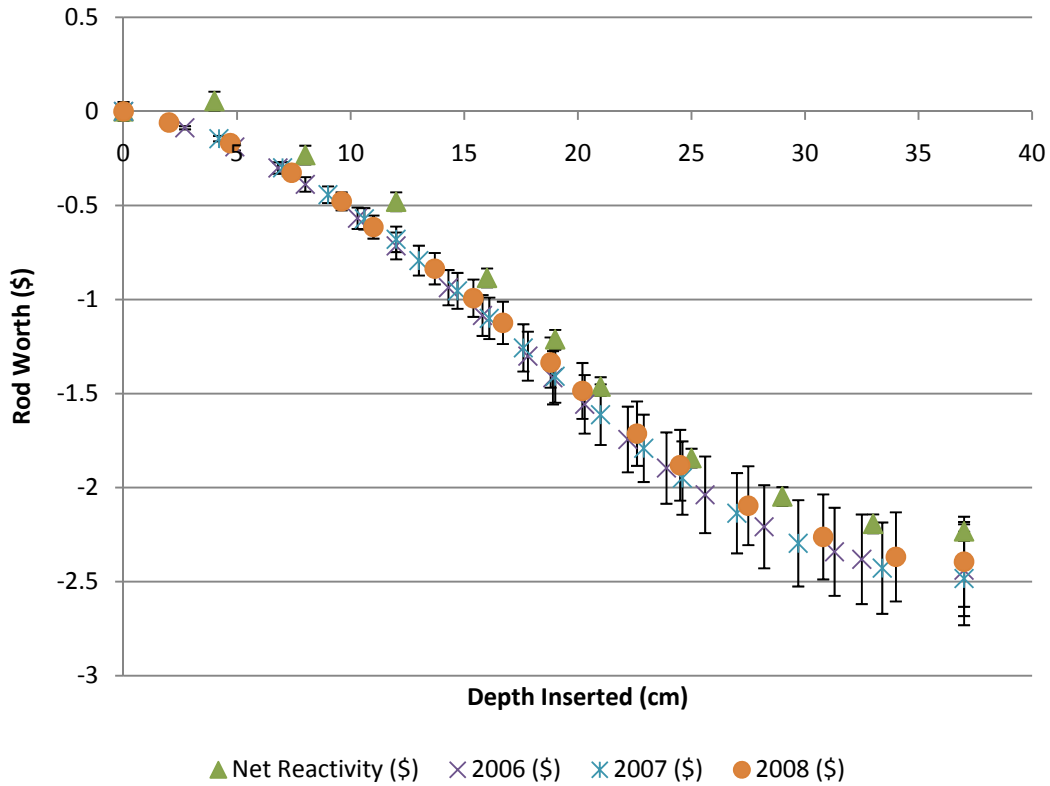


Figure 32. Integral control rod worth curve, core position 500, control rod D-1 (shim).

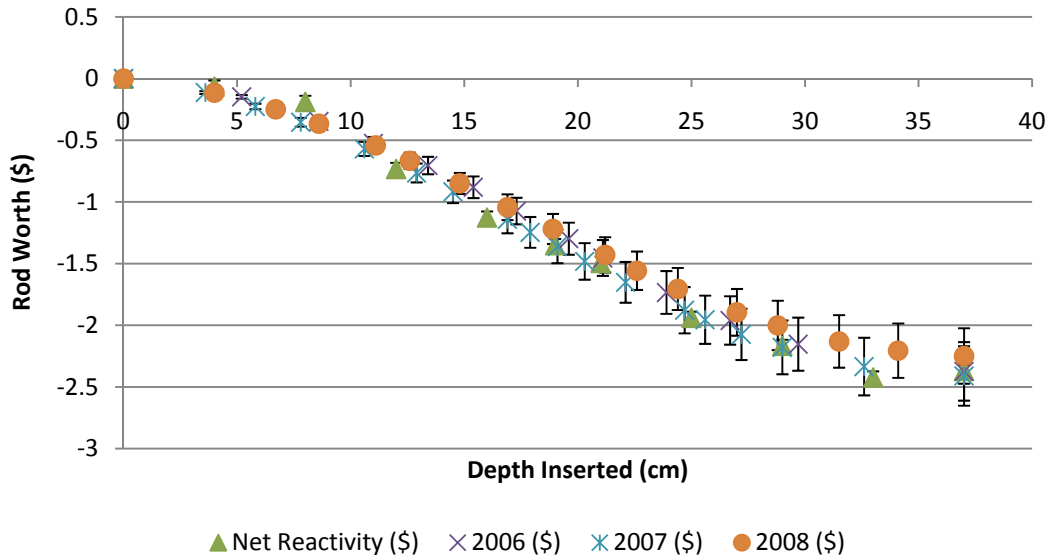


Figure 33. Integral control rod worth curve, core position 500, control rod D-7 (safety)

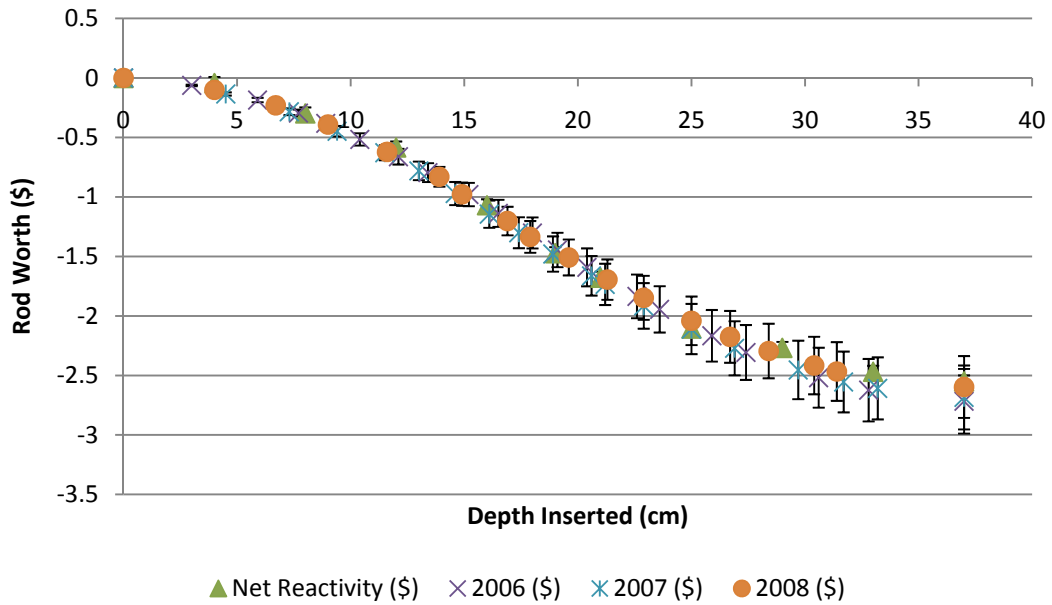


Figure 34. Integral control rod worth curve, core position 500, control rod D-13 (regulating).

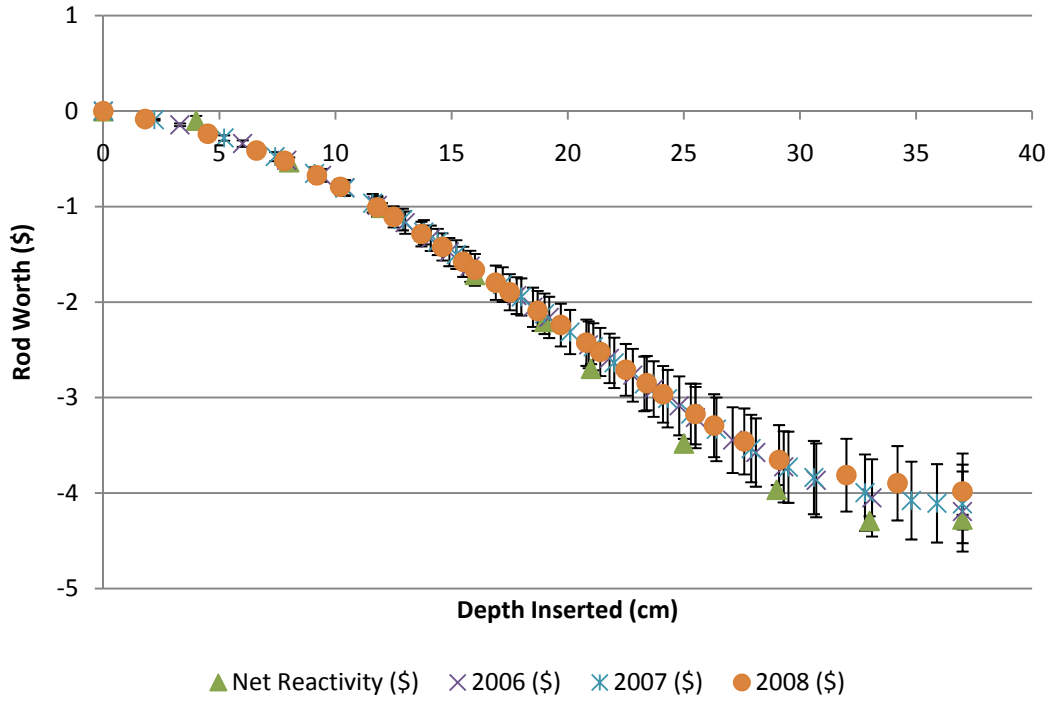


Figure 35. Integral control rod worth curve, core position 750, control rod A-1 (transient).

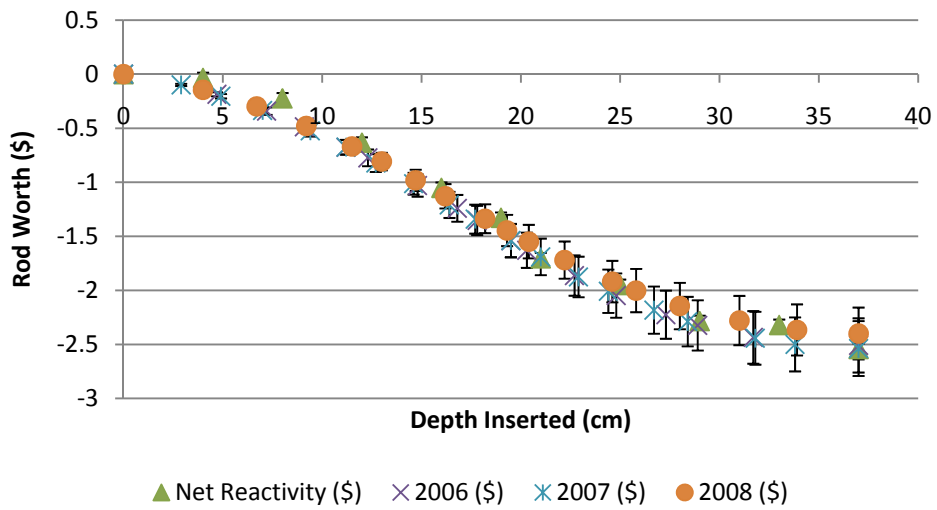


Figure 36. Integral control rod worth curve, core position 750, control rod D-1 (shim).

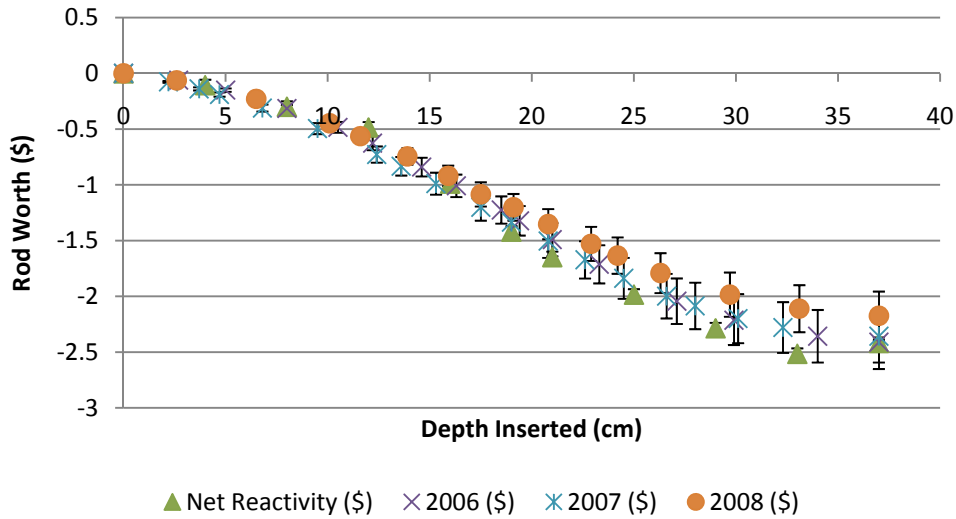


Figure 37. Integral control rod worth curve, core position 750, control rod D-7 (safety).

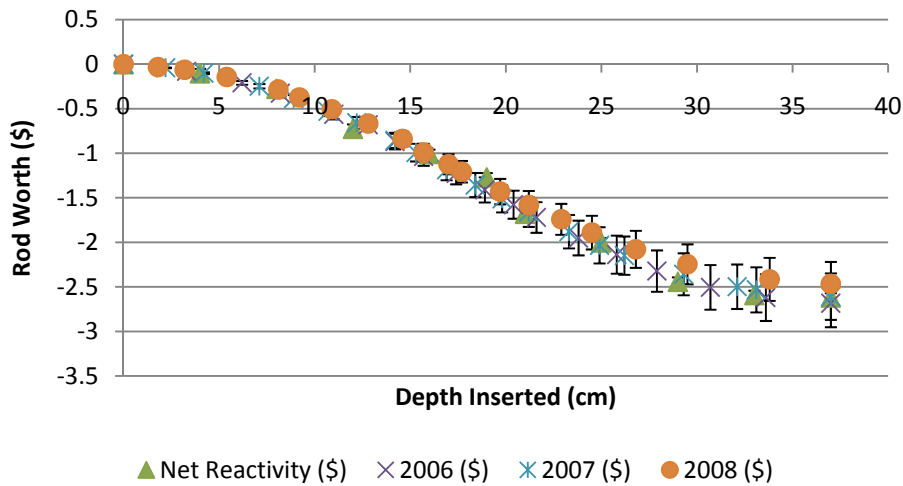


Figure 38. Integral control rod worth curve, core position 750, control rod D-13 (regulating).

Total Excess Reactivity

Total excess reactivity was modeled and compared to measured values. Under experimental conditions, the reactor is brought to critical at full power, and control rod positions are measured. Using control rod worth curves, the amount of reactivity inserted into the core is computed, and this yields the resultant excess reactivity

present within the core. During the 2008 maintenance outage, the total excess reactivity in the core was calculated to be \$4.36 when measured with the core in the center of the reactor pool.[126]

In order to measure total excess reactivity within the MCNP model, the core was placed in the center of the reactor pool (core position 500), and all control rods were withdrawn to a zero-inserted position—the bottom of the poison sections of the rods at the same height in the core as the top of the active fuel regions of the fuel rods. The model was then run for 500 cycles of 10,000 particles, and yielded a final  $k_{\text{eff}}$  of 1.032, which in turn yielded an excess reactivity of  $\$4.47 \pm 0.05$ . This is well within the 10% error assumed in the measurement of experimental values in the AFRI TRIGA reactor.

### Summary and Conclusion

The MCNP model of the reactor provided a good approximation to experimental data in all benchmarked areas. This is consistent with other models of TRIGA reactors and indicates that the model will provide valid results for further work involving simulations of output from the core.

## *Chapter 5: Results*

Once benchmarking calculations were completed, the model was used to replicate a variety of operating conditions. Many of these calculations involved movement of the core within the reactor pool; others mimicked configurations within the exposure facilities. The goal in all cases was to better understand the performance of the reactor and the radiation environment within the exposure rooms.

### *Fuel Depletion Calculations*

As depicted in the two diagrams below, fuel depletion within the AFRRI TRIGA core is complicated by the ability to move the core within the reactor pool. As the core is moved within the pool, and particularly when it is positioned within the reactor tank wall protrusions into exposure room 1 and 2, the shape of the flux within the core is distorted due to the asymmetric distribution of the water moderator around the core, with a higher flux observed in the portion of the core located away from the tank protrusion wall.[17] The reduced amount of moderator on one side of the core distorts the flux profile within the core, in turn leading to an asymmetrical depletion of fuel within the core. Additionally, a water moderator serves to flatten the flux distribution within the core, evening the amount of depletion within the fuel elements to some extent when the core is located in core position 500, but resulting in uneven depletion when the core is in positions 250 and 750.[131]

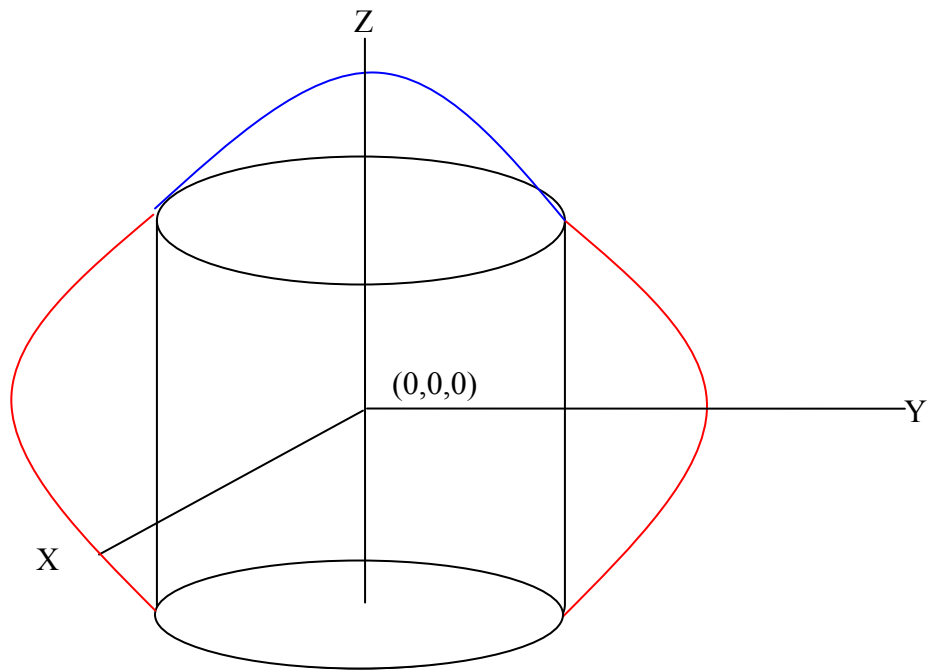


Figure 39. Theoretical radial and axial flux distribution within the AFRRRI TRIGA core at core position 500. AFRRRI drawing, from [17].

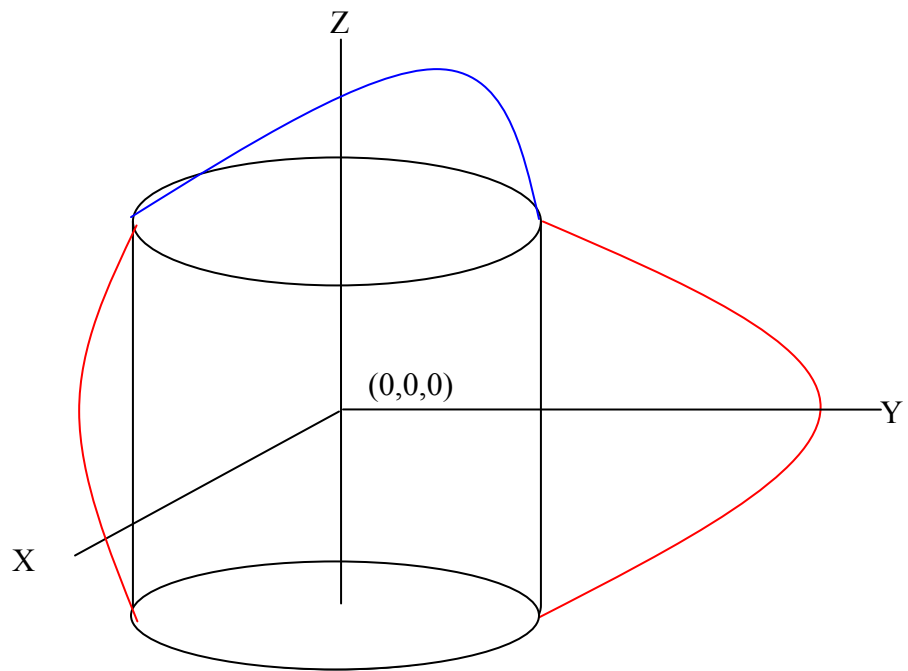


Figure 40. Theoretical radial and axial flux distribution within the AFRRRI TRIGA core at core position 250. AFRRRI drawing, from [17]

At the end of 2008, the AFRRRI TRIGA reactor's current core had produced approximately 43 megawatt days of energy. In order to determine the effects of core position on fuel depletion, MCNPX was run to determine burn-up within the core for each of three positions—core position 250, core position 500, and core position 750. This, it was felt, would show both the sensitivity of fuel consumption on core position within the reactor tank and also serve to establish outer limits within which the core's actual burn-up fell.

#### *Excess Reactivity Over Time*

In order to observe the effect of fuel depletion over time, depletion calculations were performed for 5 MW day time steps between 0 and 40 MW days, and a final time step of 3 MW days and the  $k_{\text{eff}}$  over time was reviewed. Additionally, changes in the inventories of the Actinides present in the core were also reviewed over time. These combined reviews show that 43 MW days of operation are only marginally sufficient to achieve equilibrium concentrations of the actinides present within the fuel elements. This assessment is further supported by a review of the reactor logs since the 1991 core reloading, which shows only minimal change in the excess reactivity within the core over time.[25, 126]

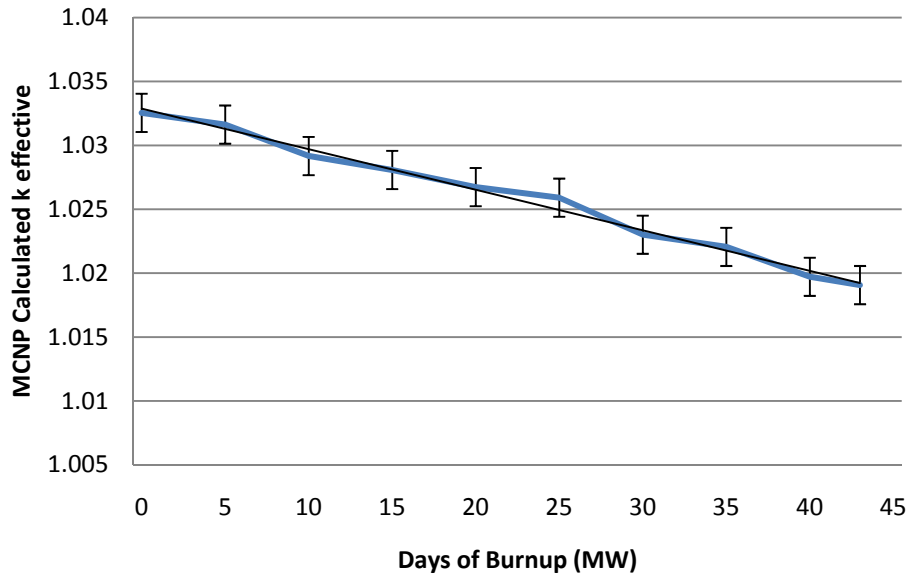


Figure 41. Change in system  $k_{\text{eff}}$  with burnup.

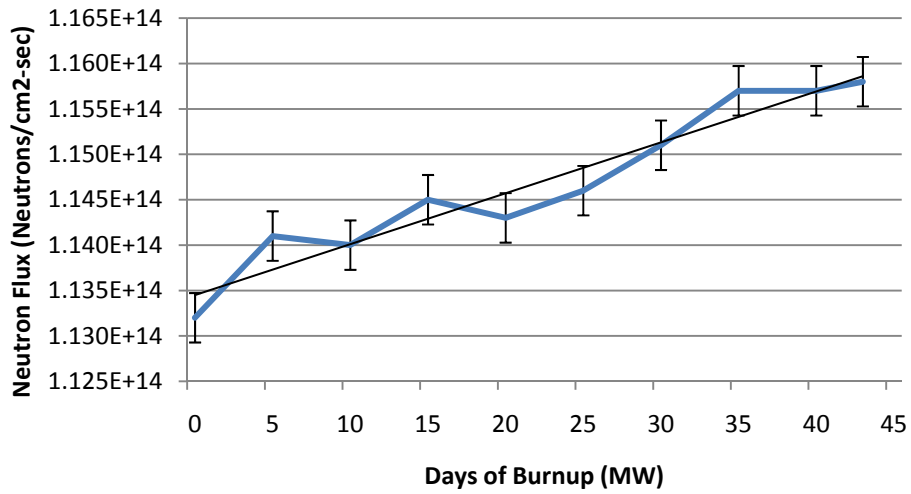


Figure 42. Change in average reactor flux with burnup.

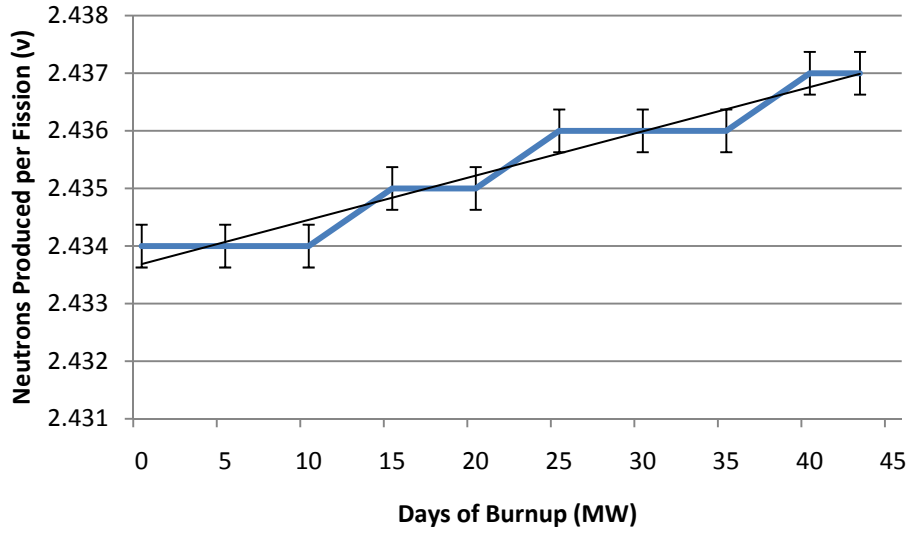


Figure 43. System averaged number of neutrons released per fission ( $\nu$ ) versus burnup.

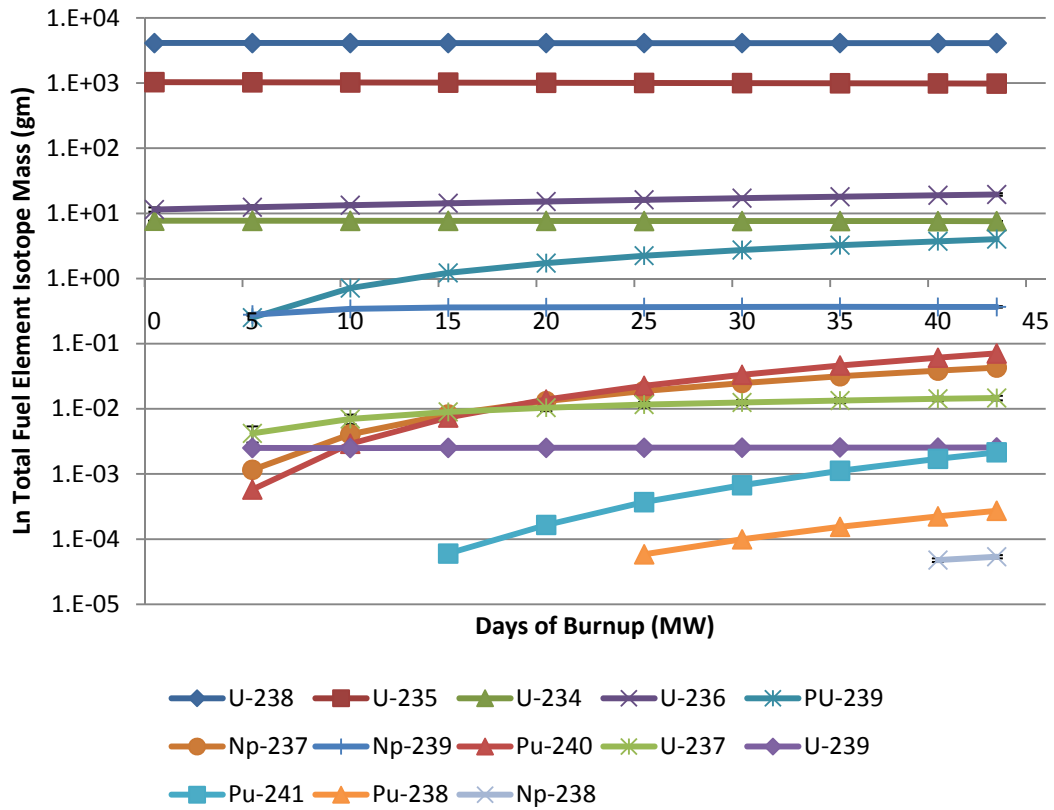


Figure 44. Total actinide inventory by isotope within fuel elements versus burnup.

## Flux Distribution

The flux in each fuel element was calculated for the core in each of the three positions of interest in the pool. Because MCNP produces a normalized flux, expressed in terms of flux per source particle, it was necessary to scale the flux to a single reactor power level. To scale the flux, the reactor thermal power in watts was multiplied by the number of fissions per watt second ( $3.467 \times 10^{10}$ ) times  $\nu$ , which is 2.47 neutrons/fission for the AFRRRI TRIGA Mark F Reactor.[17]

For presentation of these data, the flux was normalized to represent a reactor power level of 1 megawatt thermal. This resulted in a scaling factor of  $8.564 \times 10^{16}$ . Results were then graphed for each core position and the beginning and ending burnup. Results were then graphed for the entire core, and to better present the spatial distribution of the flux were also graphed for each fuel ring.

The amount of energy released in the fission of a nucleus of  $U^{235}$  and  $Pu^{239}$  is approximately the same, on the order of 200 Mev per fission event.[132] In reactor operations under constant power conditions, then, the number of fission events within the core per unit time will remain constant. However, as  $U^{238}$  is converted to  $Pu^{239}$  through neutron absorption and subsequent decay, a portion of the fission events will be caused by the fission of  $Pu^{239}$ , increasing over time as more plutonium is produced.[133] The average number of neutrons produced per fission,  $\nu$ , is approximately 2.4 for  $U^{235}$  and nearly 2.9 for  $Pu^{239}$ . [134] This causes an upward shift in the average  $\nu$  for the reactor system over time, in turn causing an increase in the flux within the system over time. While it may at first seem counterintuitive, the depletion within individual fuel elements will cause shifts in the average flux within

individual fuel elements, simply shifting the peak flux between elements over time, while the loss of overall reactivity within the system is compensated for within the system through the removal of negative reactivity from the system through the removal of the control rods and, in the case of the AFRRR TRIGA reactor, depletion of the samarium wafers added at the top and bottom of the active fuel region of the fuel elements as a burnable poison.[124, 135]

As expected, shifts in the flux were observed as the core was moved from position to position, with the peak flux shifting in the direction of the pool for core positions 250 and 750. This was also as expected, due to the leakage of neutrons into the void of the exposure rooms.[17] Additional distortions in the flux were also noted due to the presence of the control rods, the core exposure tube at core position F-23, and the empty element position at core position F-9.

The uneven flux distribution resulted in uneven depletion of the fuel during operations, as described below, and this in turn led to further distortion of the flux with increased reactor operation.

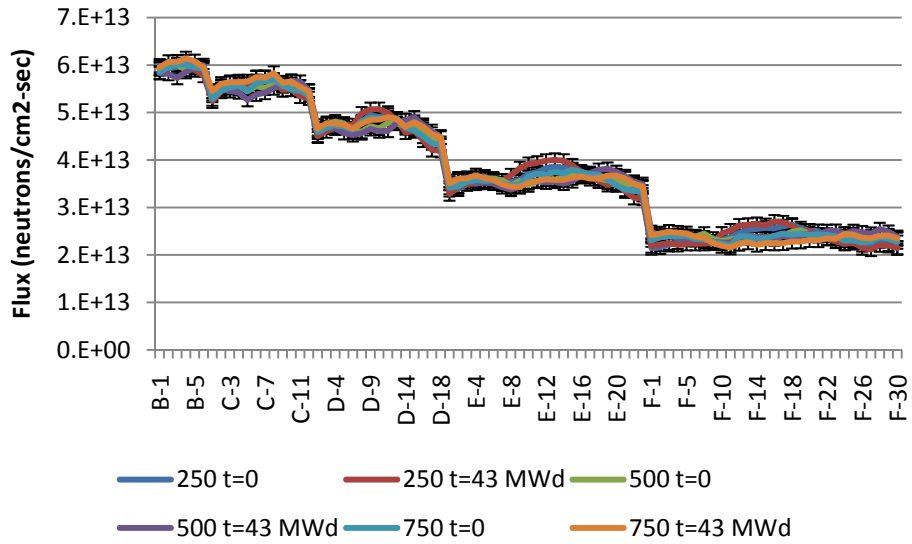


Figure 45. Neutron flux profile by fuel element, burnup, and core position.

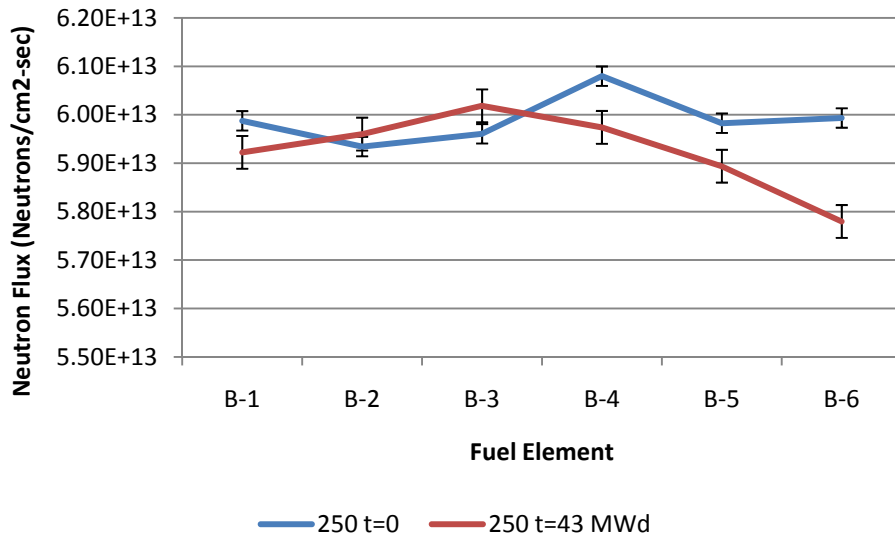


Figure 46. Neutron flux in neutrons/cms-sec in the B ring of the AFRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 250.

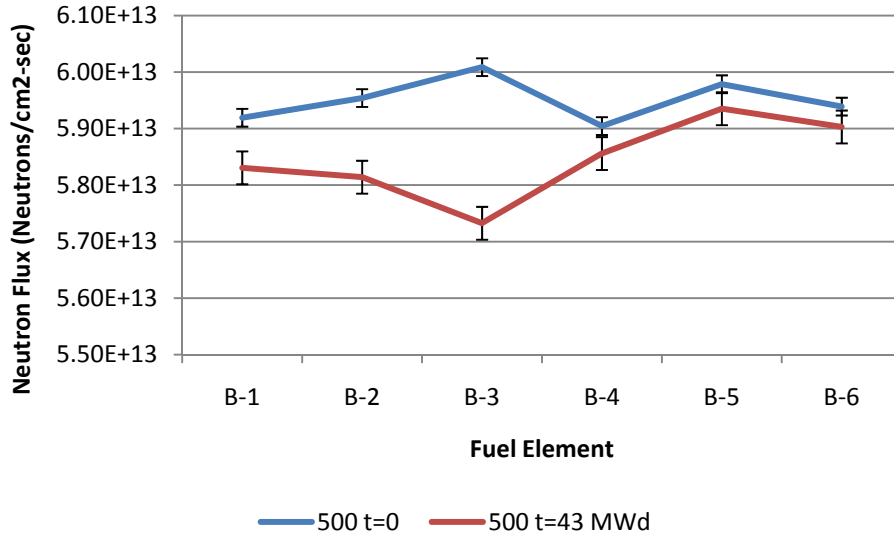


Figure 47. Neutron flux in neutrons/cms-sec in the B ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 500.

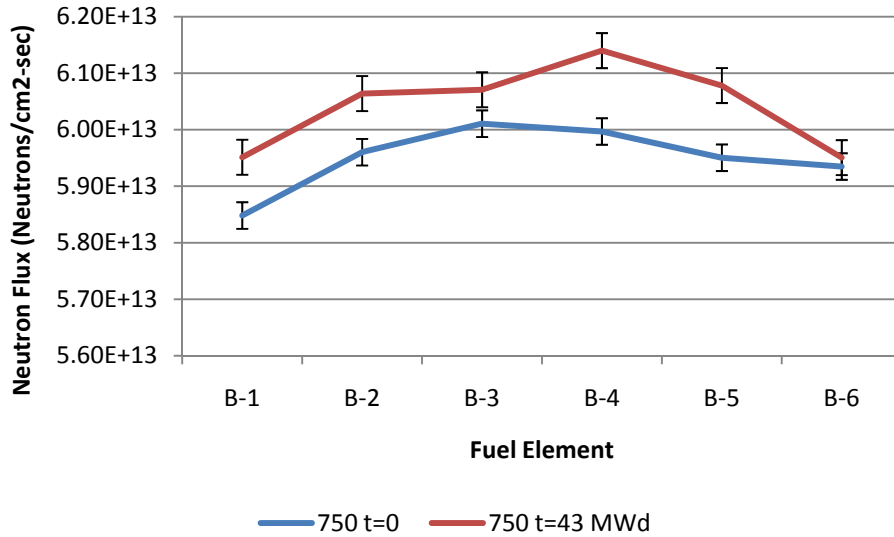


Figure 48. Neutron flux in neutrons/cms-sec in the B ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 750.

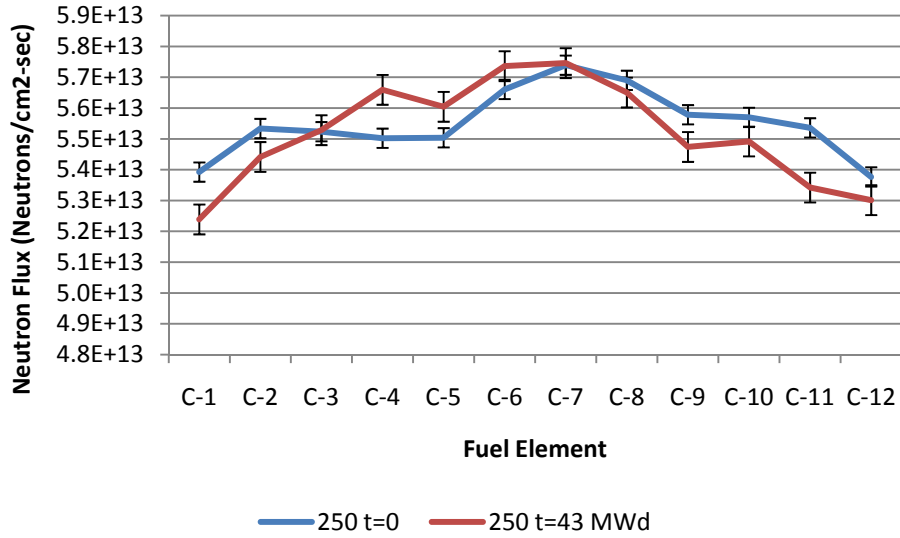


Figure 49. Neutron flux in neutrons/cms-sec in the C ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 250.

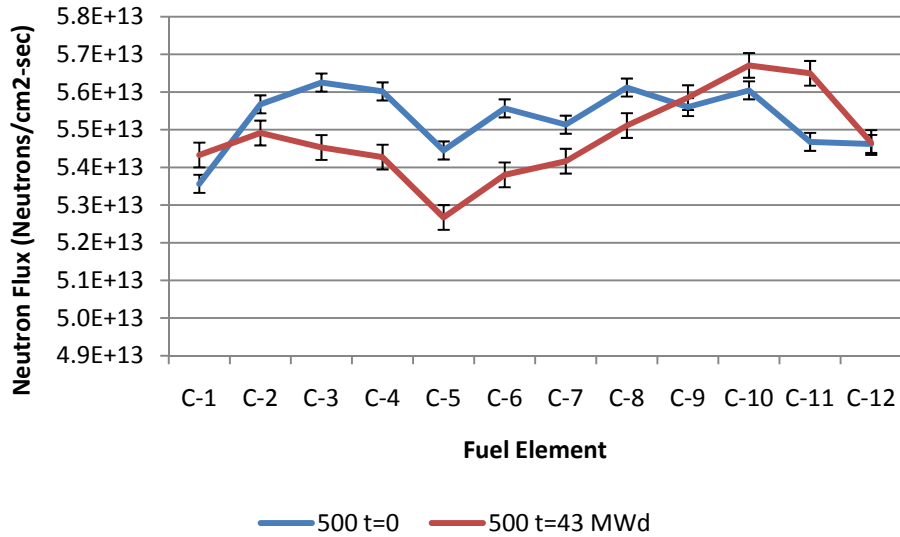


Figure 50. Neutron flux in neutrons/cms-sec in the C ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 500.

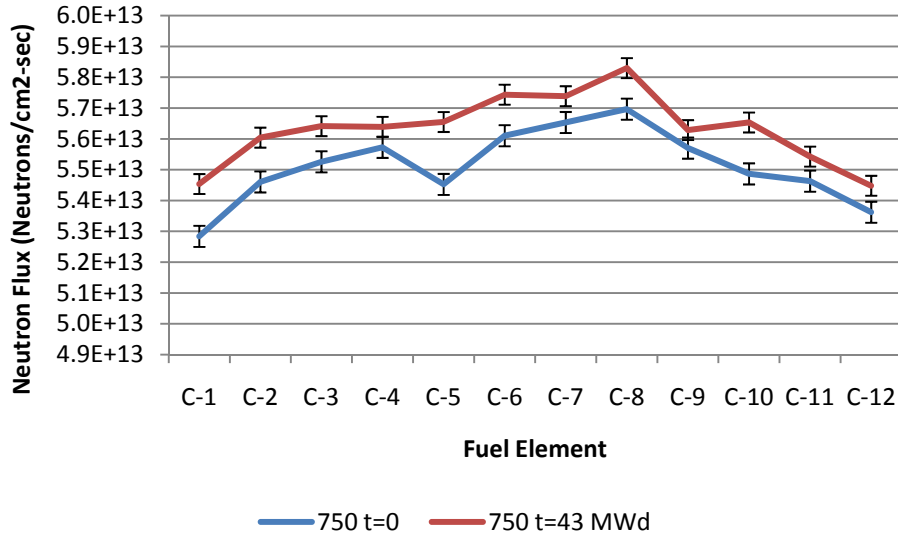


Figure 51. Neutron flux in neutrons/cms-sec in the C ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 750.

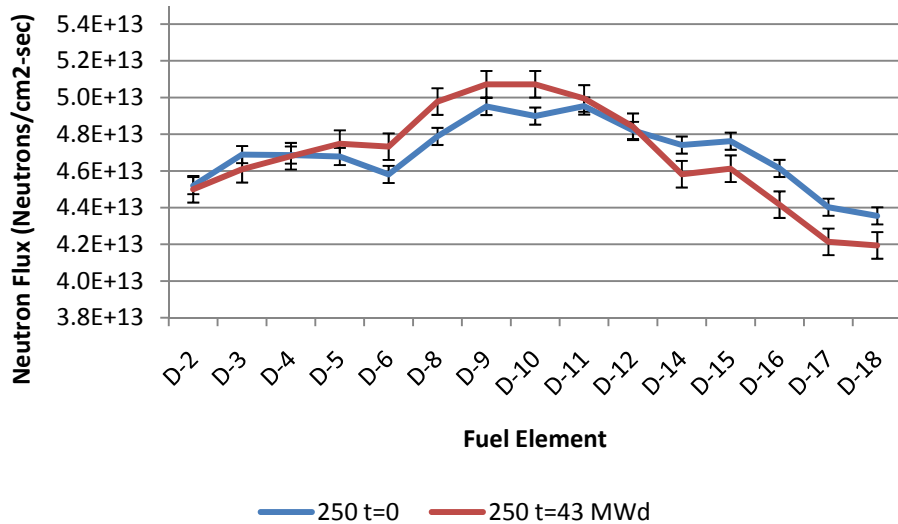


Figure 52. Neutron flux in neutrons/cms-sec in the D ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 250.

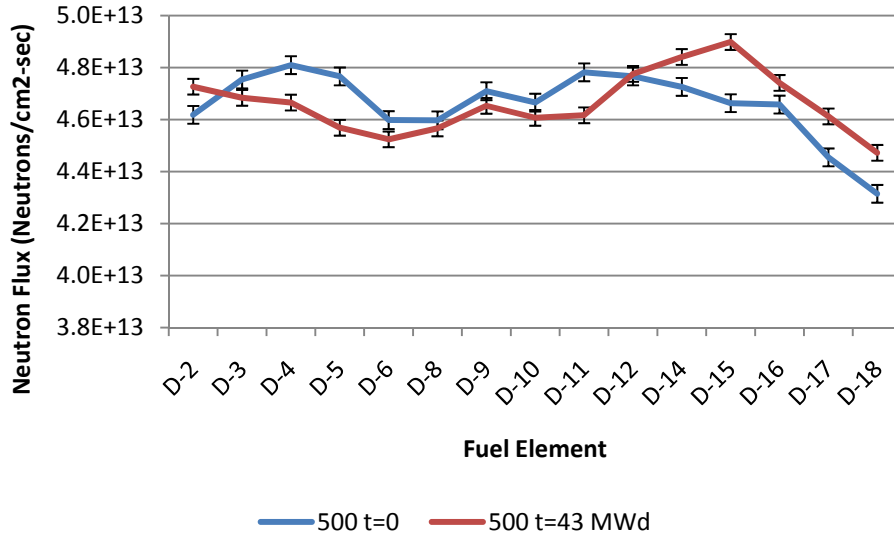


Figure 53. Neutron flux in neutrons/cms-sec in the D ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 500.

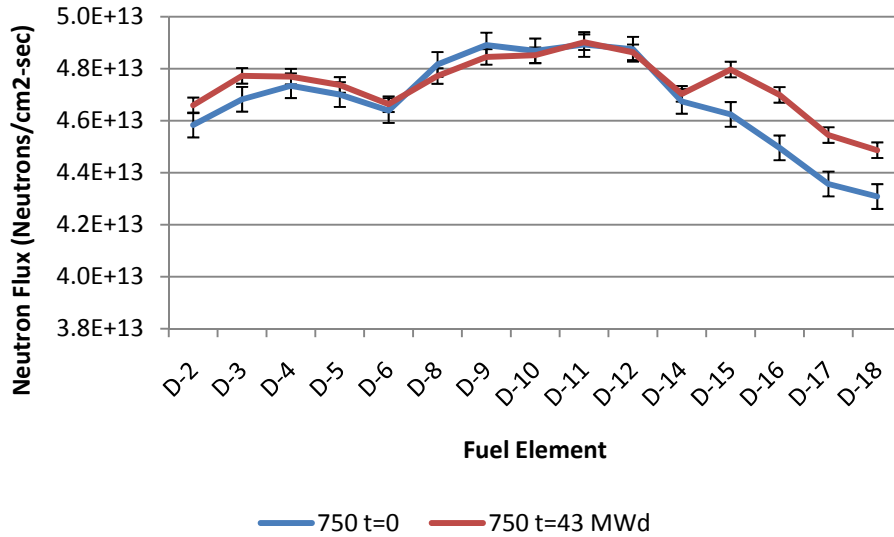


Figure 54. Neutron flux in neutrons/cms-sec in the D ring of the AFRRR TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 750.

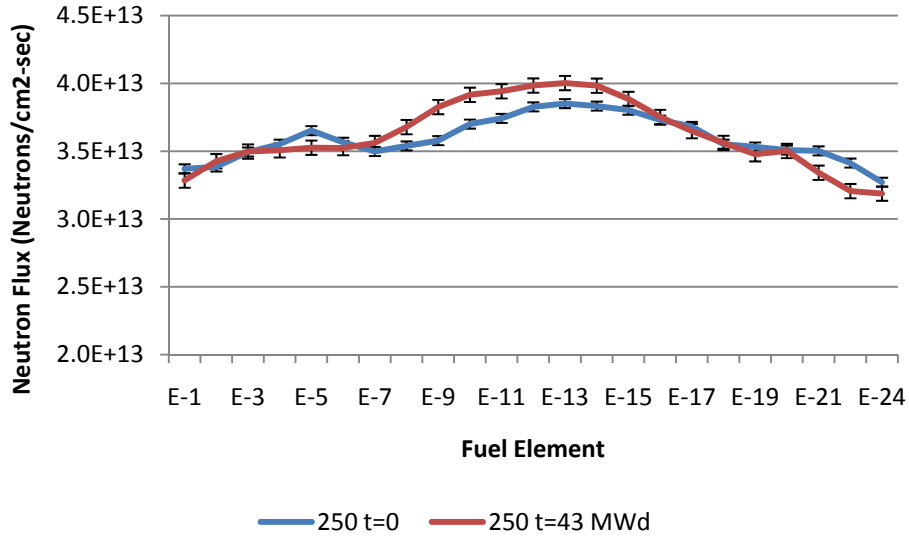


Figure 55. Neutron flux in neutrons/cms-sec in the E ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 250.

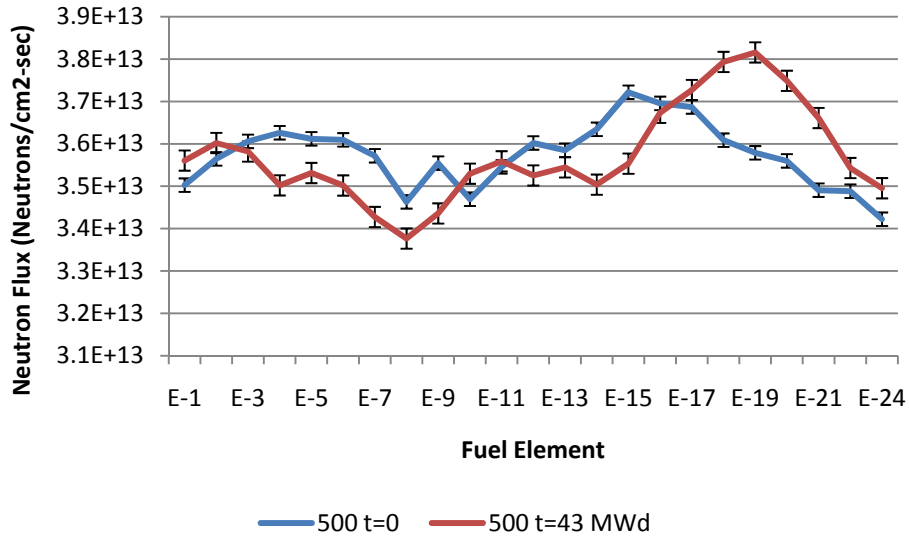


Figure 56. Neutron flux in neutrons/cms-sec in the E ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 500.

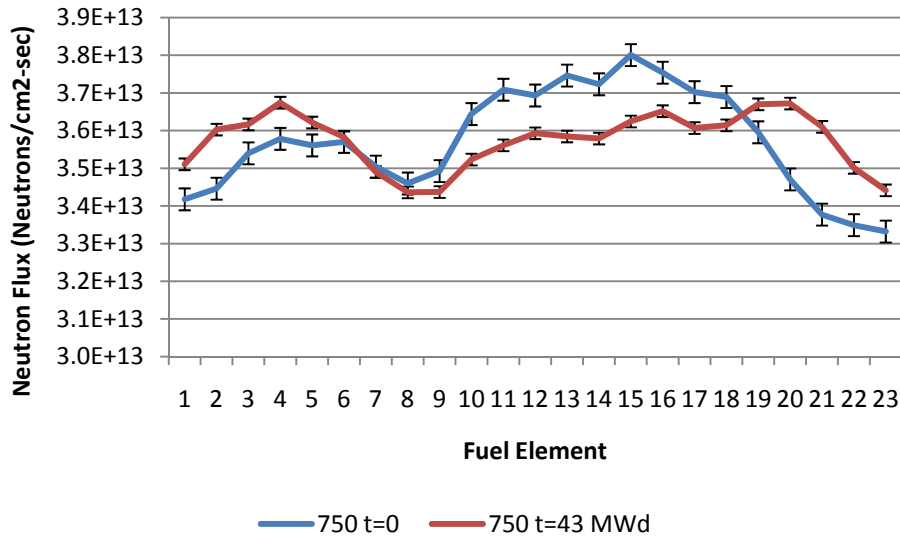


Figure 57. Neutron flux in neutrons/cms-sec in the E ring of the AFRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 750.

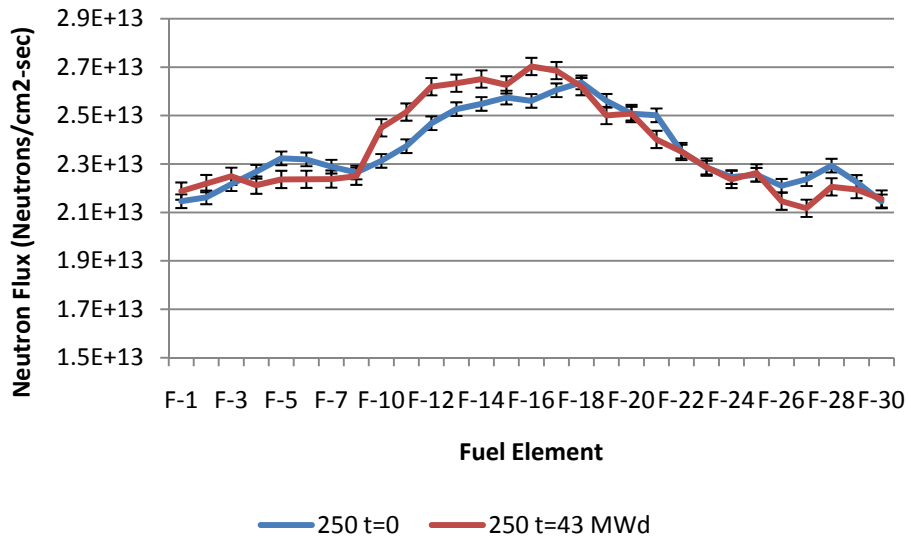


Figure 58. Neutron flux in neutrons/cms-sec in the F ring of the AFRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 250.

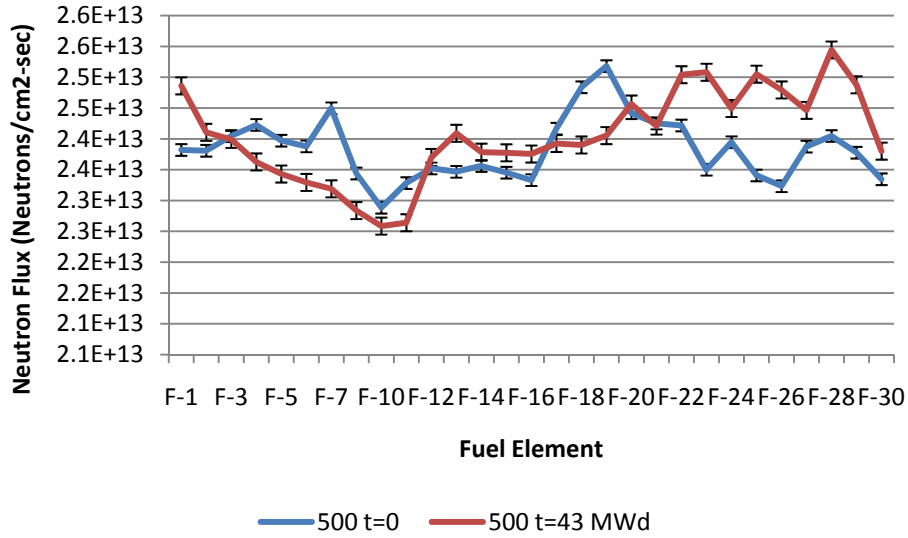


Figure 59. Neutron flux in neutrons/cms-sec in the F ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 500.

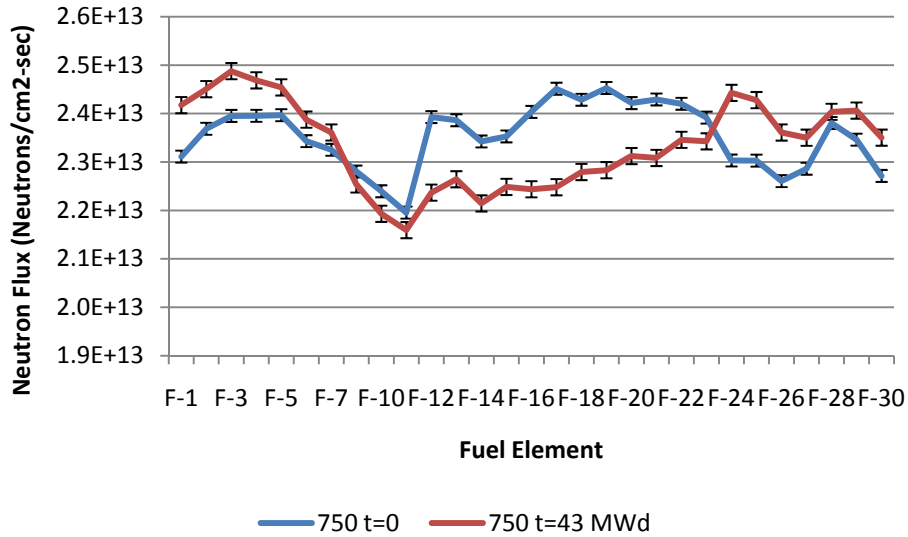


Figure 60. Neutron flux in neutrons/cms-sec in the F ring of the AFRRRI TRIGA reactor at 1 MW thermal power level in new core and after 43 MW days of operation, core position 750.

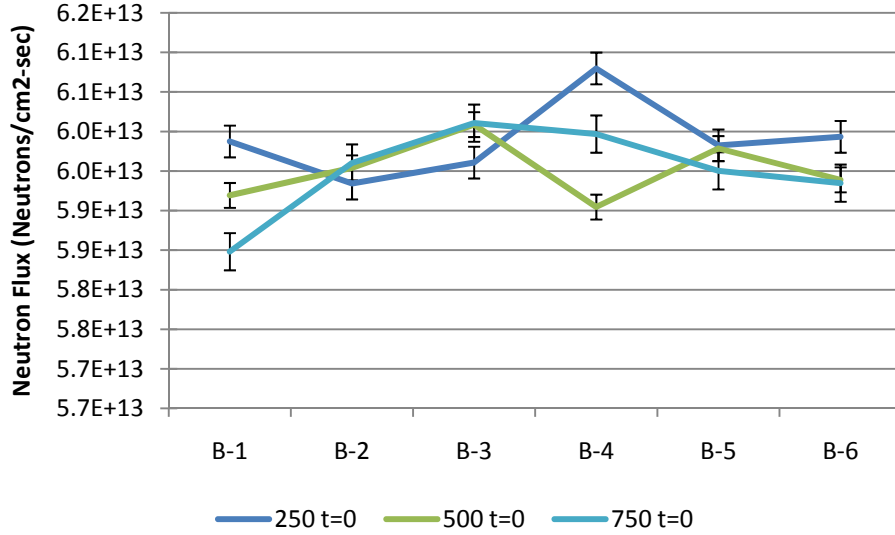


Figure 61. Neutron flux in neutrons/cm<sup>s</sup>-sec in the B ring of the AFRRI TRIGA reactor at 1 MW thermal power level prior to burnup.

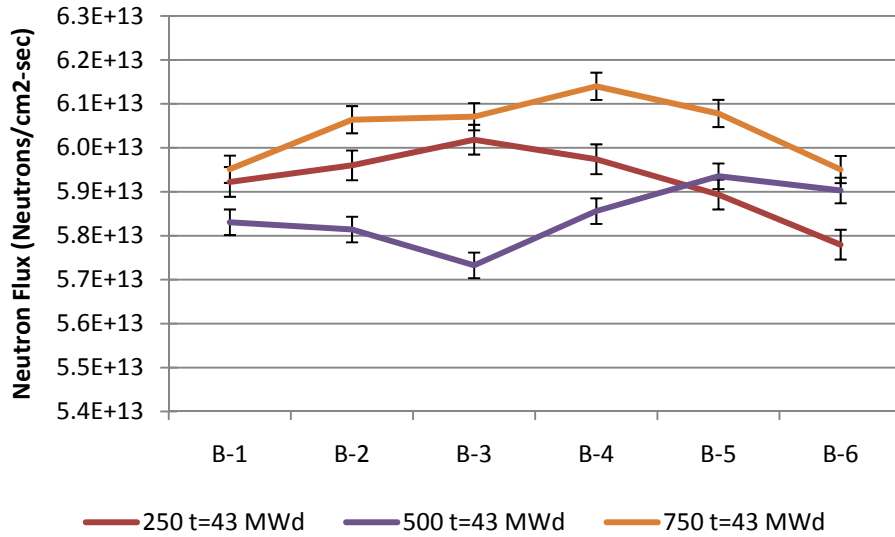


Figure 62. Neutron flux in neutrons/cm<sup>s</sup>-sec in the B ring of the AFRRI TRIGA reactor at 1 MW thermal power level after 43 MW days of operation.

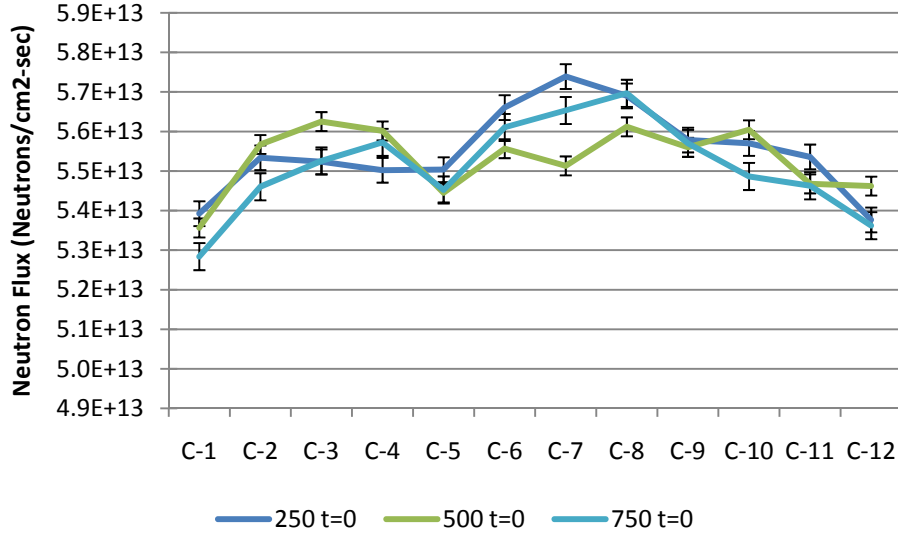


Figure 63. Neutron flux in neutrons/cm<sup>s</sup>-sec in the C ring of the AFRRI TRIGA reactor at 1 MW thermal power level prior to burnup.

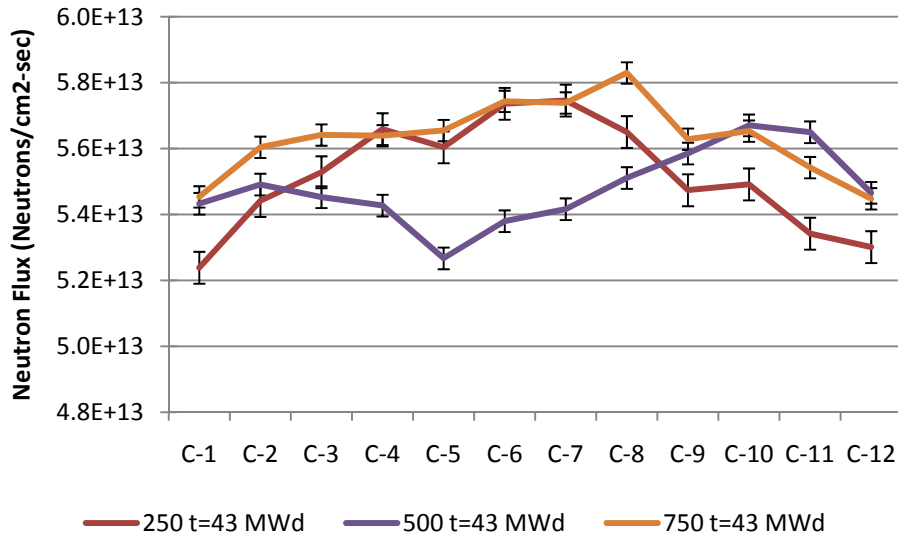


Figure 64. Neutron flux in neutrons/cm<sup>s</sup>-sec in the C ring of the AFRRI TRIGA reactor at 1 MW thermal power level after 43 MW days of operation.

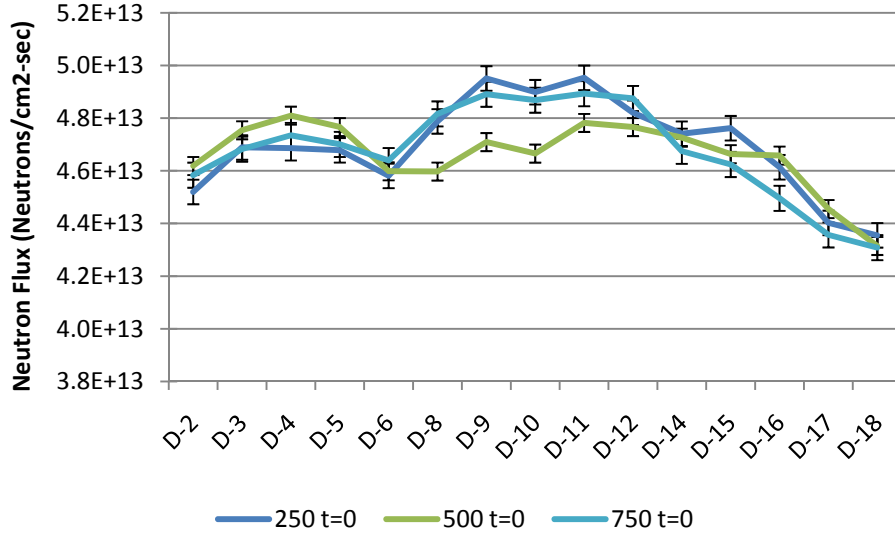


Figure 65. Neutron flux in neutrons/cm<sup>s</sup>-sec in the D ring of the AFRRRI TRIGA reactor at 1 MW thermal power level prior to burnup.

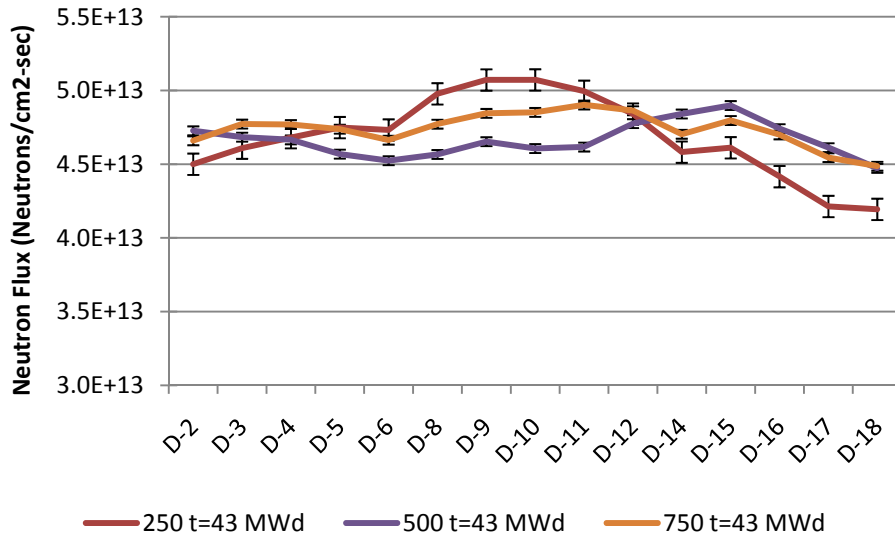


Figure 66. Neutron flux in neutrons/cm<sup>s</sup>-sec in the D ring of the AFRRRI TRIGA reactor at 1 MW thermal power level after 43 MW days of operation.

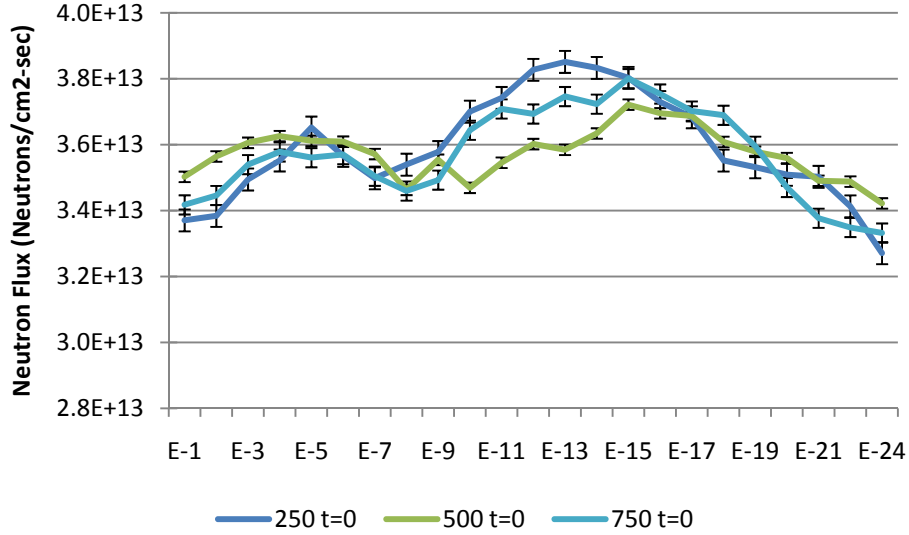


Figure 67. Neutron flux in neutrons/cm<sup>s</sup>-sec in the E ring of the AFRRI TRIGA reactor at 1 MW thermal power level prior to burnup.

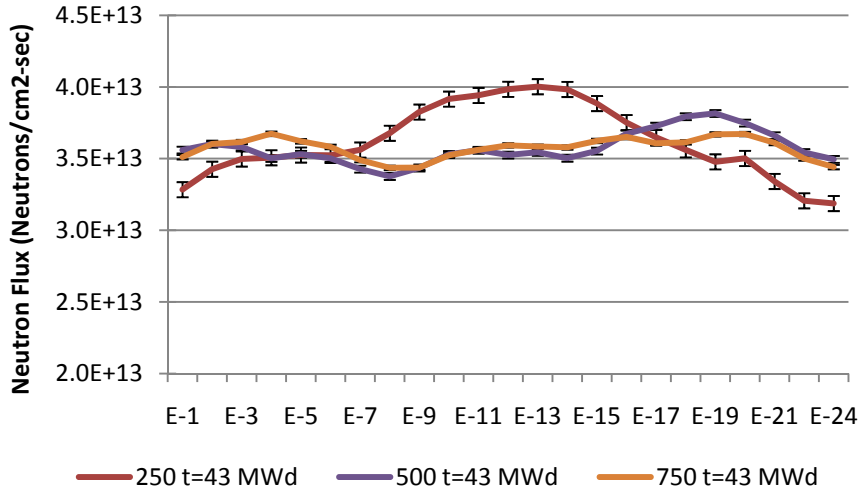


Figure 68. Neutron flux in neutrons/cm<sup>s</sup>-sec in the E ring of the AFRRI TRIGA reactor at 1 MW thermal power level after 43 MW days of operation.

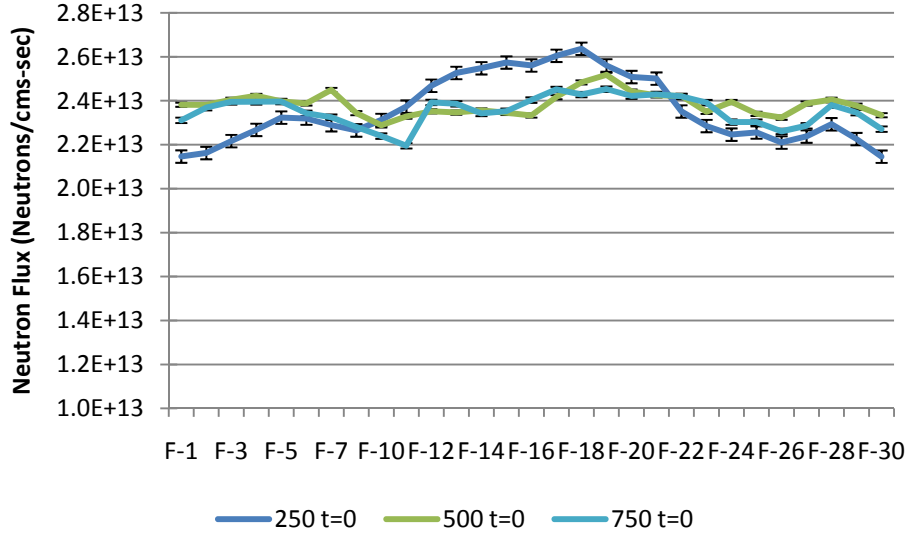


Figure 69. Neutron flux in neutrons/cm<sup>s</sup>-sec in the F ring of the AFRRI TRIGA reactor at 1 MW thermal power level prior to burnup.

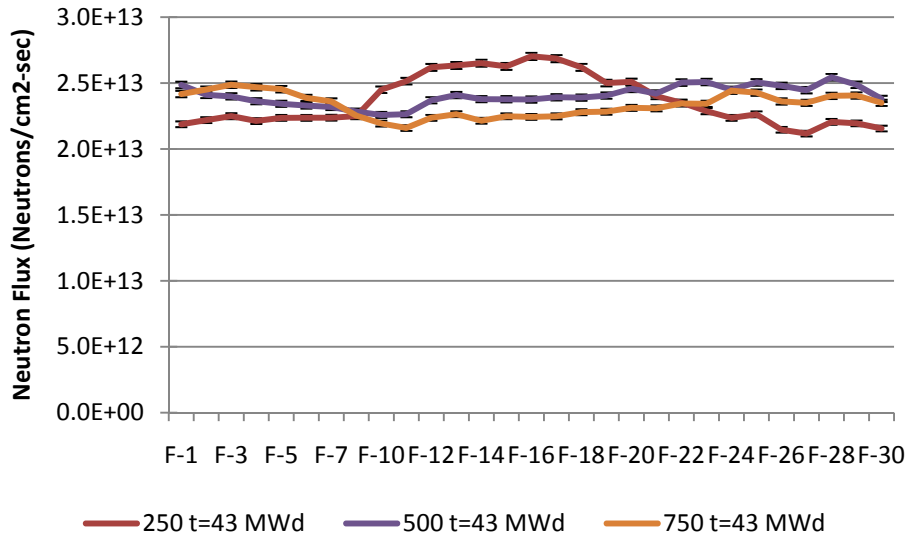


Figure 70. Neutron flux in neutrons/cm<sup>s</sup>-sec in the F ring of the AFRRI TRIGA reactor at 1 MW thermal power level after 43 MW days of operation.

#### Fissile Material Inventory

Fissile material ( $U^{235}$  in the initial core, and both  $U^{235}$  and  $Pu^{239}$  following depletion calculations), as expected, was also found to differ by both location within the core and the core's position within the pool. Higher burnup was noted on the side

of the core closer to the pool center in core positions 250 and 750, with a more uniform depletion within each ring of the core with the core in position 500.

Distortions due to the presence of the core exposure tube at position E-23, the empty element at position F-9, and the control rods was also noted.

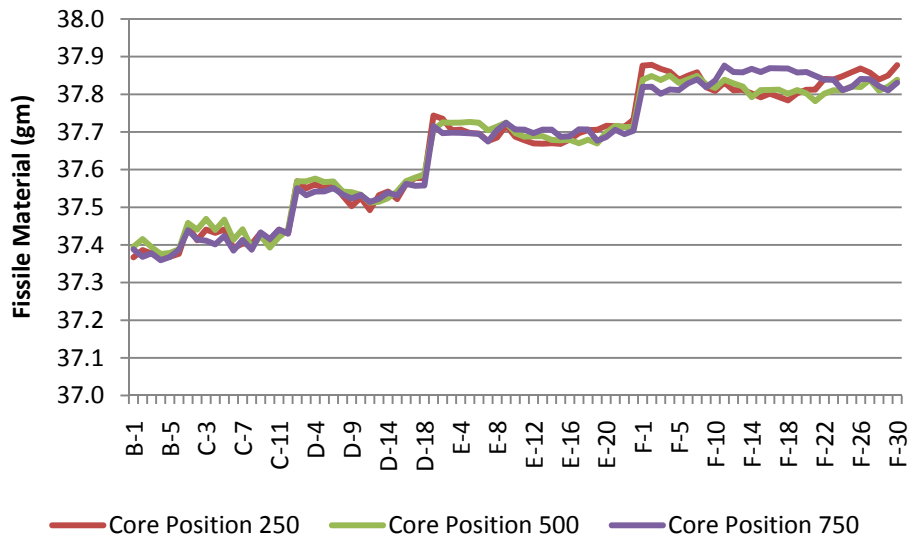


Figure 71. Fissile material inventory within the AFRRRI TRIGA Core, by fuel element, following 43 MW days of operation.

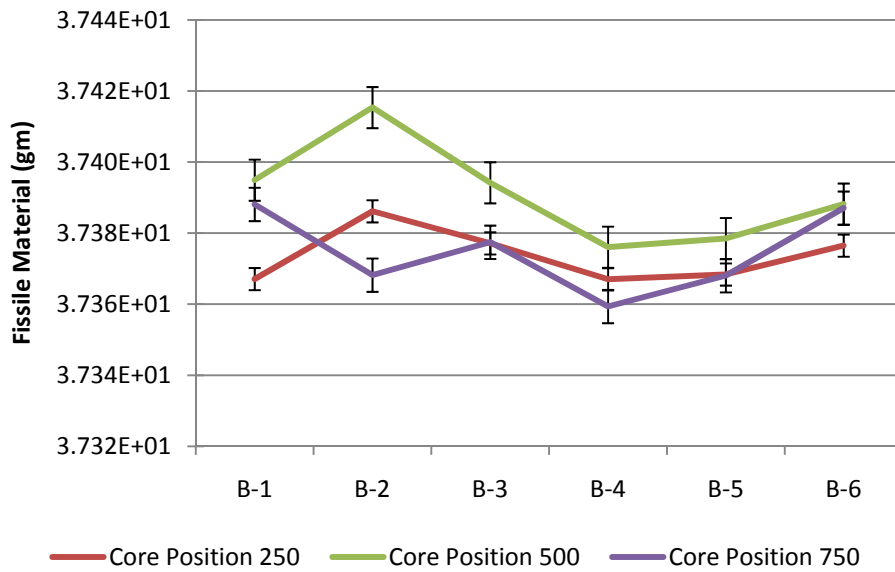


Figure 72. Fissile material inventory in grams in B ring of the AFRRRI TRIGA reactor core following 43 MW days of operation.

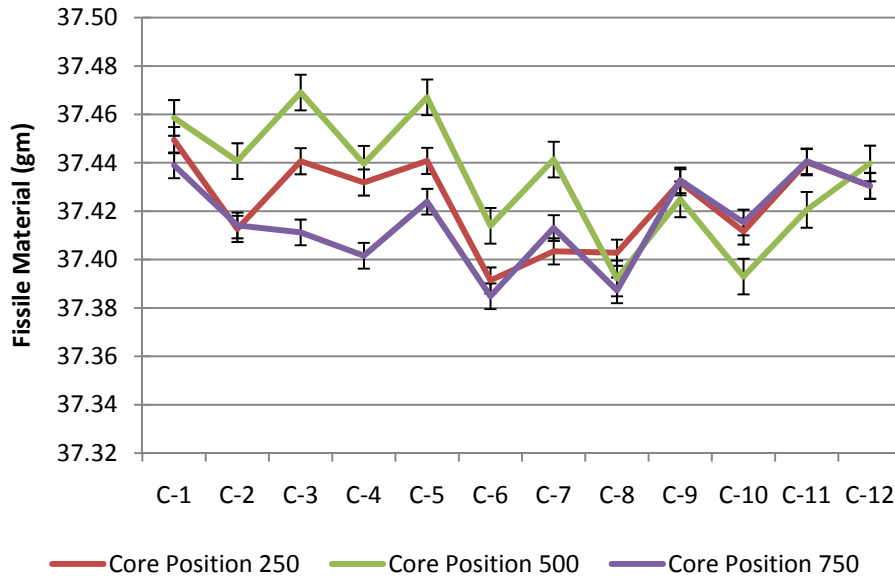


Figure 73. Fissile material inventory in grams in C ring of the AFRRRI TRIGA reactor core following 43 MW days of operation.

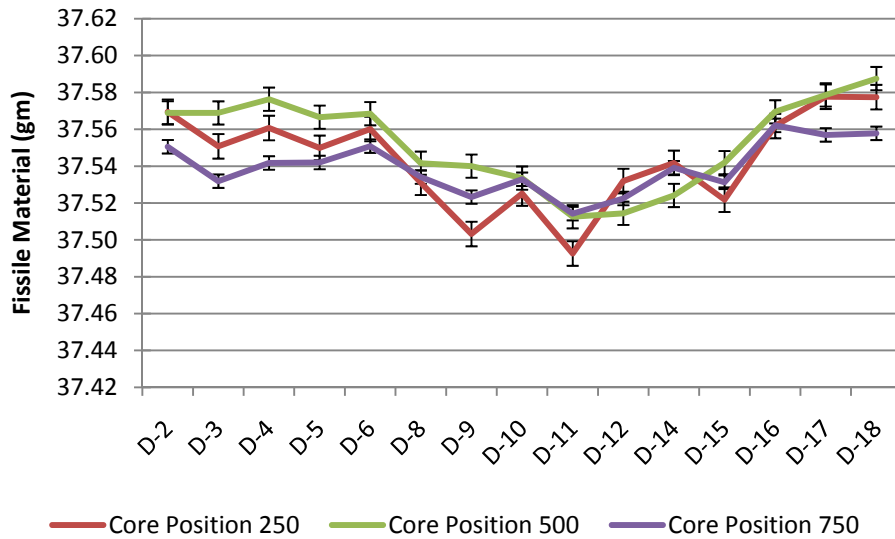


Figure 74. Fissile material inventory in grams in D ring of the AFRRRI TRIGA reactor core following 43 MW days of operation.

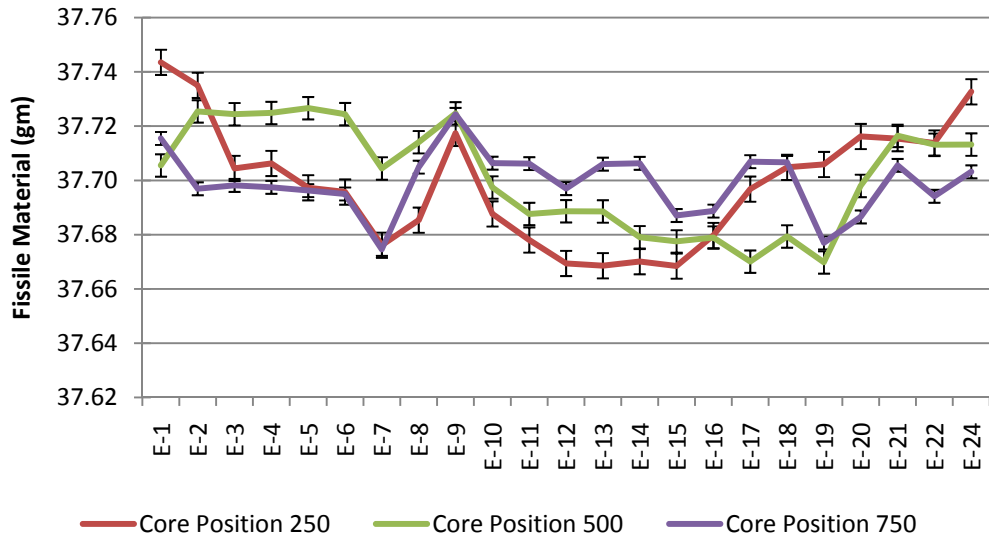


Figure 75. Fissile material inventory in grams in E ring of the AFRRI TRIGA reactor core following 43 MW days of operation.

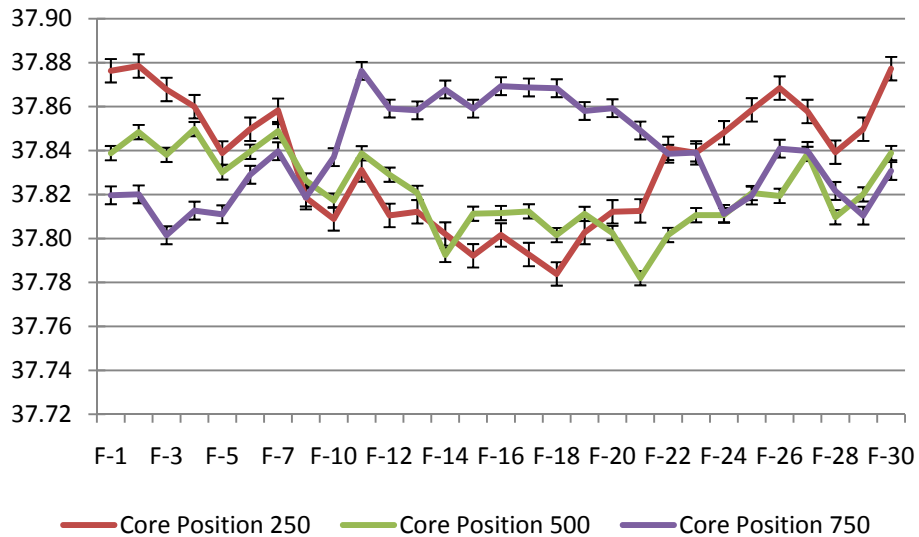


Figure 76. Fissile material inventory in grams in F ring of the AFRRI TRIGA reactor core following 43 MW days of operation.

#### Actinide Inventory

The total actinide inventory (isotopes of uranium, as well as any transuranics formed within the core during operation) in the core following depletion was much less sensitive to core position during operation. Most elements showed identical

actinide inventories for all three core positions within the pool; those that did not varied by 0.1 gram, with no discernable pattern to the fluctuation. MCNP does not provide calculated error for fuel depletion calculations; if we assume that the actinide inventory error varies as the MCNP calculated flux error, on the order of up to one percent, the actinide inventories in each ring are identical for each of the three core positions calculated.

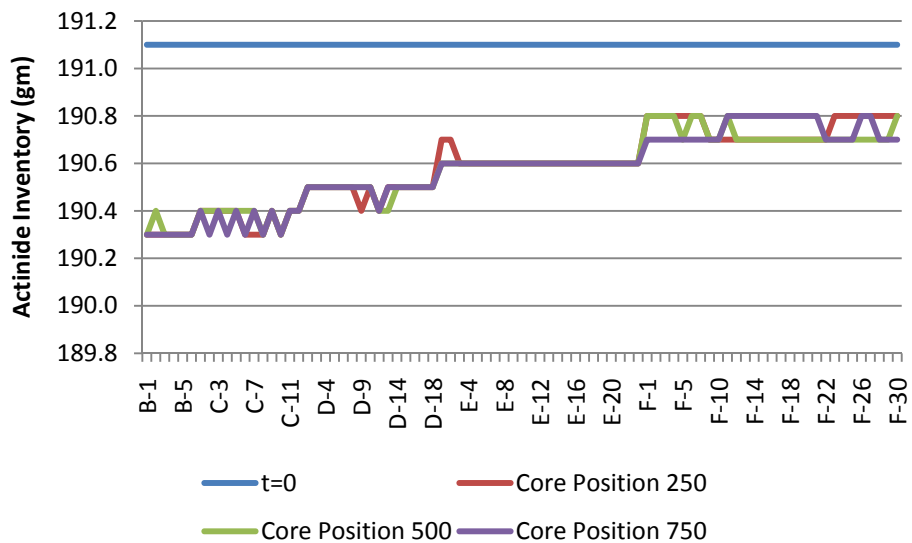


Figure 77. Actinide material inventory within the AFRRRI TRIGA Core, by fuel element, following 43 MW days of operation.

#### Comparison of Results

While the flux and fuel depletion varied considerably by element position and by core position within the pool, the overall actinide inventory and fissile material inventory at the end of 43 megawatt days of operation was identical for all three core positions, to within 0.1 gram for each calculation. This is not unexpected, as identical total power output would require identical neutron fluencies, in turn requiring the same number of fission events in each core position.

These data would also indicate that, from an overall operational fuel management perspective, that the core position within the pool is much less important to fuel management strategies than the position of the fuel elements by ring are. This will become increasingly important as the AFRRR TRIGA core approaches the end of its useful life, at which point fuel management techniques might be required to extend useful core life, or should movement of elements within the core be required for other reasons.

#### *Effects of Moving the Core on Radiation Levels Within the Exposure Rooms*

The position of the core within the reactor pool, and particularly its position in relation to the walls of the tank protrusion within each exposure room, can significantly vary the energy spectrum of radiation within the room, especially for neutron fluxes. At the extremes of the traverse of the core within the reactor tank (core position 250 for exposure room 1 and core position 750 for exposure room 2), the exterior of the core shroud is positioned approximately 2.5 cm from the inner surface of the tank protrusion into the exposure room. The surface of the fuel element closest to the tank wall is positioned approximately 4.67 cm from the interior of the tank wall in that position, with 4.19 cm of that distance being water and the remaining 0.476 cm the aluminum alloy of the core shroud.

As the core is moved from its position near the tank wall into a position further into the tank, the water between the core and the tank wall serves as a neutron moderator and reflector.[131, 136] It was expected, therefore, that results of the core movement would show an increase in the number of thermal neutrons entering the exposure rooms and then, as the core moved further into the tank, a decrease in the

overall number of neutrons entering the room at the water between the core and the tank wall approached the thickness of an infinite reflector, approximately 18 cm in the AFRRI TRIGA reactor.[17]

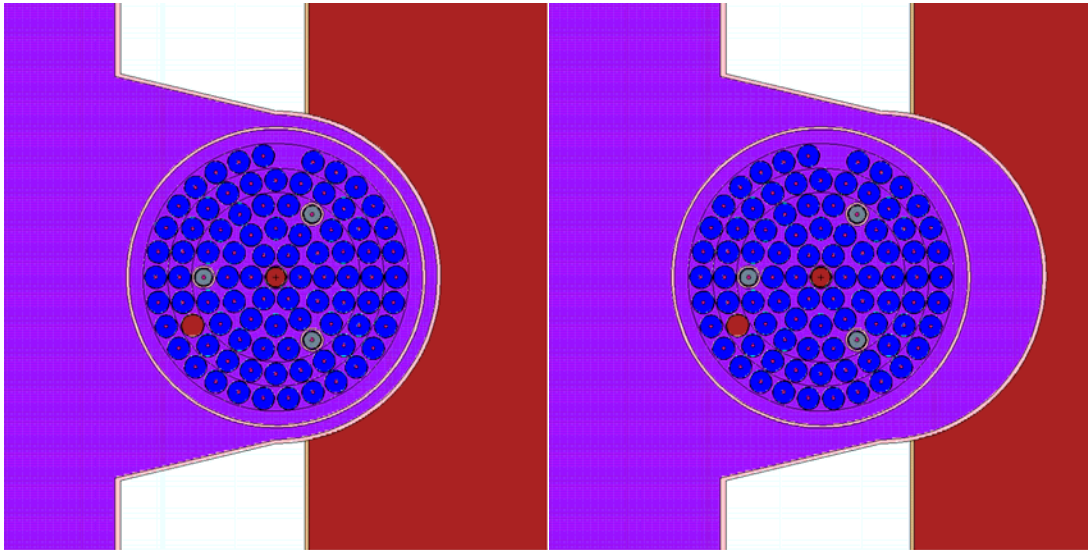


Figure 78. Moving the core. Core in position 750 (left) and moved 10 cm into reactor pool from position 750 (right).

Neutrons are emitted during the fission process with energies ranging up to in excess of 10 MeV. The average energy of fission neutrons is  $\sim 2$  MeV, with a most probable energy of  $\sim 1$  MeV.[137] Initial runs were performed on MCNPX which showed no neutron production above 2.5 MeV, so all MCNPX runs involving phantoms were performed with a maximum neutron energy bin of 2.5 MeV. Gamma spectrums were calculated with energy bins ranging as high as 10 MeV, although there was found to be little gamma production above approximately 8 MeV.

To determine the neutron spectrum and total neutron and gamma fluxes for core position 250, the reactor was modeled at its closest position to the wall of the exposure room tank protrusion. Mouse phantoms—Lucite cylinders 2.54 cm in diameter and 7.62 cm in height were then modeled at 50 cm intervals from the core

center along the core midline ranging from 50 cm to 600 cm from the core midpoint. Energy dependant neutron and gamma fluxes were then calculated within the phantoms positioned 50 cm and 100 cm from the core center, while total neutron and gamma fluxes were computed for each of the phantoms within the exposure room.. The core was then moved 2 cm at a time away from the tank protrusion wall while the Lucite mouse phantoms were maintained in their original positions within the exposure room, so their distance from the core midline increased as the core was moved further into the pool.

```

10/20/09 15:42:34
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 10/20/09 05:56:36
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -302.27,  0.00,  0.00)
extent = ( 371.54, 371.54)

```

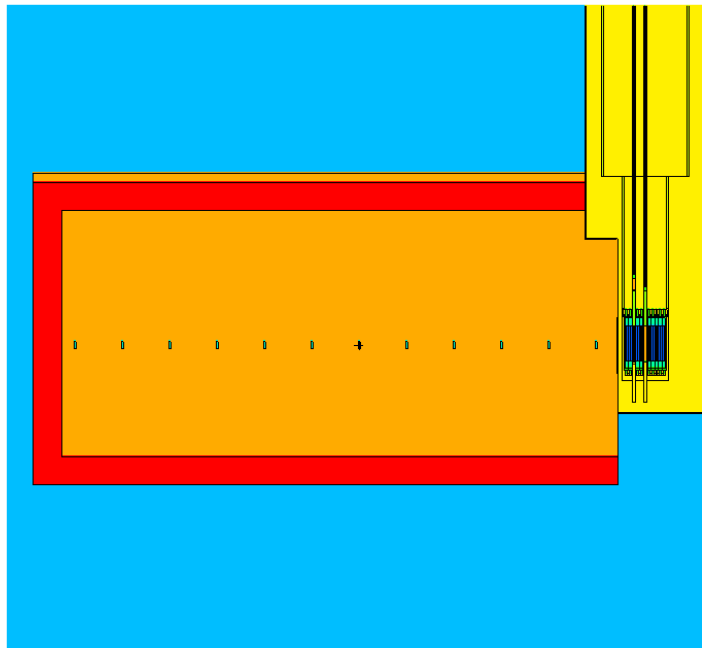


Figure 79. MCNP generated diagram through the x-z plane of exposure room 1, showing placement of mouse phantoms.

```
10/20/09 15:41:54
c  AFRR1 TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 10/20/09 05:56:36
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -302.27,  0.00,  0.00)
extent = ( 371.54, 371.54)
```

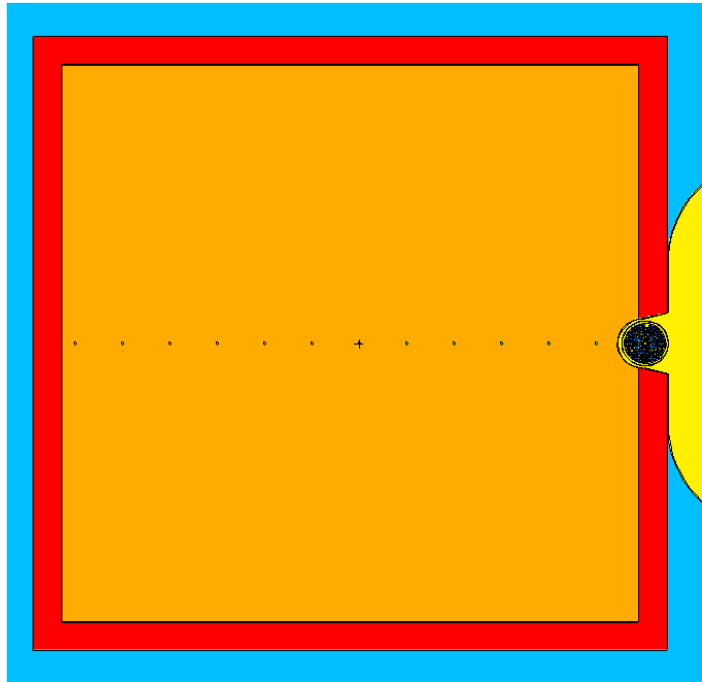


Figure 80. MCNP generated diagram through the x-y plane of exposure room 1, showing placement of mouse phantoms.

Similar to operation of the model at core position 250, for core position 750 the reactor core was placed at its closest position to the interior tank wall. Mouse phantoms—Lucite cylinders 2.54 cm in diameter and 7.62 in height—were then modeled within exposure room 2 along the core midline at 50 cm intervals at distances ranging from 50 cm, to 350 cm from the center of the core. Energy dependant neutron and gamma fluxes were then calculated within the phantoms positioned 50 cm and 100 cm from the core center, while total neutron and gamma fluxes were computed for each of the phantoms within the exposure room. The core was then moved 2 cm at a time away from the tank protrusion wall while the Lucite mouse phantoms were maintained in their original positions within the exposure

room, so that their distance from the core midline increased as the core was moved deeper into the tank..

```
10/12/09 18:59:26  
c  AFRRI TRIGA Mark-F Reactor  
and supporting exposure  
facilities  
probid = 10/12/09 18:58:09  
basis: XZ  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 0.000000, 1.000000)  
origin:  
( 172.49,  0.00,  0.00)  
extent = ( 239.88, 239.88)
```

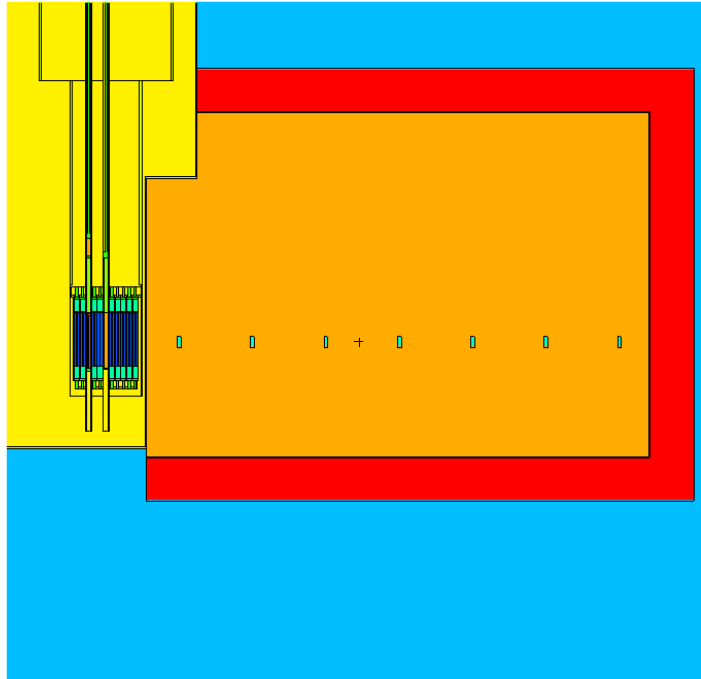


Figure 81. MCNP generated diagram through the x-z plane of exposure room 2, showing placement of mouse phantoms.

```

10/12/09 18:58:51
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 10/12/09 18:58:09
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( 172.49, 0.00, 0.00)
extent = ( 239.88, 239.88)

```

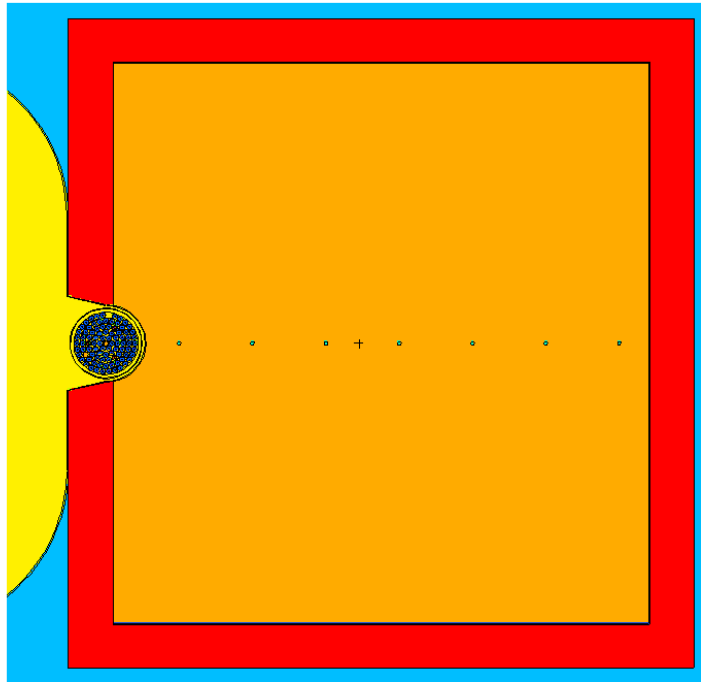


Figure 82. MCNP generated diagram through the x-y plane of exposure room 2, showing placement of mouse phantoms.

Because MCNP produces a normalized flux, in terms of flux per source particle, it was necessary to scale the flux to a single reactor power level. To scale the flux, the reactor thermal power in watts was multiplied by the number of fissions per watt second ( $3.467 \times 10^{10}$ ) times  $\nu$ , which is 2.47 neutrons/fission for the AFRRI TRIGA Mark F Reactor.[17] These results were then scaled to a power level of 1 kilowatt, to allow later comparison to the Verbinski reports, which also provided results in flux per kilowatt, resulting in a scaling factor of  $8.56 \times 10^{13}$ .

Neutron Spectrum, Core Position 250

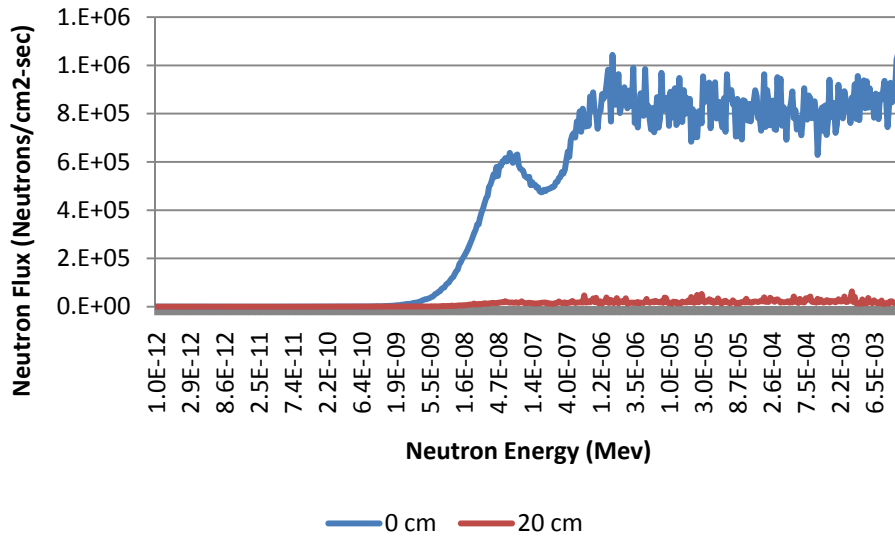


Figure 83. Energy dependant neutron spectrum by core position, phantom at 50 cm from core center, exposure room 1.

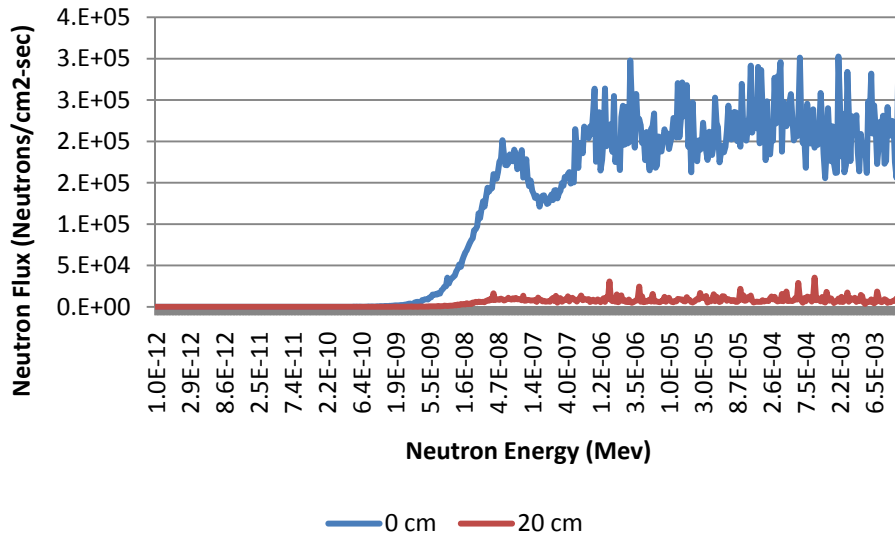


Figure 84. Energy dependant neutron spectrum by core position, phantom at 100 cm from core center, exposure room 1.

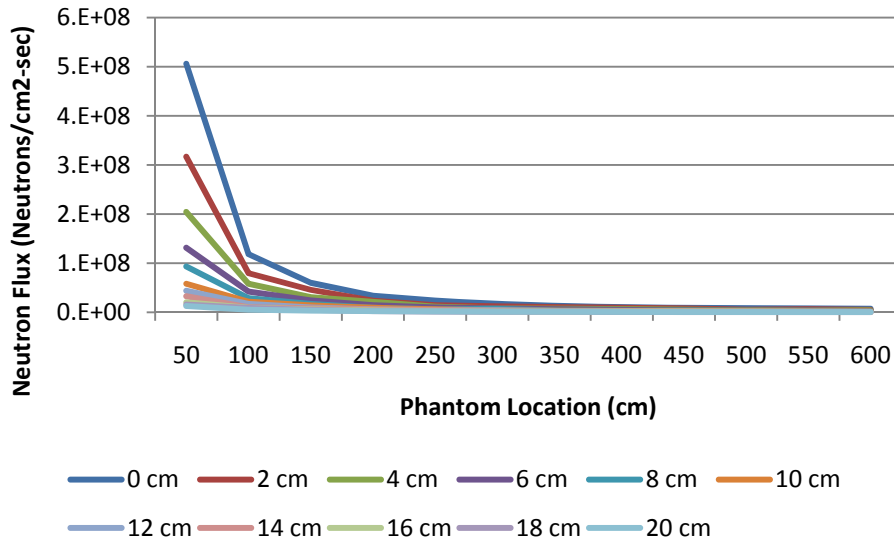


Figure 85. Total Neutron flux by phantom location and core position, exposure room 1.

Within exposure room 1, the neutron flux is proportional to  $1/r^2$  within 200 cm of the core center, and is relatively flat beyond that distance, showing the effect of neutrons being returned to the exposure room from the wood lining of the room. This neutron return is discussed further in the section on gadolinium paint, below.

The modeling also shows that, while the core position relative to the tank wall affects the intensity of the gamma and neutron fluxes, it does not cause a significant change in the energy distribution. Although the flux at peak energy decreases with distance from the core wall, the location of the peaks within the spectrum are unchanged. Additionally, the movement of the core within the tank does not significantly affect the energy distribution of the flux.

Neutron Spectrum, Core Position 750

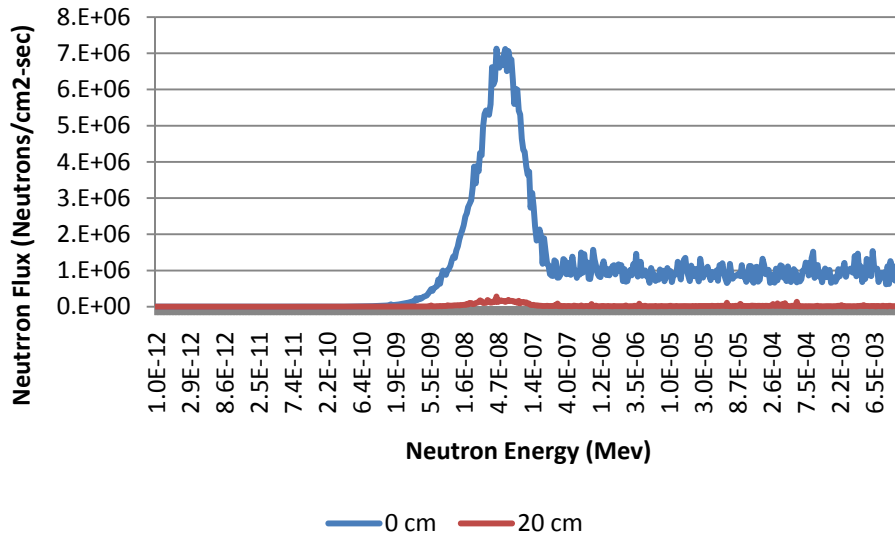


Figure 86. Energy dependant neutron spectrum by core position, phantom at 50 cm from core center, exposure room 2.

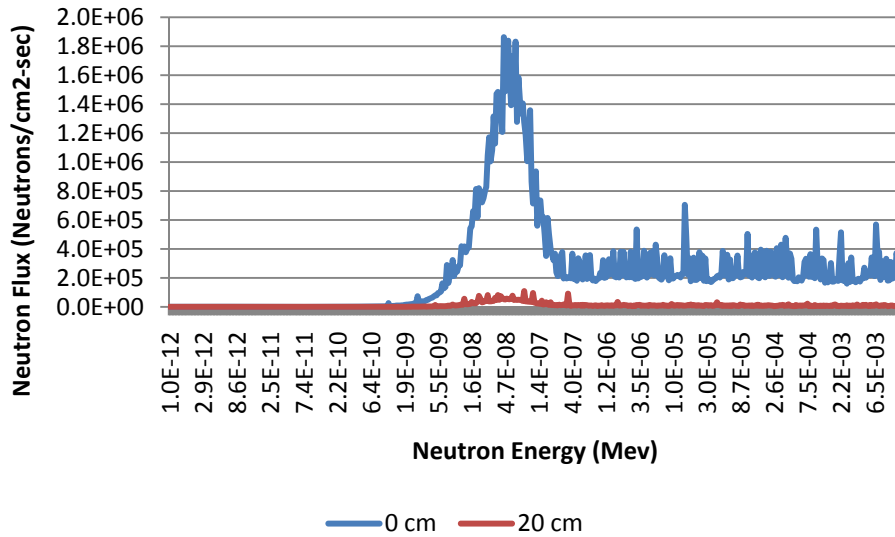


Figure 87. Energy dependant neutron spectrum by core position, phantom at 100 cm from core center, exposure room 2.

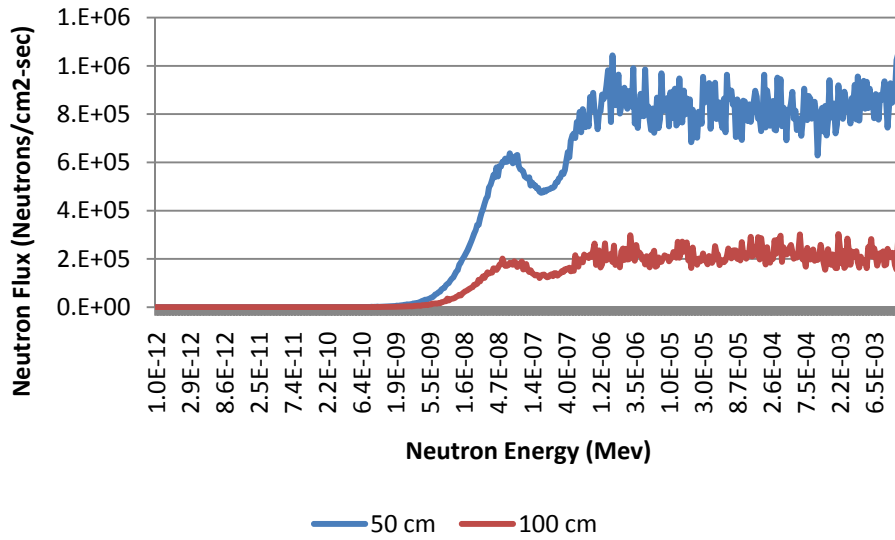


Figure 88. Comparison of energy dependant neutron flux in mouse phantoms located 50 cm and 100 cm from core centerline, reactor 0 cm from tank protrusion wall, in exposure room 1.

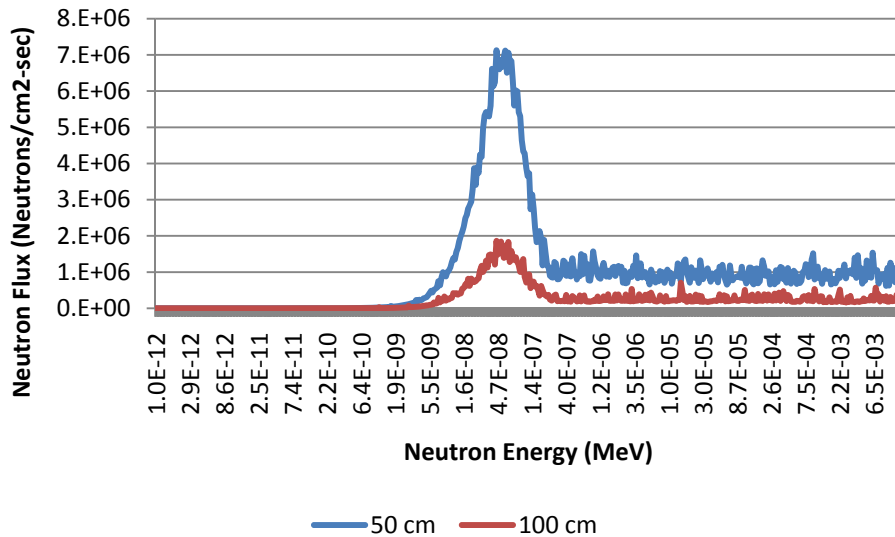


Figure 89. Comparison of energy dependant neutron flux in mouse phantoms located 50 cm and 100 cm from core centerline, reactor 0 cm from tank protrusion wall, in exposure room 2.

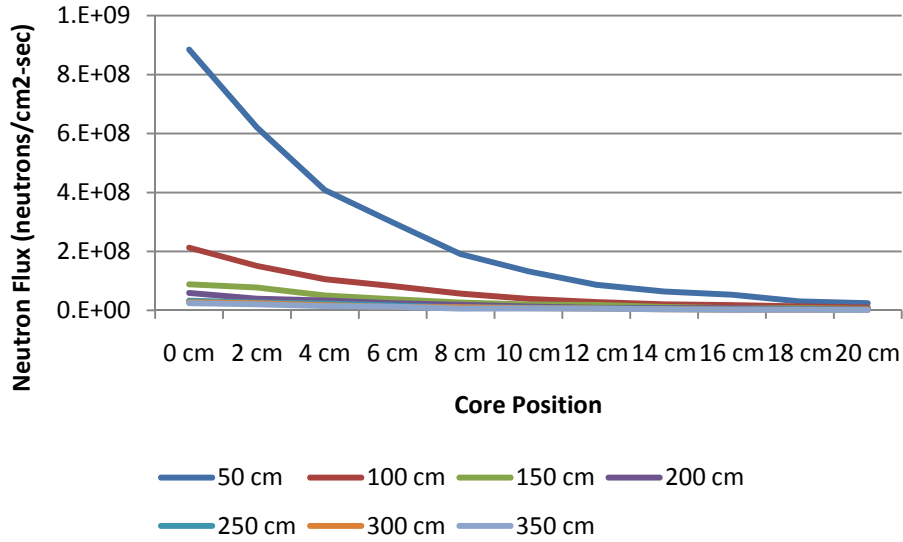


Figure 90. Total Neutron flux by phantom location and core position, exposure room 2.

As in core position 250, the neutron flux is proportional to  $1/r^2$  within 200 cm of the core center, and is relatively flat beyond that distance, showing the effect of neutrons being returned to the exposure room from the wood lining of the room.

Gamma Spectrum, Core Position 250

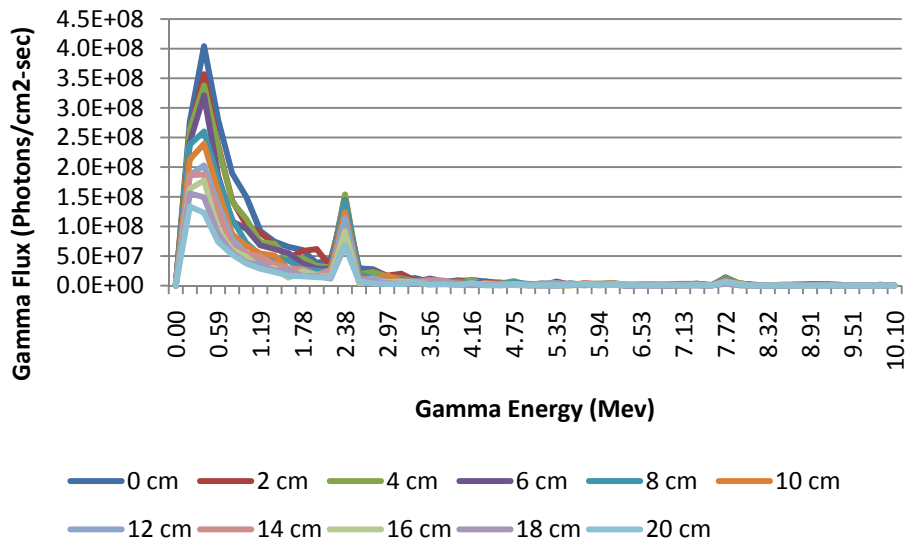


Figure 91. Energy dependant gamma spectrum by core position, phantom at 50 cm from core center, exposure room 1.

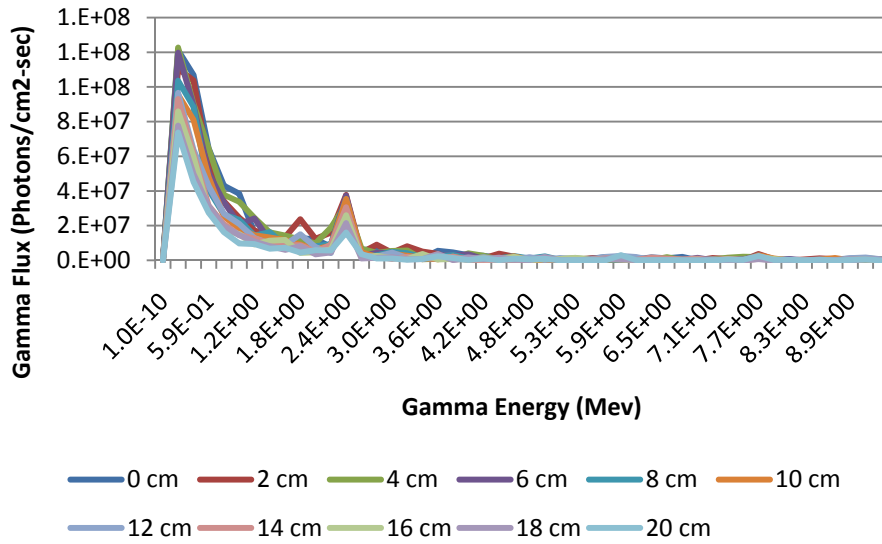


Figure 92. Energy dependant gamma spectrum by core position, phantom at 100 cm from core center, exposure room 1.

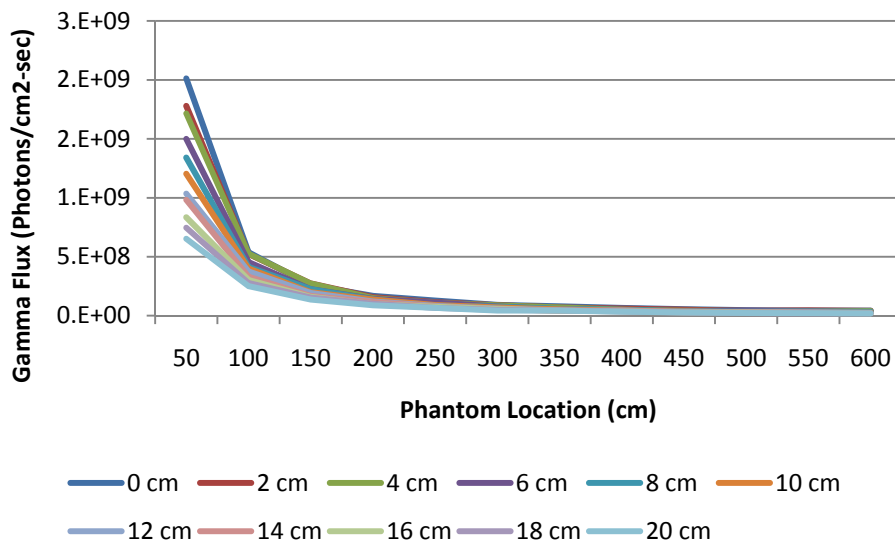


Figure 93. Total Gamma flux by phantom location and core position, exposure room 1.

Gamma Spectrum, Core Position 750

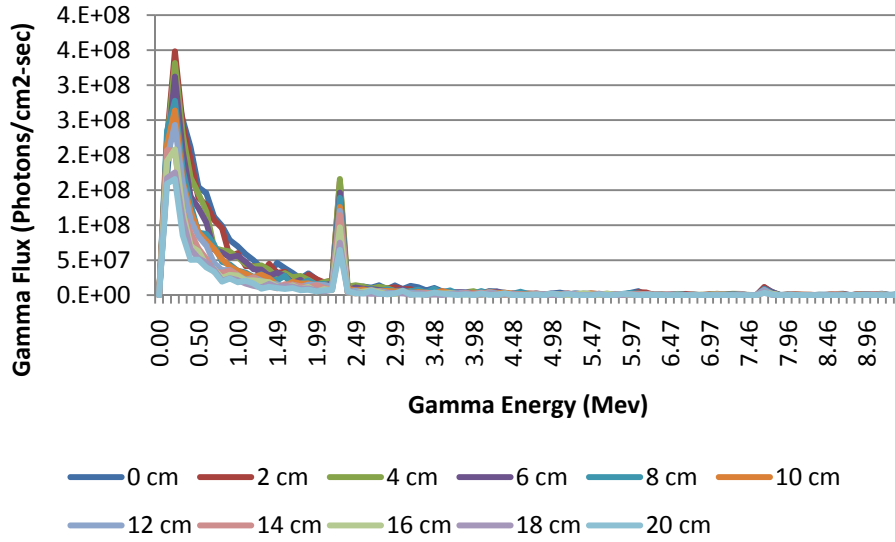


Figure 94. Energy dependant gamma spectrum by core position, phantom at 50 cm from core center, exposure room 2.

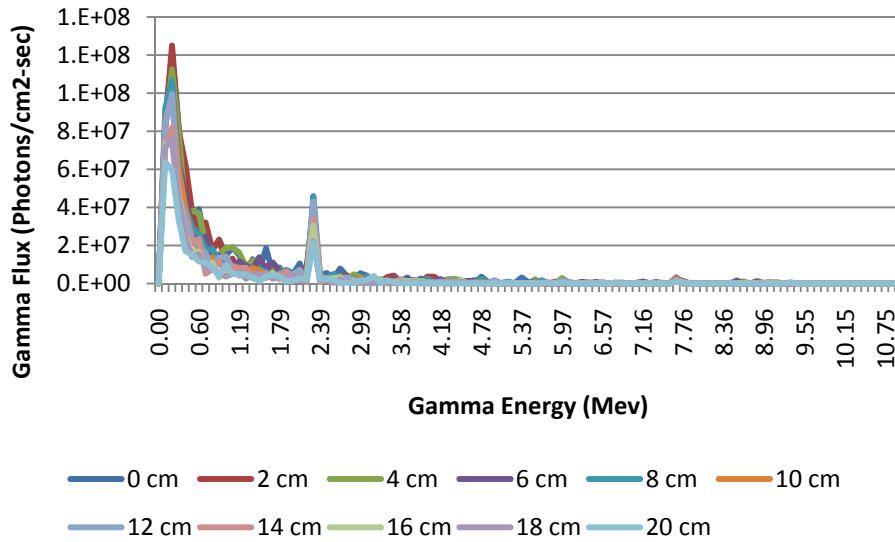


Figure 95. Energy dependant gamma spectrum by core position, phantom at 100 cm from core center, exposure room 2.

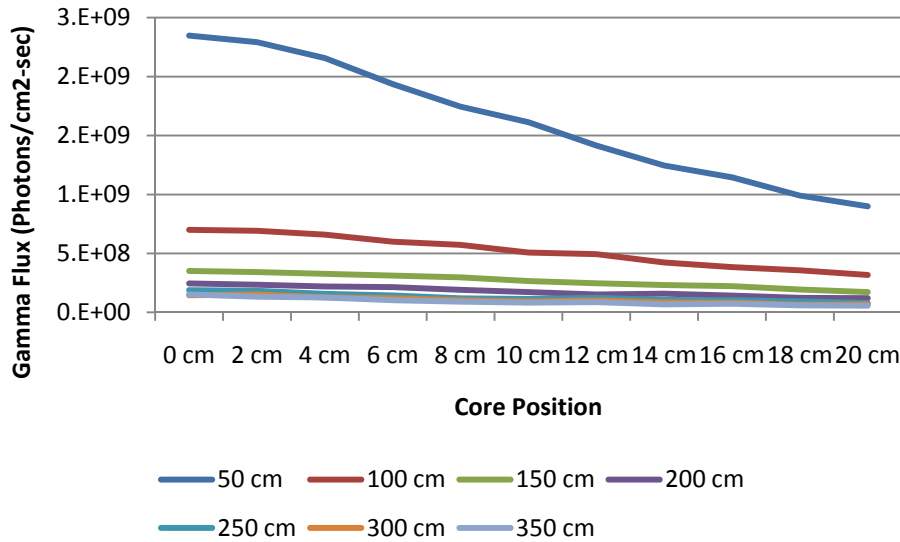


Figure 96. Total Gamma flux by phantom location and core position, exposure room 2.

#### Comparison Between Results of exposure rooms

In order to better model the fluxes within the exposure rooms, following completion of the modeling the fluxes within phantoms located 50 cm and 100 cm from the core centerlines were compared between the two exposure rooms. As expected, the cadmium and gadolinium shield installed on the reactor tank protrusion in exposure room 1 had significantly reduced the thermal neutron flux in exposure room 1 relative to exposure room 2. This is consistent with exposure room 1's designation as a fast neutron exposure room, and exposure room 2's original designation as a thermal neutron exposure room, and shows that there is a significant thermal component to the flux in exposure room 2 even after the removal of the heavy water tank originally provided to thermalize neutrons within exposure room 2.

The gamma spectrum in both rooms is virtually identical between the two exposure rooms at both phantom locations within the room, within calculated margins of error.

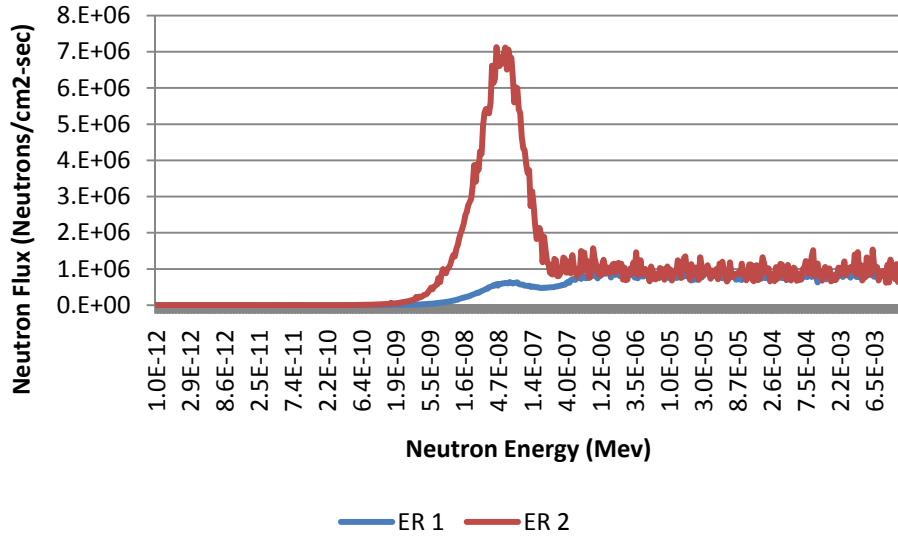


Figure 97. Comparison between energy dependant neutron fluxes, phantom located 50cm from core center, reactor 0 cm from tank protrusion wall.

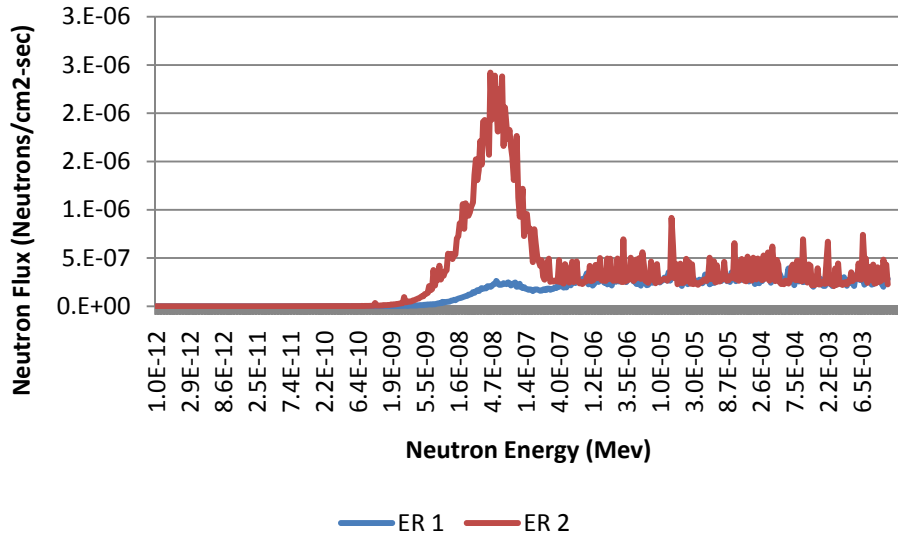


Figure 98. Comparison between energy dependant neutron fluxes, phantom located 100cm from core center, reactor 0 cm from tank protrusion wall.

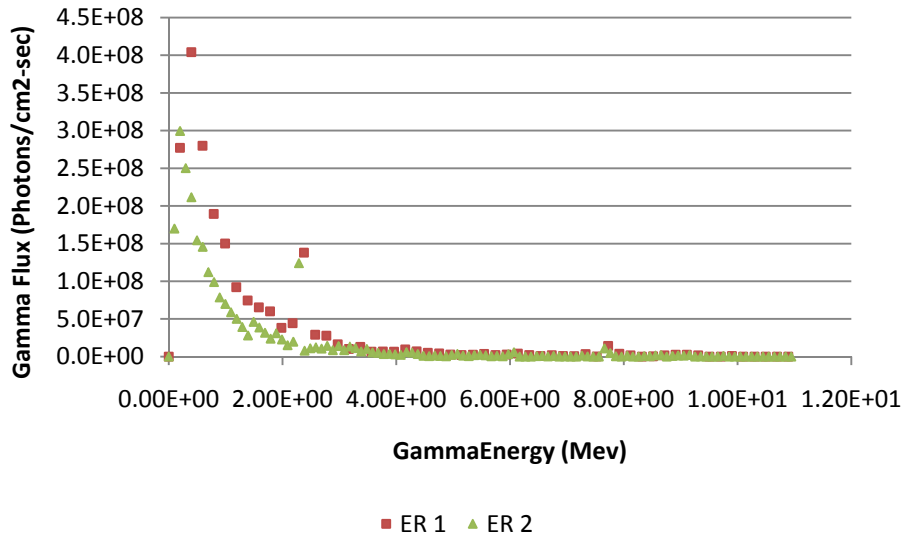


Figure 99. Comparison between energy dependant gamma fluxes, phantom located 50cm from core center, reactor 0 cm from tank protrusion wall.

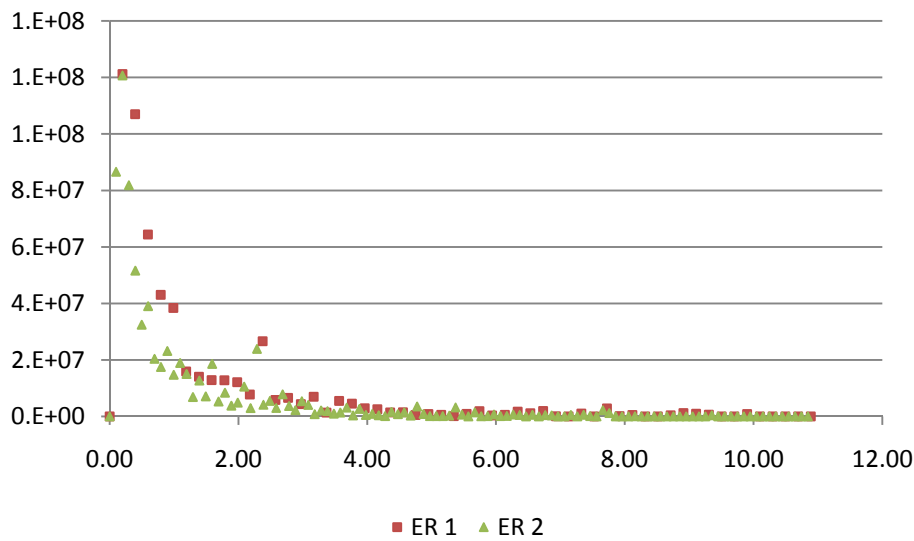


Figure 100. Comparison between energy dependant gamma fluxes, phantom located 100cm from core center, reactor 0 cm from tank protrusion wall.

The Effect of Gadolinium Paint

MCNP Modeling of the Effects of Gadolinium Paint

In order to determine the effects of the gadolinium paint on the thermal flux within the exposure rooms, MCNP modeling was performed of the rooms both with and without gadolinium in the Masonite lining of the walls of the exposure room.

Because the modeling was performed using a homogenized mixture of Masonite and gadolinium for the inner layer of the walls of the exposure room rather than modeling the paint itself, the removal of the gadolinium was rather simple, involving merely removing the gadolinium from the material card for the Masonite lining within the model. Within the MCNP model, all parameters were identical in the runs except for the presence or absence of gadolinium within the Masonite lining of the exposure room walls. Additionally, exposure room 1 was modeled with gadolinium in the Masonite lining of the exposure room, but both with and without the cadmium shielding on the reactor tank protrusion.

Plotting collisions of neutrons within each exposure room showed a marked decrease in number of thermal neutron collisions within the rooms when gadolinium was included on the room surfaces when compared to the rooms without the gadolinium, serving to confirm through modeling the experimental data originally presented in 1969.[118, 119] While there was insufficient data presented in the papers to allow a modeling of the original experiments explicitly, the results of the collision tracking model are consistent with those of the original papers.

```
09/23/09 06:11:50
c AFRRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/23/09 06:10:19
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -327.70, 0.00, 0.00)
extent = ( 380.19, 380.19)
```

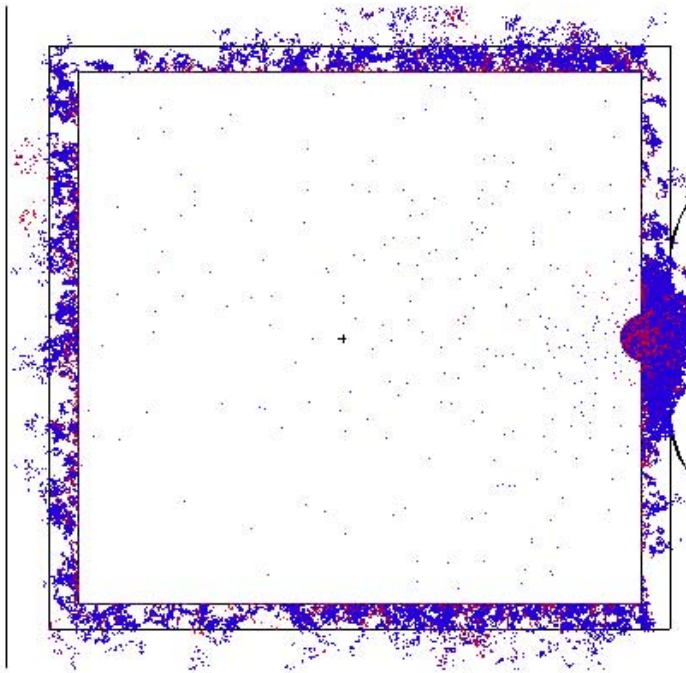


Figure 101. MCNP run of exposure room 1 showing the x-y plane through the core center, with gadolinium paint on room walls, floor or ceiling but no cadmium shielding on the reactor tank protrusion wall, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
10/01/09 20:53:24
c  AFRR1 TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 10/01/09 20:52:24
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -320.30,  1.03,  0.00)
extent = ( 380.19, 380.19)
```

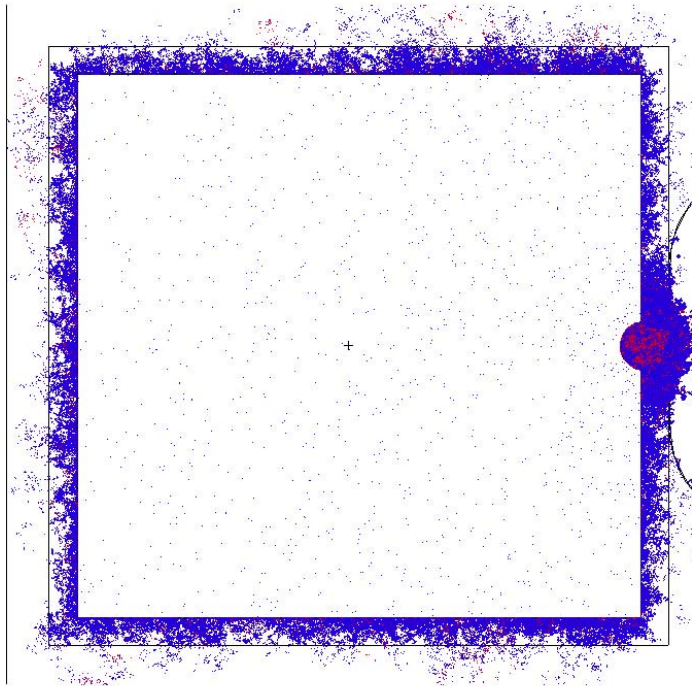


Figure 102. MCNP run of exposure room 1 showing the x-y plane through the core center, with no gadolinium paint on room walls, floor or ceiling but no cadmium shielding on the reactor tank wall protrusion, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/30/09 20:38:08
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/30/09 19:58:20
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -402.23, -17.21,  0.00)
extent = ( 501.19, 501.19)
```

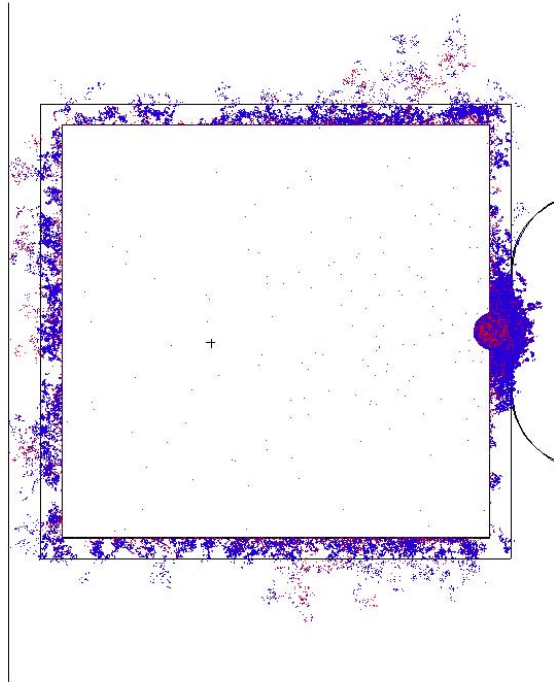


Figure 103. MCNP run of exposure room 1 showing the x-y plane through the core center, with gadolinium paint on room walls, floor s and ceiling and cadmium shielding on the reactor tank wall protrusion, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/23/09 06:38:05
c AFRR1 TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/23/09 06:11:52
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -327.70, 0.00, 0.00)
extent = ( 380.19, 380.19)
```

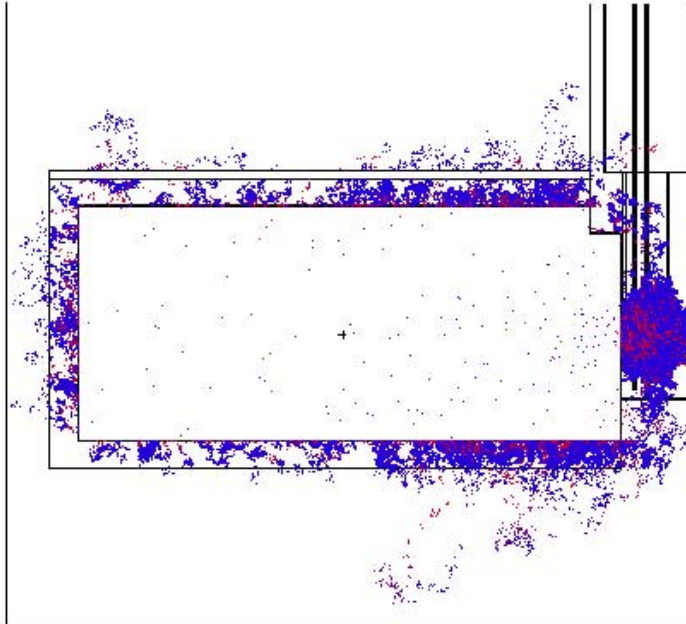


Figure 104. MCNP run of exposure room 1 showing the x-z plane through the core center, with gadolinium paint on room walls, floor or ceiling but no cadmium shielding on the reactor tank wall protrusion, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
10/01/09 21:18:09
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 10/01/09 20:53:24
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -320.30,  1.03,  0.00)
extent = ( 380.19, 380.19)
```

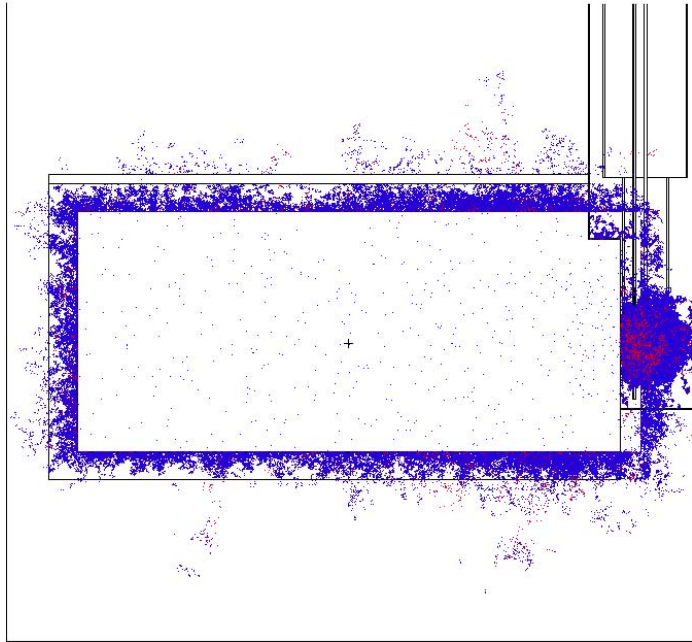


Figure 105. MCNP run of exposure room 1 showing the x-z plane through the core center, with no gadolinium paint on room walls, floor or ceiling and no cadmium shielding the reactor tank wall protrusion, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/30/09 21:02:28
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/30/09 20:38:08
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -402.23, -17.21, 0.00)
extent = ( 501.19, 501.19)
```

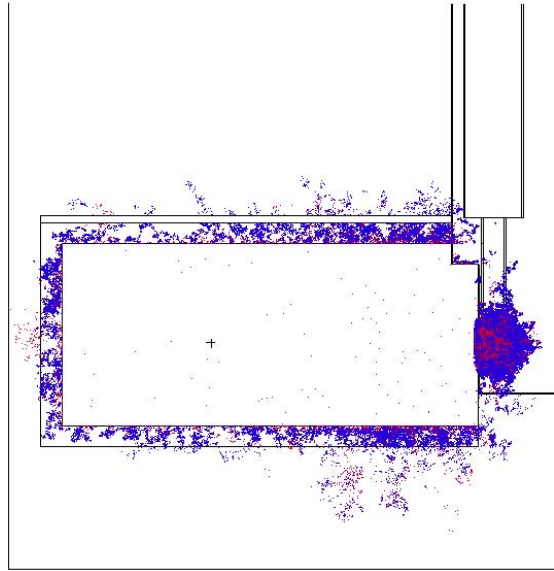


Figure 106. MCNP run of exposure room 1 showing the x-z plane through the core center, with gadolinium paint on room walls, floor and ceiling and cadmium shielding on the reactor tank wall protrusion, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/03/09 05:36:33
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/03/09 05:36:32
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 407.00, 407.00)
```

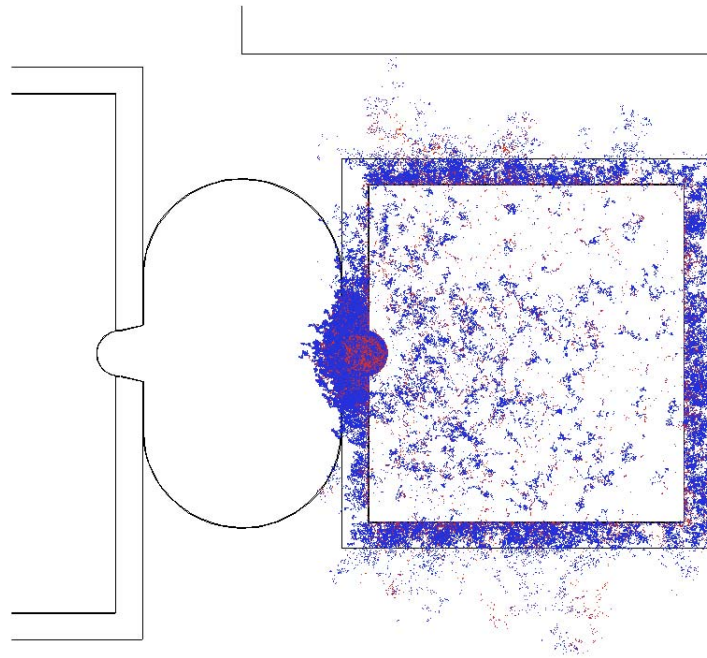


Figure 107. MCNP run of exposure room 2 showing the x-y plane through the core center, with gadolinium paint on room walls, floor or ceiling, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/03/09 11:37:05
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/03/09 11:37:04
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 407.00, 407.00)
```

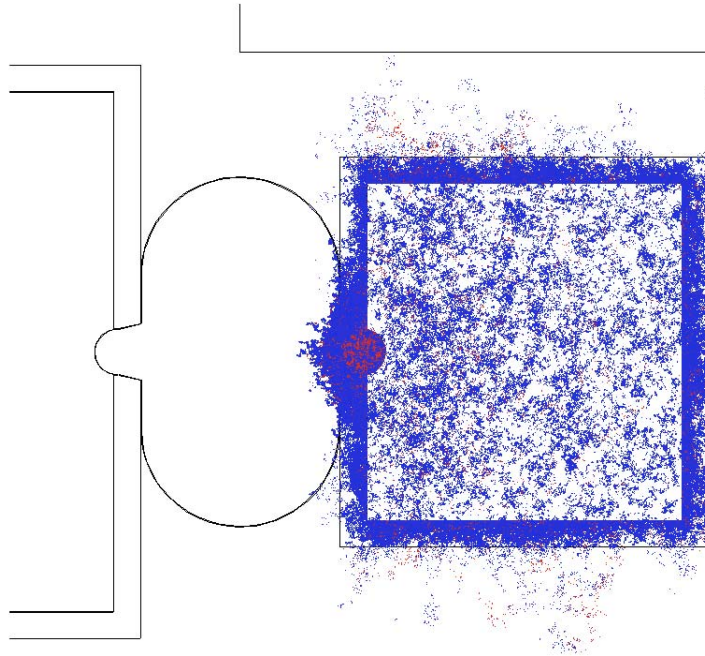


Figure 108. MCNP run of exposure room 2 showing the x-y plane through the core center, with no gadolinium paint on room walls, floor or ceiling, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/03/09 05:43:30
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/03/09 05:43:29
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 407.00, 407.00)
```

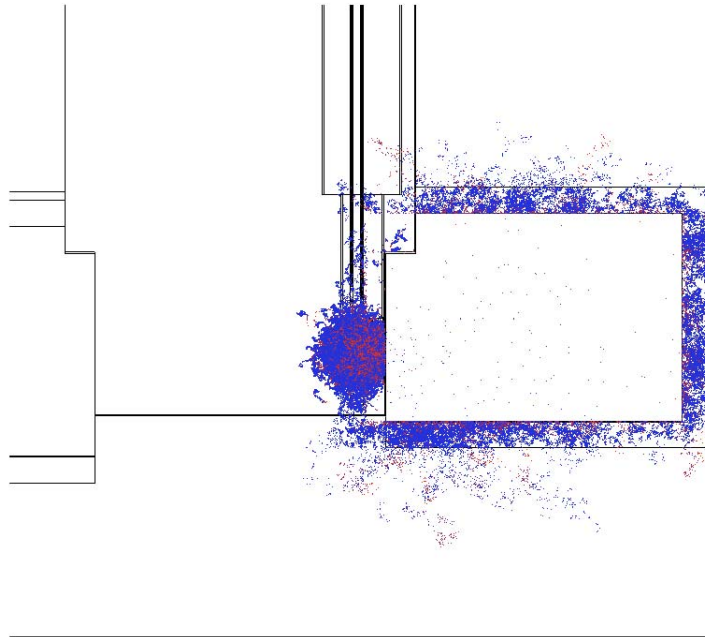


Figure 109. MCNP run of exposure room 2 showing the x-z plane through the core center, with gadolinium paint on room walls, floor or ceiling, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

```
09/03/09 11:45:06
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/03/09 11:45:05
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( 0.00, 0.00, 0.00)
extent = ( 407.00, 407.00)
```

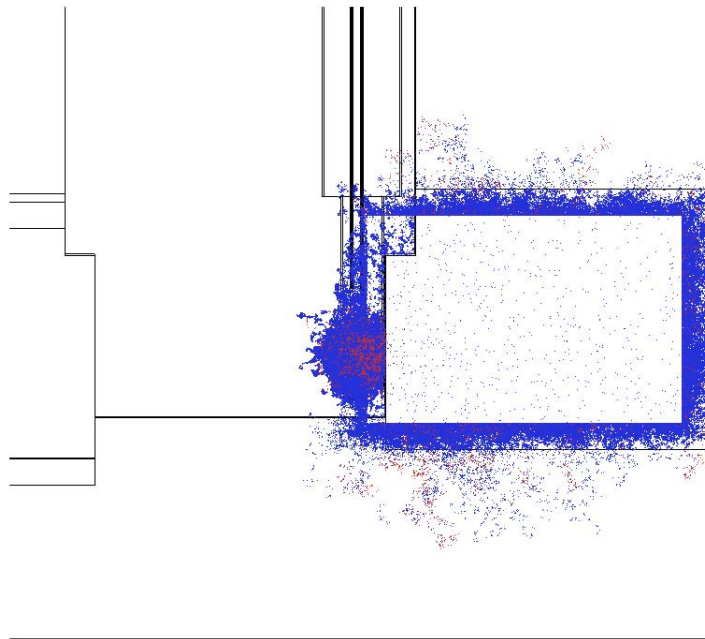


Figure 110. MCNP run of exposure room 2 showing the x-z plane through the core center, with no gadolinium paint on room walls, floor or ceiling, showing collisions caused by 30,000 source particles. Blue dots represent low energy neutron collisions and red high energy neutron collisions.

#### Flux Mapping

In addition to the collision mapping, neutron fluxes were mapped in both the X-Y and X-Z planes under both conditions—gadolinium present in the Masonite lining and no gadolinium present—as well as with the cadmium shield present on the reactor tank protrusion in exposure room 1. Relative total flux by location within the room was then plotted, and is presented graphically below. The graphics indicate the relative strength of the flux within the room, and clearly show the flattening of the flux within the rooms caused by the re-entry of thermalized neutrons into the room from the wood lining of the room when no gadolinium is present, with a much steeper

gradient in the flux from the core into the room when gadolinium is present in the room linings.

In an ideal situation, it is expected that the neutron flux within the exposure rooms would decrease as  $1/r^2$  across the rooms. This distribution was not observed in the flux mapping, and was also not observed in the phantom tallies described above. Instead, observed results show a more even flux distribution throughout the room, beyond approximately 200 cm from the core midline. This conclusion is supported by the even more flattened flux within the exposure rooms seen when the gadolinium was removed from the wall linings of the room. This further supports the findings of the original studies on the gadolinium paint, that the paint reduces the thermal flux within the exposure rooms by a factor of 10-30.

```
09/23/09 05:59:49
c AFRRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/22/09 06:56:29
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -323.49, 0.00, 0.00)
extent = ( 363.08, 363.08)
```

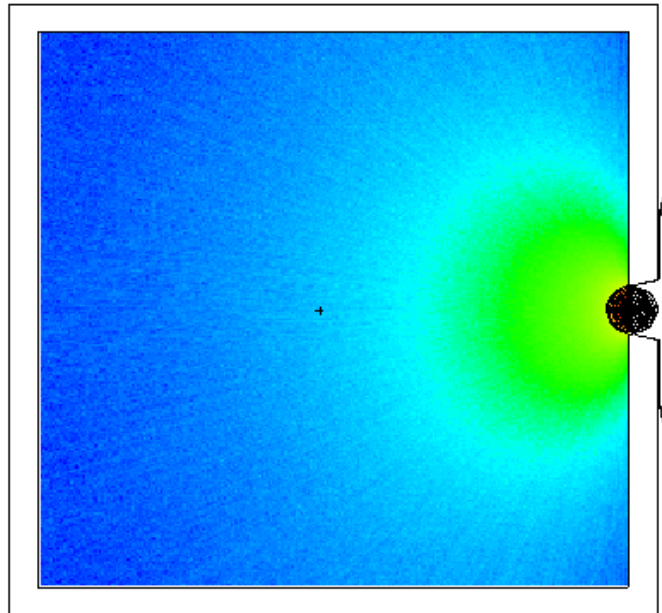


Figure 111. MCNP run of exposure room 1 showing the x-y plane through the core center, with gadolinium paint on room walls, floor or ceiling but no cadmium

shielding around the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/24/09 05:10:10
c AFRRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/23/09 07:07:37
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -298.45, 0.00, 0.00)
extent = ( 363.08, 363.08)
```

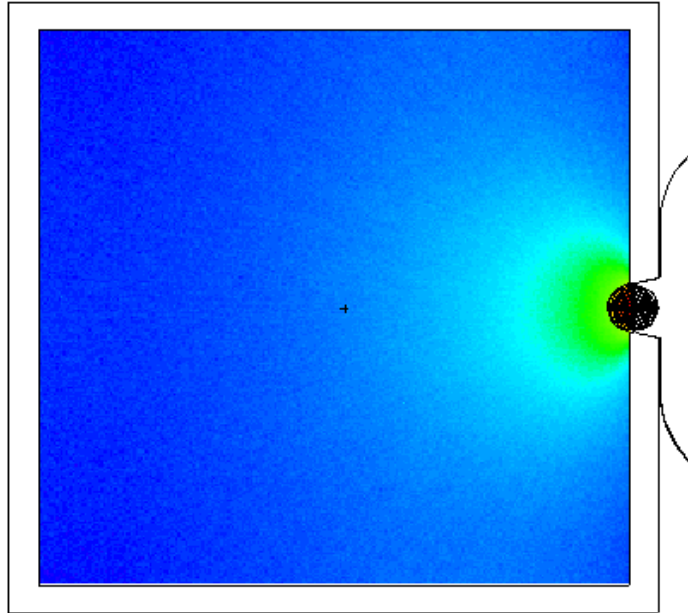


Figure 112. MCNP run of exposure room 1 showing the x-y plane through the core center, with no gadolinium paint on room walls, floor or ceiling and no cadmium shielding on the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/29/09 19:33:17
c  AFRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/28/09 22:38:53
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( -310.64,  0.00,  0.00)
extent = ( 371.54, 371.54)
```

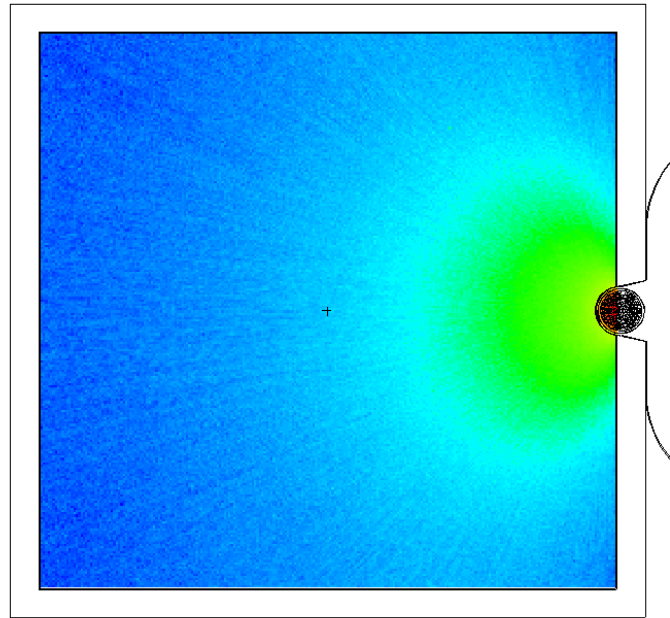


Figure 113. MCNP run of exposure room 1 showing the x-y plane through the core center, with gadolinium paint on room walls, floor and ceiling and cadmium shielding on the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/25/09 17:31:06
c - AFRRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/25/09 06:49:05
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -233.69, 0.00, 0.00)
extent = ( 457.09, 457.09)
```

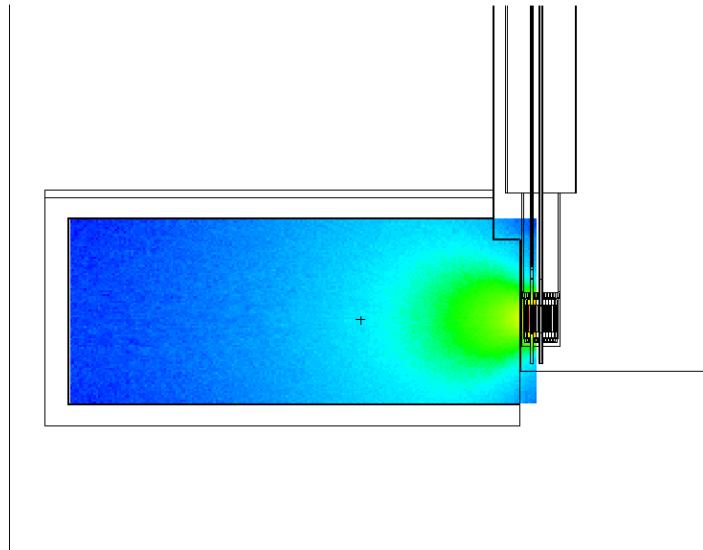


Figure 114. MCNP run of exposure room 1 showing the x-z plane through the core center, with gadolinium paint on room walls, floor or ceiling but no cadmium shielding surrounding the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/25/09 20:14:47
c AFRRRI TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/25/09 08:52:37
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -312.26, 0.00, 0.00)
extent = ( 416.87, 416.87)
```

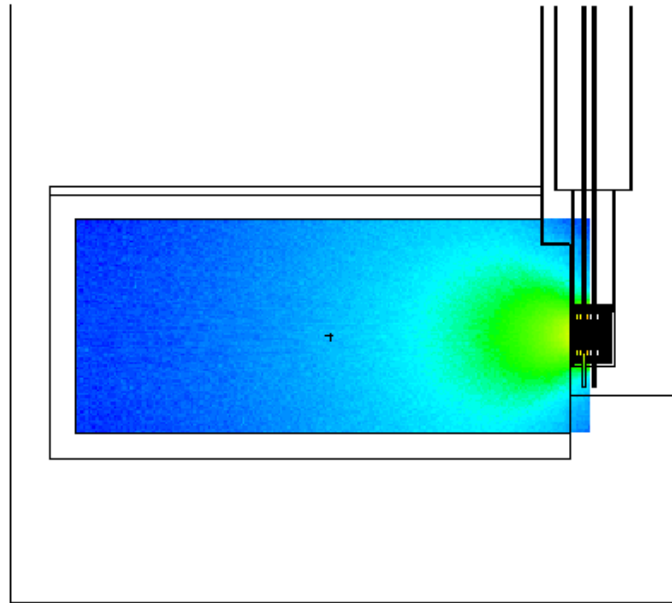


Figure 115. MCNP run of exposure room 1 showing the x-z plane through the core center, with no gadolinium paint on room walls, floor or ceiling and no cadmium shielding on the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/30/09 05:46:33
c  AFRR1 TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/29/09 20:06:10
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( -261.65,  0.00,  0.00)
extent = ( 407.38, 407.38)
```

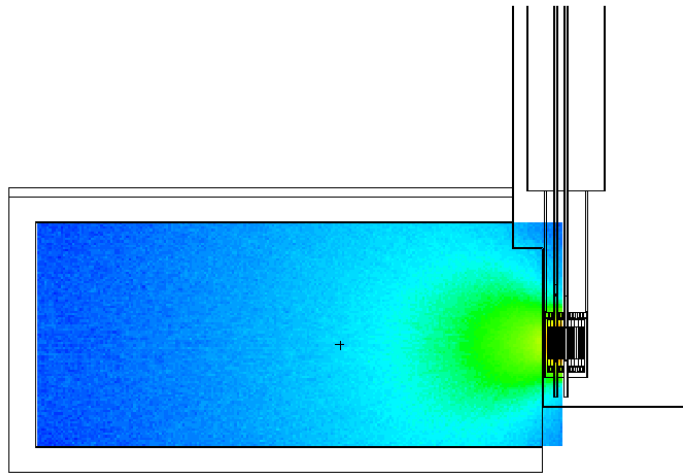


Figure 116. MCNP run of exposure room 1 showing the x-z plane through the core center, with gadolinium paint on room walls, floor and ceiling and cadmium shielding on the reactor tank protrusion wall, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

09/17/09 18:33:08  
c AFRRRI TRIGA Mark-F Reactor  
and supporting exposure  
facilities  
probid = 09/16/09 20:14:31  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 172.62, -14.53, 0.00)  
extent = ( 245.47, 245.47)

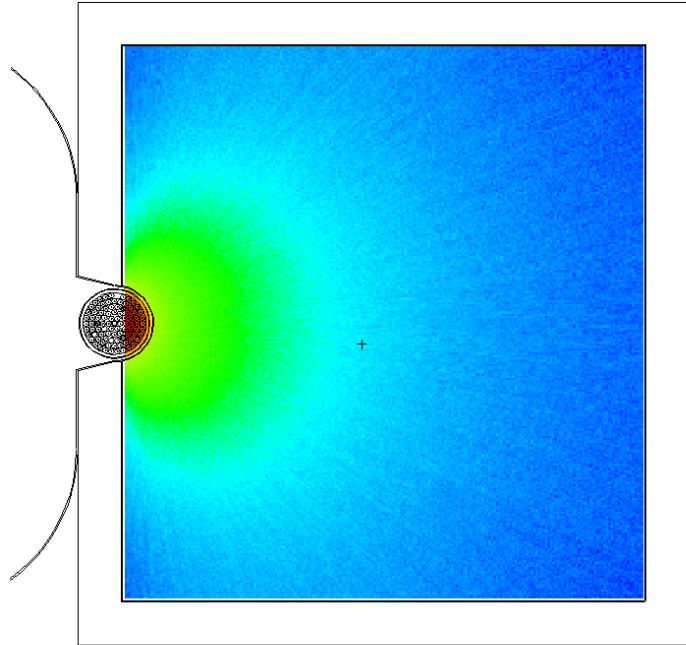


Figure 117. MCNP run of exposure room 2 showing the x-y plane through the core center, with gadolinium paint on room walls, floor or ceiling, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

09/18/09 21:47:24  
c AFRR1 TRIGA Mark-F Reactor  
and supporting exposure  
facilities  
probid = 09/18/09 05:53:24  
basis: XY  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 1.000000, 0.000000)  
origin:  
( 139.24, 25.57, 0.00)  
extent = ( 281.84, 281.84)

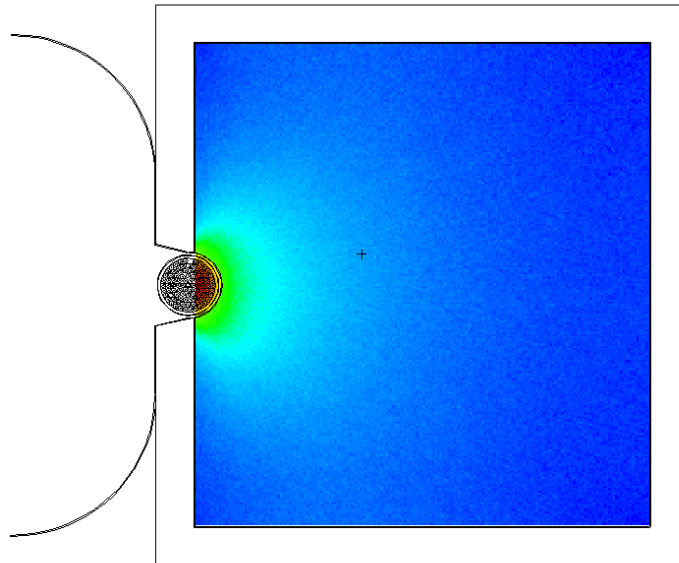


Figure 118. MCNP run of exposure room 2 showing the x-y plane through the core center, with no gadolinium paint on room walls, floor or ceiling, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

09/18/09 05:38:25  
c AFRRRI TRIGA Mark-F Reactor  
and supporting exposure  
facilities  
probid = 09/17/09 18:48:03  
basis: XZ  
( 1.000000, 0.000000, 0.000000)  
( 0.000000, 0.000000, 1.000000)  
origin:  
( 182.23, 0.00, 22.12)  
extent = ( 229.09, 229.09)

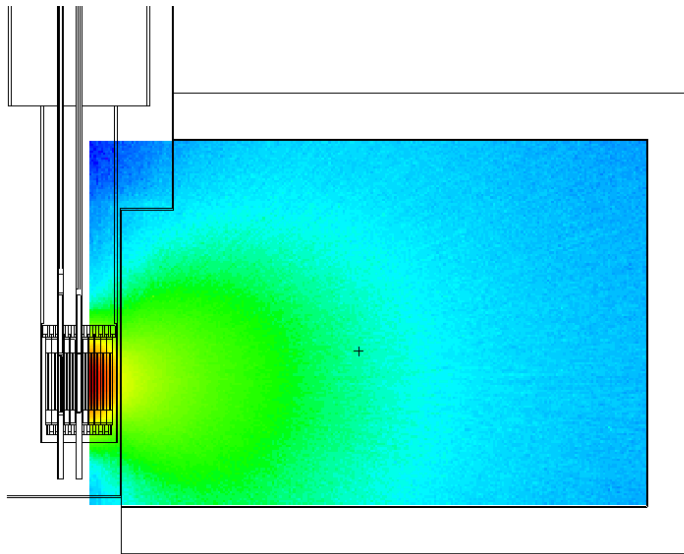


Figure 119. MCNP run of exposure room 2 showing the x-z plane through the core center, with gadolinium paint on room walls, floor or ceiling, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

```
09/19/09 07:40:12
c AFRR1 TRIGA Mark-F Reactor
and supporting exposure
facilities
probid = 09/18/09 21:53:42
basis: XZ
( 1.000000, 0.000000, 0.000000)
( 0.000000, 0.000000, 1.000000)
origin:
( 177.93, -6.27, 0.00)
extent = ( 234.42, 234.42)
```

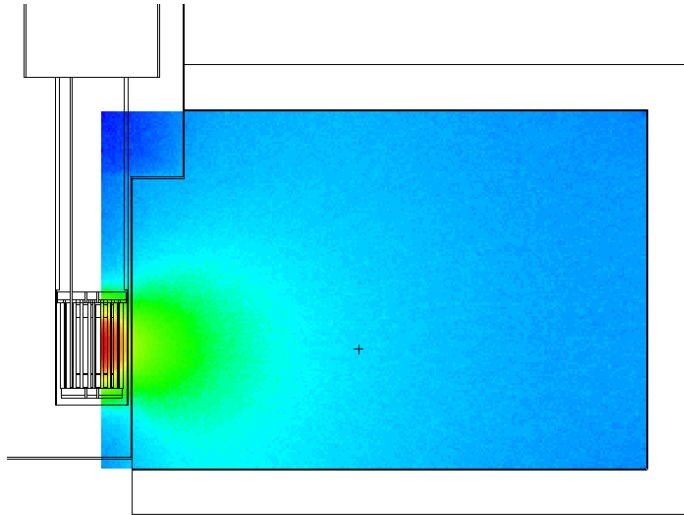


Figure 120. MCNP run of exposure room 2 showing the x-z plane through the core center, with no gadolinium paint on room walls, floor or ceiling, showing total neutron flux mapping within the exposure room. Red indicates areas of highest flux, blue areas of lowest flux.

#### Gadolinium—Does it Work?

The modeling of the flux within the exposure rooms confirms the experimental data from 1968—that the gadolinium is, in fact, an effective measure to reduce the flux, and hence the  $\text{Ar}^{41}$  production, within the exposure rooms.[116, 118, 119] It also further shows that the model is effective at modeling conditions within the exposure rooms.

## Chapter 6: Recommendations for Future Work

The completion of the MCNP model of the AFRRI TRIGA Mark F reactor and its associated exposure facilities provides a powerful tool for researchers to perform calculations involving the reactor facility. That said, however, there is much additional work which could be completed using the existing model or through its modification

### Fuel History and Depletion

The ability to move the AFRRI TRIGA core within the reactor pool and the subsequent changes to the flux profile within the core introduces the greatest degree of uncertainty among the variables involved in constructing the model. In order to more accurately determine the spatial distribution of fuel burnup, the position of the core in the pool and the total power generated in each run needs to be determined. Using that data, a complete history of the reactor's operations could be constructed, allowing the MCNPX burnup routine to be run for the reactor run time in each core position, yielding a cumulative burnup with a more accurate spatial distribution.

Fortunately this information could be reconstructed readily, albeit with much effort, from the set of existing reactor operation logbooks currently maintained by the AFRRI reactor staff. Indeed, the remarkable completeness of the reactor's operational records, as well as their on-site and readily accessible storage at AFRRI, presents an unprecedented opportunity for future research which might require records with this level of detail.

A detailed and accurate modeling of the burn-up within each element could prove quite valuable in implementing fuel management plans as excess reactivity within the core decreases to an extent that such techniques become necessary to maximize the use of existing fuel prior to shutdown or partial core refueling.[138]

### *Refining Reactor and Support Structure Modeling*

As noted in chapter 3, a number of approximations were made in the support structure of the reactor. While the results of the research show that these approximations do not significantly impact the results of the model, they could yield additional useful results.

#### Pneumatic Tube System

The pneumatic tube system originally installed with the reactor allowed the rapid insertion and removal of samples from the vicinity of the core when the core was positioned at core position 600—approximately at the location where the core protrusion into exposure room 2 joins the main portion of the reactor pool. While the system has not been used in nearly two decades, an effort is currently underway to restore the system. Modeling the tube system, or at least the section of it in close proximity to the core, would allow researchers to accurately predict the radiation fields experienced in the tubes, allowing more accurate estimates of radiation dose to samples in the tubes.

#### In-tank Shielding

The extensive shielding within the reactor pool used to shield personnel operating within one exposure room while an experiment is ongoing in the other

exposure room were not modeled. This was not believed to affect the outcome of the modeling, as the current research only models the radiation field within one exposure room at a time. A more detailed model of the shielding would serve to further confirm this hypothesis.

Moreover, the shielding is not made of solid lead, rather, the shields are aluminum alloy shells filled with reactor grade lead shot with a small amount of transformer oil to lubricate the shot. This could be more accurately modeled.

#### Exposure Room 1 Extractor System

The manual extractor system in exposure room 1, used to insert and remove small samples from the exposure room without opening the plug door, was not modeled. Modeling the extractor system would allow researchers to accurately determine the exposure of samples using the system.

#### Exposure room penetrations

Each of the exposure rooms contains a number of penetrations for air sampling, air circulation, and instrumentation cabling. These penetrations could be more explicitly modeled to determine the effectiveness of the shielding associated with the penetrations in reducing radiation exposure to personnel operating in the vicinity of the penetrations and the effects of radiation streaming, if any, through the penetrations.

#### *Addition of Animal Phantoms*

The model developed in support of this dissertation included modeling of radiation dose within phantoms, to replicate conditions used in measurements by the

AFRRI dosimetrists. MCNP has very powerful capabilities which could, however, be used to calculate specific organ dose to experimental animals or within tissue cultures being irradiated. Such organ specific doses would greatly inform the research supported by animal studies, in turn allowing better correlation between dose and effects observed in the animals. Although such MCNP models do have some limitations, particularly at soft tissue/bone interfaces, they would serve researchers much better than the current dosimetry modeling.

While models of several species of animals used by the AFRRI in its animal work can be found, and could be used, such pre-existing models are less than optimal for AFRRI's research purposes. As a better alternative, new models could be created using CT or MRI imaging techniques.[139] Developing MCNP animal phantoms using this technique would provide significant flexibility because animals could be scanned and modeled in the same positions in which they would be exposed.

Such models would have the added advantage of also being useful in any further future modeling of AFRRI's exposure facilities other than the TRIGA reactor facility.

### *Transient Behavior*

The model currently operates in the steady state mode. Additional work should be done to model behavior of the reactor in pulse mode. Similar modeling of pulse behavior on other TRIGAs has shown interesting results, including that existing models of the TRIGA system behavior may underestimate maximum power, total power, and pulse duration during operations.

### Modeling

Some additional changes to the model could make it easier to work with on a routine basis. For example, while the placement of the origin of the model's coordinate system simplified the movement of the core within the pool (or, more accurately, the pool and supporting facilities around the core), defining the core, core shroud, and support structure as a universe could allow its movement with a single command, reducing the possibility of introducing errors into the model while changing the input file to move the core.

### Modeling the Source Term

A significant amount of computational power and time is consumed in tracking particles generated in the core, many of which do not reach the exposure room under examination. Modeling the energy dependant neutron and gamma fluxes across the tank wall adjacent to the exposure room under examination, and in turn converting that to a surface source, would greatly reduce computational time and improve the quality of results within the exposure room. By breaking computations into two parts in this manner, significant increases in problem execution speeds could be achieved, particular in repeated permutations within the exposure room using the same core configuration as a source.

## Appendix 1—Core Position 250

Presented below is the MCNP source file for the AFRRI TRIGA reactor in core position 250.

```
c  AFRRI TRIGA Mark-F Reactor and supporting exposure facilities
c  Core position 250
C  Cell cards
c  -----
c  Control rod A1
c  -----
C  cell 1110 is the air gap surrounding the B4C poison section
1110 9 -0.001205 1001 -1002 1011 -1009      imp:n=1
C  cell 1111 is the air follower
1111 9 -0.001205 -1002 1008 -1010          imp:n=1
c  cell 1112 is a stainless steel spacer between the poison section
c  and the air follower
1112 5 -7.92 1010 -1011 -1002            imp:n=1
C  cell 1113 is the B4C poison section
1113 6 0.135714 -1001 1011 -1009          imp:n=1
C  cell 1115 is the cladding
1115 5 -7.92 (1002:-1008: 1009) (-1003 1006 -1012):
      (-1004 -503 1012)                    imp:n=1
c  -----
c  Control rod D1
c  -----
C  cell 1120 is the zirconium center rod of the fuel follower section
1120 1 -6.51 -1021 1028 -1030            imp:n=1
C  cell 1121 is the fuel follower section
1121 10 0.09626819 1021 -1025 1028 -1030    imp:n=1
C  cell 1122 is the lower Magnaform
1122 5 -7.92 -1022 1034 -1031            imp:n=1
C  cell 1123 is the B4C poison section
1123 6 0.135714 -1037 1031 -1029          imp:n=1
C  cell 1124 is the void at the top of the fuel element
1124 9 -0.001205 -1022 1036 -1027          imp:n=1
C  cell 1125 is the cladding
1125 5 -7.92 (1022:-1028: 1027)
      (-1023 1026 -1032):
      (-1024 -503 1032)
                                           imp:n=1
```

c cell 1126 is the fuel follower gap  
1126 9 -0.001205 1025 -1022 1028 -1030 imp:n=1  
c cell 1127 is the fuel follower/clad void  
1127 9 -0.001205 1030 -1034 -1022 imp:n=1  
c cell 1128 is the poison section/clad gap  
1128 9 -0.001205 1031 -1029 1037 -1022 imp:n=1  
c cell 1129 is the poison section void  
1129 9 -0.001205 1029 -1035 -1022 imp:n=1  
c cell 1152 is the upper Magnaform  
1152 5 -7.92 1035 -1036 -1022 imp:n=1  
c -----  
c Control rod D7  
c -----  
C cell 1130 is the zirconium center rod of the fuel follower section  
1130 1 -6.51 -1041 1048 -1050 imp:n=1  
C cell 1131 is the fuel follower section  
1131 10 0.09626819 1041 -1045 1048 -1050 imp:n=1  
C cell 1132 is the lower Magnaform  
1132 5 -7.92 -1042 1054 -1051 imp:n=1  
C cell 1133 is the B4C poison section  
1133 6 0.135714 -1058 1051 -1049 imp:n=1  
C cell 1134 is the void at the top of the fuel element  
1134 9 -0.001205 -1042 1056 -1047 imp:n=1  
C cell 1135 is the cladding  
1135 5 -7.92 (1042:-1048: 1047)  
(-1043 1046 -1052):  
(-1044 -503 1052)  
imp:n=1  
c cell 1136 is the fuel follower gap  
1136 9 -0.001205 1045 -1042 1048 -1050 imp:n=1  
c cell 1137 is the fuel follower/clad void  
1137 9 -0.001205 1050 -1054 -1042 imp:n=1  
c cell 1138 is the poison section/clad gap  
1138 9 -0.001205 1051 -1049 1058 -1042 imp:n=1  
c cell 1139 is the poison section void  
1139 9 -0.001205 1049 -1055 -1042 imp:n=1  
c cell 1153 is the upper Magnaform  
1153 5 -7.92 1055 -1056 -1042 imp:n=1  
c -----  
c Control rod D13  
c -----  
C cell 1140 is the zirconium center rod of the fuel follower section  
1140 1 -6.51 -1061 1068 -1070 imp:n=1  
C cell 1141 is the fuel follower section  
1141 10 0.09626819 1061 -1065 1068 -1070 imp:n=1  
C cell 1142 is the lower Magnaform

```

1142 5 -7.92 -1062 1074 -1071          imp:n=1
C   cell 1143 is the B4C poison section
1143 6 0.135714 -1078 1071 -1069       imp:n=1
C   cell 1144 is the void at the top of the fuel element
1144 9 -0.001205 -1062 1076 -1067     imp:n=1
C   cell 1145 is the cladding
1145 5 -7.92 (1062:-1068: 1067)
      (-1063 1066 -1072):
      (-1064 -503 1072)
                                     imp:n=1
c   cell 1146 is the fuel follower gap
1146 9 -0.001205 1065 -1062 1068 -1070  imp:n=1
c   cell 1147 is the fuel follower/clad void
1147 9 -0.001205 1070 -1074 -1062     imp:n=1
c   cell 1148 is the poison section/clad gap
1148 9 -0.001205 1071 -1069 1078 -1062  imp:n=1
c   cell 1149 is the poison section void
1149 9 -0.001205 1069 -1075 -1062     imp:n=1
c   cell 1143 is the upper Magnaform
1150 5 -7.92 1075 -1076 -1062         imp:n=1
C   -----
C   Cells 501 thru 508 define a fuel element to fill cell 401's universe
c   -----
C
C   Cell 501 is the central zirconium rod
501 1 -6.51 -1 -4 5                    u=1 imp:n=1
C   Cell 502 is the fuel area of the fuel rod
502 2 0.09690183 1 -2 -4 5            u=1 imp:n=1
C   Cell 503 is the upper Samarium/aluminum poison disk
503 3 -5.27 4 -6 -2                   u=1 imp:n=1
C   Cell 504 is the lower Samarium/aluminum poison disk
504 3 -5.27 -5 7 -2                   u=1 imp:n=1
C   Cell 505 is the upper Carbon reflector
505 4 -1.75 -8 6 -2                   u=1 imp:n=1
C   Cell 506 is the lower Carbon Reflector
506 4 -1.75 -7 9 -2                   u=1 imp:n=1
C   Cell 507 is the Stainless Steel cladding of the fuel element
C   and support structure
507 5 -7.92 2:15:-9                   u=1 imp:n=1
C   Cell 508 is the void at the top of the fuel element
508 9 -0.001205 -2 -15 8              u=1 imp:n=1
C   Cell 401 creates a universe for the fuel element to be replicated later
401 0 (-3 -10 11)                     fill=1 imp:n=1
c
C   -----
c   Cell 202 is the lower grid plate

```

```

c -----
202 7 0.059195
-200 201 -202 203 204 205 206 207 208 209
210 211 213 214 215 216 217 218 219
220 221 222 223 224 225 226 227 228 229
230 231 232 233 234 235 236 237 238 239
240 241 242 243 244 245 246 247 248 249
250 251 252 253 254 255 256 257 258 259
260 261 262 263 264 265 266 267 268 269
270 271 272 273 274 275 276 277 278 279
280 281 282 283 284 285 286 287 288 289
290 291 292 293 294
imp:n=1
C -----
c Cell 301 is the lower plenum region
c -----
301 8 -1.0
-11 200 -202 203 204 205 206 207 208 209
210 211 213 214 215 216 217 218 219
220 221 222 223 224 225 226 227 228 229
230 231 232 233 234 235 236 237 238 239
240 241 242 243 244 245 246 247 248 249
250 251 252 253 254 255 256 257 258 259
260 261 262 263 264 265 266 267 268 269
270 271 272 274 275 276 277 278 279
280 281 282 283 284 285 286 287 288 289
290 291 292 293 294
imp:n=1
C -----
c Cell 300 is the reactor pool inside the support structure
c -----
300 8 -1.0 ((11: -201: 202:-203:-223:-229:-235)
(10: -11: -203:-223:-229:-235: 152)
(13: -51: 52: -53: -73: -79: -85)
223 229 203 235 (113 201)
(-1080 1084 -1085):
(-1088 -1087 1085 203 223 229 235 (113 201))):
(-201 203 223 229 235 1084 -1080)
imp:n=1
c
C -----
c core shroud and support structure
c -----
c
c cell 350 is the core shroud
350 7 0.059195 1080 -1081 1084 -1085 imp:n=1

```

c cell 351 is the core support  
351 7 0.059195 1082 -1083 1087 -503 imp:n=1  
c cell 353 is the shroud support extension  
353 7 0.059195 1088 -1081 1085 -1087 imp:n=1  
c Cell 352 is the reactor pool  
352 8 -1.0 (((500 -502 1083 (-504:-505)):  
(-506 507 -520 521 500 -502):  
(500 -501 -508):  
(500 -501 -510):  
(501 -502 -509):  
(501 -502 -511):  
(501 -502 -516 506 -512 -515):  
(501 -502 519 -507 -522 -523):  
(500 -501 -516 506 -513 -514):  
(500 -501 519 -507 -517 -518)))  
(((-502 1083 1087):  
(-1087 1084 1081)):  
(-1084 1033 203 235 223 229):  
(-1033 500))  
imp:n=1  
c Cell 354 is the air in the tank above the water level  
354 9 -0.001205 ((502 -503 (-504:-505)):  
(-506 507 -520 521 502 -503):  
(502 -503 -516 506 -512 -515):  
(502 -503 519 -507 -522 -523):  
(502 -503 -519 -511):  
(502 -503 516 -509)) 1083  
imp:n=1  
c Cell 355 is the reactor tank lining  
355 7 0.059195 (-500 550 (-552: -553)):  
(-554 555 -520 521 550 -500):  
(550 -500 -556 516):  
(550 -500 -558 -519):  
(550 -500 -516 554 -562 -563):  
(550 -500 519 -507 -564 -565):  
551 -501 ((516 508 -557):  
(513 506 -516 -566):  
(514 506 -516 -567)):  
551 -501((-519 510 -559):  
(517 -507 519 -568):  
(518 -507 519 -569)):  
(500 -503)((505 -553 -521):  
(504 -552 520)):  
500 -551 ((513 506 -554 -520):  
(514 506 -554 521):  
(517 -507 555 -520):

(518 -507 555 521):  
 ((516 508 -556):  
 (506 -516 513 -562):  
 (506 -516 514 -563)):  
 ((-519 510 -558):  
 (-507 519 517 -564):  
 (-507 519 518 -565)))  
 (501 -503(((512 506 -554 -520):  
 (515 506 -554 521))):  
 (-520 568 -507 555):  
 (521 569 -507 555):  
 ((516 509 -557):  
 (506 -516 512 -566):  
 (506 -516 515 -567))):  
 ((-519 511 -559):  
 (-507 519 522 -568):  
 (-507 519 523 -569))))):  
 ( 506 -554 -501 551 -520 566):  
 ( 506 -554 -501 551 567 521):  
 (-501 551 555 -507 -520 568):  
 (-501 551 555 -507 521 569)

imp:n=1

c Cell 356 is the air inside the top of the core support structure

356 9 -0.001205 502 -503 -1082

223

229

235

203

imp:n=1

c Cell 357 is the water inside the core support

357 8 -1.0 -1082 1087 -502

223

229

235

203

imp:n=1

c

c -----

c control rod support structure

c -----

c

c cell 304 holds control rod A1

304 8 -1.0 (-1006:1003:

(1012 1004))

(-1013 1033 -502) imp:n=1

c cell 305 holds control rod D1

305 8 -1.0 (-1026:1023:  
(1032 1024))  
(-1039 1033 -502) imp:n=1  
c cell 306 holds control rod D7

306 8 -1.0 (-1046:1043:  
(1052 1044))  
(-1053 1033 -502) imp:n=1  
c cell 307 holds control rod D13

307 8 -1.0 (-1066:1063:  
(1072 1064))  
(-1073 1033 -502) imp:n=1  
c Cell 150 is the water filled region in rings B thru D

150 8 -1.0 (-10 11 203 223 229 235 -150)  
( 3: 10: -11)  
402003 403003 404003 405003 406003 407003 408003 409003 410003  
411003 412003 413003 414003 415003 416003 417003 418003 420003  
421003 422003 423003 424003 426003 428003 429003 430003 431003  
433003 434003 435003 436003 437003  
imp:n=1  
c Cell 151 is a water filled torus in ring E

151 8 -1.0 -10 11 150 -151  
438003 439003 440003 441003 442003 443003 444003 445003 446003  
447003 448003 449003 450003 451003 452003 453003 454003 455003  
456003 457003 458003 459003 461003 113  
imp:n=1  
c Cell 152 is a water filled torus in ring F

152 8 -1.0 -10 11 151 -152  
462003 463003 464003 465003 466003 467003 468003 469003  
471003 472003 473003 474003 475003 476003 477003 478003 479003  
480003 481003 482003 483003 484003 485003 486003 487003 488003  
489003 490003 491003  
imp:n=1  
c  
c -----  
c Cell 900 is the concrete surrounding the reactor  
c -----

900 13 -2.25 ((-503 800 802 -850 -804 805):  
(-503 800 850 -803 806 -807))  
(503: -550: (564 519 -555 -551):  
(565 519 -555 -551):  
(554 -516 563 -551):  
(554 -516 562 -551):  
(556 516 -551):  
(558 -551 -519):  
(552 520):  
(553 -521):

(551 519 568 -555):  
 (551 519 569 -555):  
 (-519 559 551):  
 (551 554 566 -516):  
 (551 554 567 -516):  
 (516 551 557))  
 ((555: -601: 602: -603: -604: 605):  
 (555 519 -564 -565 -551):  
 (-519 -558 -551):  
 (-519 -559 551):  
 (-555 519 -568 -569 551):  
 (-555 -564 -565 519 -551))  
 ((-554: 651: 652: -653: -654: 655):  
 (554 -516 -562 -563 -551):  
 (516 -556 -551):  
 (516 -557 551):  
 (554 -516 -566 -567 551):  
 (554 -562 -563 -516 -551))

imp:n=1

C -----

c Cell 901 is the outside world

c -----

901 0 (503: -800: -802: 850: 804: -805)  
 (503: -800: -850: 803: -806: 807)

imp:n=0

c

c -----

C Cell 201 is the top grid plate

c -----

C

201 7 0.059195

-50 51 -52 53 54 55 56 57 58 59  
 60 61 63 64 65 66 67 68 69  
 70 71 72 73 74 75 76 77 78 79  
 80 81 82 83 84 85 86 87 88 89  
 90 91 92 93 94 95 96 97 98 99  
 100 101 102 103 104 105 106 107 108 109  
 110 111 112 113 114 115 116 117 118 119  
 120 121 122 123 124 125 126 127 128 129  
 130 131 132 133 134 135 136 137 138 139  
 140 141 142 143 144 imp:n=1

c

C -----

c cell 302 is the water in the upper plenum region

c -----

c

302 8 -1.0  
 -13 50 -52 53 204 205 206 207 208 209  
 210 211 213 214 215 216 217 218 219  
 220 221 222 73 224 225 226 227 228 79  
 230 231 232 233 234 85 236 237 238 239  
 240 241 242 243 244 245 246 247 248 249  
 250 251 252 253 254 255 256 257 258 259  
 260 261 262 113 264 265 266 267 268 269  
 270 271 272 274 275 276 277 278 279  
 280 281 282 283 284 285 286 287 288 289  
 290 291 292 293 294 imp:n=1  
 601 8 -1.0 -50 204 10 -54 imp:n=1 \$ B1  
 602 8 -1.0 -50 205 10 -55 imp:n=1 \$ B2  
 603 8 -1.0 -50 206 10 -56 imp:n=1 \$ B3  
 604 8 -1.0 -50 207 10 -57 imp:n=1 \$ B4  
 605 8 -1.0 -50 208 10 -58 imp:n=1 \$ B5  
 606 8 -1.0 -50 209 10 -59 imp:n=1 \$ B6  
 607 8 -1.0 -50 210 10 -60 imp:n=1 \$ C1  
 608 8 -1.0 -50 211 10 -61 imp:n=1 \$ C2  
 609 8 -1.0 -50 213 10 -63 imp:n=1 \$ C3  
 610 8 -1.0 -50 214 10 -64 imp:n=1 \$ C4  
 611 8 -1.0 -50 215 10 -65 imp:n=1 \$ C5  
 612 8 -1.0 -50 216 10 -66 imp:n=1 \$ C6  
 613 8 -1.0 -50 217 10 -67 imp:n=1 \$ C7  
 614 8 -1.0 -50 218 10 -68 imp:n=1 \$ C8  
 615 8 -1.0 -50 219 10 -69 imp:n=1 \$ C9  
 616 8 -1.0 -50 220 10 -70 imp:n=1 \$ C10  
 617 8 -1.0 -50 221 10 -71 imp:n=1 \$ C11  
 618 8 -1.0 -50 222 10 -72 imp:n=1 \$ C12  
 619 8 -1.0 -50 224 10 -74 imp:n=1 \$ D2  
 620 8 -1.0 -50 225 10 -75 imp:n=1 \$ D3  
 621 8 -1.0 -50 226 10 -76 imp:n=1 \$ D4  
 622 8 -1.0 -50 227 10 -77 imp:n=1 \$ D5  
 623 8 -1.0 -50 228 10 -78 imp:n=1 \$ D6  
 624 8 -1.0 -50 230 10 -80 imp:n=1 \$ D8  
 625 8 -1.0 -50 231 10 -81 imp:n=1 \$ D9  
 626 8 -1.0 -50 232 10 -82 imp:n=1 \$ D20  
 627 8 -1.0 -50 233 10 -83 imp:n=1 \$ D11  
 628 8 -1.0 -50 234 10 -84 imp:n=1 \$ D12  
 629 8 -1.0 -50 236 10 -86 imp:n=1 \$ D14  
 630 8 -1.0 -50 237 10 -87 imp:n=1 \$ D15  
 631 8 -1.0 -50 238 10 -88 imp:n=1 \$ D16  
 632 8 -1.0 -50 239 10 -89 imp:n=1 \$ D17  
 633 8 -1.0 -50 240 10 -90 imp:n=1 \$ D18  
 634 8 -1.0 -50 241 10 -91 imp:n=1 \$ E1  
 635 8 -1.0 -50 242 10 -92 imp:n=1 \$ E2

636	8 -1.0	-50	243	10 -93	imp:n=1 \$ E3
637	8 -1.0	-50	244	10 -94	imp:n=1 \$ E4
638	8 -1.0	-50	245	10 -95	imp:n=1 \$ E5
639	8 -1.0	-50	246	10 -96	imp:n=1 \$ E6
640	8 -1.0	-50	247	10 -97	imp:n=1 \$ E7
641	8 -1.0	-50	248	10 -98	imp:n=1 \$ E8
642	8 -1.0	-50	249	10 -99	imp:n=1 \$ E9
643	8 -1.0	-50	250	10 -100	imp:n=1 \$ E10
644	8 -1.0	-50	251	10 -101	imp:n=1 \$ E11
645	8 -1.0	-50	252	10 -102	imp:n=1 \$ E12
646	8 -1.0	-50	253	10 -103	imp:n=1 \$ E13
647	8 -1.0	-50	254	10 -104	imp:n=1 \$ E14
648	8 -1.0	-50	255	10 -105	imp:n=1 \$ E15
649	8 -1.0	-50	256	10 -106	imp:n=1 \$ E16
650	8 -1.0	-50	257	10 -107	imp:n=1 \$ E17
651	8 -1.0	-50	258	10 -108	imp:n=1 \$ E18
652	8 -1.0	-50	259	10 -109	imp:n=1 \$ E19
653	8 -1.0	-50	260	10 -110	imp:n=1 \$ E20
654	8 -1.0	-50	261	10 -111	imp:n=1 \$ E21
655	8 -1.0	-50	262	10 -112	imp:n=1 \$ E22
657	8 -1.0	-50	264	10 -114	imp:n=1 \$ E24
658	8 -1.0	-50	265	10 -115	imp:n=1 \$ F1
659	8 -1.0	-50	266	10 -116	imp:n=1 \$ F2
660	8 -1.0	-50	267	10 -117	imp:n=1 \$ F3
661	8 -1.0	-50	268	10 -118	imp:n=1 \$ F4
662	8 -1.0	-50	269	10 -119	imp:n=1 \$ F5
663	8 -1.0	-50	270	10 -120	imp:n=1 \$ F6
664	8 -1.0	-50	271	10 -121	imp:n=1 \$ F7
665	8 -1.0	-50	272	10 -122	imp:n=1 \$ F8
666	8 -1.0	-50	10 -123	imp:n=1 \$ F9	
667	8 -1.0	-50	274	10 -124	imp:n=1 \$ F10
668	8 -1.0	-50	275	10 -125	imp:n=1 \$ F11
669	8 -1.0	-50	276	10 -126	imp:n=1 \$ F12
670	8 -1.0	-50	277	10 -127	imp:n=1 \$ F13
671	8 -1.0	-50	278	10 -128	imp:n=1 \$ F14
672	8 -1.0	-50	279	10 -129	imp:n=1 \$ F15
673	8 -1.0	-50	280	10 -130	imp:n=1 \$ F16
674	8 -1.0	-50	281	10 -131	imp:n=1 \$ F17
675	8 -1.0	-50	282	10 -132	imp:n=1 \$ F18
676	8 -1.0	-50	283	10 -133	imp:n=1 \$ F19
677	8 -1.0	-50	284	10 -134	imp:n=1 \$ F20
678	8 -1.0	-50	285	10 -135	imp:n=1 \$ F21
679	8 -1.0	-50	286	10 -136	imp:n=1 \$ F22
680	8 -1.0	-50	287	10 -137	imp:n=1 \$ F23
681	8 -1.0	-50	288	10 -138	imp:n=1 \$ F24
682	8 -1.0	-50	289	10 -139	imp:n=1 \$ F25

683	8	-1.0	-50	290	10	-140	imp:n=1 \$ F26
684	8	-1.0	-50	291	10	-141	imp:n=1 \$ F27
685	8	-1.0	-50	292	10	-142	imp:n=1 \$ F28
686	8	-1.0	-50	293	10	-143	imp:n=1 \$ F29
687	8	-1.0	-50	294	10	-144	imp:n=1 \$ F30
54	5	-7.92	-54	-10	51:	(-204 -13 10)	imp:n=1 \$ B1
55	5	-7.92	-55	-10	51:	(-205 -13 10)	imp:n=1 \$ B2
56	5	-7.92	-56	-10	51:	(-206 -13 10)	imp:n=1 \$ B3
57	5	-7.92	-57	-10	51:	(-207 -13 10)	imp:n=1 \$ B4
58	5	-7.92	-58	-10	51:	(-208 -13 10)	imp:n=1 \$ B5
59	5	-7.92	-59	-10	51:	(-209 -13 10)	imp:n=1 \$ B6
60	5	-7.92	-60	-10	51:	(-210 -13 10)	imp:n=1 \$ C1
61	5	-7.92	-61	-10	51:	(-211 -13 10)	imp:n=1 \$ C2
63	5	-7.92	-63	-10	51:	(-213 -13 10)	imp:n=1 \$ C3
64	5	-7.92	-64	-10	51:	(-214 -13 10)	imp:n=1 \$ C4
65	5	-7.92	-65	-10	51:	(-215 -13 10)	imp:n=1 \$ C5
66	5	-7.92	-66	-10	51:	(-216 -13 10)	imp:n=1 \$ C6
67	5	-7.92	-67	-10	51:	(-217 -13 10)	imp:n=1 \$ C7
68	5	-7.92	-68	-10	51:	(-218 -13 10)	imp:n=1 \$ C8
69	5	-7.92	-69	-10	51:	(-219 -13 10)	imp:n=1 \$ C9
70	5	-7.92	-70	-10	51:	(-220 -13 10)	imp:n=1 \$ C10
71	5	-7.92	-71	-10	51:	(-221 -13 10)	imp:n=1 \$ C11
72	5	-7.92	-72	-10	51:	(-222 -13 10)	imp:n=1 \$ C12
74	5	-7.92	-74	-10	51:	(-224 -13 10)	imp:n=1 \$ D2
75	5	-7.92	-75	-10	51:	(-225 -13 10)	imp:n=1 \$ D3
76	5	-7.92	-76	-10	51:	(-226 -13 10)	imp:n=1 \$ D4
77	5	-7.92	-77	-10	51:	(-227 -13 10)	imp:n=1 \$ D5
78	5	-7.92	-78	-10	51:	(-228 -13 10)	imp:n=1 \$ D6
80	5	-7.92	-80	-10	51:	(-230 -13 10)	imp:n=1 \$ D8
81	5	-7.92	-81	-10	51:	(-231 -13 10)	imp:n=1 \$ D9
82	5	-7.92	-82	-10	51:	(-232 -13 10)	imp:n=1 \$ D10
83	5	-7.92	-83	-10	51:	(-233 -13 10)	imp:n=1 \$ D11
84	5	-7.92	-84	-10	51:	(-234 -13 10)	imp:n=1 \$ D12
86	5	-7.92	-86	-10	51:	(-236 -13 10)	imp:n=1 \$ D14
87	5	-7.92	-87	-10	51:	(-237 -13 10)	imp:n=1 \$ D15
88	5	-7.92	-88	-10	51:	(-238 -13 10)	imp:n=1 \$ D16
89	5	-7.92	-89	-10	51:	(-239 -13 10)	imp:n=1 \$ D17
90	5	-7.92	-90	-10	51:	(-240 -13 10)	imp:n=1 \$ D18
91	5	-7.92	-91	-10	51:	(-241 -13 10)	imp:n=1 \$ E1
92	5	-7.92	-92	-10	51:	(-242 -13 10)	imp:n=1 \$ E2
93	5	-7.92	-93	-10	51:	(-243 -13 10)	imp:n=1 \$ E3
94	5	-7.92	-94	-10	51:	(-244 -13 10)	imp:n=1 \$ E4
95	5	-7.92	-95	-10	51:	(-245 -13 10)	imp:n=1 \$ E5
96	5	-7.92	-96	-10	51:	(-246 -13 10)	imp:n=1 \$ E6
97	5	-7.92	-97	-10	51:	(-247 -13 10)	imp:n=1 \$ E7
98	5	-7.92	-98	-10	51:	(-248 -13 10)	imp:n=1 \$ E8

99	5	-7.92	-99	-10	51:(-249 -13 10)	imp:n=1 \$ E9
100	5	-7.92	-100	-10	51:(-250 -13 10)	imp:n=1 \$ E10
101	5	-7.92	-101	-10	51:(-251 -13 10)	imp:n=1 \$ E11
102	5	-7.92	-102	-10	51:(-252 -13 10)	imp:n=1 \$ E12
103	5	-7.92	-103	-10	51:(-253 -13 10)	imp:n=1 \$ E13
104	5	-7.92	-104	-10	51:(-254 -13 10)	imp:n=1 \$ E14
105	5	-7.92	-105	-10	51:(-255 -13 10)	imp:n=1 \$ E15
106	5	-7.92	-106	-10	51:(-256 -13 10)	imp:n=1 \$ E16
107	5	-7.92	-107	-10	51:(-257 -13 10)	imp:n=1 \$ E17
108	5	-7.92	-108	-10	51:(-258 -13 10)	imp:n=1 \$ E18
109	5	-7.92	-109	-10	51:(-259 -13 10)	imp:n=1 \$ E19
110	5	-7.92	-110	-10	51:(-260 -13 10)	imp:n=1 \$ E20
111	5	-7.92	-111	-10	51:(-261 -13 10)	imp:n=1 \$ E21
112	5	-7.92	-112	-10	51:(-262 -13 10)	imp:n=1 \$ E22
114	5	-7.92	-114	-10	51:(-264 -13 10)	imp:n=1 \$ E24
115	5	-7.92	-115	-10	51:(-265 -13 10)	imp:n=1 \$ F1
116	5	-7.92	-116	-10	51:(-266 -13 10)	imp:n=1 \$ F2
117	5	-7.92	-117	-10	51:(-267 -13 10)	imp:n=1 \$ F3
118	5	-7.92	-118	-10	51:(-268 -13 10)	imp:n=1 \$ F4
119	5	-7.92	-119	-10	51:(-269 -13 10)	imp:n=1 \$ F5
120	5	-7.92	-120	-10	51:(-270 -13 10)	imp:n=1 \$ F6
121	5	-7.92	-121	-10	51:(-271 -13 10)	imp:n=1 \$ F7
122	5	-7.92	-122	-10	51:(-272 -13 10)	imp:n=1 \$ F8
124	5	-7.92	-124	-10	51:(-274 -13 10)	imp:n=1 \$ F9
125	5	-7.92	-125	-10	51:(-275 -13 10)	imp:n=1 \$ F10
126	5	-7.92	-126	-10	51:(-276 -13 10)	imp:n=1 \$ F11
127	5	-7.92	-127	-10	51:(-277 -13 10)	imp:n=1 \$ F12
128	5	-7.92	-128	-10	51:(-278 -13 10)	imp:n=1 \$ F13
129	5	-7.92	-129	-10	51:(-279 -13 10)	imp:n=1 \$ F14
130	5	-7.92	-130	-10	51:(-280 -13 10)	imp:n=1 \$ F15
131	5	-7.92	-131	-10	51:(-281 -13 10)	imp:n=1 \$ F16
132	5	-7.92	-132	-10	51:(-282 -13 10)	imp:n=1 \$ F17
133	5	-7.92	-133	-10	51:(-283 -13 10)	imp:n=1 \$ F18
134	5	-7.92	-134	-10	51:(-284 -13 10)	imp:n=1 \$ F19
135	5	-7.92	-135	-10	51:(-285 -13 10)	imp:n=1 \$ F20
136	5	-7.92	-136	-10	51:(-286 -13 10)	imp:n=1 \$ F21
137	5	-7.92	-137	-10	51:(-287 -13 10)	imp:n=1 \$ F22
138	5	-7.92	-138	-10	51:(-288 -13 10)	imp:n=1 \$ F24
139	5	-7.92	-139	-10	51:(-289 -13 10)	imp:n=1 \$ F25
140	5	-7.92	-140	-10	51:(-290 -13 10)	imp:n=1 \$ F26
141	5	-7.92	-141	-10	51:(-291 -13 10)	imp:n=1 \$ F27
142	5	-7.92	-142	-10	51:(-292 -13 10)	imp:n=1 \$ F28
143	5	-7.92	-143	-10	51:(-293 -13 10)	imp:n=1 \$ F29
144	5	-7.92	-144	-10	51:(-294 -13 10)	imp:n=1 \$ F30

c

C -----

c Cells in bottom plate

c -----

c

204	5	-7.92	201	-11	-204	imp:n=1 \$ B1
205	5	-7.92	201	-11	-205	imp:n=1 \$ B2
206	5	-7.92	201	-11	-206	imp:n=1 \$ B3
207	5	-7.92	201	-11	-207	imp:n=1 \$ B4
208	5	-7.92	201	-11	-208	imp:n=1 \$ B5
209	5	-7.92	201	-11	-209	imp:n=1 \$ B6
210	5	-7.92	201	-11	-210	imp:n=1 \$ C1
211	5	-7.92	201	-11	-211	imp:n=1 \$ C2
213	5	-7.92	201	-11	-213	imp:n=1 \$ C3
214	5	-7.92	201	-11	-214	imp:n=1 \$ C4
215	5	-7.92	201	-11	-215	imp:n=1 \$ C5
216	5	-7.92	201	-11	-216	imp:n=1 \$ C6
217	5	-7.92	201	-11	-217	imp:n=1 \$ C7
218	5	-7.92	201	-11	-218	imp:n=1 \$ C8
219	5	-7.92	201	-11	-219	imp:n=1 \$ C9
220	5	-7.92	201	-11	-220	imp:n=1 \$ C10
221	5	-7.92	201	-11	-221	imp:n=1 \$ C11
222	5	-7.92	201	-11	-222	imp:n=1 \$ C12
224	5	-7.92	201	-11	-224	imp:n=1 \$ D2
225	5	-7.92	201	-11	-225	imp:n=1 \$ D3
226	5	-7.92	201	-11	-226	imp:n=1 \$ D4
227	5	-7.92	201	-11	-227	imp:n=1 \$ D5
228	5	-7.92	201	-11	-228	imp:n=1 \$ D6
230	5	-7.92	201	-11	-230	imp:n=1 \$ D8
231	5	-7.92	201	-11	-231	imp:n=1 \$ D9
232	5	-7.92	201	-11	-232	imp:n=1 \$ D10
233	5	-7.92	201	-11	-233	imp:n=1 \$ D11
234	5	-7.92	201	-11	-234	imp:n=1 \$ D12
236	5	-7.92	201	-11	-236	imp:n=1 \$ D14
237	5	-7.92	201	-11	-237	imp:n=1 \$ D15
238	5	-7.92	201	-11	-238	imp:n=1 \$ D16
239	5	-7.92	201	-11	-239	imp:n=1 \$ D17
240	5	-7.92	201	-11	-240	imp:n=1 \$ D18
241	5	-7.92	201	-11	-241	imp:n=1 \$ E1
242	5	-7.92	201	-11	-242	imp:n=1 \$ E2
243	5	-7.92	201	-11	-243	imp:n=1 \$ E3
244	5	-7.92	201	-11	-244	imp:n=1 \$ E4
245	5	-7.92	201	-11	-245	imp:n=1 \$ E5
246	5	-7.92	201	-11	-246	imp:n=1 \$ E6
247	5	-7.92	201	-11	-247	imp:n=1 \$ E7
248	5	-7.92	201	-11	-248	imp:n=1 \$ E8
249	5	-7.92	201	-11	-249	imp:n=1 \$ E9
250	5	-7.92	201	-11	-250	imp:n=1 \$ E10

251	5	-7.92	201	-11	-251	imp:n=1 \$ E11
252	5	-7.92	201	-11	-252	imp:n=1 \$ E12
253	5	-7.92	201	-11	-253	imp:n=1 \$ E13
254	5	-7.92	201	-11	-254	imp:n=1 \$ E14
255	5	-7.92	201	-11	-255	imp:n=1 \$ E15
256	5	-7.92	201	-11	-256	imp:n=1 \$ E16
257	5	-7.92	201	-11	-257	imp:n=1 \$ E17
258	5	-7.92	201	-11	-258	imp:n=1 \$ E18
259	5	-7.92	201	-11	-259	imp:n=1 \$ E19
260	5	-7.92	201	-11	-260	imp:n=1 \$ E20
261	5	-7.92	201	-11	-261	imp:n=1 \$ E21
262	5	-7.92	201	-11	-262	imp:n=1 \$ E22
263	7	0.059195	201	-11	-263	imp:n=1 \$ E23
264	5	-7.92	201	-11	-264	imp:n=1 \$ E24
265	5	-7.92	201	-11	-265	imp:n=1 \$ F1
266	5	-7.92	201	-11	-266	imp:n=1 \$ F2
267	5	-7.92	201	-11	-267	imp:n=1 \$ F3
268	5	-7.92	201	-11	-268	imp:n=1 \$ F4
269	5	-7.92	201	-11	-269	imp:n=1 \$ F5
270	5	-7.92	201	-11	-270	imp:n=1 \$ F6
271	5	-7.92	201	-11	-271	imp:n=1 \$ F7
272	5	-7.92	201	-11	-272	imp:n=1 \$ F8
273	8	-1.00	201	-14	-273	imp:n=1 \$ F9
274	5	-7.92	201	-11	-274	imp:n=1 \$ F10
275	5	-7.92	201	-11	-275	imp:n=1 \$ F11
276	5	-7.92	201	-11	-276	imp:n=1 \$ F12
277	5	-7.92	201	-11	-277	imp:n=1 \$ F13
278	5	-7.92	201	-11	-278	imp:n=1 \$ F14
279	5	-7.92	201	-11	-279	imp:n=1 \$ F15
280	5	-7.92	201	-11	-280	imp:n=1 \$ F16
281	5	-7.92	201	-11	-281	imp:n=1 \$ F17
282	5	-7.92	201	-11	-282	imp:n=1 \$ F18
283	5	-7.92	201	-11	-283	imp:n=1 \$ F19
284	5	-7.92	201	-11	-284	imp:n=1 \$ F20
285	5	-7.92	201	-11	-285	imp:n=1 \$ F21
286	5	-7.92	201	-11	-286	imp:n=1 \$ F22
287	5	-7.92	201	-11	-287	imp:n=1 \$ F23
288	5	-7.92	201	-11	-288	imp:n=1 \$ F24
289	5	-7.92	201	-11	-289	imp:n=1 \$ F25
290	5	-7.92	201	-11	-290	imp:n=1 \$ F26
291	5	-7.92	201	-11	-291	imp:n=1 \$ F27
292	5	-7.92	201	-11	-292	imp:n=1 \$ F28
293	5	-7.92	201	-11	-293	imp:n=1 \$ F29
294	5	-7.92	201	-11	-294	imp:n=1 \$ F30

C

C -----

C Adding additional fuel elements

c -----

C

C Ring B

C

402	Like 401 but trcl (	2.02692	3.510534	0.0)	\$ Core position B2
403	Like 401 but trcl (	6.08076	3.510534	0.0)	\$ Core position B3
404	Like 401 but trcl (	8.10768	0.0	0.0)	\$ Core position B4
405	Like 401 but trcl (	6.08076	-3.510534	0.0)	\$ Core position B5
406	Like 401 but trcl (	2.02692	-3.510534	0.0)	\$ Core position B6

C

C Ring C

C

407	Like 401 but trcl (	-3.92684	0.0	0.0)	\$ Core position C1
408	Like 401 but trcl (	-2.85750	3.99034	0.0)	\$ Core position C2
409	Like 401 but trcl (	-0.06350	6.91134	0.0)	\$ Core position C3
410	Like 401 but trcl (	4.05384	7.98068	0.0)	\$ Core position C4
411	Like 401 but trcl (	8.04418	6.91134	0.0)	\$ Core position C5
412	Like 401 but trcl (	10.96518	3.99034	0.0)	\$ Core position C6
413	Like 401 but trcl (	12.03452	0.0	0.0)	\$ Core position C7
414	Like 401 but trcl (	10.96518	-3.99034	0.0)	\$ Core position C8
415	Like 401 but trcl (	8.04418	-6.91134	0.0)	\$ Core position C9
416	Like 401 but trcl (	4.05384	-7.98068	0.0)	\$ Core position C10
417	Like 401 but trcl (	-0.06350	-6.91134	0.0)	\$ Core position C11
418	Like 401 but trcl (	-2.85750	-3.99034	0.0)	\$ Core position C12

c

C Ring D

c

420	Like 401 but trcl (	-7.17144	4.085336	0.0)	\$ Core position D2
421	Like 401 but trcl (	-5.09651	7.678736	0.0)	\$ Core position D3
422	Like 401 but trcl (	-1.91897	10.344912	0.0)	\$ Core position D4
423	Like 401 but trcl (	1.980184	11.76401	0.0)	\$ Core position D5
424	Like 401 but trcl (	6.127496	11.76401	0.0)	\$ Core position D6
					Core position D7

426	Like 401 but trcl (	13.20419	7.678736	0.0)	\$ Core position D8
428	Like 401 but trcl (	15.20419	4.085336	0.0)	\$ Core position D9
429	Like 401 but trcl (	15.99946	0.0	0.0)	\$ Core position D10
430	Like 401 but trcl (	15.279116	-4.085336	0.0)	\$ Core position D11
431	Like 401 but trcl (	13.20419	-7.678736	0.0)	\$ Core position D12
					Core position D13

433	Like 401 but trcl (	6.127496	-11.76401	0.0)	\$ Core position D14
434	Like 401 but trcl (	1.980184	-11.76401	0.0)	\$ Core position D15
435	Like 401 but trcl (	-1.91897	-10.344912	0.0)	\$ Core position D16
436	Like 401 but trcl (	-5.09651	-7.678736	0.0)	\$ Core position D17
437	Like 401 but trcl (	-7.17144	-4.085336	0.0)	\$ Core position D18

c

C Ring E

c

438 Like 401 but trcl (-11.8618 0.0 0.0) \$ Core position E1  
439 Like 401 but trcl (-11.319002 4.118864 0.0) \$ Core position E2  
440 Like 401 but trcl (-9.728962 7.95782 0.0) \$ Core position E3  
441 Like 401 but trcl (-7.200138 11.253978 0.0) \$ Core position E4  
442 Like 401 but trcl (-3.92198 13.782802 0.0) \$ Core position E5  
443 Like 401 but trcl (-0.065024 15.372842 0.0) \$ Core position E6  
444 Like 401 but trcl ( 4.05384 15.91564 0.0) \$ Core position E7  
445 Like 401 but trcl ( 8.172704 15.372842 0.0) \$ Core position E8  
446 Like 401 but trcl ( 12.01166 13.782802 0.0) \$ Core position E9  
447 Like 401 but trcl ( 15.30782 11.253978 0.0) \$ Core position E10  
448 Like 401 but trcl ( 17.836642 7.95782 0.0) \$ Core position E11  
449 Like 401 but trcl ( 19.426682 4.118864 0.0) \$ Core position E12  
450 Like 401 but trcl ( 19.96948 0.0 0.0) \$ Core position E13  
451 Like 401 but trcl ( 19.426682 -4.118864 0.0) \$ Core position E14  
452 Like 401 but trcl ( 17.836642 -7.95782 0.0) \$ Core position E15  
453 Like 401 but trcl ( 15.30782 -11.253978 0.0) \$ Core position E16  
454 Like 401 but trcl ( 12.01166 -13.782802 0.0) \$ Core position E17  
455 Like 401 but trcl ( 8.172704 -15.372842 0.0) \$ Core position E18  
456 Like 401 but trcl ( 4.05384 -15.91564 0.0) \$ Core position E19  
457 Like 401 but trcl (-0.065024 -15.372842 0.0) \$ Core position E20  
458 Like 401 but trcl (-3.92198 -13.782802 0.0) \$ Core position E21  
459 Like 401 but trcl (-7.200138 -11.253978 0.0) \$ Core position E22  
461 Like 401 but trcl (-11.319002 -4.118864 0.0) \$ Core position E24

c

C Ring F

c

462 Like 401 but trcl (-15.83436 0.0 0.0) \$ Core position F1  
463 Like 401 but trcl (-15.39875 4.134866 0.0) \$ Core position F2  
464 Like 401 but trcl (-14.114018 8.08863 0.0) \$ Core position F3  
465 Like 401 but trcl (-12.03579 11.69035 0.0) \$ Core position F4  
466 Like 401 but trcl (-9.238234 14.77899 0.0) \$ Core position F5  
467 Like 401 but trcl (-5.89026 17.223232 0.0) \$ Core position F6  
468 Like 401 but trcl (-2.09169 18.915634 0.0) \$ Core position F7  
469 Like 401 but trcl ( 1.975612 19.915634 0.0) \$ Core position F8  
471 Like 401 but trcl ( 10.19937 18.915634 0.0) \$ Core position F10  
472 Like 401 but trcl ( 13.99794 17.223232 0.0) \$ Core position F11  
473 Like 401 but trcl ( 17.345914 14.77899 0.0) \$ Core position F12  
474 Like 401 but trcl ( 20.14347 11.69035 0.0) \$ Core position F13  
475 Like 401 but trcl ( 22.221698 8.08863 0.0) \$ Core position F14  
476 Like 401 but trcl ( 23.50643 4.134866 0.0) \$ Core position F15  
477 Like 401 but trcl ( 23.94204 0.0 0.0) \$ Core position F16  
478 Like 401 but trcl ( 20.14347 -11.69035 0.0) \$ Core position F17  
479 Like 401 but trcl ( 22.221698 -8.08863 0.0) \$ Core position F18  
480 Like 401 but trcl ( 23.50643 -4.134866 0.0) \$ Core position F19

481 Like 401 but trcl ( 17.345914 -14.77899 0.0) \$ Core position F20  
 482 Like 401 but trcl ( 13.99794 -17.223232 0.0) \$ Core position F21  
 483 Like 401 but trcl ( 10.19937 -18.915634 0.0) \$ Core position F22  
 484 Like 401 but trcl ( 6.132068 -19.915634 0.0) \$ Core position F23  
 485 Like 401 but trcl ( 1.975612 -19.915634 0.0) \$ Core position F24  
 486 Like 401 but trcl ( -2.09169 -18.915634 0.0) \$ Core position F25  
 487 Like 401 but trcl ( -5.89026 -17.223232 0.0) \$ Core position F26  
 488 Like 401 but trcl ( -9.238234 -14.77899 0.0) \$ Core position F27  
 489 Like 401 but trcl (-12.03579 -11.69035 0.0) \$ Core position F28  
 490 Like 401 but trcl (-14.114018 -8.08863 0.0) \$ Core position F29  
 491 Like 401 but trcl (-15.39875 -4.134866 0.0) \$ Core position F30

c

c -----

c Exposure room 1

c -----

c

c Cell 702 is the wood lining of the exposure room

702 11 -0.650 -555 601 -602 603 604 -630  
 (610: -611: 612: -613: -614: 615)  
 ((-519 558 -551 604):  
 (-519 559 551 -630)):  
 (-551 565 603 519 -555 604):  
 (551 -555 519 569 603 -630):  
 (551 -555 519 568 -602 -630):  
 (-551 564 -602 519 -555 604)

imp:n=1

c Cell 703 is the masonite/gadolinium lining of the exposure room

703 12 -1.30 -610 611 -612 613 614 -615  
 (620: -621: 622: -623: -624: 625)  
 ((558 -551):(559 551))

imp:n=1

c Cell 704 defines the interior volume of the exposure room

704 9 -0.001205 -620 621 -622 623 624 -625  
 ((558 -551):(559 551)) #706 imp:n=1

c

c Cell 706 is the cadmium curtain

c

706 15 -8.69 558 -3002 -620 -3001 3003 imp:n=1

C

c Cell 707 is the air gap between the wood and concrete on ceiling

C

707 9 -0.001205 (-555 601 -602 603 630 -605)  
 (-519 559):  
 (568 519 -602 -555 630 -605):  
 (569 519 603 -555 630 -605)

imp:n=1

```

c
c -----
c Exposure room 2
c -----
c
c Cell 710 is the wood lining of the exposure room
710 11 -0.650 554 -651 -652 653 654 -655
      (-660: 661: 662: -663: -664: 665)
      ((516 556 -551 654):
       (516 557 551 -655)):
      (-551 563 653 -516 554 654):
      (551 554 -516 567 653 -655):
      (551 554 -516 566 -652 -655):
      (-551 562 -652 -516 554 654) imp:n=1
c Cell 711 is the masonite/gadolinium lining of the exposure room
711 12 -1.30      660 -661 -662 663 664 -665
      (-670: 671: 672: -673: -674: 675)
      ((556 -551):(557 551)) imp:n=1
c Cell 712 defines the interior volume of the exposure room
712 9 -0.001205 670 -671 -672 673 674 -675 ((556 -551):(557 551)) imp:n=1
c Cell 713 is the lead shield
c
c -----
c Control rod guide tubes
c -----
c
c Control rod A-1
c
358 7 0.059195
     -503 1013 -53 1033
     imp:n=1
c Air in guide tube A-1
362 9 -0.001205
     -503 502 1004 -1013
     imp:n=1
c
c Control rod D-1
c
359 7 0.059195
     -503 1039 -73 1033
     imp:n=1
c Air in guide tube D-1
363 9 -0.001205
     -503 502 1024 -1039
     imp:n=1
c

```

c Control rod D-7  
c  
360 7 0.059195  
-503 1053 -79 1033  
imp:n=1  
c Air in guide tube D-7  
364 9 -0.001205  
-503 502 1044 -1053  
imp:n=1  
c  
c Control rod D-13  
c  
361 7 0.059195  
-503 1073 -85 1033  
imp:n=1  
c Air in guide tube D-13  
365 9 -0.001205  
-503 502 1064 -1073  
imp:n=1  
c  
c -----  
c Core exposure tube  
c -----  
c Located at Core position E-23  
c Terminated at surface 1078; actual exposure tube serpentines to  
c surface of pool to prevent radiation streaming  
c -----  
656 7 0.059195  
-113 851 -1087 9  
imp:n=1  
1658 9 -0.001205  
-851 9 -1087  
imp:n=1  
1659 7 0.059195  
-9 11 -113  
imp:n=1  
  
C Surface cards  
150 cz 13.93063  
151 cz 17.90192  
152 cz 22.00000  
c -----  
C Surfaces 1 thru 15 define a fuel element at position B1  
c -----  
c  
C Dimensions from reactor plans sheet T3S210D170

c  
 1 c/z -4.05384 0.0 0.31 \$ Central Zirconium Rod  
 2 c/z -4.05384 0.0 1.814 \$ Interior of cladding  
 3 c/z -4.05384 0.0 1.865 \$ Exterior of cladding  
 4 pz 21.081125 \$ Top of fuel area  
 5 pz -17.018875 \$ Bottom of fuel area  
 6 pz 21.119125 \$ Top of upper Samarium wafer  
 7 pz -17.056875 \$ Bottom of lower Samarium wafer  
 8 pz 29.859125 \$ Top of upper carbon reflector  
 9 pz -25.796875 \$ Bottom of lower carbon reflector  
 10 pz 31.4325 \$ Top of cladding can  
 11 pz -27.066875 \$ Bottom of cladding can  
 13 pz 39.0017 \$ Top of fuel element  
 14 pz -31.4325 \$ Bottom of fuel element  
 15 pz 30.189325 \$ Top of void

c

c -----  
 C Upper Grid Plate

c

c

50 PZ 33.3375 \$ Top surface of plate  
 51 PZ 31.4325 \$ Bottom surface of plate  
 52 CZ 23.6601 \$ Exterior edge of plate

c A Ring

c

c

c B Ring

c

54 C/Z -4.05384 0.0 1.91135 \$ Core position B1  
 55 C/Z -2.02692 3.510534 1.91135 \$ Core position B2  
 56 C/Z 2.02692 3.510534 1.91135 \$ Core position B3  
 57 C/Z 4.05384 0.0 1.91135 \$ Core position B4  
 58 C/Z 2.02692 -3.510534 1.91135 \$ Core position B5  
 59 C/Z -2.02692 -3.510534 1.91135 \$ Core position B6

c

c C Ring

c

60 C/Z -7.98068 0.0 1.91135 \$ Core position C1  
 61 C/Z -6.91134 3.99034 1.91135 \$ Core position C2  
 63 C/Z -3.99034 6.91134 1.91135 \$ Core position C3  
 64 C/Z 0.0 7.98068 1.91135 \$ Core position C4  
 65 C/Z 3.99034 6.91134 1.91135 \$ Core position C5  
 66 C/Z 6.91134 3.99034 1.91135 \$ Core position C6  
 67 C/Z 7.98068 0.0 1.91135 \$ Core position C7  
 68 C/Z 6.91134 -3.99034 1.91135 \$ Core position C8  
 69 C/Z 3.99034 -6.91134 1.91135 \$ Core position C9

70 C/Z 0.0 -7.98068 1.91135 \$ Core position C10  
 71 C/Z -3.99034 -6.91134 1.91135 \$ Core position C11  
 72 C/Z -6.91134 -3.99034 1.91135 \$ Core position C12

c

c D Ring

c

74 C/Z -11.22528 4.085336 1.91135 \$ Core position D2  
 75 C/Z -9.15035 7.678736 1.91135 \$ Core position D3  
 76 C/Z -5.97281 10.344912 1.91135 \$ Core position D4  
 77 C/Z -2.073656 11.76401 1.91135 \$ Core position D5  
 78 C/Z 2.073656 11.76401 1.91135 \$ Core position D6  
 80 C/Z 9.15035 7.678674 1.91135 \$ Core position D8  
 81 C/Z 11.225276 4.085336 1.91135 \$ Core position D9  
 82 C/Z 11.94562 0.0 1.91135 \$ Core position D10  
 83 C/Z 11.225276 -4.085336 1.91135 \$ Core position D11  
 84 C/Z 9.15035 -7.678674 1.91135 \$ Core position D12  
 86 C/Z 2.07366 -11.76401 1.91135 \$ Core position D14  
 87 C/Z -2.07366 -11.76401 1.91135 \$ Core position D15  
 88 C/Z -5.97281 -10.344912 1.91135 \$ Core position D16  
 89 C/Z -9.15035 -7.678674 1.91135 \$ Core position D17  
 90 C/Z -11.22528 -4.085336 1.91135 \$ Core position D18

c

c E Ring

c

91 C/Z -15.91564 0.0 1.91135 \$ Core position E1  
 92 C/Z -15.372842 4.118864 1.91135 \$ Core position E2  
 93 C/Z -13.782802 7.95782 1.91135 \$ Core position E3  
 94 C/Z -11.253978 11.253978 1.91135 \$ Core position E4  
 95 C/Z -7.95782 13.782802 1.91135 \$ Core position E5  
 96 C/Z -4.118864 15.372842 1.91135 \$ Core position E6  
 97 C/Z 0.0 15.91564 1.91135 \$ Core position E7  
 98 C/Z 4.118864 15.372842 1.91135 \$ Core position E8  
 99 C/Z 7.95782 13.782802 1.91135 \$ Core position E9  
 100 C/Z 11.25398 11.253978 1.91135 \$ Core position E10  
 101 C/Z 13.782802 7.95782 1.91135 \$ Core position E11  
 102 C/Z 15.372842 4.118864 1.91135 \$ Core position E12  
 103 C/Z 15.91564 0.0 1.91135 \$ Core position E13  
 104 C/Z 15.372842 -4.118864 1.91135 \$ Core position E14  
 105 C/Z 13.782802 -7.95782 1.91135 \$ Core position E15  
 106 C/Z 11.253978 -11.253978 1.91135 \$ Core position E16  
 107 C/Z 7.95782 -13.782802 1.91135 \$ Core position E17  
 108 C/Z 4.118864 -15.372842 1.91135 \$ Core position E18  
 109 C/Z 0.0 -15.91564 1.91135 \$ Core position E19  
 110 C/Z -4.118864 -15.372842 1.91135 \$ Core position E20  
 111 C/Z -7.95782 -13.782802 1.91135 \$ Core position E21  
 112 C/Z -11.25398 -11.25398 1.91135 \$ Core position E22

113 C/Z -13.78208 -7.95782 1.91135 \$ Core position E23  
 114 C/Z -15.372842 -4.118864 1.91135 \$ Core position E24

c

c F Ring

c

115 C/Z -19.8882 0.0 1.91335 \$ Core position F1  
 116 C/Z -19.45259 4.134866 1.91135 \$ Core position F2  
 117 C/Z -18.167858 8.08863 1.91135 \$ Core position F3  
 118 C/Z -16.08963 11.69035 1.91135 \$ Core position F4  
 119 C/Z -13.292074 14.77899 1.91135 \$ Core position F5  
 120 C/Z -9.9441 17.223232 1.91135 \$ Core position F6  
 121 C/Z -6.14553 18.915634 1.91135 \$ Core position F7  
 122 C/Z -2.078228 19.915634 1.91135 \$ Core position F8  
 123 C/Z 2.078228 19.915634 1.91135 \$ Core position F9  
 124 C/Z 6.14553 18.915634 1.91135 \$ Core position F10  
 125 C/Z 9.9441 17.223232 1.91135 \$ Core position F11  
 126 C/Z 13.292074 14.77899 1.91135 \$ Core position F12  
 127 C/Z 16.08963 11.69035 1.91135 \$ Core position F13  
 128 C/Z 18.167858 8.08863 1.91135 \$ Core position F14  
 129 C/Z 19.45259 4.134866 1.91135 \$ Core position F15  
 130 C/Z 19.8882 0.0 1.91135 \$ Core position F16  
 131 C/Z 19.45259 -4.134866 1.91135 \$ Core position F17  
 132 C/Z 18.167858 -8.08863 1.91135 \$ Core position F18  
 133 C/Z 16.08963 -11.69035 1.91135 \$ Core position F19  
 134 C/Z 13.292074 -14.77899 1.91135 \$ Core position F20  
 135 C/Z 9.9441 -17.223232 1.91135 \$ Core position F21  
 136 C/Z 6.14553 -18.915634 1.91135 \$ Core position F22  
 137 C/Z 2.078228 -19.915634 1.91135 \$ Core position F23  
 138 C/Z -2.078338 -19.915634 1.91135 \$ Core position F24  
 139 C/Z -6.14553 -18.915634 1.91135 \$ Core position F25  
 140 C/Z -9.9441 -17.223232 1.91135 \$ Core position F26  
 141 C/Z -13.292074 -14.77899 1.91135 \$ Core position F27  
 142 C/Z -16.08963 -11.69035 1.91135 \$ Core position F28  
 143 C/Z -18.167858 -8.08864 1.91135 \$ Core position F29  
 144 C/Z -19.45259 -4.134866 1.91135 \$ Core position F30  
 C 145 C/Z 1.13665 \$ External neutron source position

c

c -----

C Lower Grid Plate

c -----

c

200 PZ -31.4325 \$ Top surface of plate  
 201 PZ -33.3375 \$ Bottom surface of plate  
 202 CZ 21.115 \$ Exterior edge of plate

c

c A Ring

c  
203 CZ 1.92405 \$ Core position A1  
c  
c B Ring  
c  
204 C/Z -4.05384 0.0 0.79375 \$ Core position B1  
205 C/Z -2.02692 3.510534 0.79375 \$ Core position B2  
206 C/Z 2.02692 3.510534 0.79375 \$ Core position B3  
207 C/Z 4.05384 0.0 0.79375 \$ Core position B4  
208 C/Z 2.02692 -3.510534 0.79375 \$ Core position B5  
209 C/Z -2.02692 -3.510534 0.79375 \$ Core position B6  
c  
c C Ring  
c  
210 C/Z -7.98068 0.0 0.79375 \$ Core position C1  
211 C/Z -6.91134 3.99034 0.79375 \$ Core position C2  
213 C/Z -3.99034 6.91134 0.79375 \$ Core position C3  
214 C/Z 0.0 7.98068 0.79375 \$ Core position C4  
215 C/Z 3.99034 6.91134 0.79375 \$ Core position C5  
216 C/Z 6.91134 3.99034 0.79375 \$ Core position C6  
217 C/Z 7.98068 0.0 0.79375 \$ Core position C7  
218 C/Z 6.91134 -3.99034 0.79375 \$ Core position C8  
219 C/Z 3.99034 -6.91134 0.79375 \$ Core position C9  
220 C/Z 0.0 -7.98068 0.79375 \$ Core position C10  
221 C/Z -3.99034 -6.91134 0.79375 \$ Core position C11  
222 C/Z -6.91134 -3.99034 0.79375 \$ Core position C12  
c  
c D Ring  
c  
223 C/Z -11.94562 0.0 1.92405 \$ Core position D1  
224 C/Z -11.22528 4.085336 0.79375 \$ Core position D2  
225 C/Z -9.15035 7.678736 0.79375 \$ Core position D3  
226 C/Z -5.97281 10.344912 0.79375 \$ Core position D4  
227 C/Z -2.073656 11.76401 0.79375 \$ Core position D5  
228 C/Z 2.073656 11.76401 0.79375 \$ Core position D6  
229 C/Z 5.97281 10.344912 1.92405 \$ Core position D7  
230 C/Z 9.15035 7.678674 0.79375 \$ Core position D8  
231 C/Z 11.225276 4.085336 0.79375 \$ Core position D9  
232 C/Z 11.94562 0.0 0.79375 \$ Core position D10  
233 C/Z 11.225276 -4.085336 0.79375 \$ Core position D11  
234 C/Z 9.15035 -7.678674 0.79375 \$ Core position D12  
235 C/Z 5.97281 -10.344912 1.92405 \$ Core position D13  
236 C/Z 2.07366 -11.76401 0.79375 \$ Core position D14  
237 C/Z -2.07366 -11.76401 0.79375 \$ Core position D15  
238 C/Z -5.97281 -10.344912 0.79375 \$ Core position D16  
239 C/Z -9.15035 -7.678674 0.79375 \$ Core position D17

240 C/Z -11.22528 -4.085336 0.79375 \$ Core position D18

c

c E Ring

c

241 C/Z -15.91564 0.0 0.79375 \$ Core position E1

242 C/Z -15.372842 4.118864 0.79375 \$ Core position E2

243 C/Z -13.782802 7.95782 0.79375 \$ Core position E3

244 C/Z -11.253978 11.253978 0.79375 \$ Core position E4

245 C/Z -7.95782 13.782802 0.79375 \$ Core position E5

246 C/Z -4.118864 15.372842 0.79375 \$ Core position E6

247 C/Z 0.0 15.91564 0.79375 \$ Core position E7

248 C/Z 4.118864 15.372842 0.79375 \$ Core position E8

249 C/Z 7.95782 13.782802 0.79375 \$ Core position E9

250 C/Z 11.25398 11.253978 0.79375 \$ Core position E10

251 C/Z 13.782802 7.95782 0.79375 \$ Core position E11

252 C/Z 15.372842 4.118864 0.79375 \$ Core position E12

253 C/Z 15.91564 0.0 0.79375 \$ Core position E13

254 C/Z 15.372842 -4.118864 0.79375 \$ Core position E14

255 C/Z 13.782802 -7.95782 0.79375 \$ Core position E15

256 C/Z 11.253978 -11.253978 0.79375 \$ Core position E16

257 C/Z 7.95782 -13.782802 0.79375 \$ Core position E17

258 C/Z 4.118864 -15.372842 0.79375 \$ Core position E18

259 C/Z 0.0 -15.91564 0.79375 \$ Core position E19

260 C/Z -4.118864 -15.372842 0.79375 \$ Core position E20

261 C/Z -7.95782 -13.782802 0.79375 \$ Core position E21

262 C/Z -11.25398 -11.25398 0.79375 \$ Core position E22

263 C/Z -13.78208 -7.95782 0.79375 \$ Core position E23

264 C/Z -15.372842 -4.118864 0.79375 \$ Core position E24

c

c F Ring

c

265 C/Z -19.8882 0.0 0.79375 \$ Core position F1

266 C/Z -19.45259 4.134866 0.79375 \$ Core position F2

267 C/Z -18.167858 8.08863 0.79375 \$ Core position F3

268 C/Z -16.08963 11.69035 0.79375 \$ Core position F4

269 C/Z -13.292074 14.77899 0.79375 \$ Core position F5

270 C/Z -9.9441 17.223232 0.79375 \$ Core position F6

271 C/Z -6.14553 18.915634 0.79375 \$ Core position F7

272 C/Z -2.078228 19.915634 0.79375 \$ Core position F8

273 C/Z 2.078228 19.915634 0.79375 \$ Core position F9

274 C/Z 6.14553 18.915634 0.79375 \$ Core position F10

275 C/Z 9.9441 17.223232 0.79375 \$ Core position F11

276 C/Z 13.292074 14.77899 0.79375 \$ Core position F12

277 C/Z 16.08963 11.69035 0.79375 \$ Core position F13

278 C/Z 18.167858 8.08863 0.79375 \$ Core position F14

279 C/Z 19.45259 4.134866 0.79375 \$ Core position F15

280	C/Z	19.8882	0.0	0.79375	\$ Core position F16
281	C/Z	19.45259	-4.134866	0.79375	\$ Core position F17
282	C/Z	18.167858	-8.08863	0.79375	\$ Core position F18
283	C/Z	16.08963	-11.69035	0.79375	\$ Core position F19
284	C/Z	13.292074	-14.77899	0.79375	\$ Core position F20
285	C/Z	9.9441	-17.223232	0.79375	\$ Core position F21
286	C/Z	6.14553	-18.915634	0.79375	\$ Core position F22
287	C/Z	2.078228	-19.915634	0.79375	\$ Core position F23
288	C/Z	-2.078338	-19.915634	0.79375	\$ Core position F24
289	C/Z	-6.14553	-18.915634	0.79375	\$ Core position F25
290	C/Z	-9.9441	-17.223232	0.79375	\$ Core position F26
291	C/Z	-13.292074	-14.77899	0.79375	\$ Core position F27
292	C/Z	-16.08963	-11.69035	0.79375	\$ Core position F28
293	C/Z	-18.167858	-8.08864	0.79375	\$ Core position F29
294	C/Z	-19.45259	-4.134866	0.79375	\$ Core position F30
1033	pz	-62.865			

c

c Control rods

c

c -----

c Control rod A1

c Dimensions from drawing T3S 250 D 136, converted from inches to cm

c

1001	cz	1.50745			\$ Exterior of B4C section
1002	cz	1.5875			\$ Interior of cladding
1003	cz	1.65862			\$ Exterior of cladding
1004	cz	0.79375			\$ exterior of top extension
1006	pz	-18.923875			\$ bottom of control rod
1008	pz	-18.288875			\$ bottom of Al follower
1009	pz	59.181125			\$ top of poison section
1010	pz	20.446125			\$ top of Al follower
1011	pz	21.081125			\$ bottom of poison
1012	pz	63.296125			\$ top of cladding
1013	cz	1.75655			\$ interior of CR guide

c

c -----

c Control rod D1

C Dimensions from AFRRI TR94-1, converted from inches to cm

c

1021	c/z	-11.94562	0.0	0.3175	\$ zirconium center rod
1022	c/z	-11.94562	0.0	1.42875	\$ Interior of cladding
1023	c/z	-11.94562	0.0	1.47955	\$ Exterior of cladding
1024	c/z	-11.94562	0.0	0.79375	\$ exterior of top extension
1025	c/z	-11.94562	0.0	1.37668	\$ Fuel follower exterior
1026	pz	-20.511875			\$ bottom of control rod
1027	pz	72.834125			\$ top of upper void

1028	pz	-18.606875			\$ bottom of fuel follower
1029	pz	59.181125			\$ top of poison section/bottom of poison void
1030	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1031	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1032	pz	76.974125			\$ top of cladding
1037	c/z	-11.94562	0.0	1.34874	\$ Poison section exterior
1034	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1035	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1036	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1039	c/z	-11.94562	0.0	1.60655	\$ interior of CR guide

c -----

c Control rod D7

C Dimensions from AFRRI TR94-1, converted from inches to cm

c -----

1041	c/z	5.97281	10.344912	0.3175	\$ zirconium center rod
1042	c/z	5.97281	10.344912	1.42875	\$ Interior of cladding
1043	c/z	5.97281	10.344912	1.47955	\$ Exterior of cladding
1044	c/z	5.97281	10.344912	0.79375	\$ exterior of top extension
1045	c/z	5.97281	10.344912	1.37668	\$ Fuel follower exterior
1046	pz	-20.511875			\$ bottom of control rod
1047	pz	72.834125			\$ top of upper void
1048	pz	-18.606875			\$ bottom of fuel follower
1049	pz	59.181125			\$ top of poison section/bottom of poison void
1050	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1051	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1052	pz	76.974125			\$ top of cladding
1053	c/z	5.97281	10.344912	1.60655	\$ interior of CR guide
1058	c/z	5.97281	10.344912	1.34874	\$ Poison section exterior
1054	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1055	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1056	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1059	c/z	5.97281	10.344912	1.60655	\$ interior of CR guide

c -----

c Control rod D13

C Dimensions from AFRRI TR94-1, converted from inches to cm

c -----

1061	c/z	5.97281	-10.344912	0.3175	\$ zirconium center rod
1062	c/z	5.97281	-10.344912	1.42875	\$ Interior of cladding
1063	c/z	5.97281	-10.344912	1.47955	\$ Exterior of cladding
1064	c/z	5.97281	-10.344912	0.79375	\$ exterior of top extension
1065	c/z	5.97281	-10.344912	1.37668	\$ Fuel follower exterior
1066	pz	-20.511875			\$ bottom of control rod
1067	pz	72.834125			\$ top of upper void
1068	pz	-18.606875			\$ bottom of fuel follower
1069	pz	59.181125			\$ top of poison section/bottom of poison void
1070	pz	18.541125			\$ top of fuel follower/bottom of fuel void

1071 pz 21.081125 \$ bottom of poison/top of lower Magnaform  
 1072 pz 76.974125 \$ top of cladding  
 1073 c/z 5.97281 -10.344912 1.60655 \$ interior of CR guide  
 1074 pz 19.811125 \$ top of fuel gap/bottom of lower Magnaform  
 1075 pz 59.499125 \$ top of poison gap/bottom of upper Magnaform  
 1076 pz 60.769125 \$ bottom of upper void/top of upper Magnaform  
 1078 c/z 5.97281 -10.344912 1.34874 \$ Poison section exterior  
 1079 c/z 5.97281 -10.344912 1.60655 \$ interior of CR guide

c

53 CZ 1.92405 \$ Core position A1  
 73 C/Z -11.94562 0.0 1.92405 \$ Core position D1  
 79 C/Z 5.97281 10.344912 1.92405 \$ Core position D7  
 85 C/Z 5.97281 -10.344912 1.92405 \$ Core position D13

c

c -----

c Core shroud and support structure

c

c

1080 cz 24.28875 \$ interior of core shroud  
 1081 cz 24.765 \$ exterior of core shroud  
 1082 cz 44.1325 \$ interior of core support  
 1083 cz 45.72 \$ exterior of core support  
 1088 cz 22.70125 \$ interior of shroud support  
 1084 pz -38.3375 \$ bottom of core shroud  
 1085 pz 40.30625 \$ top of core shroud  
 1087 pz 184.70625 \$ top of shroud support

c

c -----

c Reactor pool  
 c Dimensions read manually from drawing T3B200J100  
 c and converted from inches to centimeters

c

c -----

500 pz -73.66 \$ bottom of reactor pool  
 501 pz 116.84 \$ Projection shelf  
 502 pz 502.92 \$ pool water surface  
 503 pz 553.72 \$ reactor room floor  
 504 c/z 140.97 89.662 114.3 \$ left tank wing  
 505 c/z 140.97 -89.662 114.3 \$ right tank wing  
 506 px 255.27 \$ tank edge--ER 2  
 507 px 26.67 \$ tank edge--ER 1  
 508 c/z 281.94 0.0 26.67 \$ ER 2 penetration  
 509 c/z 281.94 0.0 60.96 \$ above ER 2 penetration  
 510 c/z 0.0 0.0 26.67 \$ ER 1 penetration  
 511 c/z 0.0 0.0 60.96 \$ above ER 1 penetration

c

c surfaces 512 and 515 are the penetration walls above ER 2

c

512 p 255.24 67.31 116.84 281.94 60.96 116.84 255.24 67.31 502.92  
515 p 255.24 -67.31 116.84 281.94 -60.96 116.84 255.24 -67.31 502.92  
c  
c surfaces 513 and 514 are the penetration walls in ER 2  
c  
513 p 255.24 33.02 116.84 281.94 26.67 116.84 255.24 33.02 502.92  
514 p 255.24 -33.02 116.84 281.94 -26.67 116.84 255.24 -33.02 502.92  
516 px 281.94  
c  
c surfaces 517 and 518 are the penetration walls in ER 1  
c  
517 p 26.67 33.02 116.84 0.0 26.67 116.84 26.67 33.02 502.92  
518 p 26.67 -33.02 116.84 0.0 -26.67 116.84 26.67 -33.02 502.92  
519 px 0.0  
520 py 89.662  
521 py -89.662  
c  
c surfaces 522 and 523 are the penetration walls above ER 1  
c  
522 p 26.67 67.31 116.84 0.0 60.96 116.84 26.67 67.31 502.92  
523 p 26.67 -67.31 116.84 0.0 -60.96 116.84 26.67 -67.31 502.92  
c -----  
c Reactor tank lining  
c thicknesses from Safety Analysis Report, dated January 2000  
c bottom and tank shelf thickness .5 inch (1.27 cm)  
c Exposure room protusion thickness .25 inch (0.635 cm)  
c Other tank wall thickness .375 inch (0.9525 cm)  
c -----  
550 pz -74.93 \$ bottom of reactor pool  
551 pz 115.57 \$ Projection shelf  
552 c/z 140.97 89.662 115.2525 \$ left tank wing  
553 c/z 140.97 -89.662 115.2525 \$ right tank wing  
554 px 256.2225 \$ tank edge--ER 2  
555 px 25.7175 \$ tank edge--ER 1  
556 c/z 281.94 0.0 27.305 \$ ER 12 penetration  
557 c/z 281.94 0.0 61.595 \$ above ER 2 penetration  
558 c/z 0.0 0.0 27.305 \$ ER 1 penetration  
559 c/z 0.0 0.0 61.595 \$ above ER 1 penetration  
c  
c surfaces 562 and 563 are the penetration walls in ER 2  
c  
562 p 255.24 33.665 115.2525 281.94 27.3 115.2525 255.24 33.665 -74.93  
563 p 255.24 -33.665 115.2525 281.94 -27.3 115.2525 255.24 -33.665 -74.93  
c  
c surfaces 564 and 565 are the penetration walls in ER 1  
c

564 p 26.67 33.665 115.2525 0.0 27.3 115.2525 26.67 33.655 -74.93  
565 p 26.67 -33.665 115.2525 0.0 -27.3 115.2525 26.67 -33.655 -74.93  
c  
c surfaces 566 and 567 are the penetration walls above ER 2  
c  
566 p 255.24 67.945 116.84 281.94 61.595 116.84 255.24 67.945 502.92  
567 p 255.24 -67.945 116.84 281.94 -61.595 116.84 255.24 -67.945 502.92  
c  
c surfaces 568 and 569 are the penetration walls above ER 1  
c  
568 p 26.67 67.945 116.84 0.0 61.595 116.84 26.67 67.945 502.92  
569 p 26.67 -67.945 116.84 0.0 -61.595 116.84 26.67 -67.945 502.92  
c  
c -----  
c Exposure room 1  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Exposure room walls  
c -----  
c Surface 555 forms wall of exposure room  
601 px -644.8425 \$ wall furthest from reactor pool  
602 py 335.28 \$ left wall  
603 py -335.28 \$ right wall  
604 pz -153.035 \$ exposure room floor  
605 pz 187.96 \$ exposure room ceiling  
c -----  
c Wood lining of exposure room  
c -----  
610 px -4.7625 \$ wall nearest reactor pool  
611 px -614.3625 \$ wall furthest from reactor pool  
612 py 304.8 \$ left wall  
613 py -304.8 \$ right wall  
614 pz -122.555 \$ exposure room floor  
615 pz 147.32 \$ exposure room ceiling  
c -----  
c masonite lining of exposure room  
c -----  
620 px -5.3975 \$ wall nearest reactor pool  
621 px -613.7275 \$ wall furthest from reactor pool  
622 py 304.165 \$ left wall  
623 py -304.165 \$ right wall  
624 pz -121.92 \$ exposure room floor  
625 pz 146.685 \$ exposure room ceiling

c -----  
630 pz 177.8 \$ bottom of ceiling air gap  
c -----  
c Exposure room 2  
c -----  
c -----  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Exposure room walls  
c -----  
c Surface 554 defines exterior wall of exposure room 2  
651 px 682.9425 \$ wall furthest from reactor pool  
652 py 228.6 \$ right wall  
653 py -228.6 \$ left wall  
654 pz -112.395 \$ exposure room floor  
655 pz 193.04 \$ exposure room ceiling  
c -----  
c Wood lining of exposure room  
c -----  
660 px 286.7025 \$ wall nearest reactor pool  
661 px 652.4625 \$ wall furthest from reactor pool  
662 py 198.12 \$ right wall  
663 py -198.12 \$ left wall  
664 pz -81.915 \$ exposure room floor  
665 pz 162.56 \$ exposure room ceiling  
c -----  
c masonite lining of exposure room  
c -----  
670 px 287.3375 \$ wall nearest reactor pool  
671 px 651.8275 \$ wall furthest from reactor pool  
672 py 197.485 \$ right wall  
673 py -197.485 \$ left wall  
674 pz -81.28 \$ exposure room floor  
675 pz 161.925 \$ exposure room ceiling  
c -----  
c Concrete surrounding the reactor pool and exposure rooms  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Dimensions are approximations. Actual region surrounding the reactor

c varies from floor to floor of the facility and is a combination of  
c concrete and backfilled soil

c -----  
800 pz -334.01 \$ soil surface  
802 px -690.5625 \$ beyond ER 1  
803 px 977.5825 \$ beyond ER 2  
804 py 599.12 \$ right of ER 1  
805 py -721.04 \$ left of ER 1  
806 py -502.92 \$ right of ER 2  
807 py 350.52 \$ left of ER 2  
850 px 140.97

c -----  
c Core exposure tube

c -----  
c Located at Core position E-23

c -----  
851 C/Z -13.78208 -7.95782 1.814

c -----  
c Cadmium shielding of reactor tank protrusion in Exposure Room 1

c -----  
3001 c/z 0.00 0.00 27.4066  
3002 pz 30.48  
3003 pz -30.48

C Data cards

c -----  
C Material cards

c -----  
C Material 1 is zirconium

c  
m1 40000.60c 0.99994 \$ Zr  
72000.60c 0.00006 \$ Hf

c  
C Material 2 is the UZrH fuel

c  
m2 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676

72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
 mt2 h/zr.60t zr/h.60t  
 c  
 C Material 3 is the Samarium/aluminum burnable poison wafer  
 c 1% wt of Samarium, per Volkov, et al, 1960  
 c  
 m3 13027.60c 0.99 \$ Al  
 62147.66c 0.004312 \$ Sm-247  
 62149.66c 0.004312 \$ Sm-149  
 8016.60c 0.001376 \$ O  
 c  
 C Material 4 is the Carbon reflector layer  
 c  
 m4 6000.60c 1 \$ C  
 mt4 grph.60t  
 c  
 C Material 5 is the stainless steel 304 cladding  
 c  
 m5 24050.60 0.000778 \$ Cr-50  
 24052.60 0.015003 \$ Cr-52  
 24053.60 0.001701 \$ Cr-53  
 26056.60 0.05673 \$ Fe-56  
 28058.60 0.007939 \$ Ni  
 25055.60 0.001697 \$ Mn  
 c  
 C Material 6 is boron carbide  
 c  
 m6 5010.60c 0.02095 \$ B-10  
 5011.60c 0.08431 \$ B-11  
 6000.60c 0.02632 \$ C  
 c  
 C Material m7 is 6061 aluminum alloy  
 c  
 m7 13027.60c 0.058693 \$ Al-27  
 26056.60c 0.000502 \$ Fe-56  
 c  
 c Material m8 is water  
 c  
 m8 1001.60c -0.111894 \$ H  
 8016.60c -0.888106 \$ O  
 mt8 lwtr.60t  
 c  
 c Material m9 is air  
 c  
 m9 6000.60c -0.000124 \$ C  
 7014.60c -0.755268 \$ N

8016.60c -0.231781 \$ O  
 18000.35d -0.012827 \$ Ar  
 c  
 c Material m10 is the fuel in the fuel follower control rods  
 c  
 m10 1001.60 0.05777811 \$ H  
 6000.60c 0.00152383 \$ C  
 40000.60 0.03511576 \$ Sm  
 92234.61c 0.00000198 \$ U-234  
 92235.61c 0.00037003 \$ U-235  
 92236.61c 0.00000290 \$ U-236  
 92238.61c 0.00147347 \$ U-238  
 72000.60c 2.1069456e-6 \$ Hf  
 mt10 h/zr.60t  
 zr/h.60t  
 c  
 c Material m11 is wood (pine)  
 c  
 m11 1001.60c 0.476191 \$ H  
 6000.60c 0.285714 \$ C  
 8016.60c 0.238095 \$ O-16  
 c  
 c Material m12 is masonite/gadolinium  
 c  
 m12 1001.60c 0.47144526 \$ H  
 6000.60c 0.28284630 \$ C  
 8016.60c 0.23570844 \$ O-16  
 64000 0.01 \$ Gd  
 c  
 c material 13 is ORNL composition concrete  
 c  
 m13 1001.60c 0.00453 \$ H-1  
 8016.60c 0.5126 \$ O-16  
 11023.62c 0.01527 \$ Na-23  
 13027.60c 0.03555 \$ Al-27  
 14000.60c 0.36036 \$ Si  
 20000.60c 0.05791 \$ Ca  
 26000.50c 0.01378 \$ Fe  
 c  
 c material 14 is Lucite  
 c  
 m14 1001 -0.080538 \$ H-1  
 6000 -0.599848 \$ C  
 8016 -0.319614 \$ O-16  
 c  
 c material 15 is the cadmium shielding in Exposure Room 1

c Gadolinium paint on interior of shield is approximated by  
 c including 0.2% by weight of gadolinium

c  
 m15 48000 -99.8 \$ Cd  
 64000 -0.2 \$ Gd

c  
 c -----  
 C Criticality control cards  
 c -----

c  
 Kcode 10000 1.0 50 500

c -----  
 c No source in A-1, E-23, or F-9  
 c sources in D-1, D-7, and D-13 offset to ensure they remain in active  
 c fuel region regardless of Control Rod position (below 37 cm inserted)  
 c -----

Ksrc	-3.23559	0.0	0.0	-1.20867	3.510534	0.0
	2.84517	3.510534	0.0	4.87209	0.0	0.0
	2.84517	-3.510534	0.0	-1.20867	-3.510534	0.0
	-7.16243	0.0	0.0	-6.09309	3.99034	0.0
	-3.17209	6.91134	0.0	0.81825	7.98068	0.0
	4.80859	6.91134	0.0	7.72959	3.99034	0.0
	8.79893	0.0	0.0	7.72959	-3.99034	0.0
	4.80859	-6.91134	0.0	0.81825	-7.98068	0.0
	-3.17209	-6.91134	0.0	-6.09309	-3.99034	0.0
	-10.40703	4.085336	0.0	-8.3321	7.678736	0.0
	-5.15456	10.344912	0.0	-1.255406	11.76401	0.0
	2.891906	11.76401	0.0	9.9686	7.678674	0.0
	12.043526	4.085336	0.0	12.76387	0.0	0.0
	12.043526	-4.085336	0.0	9.9686	-7.678674	0.0
	2.89191	-11.76401	0.0	-1.25541	-11.76401	0.0
	-5.15456	-10.344912	0.0	-8.3321	-7.678674	0.0
	-10.40703	-4.085336	0.0	-15.09739	0.0	0.0
	-14.554592	4.118864	0.0	-12.964552	7.95782	0.0
	-10.435728	11.253978	0.0	-7.13957	13.782802	0.0
	-3.300614	15.372842	0.0	0.81825	15.91564	0.0
	4.937114	15.372842	0.0	8.77607	13.782802	0.0
	12.07223	11.253978	0.0	14.601052	7.95782	0.0
	16.191092	4.118864	0.0	16.73389	0.0	0.0
	15.191092	-4.118864	0.0	14.600332	-7.95782	0.0
	12.072228	-11.253978	0.0	8.77607	-13.782802	0.0
	4.937114	-15.372842	0.0	0.81825	-15.91564	0.0
	-3.300614	-15.372842	0.0	-7.13957	-13.782802	0.0
	-10.43573	-11.25398	0.0	-14.554592	-4.118864	0.0
	-19.06995	0.0	0.0	-18.63434	4.134866	0.0
	-17.349608	8.08863	0.0	-15.27138	11.69035	0.0

-12.473824 14.77899 0.0 -9.12585 17.223232 0.0  
-5.32728 18.915634 0.0 -1.259978 19.915634 0.0  
6.96378 18.915634 0.0 10.76235 17.223232 0.0  
14.110324 14.77899 0.0 16.90788 11.69035 0.0  
18.986108 8.08863 0.0 20.27084 4.134866 0.0  
20.70645 0.0 0.0 20.27084 -4.134866 0.0  
18.986108 -8.08863 0.0 16.090788 -11.69035 0.0  
14.110324 -14.77899 0.0 10.76235 -17.223232 0.0  
6.96378 -18.915634 0.0 2.896478 -19.915634 0.0  
-21.259978 -19.915634 0.0 -5.32728 -18.915634 0.0  
-9.12585 -17.223232 0.0 -12.473824 -14.77899 0.0  
-15.27138 -11.69035 0.0 -17.349608 -8.08864 0.0  
-18.63434 -4.134866 0.0  
-11.12737 0.0 -17.0 6.79106 10.344912 -17.0  
6.79106 -10.344912 -17.0

## Appendix 2—Core Position 500 with Separate Elements

Presented below is the MCNP source file for the AFRRRI TRIGA reactor in core position 500, modified with separate elements to allow burnup calculations to be preformed.

```
c AFRRRI TRIGA Mark-F Reactor and supporting exposure facilities
c Core position 500
C Cell cards
c -----
c Control rod A1
c -----
C cell 1110 is the air gap surrounding the B4C poison section
1110 9 -0.001205 1001 -1002 1011 -1009 imp:n=1
C cell 1111 is the air follower
1111 9 -0.001205 -1002 1008 -1010 imp:n=1
c cell 1112 is a stainless steel spacer between the poison section
c and the air follower
1112 5 -7.92 1010 -1011 -1002 imp:n=1
C cell 1113 is the B4C poison section
1113 6 0.135714 -1001 1011 -1009 imp:n=1
C cell 1115 is the cladding
1115 5 -7.92 (1002:-1008: 1009) (-1003 1006 -1012):
(-1004 -503 1012) imp:n=1
c -----
c Control rod D1
c -----
C cell 1120 is the zirconium center rod of the fuel follower section
1120 1 -6.51 -1021 1028 -1030 imp:n=4
C cell 1121 is the fuel follower section
1121 419 0.09626819 1021 -1025 1028 -1030 vol=209.418124 imp:n=16
C cell 1122 is the lower Magnaform
1122 5 -7.92 -1022 1034 -1031 imp:n=4
C cell 1123 is the B4C poison section
1123 6 0.135714 -1037 1031 -1029 imp:n=4
C cell 1124 is the void at the top of the fuel element
1124 9 -0.001205 -1022 1036 -1027 imp:n=4
C cell 1125 is the cladding
1125 5 -7.92 (1022:-1028: 1027)
(-1023 1026 -1032):
(-1024 -503 1032)
imp:n=4
c cell 1126 is the fuel follower gap
1126 9 -0.001205 1025 -1022 1028 -1030 imp:n=4
```

c cell 1127 is the fuel follower/clad void  
1127 9 -0.001205 1030 -1034 -1022 imp:n=4  
c cell 1128 is the poison section/clad gap  
1128 9 -0.001205 1031 -1029 1037 -1022 imp:n=4  
c cell 1129 is the poison section void  
1129 9 -0.001205 1029 -1035 -1022 imp:n=4  
c cell 1152 is the upper Magnaform  
1152 5 -7.92 1035 -1036 -1022 imp:n=4  
c -----  
c Control rod D7  
c -----  
C cell 1130 is the zirconium center rod of the fuel follower section  
1130 1 -6.51 -1041 1048 -1050 imp:n=4  
C cell 1131 is the fuel follower section  
1131 425 0.09626819 1041 -1045 1048 -1050 vol=209.418124 imp:n=16  
C cell 1132 is the lower Magnaform  
1132 5 -7.92 -1042 1054 -1051 imp:n=4  
C cell 1133 is the B4C poison section  
1133 6 0.135714 -1058 1051 -1049 imp:n=4  
C cell 1134 is the void at the top of the fuel element  
1134 9 -0.001205 -1042 1056 -1047 imp:n=4  
C cell 1135 is the cladding  
1135 5 -7.92 (1042:-1048: 1047)  
(-1043 1046 -1052):  
(-1044 -503 1052)  
imp:n=4  
c cell 1136 is the fuel follower gap  
1136 9 -0.001205 1045 -1042 1048 -1050 imp:n=4  
c cell 1137 is the fuel follower/clad void  
1137 9 -0.001205 1050 -1054 -1042 imp:n=4  
c cell 1138 is the poison section/clad gap  
1138 9 -0.001205 1051 -1049 1058 -1042 imp:n=4  
c cell 1139 is the poison section void  
1139 9 -0.001205 1049 -1055 -1042 imp:n=4  
c cell 1153 is the upper Magnaform  
1153 5 -7.92 1055 -1056 -1042 imp:n=4  
c -----  
c Control rod D13  
c -----  
C cell 1140 is the zirconium center rod of the fuel follower section  
1140 1 -6.51 -1061 1068 -1070 imp:n=4  
C cell 1141 is the fuel follower section  
1141 432 0.09626819 1061 -1065 1068 -1070 vol=209.418124 imp:n=16  
C cell 1142 is the lower Magnaform  
1142 5 -7.92 -1062 1074 -1071 imp:n=4  
C cell 1143 is the B4C poison section

```

1143 6 0.135714 -1078 1071 -1069          imp:n=1
C   cell 1144 is the void at the top of the fuel element
1144 9 -0.001205 -1062 1076 -1067          imp:n=4
C   cell 1145 is the cladding
1145 5 -7.92 (1062:-1068: 1067)
      (-1063 1066 -1072):
      (-1064 -503 1072)
                                     imp:n=4
c   cell 1146 is the fuel follower gap
1146 9 -0.001205 1065 -1062 1068 -1070    imp:n=4
c   cell 1147 is the fuel follower/clad void
1147 9 -0.001205 1070 -1074 -1062          imp:n=4
c   cell 1148 is the poison section/clad gap
1148 9 -0.001205 1071 -1069 1078 -1062    imp:n=4
c   cell 1149 is the poison section void
1149 9 -0.001205 1069 -1075 -1062          imp:n=4
c   cell 1143 is the upper Magnaform
1150 5 -7.92 1075 -1076 -1062             imp:n=4
c
C   -----
c   Cell 202 is the lower grid plate
c   -----
202 7 0.059195
    -200 201 -202 203 204 205 206 207 208 209
    210 211 213 214 215 216 217 218 219
    220 221 222 223 224 225 226 227 228 229
    230 231 232 233 234 235 236 237 238 239
    240 241 242 243 244 245 246 247 248 249
    250 251 252 253 254 255 256 257 258 259
    260 261 262 263 264 265 266 267 268 269
    270 271 272 273 274 275 276 277 278 279
    280 281 282 283 284 285 286 287 288 289
    290 291 292 293 294
    imp:n=1
C   -----
c   Cell 301 is the lower plenum region
c   -----
301 8 -1.0
    -11 200 -202 203 204 205 206 207 208 209
    210 211 213 214 215 216 217 218 219
    220 221 222 223 224 225 226 227 228 229
    230 231 232 233 234 235 236 237 238 239
    240 241 242 243 244 245 246 247 248 249
    250 251 252 253 254 255 256 257 258 259
    260 261 262 263 264 265 266 267 268 269
    270 271 272 274 275 276 277 278 279

```

```

280 281 282 283 284 285 286 287 288 289
290 291 292 293 294
imp:n=1
C -----
c Cell 300 is the reactor pool inside the support structure
c -----
300 8 -1.0 ((11: -201: 202:-203:-223:-229:-235)
      (10: -11: -203:-223:-229:-235: 152)
      (13: -51: 52: -53: -73: -79: -85)
      223 229 203 235 (113 201)
      (-1080 1084 -1085):
      (-1088 -1087 1085 203 223 229 235 (113 201))):
      (-201 203 223 229 235 1084 -1080)
imp:n=1
c
C -----
c core shroud and support structure
c -----
c
c cell 350 is the core shroud
350 7 0.059195 1080 -1081 1084 -1085 imp:n=1
c cell 351 is the core support
351 7 0.059195 1082 -1083 1087 -503 imp:n=1
c cell 353 is the shroud support extension
353 7 0.059195 1088 -1081 1085 -1087 imp:n=1
c Cell 352 is the reactor pool
352 8 -1.0 (((500 -502 1083 (-504:-505)):
      (-506 507 -520 521 500 -502):
      (500 -501 -508):
      (500 -501 -510):
      (501 -502 -509):
      (501 -502 -511):
      (501 -502 -516 506 -512 -515):
      (501 -502 519 -507 -522 -523):
      (500 -501 -516 506 -513 -514):
      (500 -501 519 -507 -517 -518)))
      (((-502 1083 1087):
      (-1087 1084 1081)):
      (-1084 1033 203 235 223 229):
      (-1033 500))
imp:n=1
c Cell 354 is the air in the tank above the water level
354 9 -0.001205 ((502 -503 (-504:-505)):
      (-506 507 -520 521 502 -503):
      (502 -503 -516 506 -512 -515):
      (502 -503 519 -507 -522 -523):

```

(502 -503 -519 -511):  
(502 -503 516 -509)) 1083

imp:n=1

c Cell 355 is the reactor tank lining

355 7 0.059195 (-500 550 (-552: -553)):

(-554 555 -520 521 550 -500):

(550 -500 -556 516):

(550 -500 -558 -519):

(550 -500 -516 554 -562 -563):

(550 -500 519 -507 -564 -565):

551 -501 ((516 508 -557):

(513 506 -516 -566):

(514 506 -516 -567)):

551 -501((-519 510 -559):

(517 -507 519 -568):

(518 -507 519 -569)):

(500 -503)((505 -553 -521):

(504 -552 520)):

500 -551 ((513 506 -554 -520):

(514 506 -554 521):

(517 -507 555 -520):

(518 -507 555 521):

((516 508 -556):

(506 -516 513 -562):

(506 -516 514 -563)):

((-519 510 -558):

(-507 519 517 -564):

(-507 519 518 -565))):

(501 -503(((512 506 -554 -520):

(515 506 -554 521)):

(-520 568 -507 555):

(521 569 -507 555):

((516 509 -557):

(506 -516 512 -566):

(506 -516 515 -567)):

((-519 511 -559):

(-507 519 522 -568):

(-507 519 523 -569))):

(506 -554 -501 551 -520 566):

(506 -554 -501 551 567 521):

(-501 551 555 -507 -520 568):

(-501 551 555 -507 521 569) imp:n=1

c Cell 356 is the air inside the top of the core support structure

356 9 -0.001205 502 -503 -1082

223

229

```

    235
    203
  imp:n=1
c   Cell 357 is the water inside the core support
357 8 -1.0 -1082 1087 -502
    223
    229
    235
    203
  imp:n=1
c
c -----
c   control rod support structure
c -----
c
c   cell 304 holds control rod A1
304 8 -1.0 (-1006:1003:
    (1012 1004))
    (-1013 1033 -502) imp:n=1
c   cell 305 holds control rod D1
305 8 -1.0 (-1026:1023:
    (1032 1024))
    (-1039 1033 -502) imp:n=1
c   cell 306 holds control rod D7
306 8 -1.0 (-1046:1043:
    (1052 1044))
    (-1053 1033 -502) imp:n=1
c   cell 307 holds control rod D13
307 8 -1.0 (-1066:1063:
    (1072 1064))
    (-1073 1033 -502) imp:n=1
c   Cell 150 is the water filled region in rings B thru D
150 8 -1.0 (-10  11  203  223  229  235 -150)
    4013
    4023 4033 4043 4053 4063 4073 4083 4093 4103
    4113 4123 4133 4143 4153 4163 4173 4183 4203
    4213 4223 4233 4243 4263 4283 4293 4303 4313
    4333 4343 4353 4363 4373
  imp:n=1
c   Cell 151 is a water filled torus in ring E
151 8 -1.0 -10  11  150 -151
    4383 4393 4403 4413 4423 4433 4443 4453 4463
    4473 4483 4493 4503 4513 4523 4533 4543 4553
    4563 4573 4583 4593 4613  113
  imp:n=1
c   Cell 152 is a water filled torus in ring F

```

152 8 -1.0 -10 11 151 -152  
4623 4633 4643 4653 4663 4673 4683 4693  
4713 4723 4733 4743 4753 4763 4773 4783 4793  
4803 4813 4823 4833 4843 4853 4863 4873 4883  
4893 4903 4913

imp:n=1

c

c -----

c Cell 900 is the concrete surrounding the reactor

c -----

900 13 -2.25 ((-503 800 802 -850 -804 805):  
(-503 800 850 -803 806 -807))  
(503: -550: (564 519 -555 -551):  
(565 519 -555 -551):  
(554 -516 563 -551):  
(554 -516 562 -551):  
(556 516 -551):  
(558 -551 -519):  
(552 520):  
(553 -521):  
(551 519 568 -555):  
(551 519 569 -555):  
(-519 559 551):  
(551 554 566 -516):  
(551 554 567 -516):  
(516 551 557))  
((555: -601: 602: -603: -604: 605):  
(555 519 -564 -565 -551):  
(-519 -558 -551):  
(-519 -559 551):  
(-555 519 -568 -569 551):  
(-555 -564 -565 519 -551))  
((-554: 651: 652: -653: -654: 655):  
(554 -516 -562 -563 -551):  
(516 -556 -551):  
(516 -557 551):  
(554 -516 -566 -567 551):  
(554 -562 -563 -516 -551))

imp:n=1

C

c -----

c Cell 901 is the outside world

c -----

901 0 (503: -800: -802: 850: 804: -805)  
(503: -800: -850: 803: -806: 807)  
imp:n=0

c

c -----  
C Cell 201 is the top grid plate

c -----  
C

201 7 0.059195  
-50 51 -52 53 54 55 56 57 58 59  
60 61 63 64 65 66 67 68 69  
70 71 72 73 74 75 76 77 78 79  
80 81 82 83 84 85 86 87 88 89  
90 91 92 93 94 95 96 97 98 99  
100 101 102 103 104 105 106 107 108 109  
110 111 112 113 114 115 116 117 118 119  
120 121 122 123 124 125 126 127 128 129  
130 131 132 133 134 135 136 137 138 139  
140 141 142 143 144 imp:n=1

c -----  
C

c cell 302 is the water in the upper plenum region

c -----

c

302 8 -1.0  
-13 50 -52 53 204 205 206 207 208 209  
210 211 213 214 215 216 217 218 219  
220 221 222 73 224 225 226 227 228 79  
230 231 232 233 234 85 236 237 238 239  
240 241 242 243 244 245 246 247 248 249  
250 251 252 253 254 255 256 257 258 259  
260 261 262 113 264 265 266 267 268 269  
270 271 272 274 275 276 277 278 279  
280 281 282 283 284 285 286 287 288 289  
290 291 292 293 294 imp:n=1  
601 8 -1.0 -50 204 10 -54 imp:n=1 \$ B1  
602 8 -1.0 -50 205 10 -55 imp:n=1 \$ B2  
603 8 -1.0 -50 206 10 -56 imp:n=1 \$ B3  
604 8 -1.0 -50 207 10 -57 imp:n=1 \$ B4  
605 8 -1.0 -50 208 10 -58 imp:n=1 \$ B5  
606 8 -1.0 -50 209 10 -59 imp:n=1 \$ B6  
607 8 -1.0 -50 210 10 -60 imp:n=1 \$ C1  
608 8 -1.0 -50 211 10 -61 imp:n=1 \$ C2  
609 8 -1.0 -50 213 10 -63 imp:n=1 \$ C3  
610 8 -1.0 -50 214 10 -64 imp:n=1 \$ C4  
611 8 -1.0 -50 215 10 -65 imp:n=1 \$ C5  
612 8 -1.0 -50 216 10 -66 imp:n=1 \$ C6  
613 8 -1.0 -50 217 10 -67 imp:n=1 \$ C7  
614 8 -1.0 -50 218 10 -68 imp:n=1 \$ C8  
615 8 -1.0 -50 219 10 -69 imp:n=1 \$ C9

616	8 -1.0	-50	220	10 -70	imp:n=1 \$ C10
617	8 -1.0	-50	221	10 -71	imp:n=1 \$ C11
618	8 -1.0	-50	222	10 -72	imp:n=1 \$ C12
619	8 -1.0	-50	224	10 -74	imp:n=1 \$ D2
620	8 -1.0	-50	225	10 -75	imp:n=1 \$ D3
621	8 -1.0	-50	226	10 -76	imp:n=1 \$ D4
622	8 -1.0	-50	227	10 -77	imp:n=1 \$ D5
623	8 -1.0	-50	228	10 -78	imp:n=1 \$ D6
624	8 -1.0	-50	230	10 -80	imp:n=1 \$ D8
625	8 -1.0	-50	231	10 -81	imp:n=1 \$ D9
626	8 -1.0	-50	232	10 -82	imp:n=1 \$ D20
627	8 -1.0	-50	233	10 -83	imp:n=1 \$ D11
628	8 -1.0	-50	234	10 -84	imp:n=1 \$ D12
629	8 -1.0	-50	236	10 -86	imp:n=1 \$ D14
630	8 -1.0	-50	237	10 -87	imp:n=1 \$ D15
631	8 -1.0	-50	238	10 -88	imp:n=1 \$ D16
632	8 -1.0	-50	239	10 -89	imp:n=1 \$ D17
633	8 -1.0	-50	240	10 -90	imp:n=1 \$ D18
634	8 -1.0	-50	241	10 -91	imp:n=1 \$ E1
635	8 -1.0	-50	242	10 -92	imp:n=1 \$ E2
636	8 -1.0	-50	243	10 -93	imp:n=1 \$ E3
637	8 -1.0	-50	244	10 -94	imp:n=1 \$ E4
638	8 -1.0	-50	245	10 -95	imp:n=1 \$ E5
639	8 -1.0	-50	246	10 -96	imp:n=1 \$ E6
640	8 -1.0	-50	247	10 -97	imp:n=1 \$ E7
641	8 -1.0	-50	248	10 -98	imp:n=1 \$ E8
642	8 -1.0	-50	249	10 -99	imp:n=1 \$ E9
643	8 -1.0	-50	250	10 -100	imp:n=1 \$ E10
644	8 -1.0	-50	251	10 -101	imp:n=1 \$ E11
645	8 -1.0	-50	252	10 -102	imp:n=1 \$ E12
646	8 -1.0	-50	253	10 -103	imp:n=1 \$ E13
647	8 -1.0	-50	254	10 -104	imp:n=1 \$ E14
648	8 -1.0	-50	255	10 -105	imp:n=1 \$ E15
649	8 -1.0	-50	256	10 -106	imp:n=1 \$ E16
650	8 -1.0	-50	257	10 -107	imp:n=1 \$ E17
651	8 -1.0	-50	258	10 -108	imp:n=1 \$ E18
652	8 -1.0	-50	259	10 -109	imp:n=1 \$ E19
653	8 -1.0	-50	260	10 -110	imp:n=1 \$ E20
654	8 -1.0	-50	261	10 -111	imp:n=1 \$ E21
655	8 -1.0	-50	262	10 -112	imp:n=1 \$ E22
657	8 -1.0	-50	264	10 -114	imp:n=1 \$ E24
658	8 -1.0	-50	265	10 -115	imp:n=1 \$ F1
659	8 -1.0	-50	266	10 -116	imp:n=1 \$ F2
660	8 -1.0	-50	267	10 -117	imp:n=1 \$ F3
661	8 -1.0	-50	268	10 -118	imp:n=1 \$ F4
662	8 -1.0	-50	269	10 -119	imp:n=1 \$ F5

663	8	-1.0	-50	270	10	-120	imp:n=1 \$ F6
664	8	-1.0	-50	271	10	-121	imp:n=1 \$ F7
665	8	-1.0	-50	272	10	-122	imp:n=1 \$ F8
666	8	-1.0	-50		10	-123	imp:n=1 \$ F9
667	8	-1.0	-50	274	10	-124	imp:n=1 \$ F10
668	8	-1.0	-50	275	10	-125	imp:n=1 \$ F11
669	8	-1.0	-50	276	10	-126	imp:n=1 \$ F12
670	8	-1.0	-50	277	10	-127	imp:n=1 \$ F13
671	8	-1.0	-50	278	10	-128	imp:n=1 \$ F14
672	8	-1.0	-50	279	10	-129	imp:n=1 \$ F15
673	8	-1.0	-50	280	10	-130	imp:n=1 \$ F16
674	8	-1.0	-50	281	10	-131	imp:n=1 \$ F17
675	8	-1.0	-50	282	10	-132	imp:n=1 \$ F18
676	8	-1.0	-50	283	10	-133	imp:n=1 \$ F19
677	8	-1.0	-50	284	10	-134	imp:n=1 \$ F20
678	8	-1.0	-50	285	10	-135	imp:n=1 \$ F21
679	8	-1.0	-50	286	10	-136	imp:n=1 \$ F22
680	8	-1.0	-50	287	10	-137	imp:n=1 \$ F23
681	8	-1.0	-50	288	10	-138	imp:n=1 \$ F24
682	8	-1.0	-50	289	10	-139	imp:n=1 \$ F25
683	8	-1.0	-50	290	10	-140	imp:n=1 \$ F26
684	8	-1.0	-50	291	10	-141	imp:n=1 \$ F27
685	8	-1.0	-50	292	10	-142	imp:n=1 \$ F28
686	8	-1.0	-50	293	10	-143	imp:n=1 \$ F29
687	8	-1.0	-50	294	10	-144	imp:n=1 \$ F30
54	5	-7.92	-54	-10	51:	(-204 -13 10)	imp:n=1 \$ B1
55	5	-7.92	-55	-10	51:	(-205 -13 10)	imp:n=1 \$ B2
56	5	-7.92	-56	-10	51:	(-206 -13 10)	imp:n=1 \$ B3
57	5	-7.92	-57	-10	51:	(-207 -13 10)	imp:n=1 \$ B4
58	5	-7.92	-58	-10	51:	(-208 -13 10)	imp:n=1 \$ B5
59	5	-7.92	-59	-10	51:	(-209 -13 10)	imp:n=1 \$ B6
60	5	-7.92	-60	-10	51:	(-210 -13 10)	imp:n=1 \$ C1
61	5	-7.92	-61	-10	51:	(-211 -13 10)	imp:n=1 \$ C2
63	5	-7.92	-63	-10	51:	(-213 -13 10)	imp:n=1 \$ C3
64	5	-7.92	-64	-10	51:	(-214 -13 10)	imp:n=1 \$ C4
65	5	-7.92	-65	-10	51:	(-215 -13 10)	imp:n=1 \$ C5
66	5	-7.92	-66	-10	51:	(-216 -13 10)	imp:n=1 \$ C6
67	5	-7.92	-67	-10	51:	(-217 -13 10)	imp:n=1 \$ C7
68	5	-7.92	-68	-10	51:	(-218 -13 10)	imp:n=1 \$ C8
69	5	-7.92	-69	-10	51:	(-219 -13 10)	imp:n=1 \$ C9
70	5	-7.92	-70	-10	51:	(-220 -13 10)	imp:n=1 \$ C10
71	5	-7.92	-71	-10	51:	(-221 -13 10)	imp:n=1 \$ C11
72	5	-7.92	-72	-10	51:	(-222 -13 10)	imp:n=1 \$ C12
74	5	-7.92	-74	-10	51:	(-224 -13 10)	imp:n=1 \$ D2
75	5	-7.92	-75	-10	51:	(-225 -13 10)	imp:n=1 \$ D3
76	5	-7.92	-76	-10	51:	(-226 -13 10)	imp:n=1 \$ D4

77	5	-7.92	-77	-10	51:(-227 -13 10)	imp:n=1 \$ D5
78	5	-7.92	-78	-10	51:(-228 -13 10)	imp:n=1 \$ D6
80	5	-7.92	-80	-10	51:(-230 -13 10)	imp:n=1 \$ D8
81	5	-7.92	-81	-10	51:(-231 -13 10)	imp:n=1 \$ D9
82	5	-7.92	-82	-10	51:(-232 -13 10)	imp:n=1 \$ D10
83	5	-7.92	-83	-10	51:(-233 -13 10)	imp:n=1 \$ D11
84	5	-7.92	-84	-10	51:(-234 -13 10)	imp:n=1 \$ D12
86	5	-7.92	-86	-10	51:(-236 -13 10)	imp:n=1 \$ D14
87	5	-7.92	-87	-10	51:(-237 -13 10)	imp:n=1 \$ D15
88	5	-7.92	-88	-10	51:(-238 -13 10)	imp:n=1 \$ D16
89	5	-7.92	-89	-10	51:(-239 -13 10)	imp:n=1 \$ D17
90	5	-7.92	-90	-10	51:(-240 -13 10)	imp:n=1 \$ D18
91	5	-7.92	-91	-10	51:(-241 -13 10)	imp:n=1 \$ E1
92	5	-7.92	-92	-10	51:(-242 -13 10)	imp:n=1 \$ E2
93	5	-7.92	-93	-10	51:(-243 -13 10)	imp:n=1 \$ E3
94	5	-7.92	-94	-10	51:(-244 -13 10)	imp:n=1 \$ E4
95	5	-7.92	-95	-10	51:(-245 -13 10)	imp:n=1 \$ E5
96	5	-7.92	-96	-10	51:(-246 -13 10)	imp:n=1 \$ E6
97	5	-7.92	-97	-10	51:(-247 -13 10)	imp:n=1 \$ E7
98	5	-7.92	-98	-10	51:(-248 -13 10)	imp:n=1 \$ E8
99	5	-7.92	-99	-10	51:(-249 -13 10)	imp:n=1 \$ E9
100	5	-7.92	-100	-10	51:(-250 -13 10)	imp:n=1 \$ E10
101	5	-7.92	-101	-10	51:(-251 -13 10)	imp:n=1 \$ E11
102	5	-7.92	-102	-10	51:(-252 -13 10)	imp:n=1 \$ E12
103	5	-7.92	-103	-10	51:(-253 -13 10)	imp:n=1 \$ E13
104	5	-7.92	-104	-10	51:(-254 -13 10)	imp:n=1 \$ E14
105	5	-7.92	-105	-10	51:(-255 -13 10)	imp:n=1 \$ E15
106	5	-7.92	-106	-10	51:(-256 -13 10)	imp:n=1 \$ E16
107	5	-7.92	-107	-10	51:(-257 -13 10)	imp:n=1 \$ E17
108	5	-7.92	-108	-10	51:(-258 -13 10)	imp:n=1 \$ E18
109	5	-7.92	-109	-10	51:(-259 -13 10)	imp:n=1 \$ E19
110	5	-7.92	-110	-10	51:(-260 -13 10)	imp:n=1 \$ E20
111	5	-7.92	-111	-10	51:(-261 -13 10)	imp:n=1 \$ E21
112	5	-7.92	-112	-10	51:(-262 -13 10)	imp:n=1 \$ E22
114	5	-7.92	-114	-10	51:(-264 -13 10)	imp:n=1 \$ E24
115	5	-7.92	-115	-10	51:(-265 -13 10)	imp:n=1 \$ F1
116	5	-7.92	-116	-10	51:(-266 -13 10)	imp:n=1 \$ F2
117	5	-7.92	-117	-10	51:(-267 -13 10)	imp:n=1 \$ F3
118	5	-7.92	-118	-10	51:(-268 -13 10)	imp:n=1 \$ F4
119	5	-7.92	-119	-10	51:(-269 -13 10)	imp:n=1 \$ F5
120	5	-7.92	-120	-10	51:(-270 -13 10)	imp:n=1 \$ F6
121	5	-7.92	-121	-10	51:(-271 -13 10)	imp:n=1 \$ F7
122	5	-7.92	-122	-10	51:(-272 -13 10)	imp:n=1 \$ F8
124	5	-7.92	-124	-10	51:(-274 -13 10)	imp:n=1 \$ F9
125	5	-7.92	-125	-10	51:(-275 -13 10)	imp:n=1 \$ F10
126	5	-7.92	-126	-10	51:(-276 -13 10)	imp:n=1 \$ F11

127	5	-7.92	-127	-10	51:(-277 -13 10)	imp:n=1 \$ F12
128	5	-7.92	-128	-10	51:(-278 -13 10)	imp:n=1 \$ F13
129	5	-7.92	-129	-10	51:(-279 -13 10)	imp:n=1 \$ F14
130	5	-7.92	-130	-10	51:(-280 -13 10)	imp:n=1 \$ F15
131	5	-7.92	-131	-10	51:(-281 -13 10)	imp:n=1 \$ F16
132	5	-7.92	-132	-10	51:(-282 -13 10)	imp:n=1 \$ F17
133	5	-7.92	-133	-10	51:(-283 -13 10)	imp:n=1 \$ F18
134	5	-7.92	-134	-10	51:(-284 -13 10)	imp:n=1 \$ F19
135	5	-7.92	-135	-10	51:(-285 -13 10)	imp:n=1 \$ F20
136	5	-7.92	-136	-10	51:(-286 -13 10)	imp:n=1 \$ F21
137	5	-7.92	-137	-10	51:(-287 -13 10)	imp:n=1 \$ F22
138	5	-7.92	-138	-10	51:(-288 -13 10)	imp:n=1 \$ F24
139	5	-7.92	-139	-10	51:(-289 -13 10)	imp:n=1 \$ F25
140	5	-7.92	-140	-10	51:(-290 -13 10)	imp:n=1 \$ F26
141	5	-7.92	-141	-10	51:(-291 -13 10)	imp:n=1 \$ F27
142	5	-7.92	-142	-10	51:(-292 -13 10)	imp:n=1 \$ F28
143	5	-7.92	-143	-10	51:(-293 -13 10)	imp:n=1 \$ F29
144	5	-7.92	-144	-10	51:(-294 -13 10)	imp:n=1 \$ F30

c

C -----

c Cells in bottom plate

c -----

c

204	5	-7.92	201	-11	-204	imp:n=1 \$ B1
205	5	-7.92	201	-11	-205	imp:n=1 \$ B2
206	5	-7.92	201	-11	-206	imp:n=1 \$ B3
207	5	-7.92	201	-11	-207	imp:n=1 \$ B4
208	5	-7.92	201	-11	-208	imp:n=1 \$ B5
209	5	-7.92	201	-11	-209	imp:n=1 \$ B6
210	5	-7.92	201	-11	-210	imp:n=1 \$ C1
211	5	-7.92	201	-11	-211	imp:n=1 \$ C2
213	5	-7.92	201	-11	-213	imp:n=1 \$ C3
214	5	-7.92	201	-11	-214	imp:n=1 \$ C4
215	5	-7.92	201	-11	-215	imp:n=1 \$ C5
216	5	-7.92	201	-11	-216	imp:n=1 \$ C6
217	5	-7.92	201	-11	-217	imp:n=1 \$ C7
218	5	-7.92	201	-11	-218	imp:n=1 \$ C8
219	5	-7.92	201	-11	-219	imp:n=1 \$ C9
220	5	-7.92	201	-11	-220	imp:n=1 \$ C10
221	5	-7.92	201	-11	-221	imp:n=1 \$ C11
222	5	-7.92	201	-11	-222	imp:n=1 \$ C12
224	5	-7.92	201	-11	-224	imp:n=1 \$ D2
225	5	-7.92	201	-11	-225	imp:n=1 \$ D3
226	5	-7.92	201	-11	-226	imp:n=1 \$ D4
227	5	-7.92	201	-11	-227	imp:n=1 \$ D5
228	5	-7.92	201	-11	-228	imp:n=1 \$ D6

230	5	-7.92	201	-11	-230	imp:n=1 \$ D8
231	5	-7.92	201	-11	-231	imp:n=1 \$ D9
232	5	-7.92	201	-11	-232	imp:n=1 \$ D10
233	5	-7.92	201	-11	-233	imp:n=1 \$ D11
234	5	-7.92	201	-11	-234	imp:n=1 \$ D12
236	5	-7.92	201	-11	-236	imp:n=1 \$ D14
237	5	-7.92	201	-11	-237	imp:n=1 \$ D15
238	5	-7.92	201	-11	-238	imp:n=1 \$ D16
239	5	-7.92	201	-11	-239	imp:n=1 \$ D17
240	5	-7.92	201	-11	-240	imp:n=1 \$ D18
241	5	-7.92	201	-11	-241	imp:n=1 \$ E1
242	5	-7.92	201	-11	-242	imp:n=1 \$ E2
243	5	-7.92	201	-11	-243	imp:n=1 \$ E3
244	5	-7.92	201	-11	-244	imp:n=1 \$ E4
245	5	-7.92	201	-11	-245	imp:n=1 \$ E5
246	5	-7.92	201	-11	-246	imp:n=1 \$ E6
247	5	-7.92	201	-11	-247	imp:n=1 \$ E7
248	5	-7.92	201	-11	-248	imp:n=1 \$ E8
249	5	-7.92	201	-11	-249	imp:n=1 \$ E9
250	5	-7.92	201	-11	-250	imp:n=1 \$ E10
251	5	-7.92	201	-11	-251	imp:n=1 \$ E11
252	5	-7.92	201	-11	-252	imp:n=1 \$ E12
253	5	-7.92	201	-11	-253	imp:n=1 \$ E13
254	5	-7.92	201	-11	-254	imp:n=1 \$ E14
255	5	-7.92	201	-11	-255	imp:n=1 \$ E15
256	5	-7.92	201	-11	-256	imp:n=1 \$ E16
257	5	-7.92	201	-11	-257	imp:n=1 \$ E17
258	5	-7.92	201	-11	-258	imp:n=1 \$ E18
259	5	-7.92	201	-11	-259	imp:n=1 \$ E19
260	5	-7.92	201	-11	-260	imp:n=1 \$ E20
261	5	-7.92	201	-11	-261	imp:n=1 \$ E21
262	5	-7.92	201	-11	-262	imp:n=1 \$ E22
263	7	0.059195	201	-11	-263	imp:n=1 \$ E23
264	5	-7.92	201	-11	-264	imp:n=1 \$ E24
265	5	-7.92	201	-11	-265	imp:n=1 \$ F1
266	5	-7.92	201	-11	-266	imp:n=1 \$ F2
267	5	-7.92	201	-11	-267	imp:n=1 \$ F3
268	5	-7.92	201	-11	-268	imp:n=1 \$ F4
269	5	-7.92	201	-11	-269	imp:n=1 \$ F5
270	5	-7.92	201	-11	-270	imp:n=1 \$ F6
271	5	-7.92	201	-11	-271	imp:n=1 \$ F7
272	5	-7.92	201	-11	-272	imp:n=1 \$ F8
273	8	-1.00	201	-14	-273	imp:n=1 \$ F9
274	5	-7.92	201	-11	-274	imp:n=1 \$ F10
275	5	-7.92	201	-11	-275	imp:n=1 \$ F11
276	5	-7.92	201	-11	-276	imp:n=1 \$ F12

277	5	-7.92	201	-11	-277	imp:n=1 \$ F13
278	5	-7.92	201	-11	-278	imp:n=1 \$ F14
279	5	-7.92	201	-11	-279	imp:n=1 \$ F15
280	5	-7.92	201	-11	-280	imp:n=1 \$ F16
281	5	-7.92	201	-11	-281	imp:n=1 \$ F17
282	5	-7.92	201	-11	-282	imp:n=1 \$ F18
283	5	-7.92	201	-11	-283	imp:n=1 \$ F19
284	5	-7.92	201	-11	-284	imp:n=1 \$ F20
285	5	-7.92	201	-11	-285	imp:n=1 \$ F21
286	5	-7.92	201	-11	-286	imp:n=1 \$ F22
287	5	-7.92	201	-11	-287	imp:n=1 \$ F23
288	5	-7.92	201	-11	-288	imp:n=1 \$ F24
289	5	-7.92	201	-11	-289	imp:n=1 \$ F25
290	5	-7.92	201	-11	-290	imp:n=1 \$ F26
291	5	-7.92	201	-11	-291	imp:n=1 \$ F27
292	5	-7.92	201	-11	-292	imp:n=1 \$ F28
293	5	-7.92	201	-11	-293	imp:n=1 \$ F29
294	5	-7.92	201	-11	-294	imp:n=1 \$ F30

C

C

C -----  
 C Adding additional fuel elements

c -----

C

C Fuel Element B-1

C

C Cell 4011 is the central zirconium rod

4011 1 -6.51 -4011 -4 5 imp:n=4

C Cell 4012 is the fuel area of the fuel rod

4012 401 0.09690183 4011 -4012 -4 5 vol=382.3638538 imp:n=16

C Cell 4013 is the upper Samarium/aluminum poison disk

4013 3 -5.27 4 -6 -4012 imp:n=4

C Cell 4014 is the lower Samarium/aluminum poison disk

4014 3 -5.27 -5 7 -4012 imp:n=4

C Cell 4015 is the upper Carbon reflector

4015 4 -1.75 -8 6 -4012 imp:n=1

C Cell 4016 is the lower Carbon Reflector

4016 4 -1.75 -7 9 -4012 imp:n=1

C Cell 4017 is the Stainless Steel cladding of the fuel element

C and support structure

4017 5 -7.92 (4012:15:-9) (-4013 -10 11) imp:n=4

C Cell 4018 is the void at the top of the fuel element

4018 9 -0.001205 -4012 -15 8 imp:n=1

C

C Fuel Element B-2

C

C Cell 4021 is the central Zirconium rod

4021 1 -6.51 -4021 -4 5 imp:n=4  
 C Cell 4022 is the fuel area of the fuel rod  
 4022 402 0.09690183 4021 -4022 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4023 is the upper Samarium/aluminum poison disk  
 4023 3 -5.27 4 -6 -4022 imp:n=4  
 C Cell 4024 is the lower Samarium/aluminum poison disk  
 4024 3 -5.27 -5 7 -4022 imp:n=4  
 C Cell 4025 is the upper Carbon reflector  
 4025 4 -1.75 -8 6 -4022 imp:n=1  
 C Cell 4026 is the lower Carbon Reflector  
 4026 4 -1.75 -7 9 -4022 imp:n=1  
 C Cell 4027 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4027 5 -7.92 (4022:15:-9) (-4023 -10 11) imp:n=4  
 C Cell 4028 is the void at the top of the fuel element  
 4028 9 -0.001205 -4022 -15 8 imp:n=1  
 C  
 C Fuel Element B-3  
 C  
 C Cell 4031 is the central Zirconium rod  
 4031 1 -6.51 -4031 -4 5 imp:n=4  
 C Cell 4032 is the fuel area of the fuel rod  
 4032 403 0.09690183 4031 -4032 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4033 is the upper Samarium/aluminum poison disk  
 4033 3 -5.27 4 -6 -4032 imp:n=4  
 C Cell 4034 is the lower Samarium/aluminum poison disk  
 4034 3 -5.27 -5 7 -4032 imp:n=4  
 C Cell 4035 is the upper Carbon reflector  
 4035 4 -1.75 -8 6 -4032 imp:n=1  
 C Cell 4036 is the lower Carbon Reflector  
 4036 4 -1.75 -7 9 -4032 imp:n=1  
 C Cell 4037 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4037 5 -7.92 (4032:15:-9) (-4033 -10 11) imp:n=4  
 C Cell 4038 is the void at the top of the fuel element  
 4038 9 -0.001205 -4032 -15 8 imp:n=1  
 C  
 C Fuel Element B-4  
 C  
 C Cell 40401 is the central Zirconium rod  
 4041 1 -6.51 -4041 -4 5 imp:n=4  
 C Cell 40402 is the fuel area of the fuel rod  
 4042 404 0.09690183 4041 -4042 -4 5 vol=382.3638538 imp:n=16  
 C Cell 40403 is the upper Samarium/aluminum poison disk  
 4043 3 -5.27 4 -6 -4042 imp:n=4  
 C Cell 40404 is the lower Samarium/aluminum poison disk

4044 3 -5.27 -5 7 -4042 imp:n=4  
 C Cell 40405 is the upper Carbon reflector  
 4045 4 -1.75 -8 6 -4042 imp:n=1  
 C Cell 40406 is the lower Carbon Reflector  
 4046 4 -1.75 -7 9 -4042 imp:n=1  
 C Cell 40407 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4047 5 -7.92 (4042:15:-9) (-4043 -10 11) imp:n=4  
 C Cell 40408 is the void at the top of the fuel element  
 4048 9 -0.001205 -4042 -15 8 imp:n=1  
 C  
 C Fuel Element B-5  
 C  
 C Cell 4051 is the central Zirconium rod  
 4051 1 -6.51 -4051 -4 5 imp:n=4  
 C Cell 4052 is the fuel area of the fuel rod  
 4052 405 0.09690183 4051 -4052 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4053 is the upper Samarium/aluminum poison disk  
 4053 3 -5.27 4 -6 -4052 imp:n=4  
 C Cell 4054 is the lower Samarium/aluminum poison disk  
 4054 3 -5.27 -5 7 -4052 imp:n=4  
 C Cell 4055 is the upper Carbon reflector  
 4055 4 -1.75 -8 6 -4052 imp:n=1  
 C Cell 4056 is the lower Carbon Reflector  
 4056 4 -1.75 -7 9 -4052 imp:n=1  
 C Cell 4057 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4057 5 -7.92 (4052:15:-9) (-4053 -10 11) imp:n=4  
 C Cell 4058 is the void at the top of the fuel element  
 4058 9 -0.001205 -4052 -15 8 imp:n=1  
 C  
 C Fuel Element B-6  
 C  
 C Cell 4061 is the central Zirconium rod  
 4061 1 -6.51 -4061 -4 5 imp:n=4  
 C Cell 4062 is the fuel area of the fuel rod  
 4062 406 0.09690183 4061 -4062 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4063 is the upper Samarium/aluminum poison disk  
 4063 3 -5.27 4 -6 -4062 imp:n=4  
 C Cell 4064 is the lower Samarium/aluminum poison disk  
 4064 3 -5.27 -5 7 -4062 imp:n=4  
 C Cell 4065 is the upper Carbon reflector  
 4065 4 -1.75 -8 6 -4062 imp:n=1  
 C Cell 4066 is the lower Carbon Reflector  
 4066 4 -1.75 -7 9 -4062 imp:n=1  
 C Cell 4067 is the Stainless Steel cladding of the fuel element

C and support structure  
 4067 5 -7.92 (4062:15:-9) (-4063 -10 11) imp:n=4  
 C Cell 4068 is the void at the top of the fuel element  
 4068 9 -0.001205 -4062 -15 8 imp:n=1  
 C  
 C Fuel Element C-1  
 C  
 C Cell 4071 is the central Zirconium rod  
 4071 1 -6.51 -4071 -4 5 imp:n=4  
 C Cell 4072 is the fuel area of the fuel rod  
 4072 407 0.09690183 4071 -4072 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4073 is the upper Samarium/aluminum poison disk  
 4073 3 -5.27 4 -6 -4072 imp:n=4  
 C Cell 4074 is the lower Samarium/aluminum poison disk  
 4074 3 -5.27 -5 7 -4072 imp:n=4  
 C Cell 4075 is the upper Carbon reflector  
 4075 4 -1.75 -8 6 -4072 imp:n=1  
 C Cell 4076 is the lower Carbon Reflector  
 4076 4 -1.75 -7 9 -4072 imp:n=1  
 C Cell 4077 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4077 5 -7.92 (4072:15:-9) (-4073 -10 11) imp:n=4  
 C Cell 4078 is the void at the top of the fuel element  
 4078 9 -0.001205 -4072 -15 8 imp:n=1  
 C  
 C Fuel Element C-2  
 C  
 C Cell 4081 is the central Zirconium rod  
 4081 1 -6.51 -4081 -4 5 imp:n=4  
 C Cell 4082 is the fuel area of the fuel rod  
 4082 408 0.09690183 4081 -4082 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4083 is the upper Samarium/aluminum poison disk  
 4083 3 -5.27 4 -6 -4082 imp:n=4  
 C Cell 4084 is the lower Samarium/aluminum poison disk  
 4084 3 -5.27 -5 7 -4082 imp:n=4  
 C Cell 4085 is the upper Carbon reflector  
 4085 4 -1.75 -8 6 -4082 imp:n=1  
 C Cell 4086 is the lower Carbon Reflector  
 4086 4 -1.75 -7 9 -4082 imp:n=1  
 C Cell 4087 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4087 5 -7.92 (4082:15:-9) (-4083 -10 11) imp:n=4  
 C Cell 4088 is the void at the top of the fuel element  
 4088 9 -0.001205 -4082 -15 8 imp:n=1  
 C  
 C Fuel Element C-3

C  
 C Cell 4091 is the central Zirconium rod  
 4091 1 -6.51 -4091 -4 5 imp:n=4  
 C Cell 4092 is the fuel area of the fuel rod  
 4092 409 0.09690183 4091 -4092 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4093 is the upper Samarium/aluminum poison disk  
 4093 3 -5.27 4 -6 -4092 imp:n=4  
 C Cell 4094 is the lower Samarium/aluminum poison disk  
 4094 3 -5.27 -5 7 -4092 imp:n=4  
 C Cell 4095 is the upper Carbon reflector  
 4095 4 -1.75 -8 6 -4092 imp:n=1  
 C Cell 4096 is the lower Carbon Reflector  
 4096 4 -1.75 -7 9 -4092 imp:n=1  
 C Cell 4097 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4097 5 -7.92 (4092:15:-9) (-4093 -10 11) imp:n=4  
 C Cell 4098 is the void at the top of the fuel element  
 4098 9 -0.001205 -4092 -15 8 imp:n=1  
 C  
 C Fuel Element C-4  
 C  
 C Cell 4101 is the central Zirconium rod  
 4101 1 -6.51 -4101 -4 5 imp:n=4  
 C Cell 4102 is the fuel area of the fuel rod  
 4102 410 0.09690183 4101 -4102 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4103 is the upper Samarium/aluminum poison disk  
 4103 3 -5.27 4 -6 -4102 imp:n=4  
 C Cell 4104 is the lower Samarium/aluminum poison disk  
 4104 3 -5.27 -5 7 -4102 imp:n=4  
 C Cell 4105 is the upper Carbon reflector  
 4105 4 -1.75 -8 6 -4102 imp:n=1  
 C Cell 4106 is the lower Carbon Reflector  
 4106 4 -1.75 -7 9 -4102 imp:n=1  
 C Cell 4107 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4107 5 -7.92 (4102:15:-9) (-4103 -10 11) imp:n=4  
 C Cell 4108 is the void at the top of the fuel element  
 4108 9 -0.001205 -4102 -15 8 imp:n=1  
 C  
 C Fuel Element C-5  
 C  
 C Cell 4111 is the central Zirconium rod  
 4111 1 -6.51 -4111 -4 5 imp:n=4  
 C Cell 4112 is the fuel area of the fuel rod  
 4112 411 0.09690183 4111 -4112 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4113 is the upper Samarium/aluminum poison disk

4113 3 -5.27 4 -6 -4112 imp:n=4  
 C Cell 4114 is the lower Samarium/aluminum poison disk  
 4114 3 -5.27 -5 7 -4112 imp:n=4  
 C Cell 4115 is the upper Carbon reflector  
 4115 4 -1.75 -8 6 -4112 imp:n=1  
 C Cell 4116 is the lower Carbon Reflector  
 4116 4 -1.75 -7 9 -4112 imp:n=1  
 C Cell 4117 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4117 5 -7.92 (4112:15:-9) (-4113 -10 11) imp:n=4  
 C Cell 4118 is the void at the top of the fuel element  
 4118 9 -0.001205 -4112 -15 8 imp:n=1  
 C  
 C Fuel Element C-6  
 C  
 C Cell 4121 is the central Zirconium rod  
 4121 1 -6.51 -4121 -4 5 imp:n=4  
 C Cell 4122 is the fuel area of the fuel rod  
 4122 412 0.09690183 4121 -4122 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4123 is the upper Samarium/aluminum poison disk  
 4123 3 -5.27 4 -6 -4122 imp:n=4  
 C Cell 4124 is the lower Samarium/aluminum poison disk  
 4124 3 -5.27 -5 7 -4122 imp:n=4  
 C Cell 4125 is the upper Carbon reflector  
 4125 4 -1.75 -8 6 -4122 imp:n=1  
 C Cell 4126 is the lower Carbon Reflector  
 4126 4 -1.75 -7 9 -4122 imp:n=1  
 C Cell 4127 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4127 5 -7.92 (4122:15:-9) (-4123 -10 11) imp:n=4  
 C Cell 4128 is the void at the top of the fuel element  
 4128 9 -0.001205 -4122 -15 8 imp:n=1  
 C  
 C Fuel Element C-7  
 C  
 C Cell 4131 is the central Zirconium rod  
 4131 1 -6.51 -4131 -4 5 imp:n=4  
 C Cell 4132 is the fuel area of the fuel rod  
 4132 413 0.09690183 4131 -4132 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4133 is the upper Samarium/aluminum poison disk  
 4133 3 -5.27 4 -6 -4132 imp:n=4  
 C Cell 4134 is the lower Samarium/aluminum poison disk  
 4134 3 -5.27 -5 7 -4132 imp:n=4  
 C Cell 4135 is the upper Carbon reflector  
 4135 4 -1.75 -8 6 -4132 imp:n=1  
 C Cell 4136 is the lower Carbon Reflector

4136 4 -1.75 -7 9 -4132 imp:n=1  
 C Cell 4137 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4137 5 -7.92 (4132:15:-9) (-4133 -10 11) imp:n=4  
 C Cell 4138 is the void at the top of the fuel element  
 4138 9 -0.001205 -4132 -15 8 imp:n=1  
 C  
 C Fuel Element C-8  
 C  
 C Cell 4141 is the central Zirconium rod  
 4141 1 -6.51 -4141 -4 5 imp:n=4  
 C Cell 4142 is the fuel area of the fuel rod  
 4142 414 0.09690183 4141 -4142 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4143 is the upper Samarium/aluminum poison disk  
 4143 3 -5.27 4 -6 -4142 imp:n=4  
 C Cell 4144 is the lower Samarium/aluminum poison disk  
 4144 3 -5.27 -5 7 -4142 imp:n=4  
 C Cell 4145 is the upper Carbon reflector  
 4145 4 -1.75 -8 6 -4142 imp:n=1  
 C Cell 4146 is the lower Carbon Reflector  
 4146 4 -1.75 -7 9 -4142 imp:n=1  
 C Cell 4147 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4147 5 -7.92 (4142:15:-9) (-4143 -10 11) imp:n=4  
 C Cell 4148 is the void at the top of the fuel element  
 4148 9 -0.001205 -4142 -15 8 imp:n=1  
 C  
 C Fuel Element C-9  
 C  
 C Cell 4151 is the central Zirconium rod  
 4151 1 -6.51 -4151 -4 5 imp:n=4  
 C Cell 4152 is the fuel area of the fuel rod  
 4152 415 0.09690183 4151 -4152 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4153 is the upper Samarium/aluminum poison disk  
 4153 3 -5.27 4 -6 -4152 imp:n=4  
 C Cell 4154 is the lower Samarium/aluminum poison disk  
 4154 3 -5.27 -5 7 -4152 imp:n=4  
 C Cell 4155 is the upper Carbon reflector  
 4155 4 -1.75 -8 6 -4152 imp:n=1  
 C Cell 4156 is the lower Carbon Reflector  
 4156 4 -1.75 -7 9 -4152 imp:n=1  
 C Cell 4157 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4157 5 -7.92 (4152:15:-9) (-4153 -10 11) imp:n=4  
 C Cell 4158 is the void at the top of the fuel element  
 4158 9 -0.001205 -4152 -15 8 imp:n=1

C  
C Fuel Element C-10  
C  
C Cell 4161 is the central Zirconium rod  
4161 1 -6.51 -4161 -4 5 imp:n=4  
C Cell 4162 is the fuel area of the fuel rod  
4162 416 0.09690183 4161 -4162 -4 5 vol=382.3638538 imp:n=16  
C Cell 4163 is the upper Samarium/aluminum poison disk  
4163 3 -5.27 4 -6 -4162 imp:n=4  
C Cell 4164 is the lower Samarium/aluminum poison disk  
4164 3 -5.27 -5 7 -4162 imp:n=4  
C Cell 4165 is the upper Carbon reflector  
4165 4 -1.75 -8 6 -4162 imp:n=1  
C Cell 4166 is the lower Carbon Reflector  
4166 4 -1.75 -7 9 -4162 imp:n=1  
C Cell 4167 is the Stainless Steel cladding of the fuel element  
C and support structure  
4167 5 -7.92 (4162:15:-9) (-4163 -10 11) imp:n=4  
C Cell 4168 is the void at the top of the fuel element  
4168 9 -0.001205 -4162 -15 8 imp:n=1  
C  
C Fuel Element C-11  
C  
C Cell 4171 is the central Zirconium rod  
4171 1 -6.51 -4171 -4 5 imp:n=4  
C Cell 4172 is the fuel area of the fuel rod  
4172 417 0.09690183 4171 -4172 -4 5 vol=382.3638538 imp:n=16  
C Cell 4173 is the upper Samarium/aluminum poison disk  
4173 3 -5.27 4 -6 -4172 imp:n=4  
C Cell 4174 is the lower Samarium/aluminum poison disk  
4174 3 -5.27 -5 7 -4172 imp:n=4  
C Cell 4175 is the upper Carbon reflector  
4175 4 -1.75 -8 6 -4172 imp:n=1  
C Cell 4176 is the lower Carbon Reflector  
4176 4 -1.75 -7 9 -4172 imp:n=1  
C Cell 4177 is the Stainless Steel cladding of the fuel element  
C and support structure  
4177 5 -7.92 (4172:15:-9) (-4173 -10 11) imp:n=4  
C Cell 4178 is the void at the top of the fuel element  
4178 9 -0.001205 -4172 -15 8 imp:n=1  
C  
C Fuel Element C-12  
C  
C Cell 4181 is the central Zirconium rod  
4181 1 -6.51 -4181 -4 5 imp:n=4  
C Cell 4182 is the fuel area of the fuel rod

4182 418 0.09690183 4181 -4182 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4183 is the upper Samarium/aluminum poison disk  
 4183 3 -5.27 4 -6 -4182 imp:n=4  
 C Cell 4184 is the lower Samarium/aluminum poison disk  
 4184 3 -5.27 -5 7 -4182 imp:n=4  
 C Cell 4185 is the upper Carbon reflector  
 4185 4 -1.75 -8 6 -4182 imp:n=1  
 C Cell 4186 is the lower Carbon Reflector  
 4186 4 -1.75 -7 9 -4182 imp:n=1  
 C Cell 4187 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4187 5 -7.92 (4182:15:-9) (-4183 -10 11) imp:n=4  
 C Cell 4188 is the void at the top of the fuel element  
 4188 9 -0.001205 -4182 -15 8 imp:n=1  
 C  
 C Fuel Element D-2  
 C  
 C Cell 4201 is the central Zirconium rod  
 4201 1 -6.51 -4201 -4 5 imp:n=4  
 C Cell 4202 is the fuel area of the fuel rod  
 4202 420 0.09690183 4201 -4202 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4203 is the upper Samarium/aluminum poison disk  
 4203 3 -5.27 4 -6 -4202 imp:n=4  
 C Cell 4204 is the lower Samarium/aluminum poison disk  
 4204 3 -5.27 -5 7 -4202 imp:n=4  
 C Cell 4205 is the upper Carbon reflector  
 4205 4 -1.75 -8 6 -4202 imp:n=1  
 C Cell 4206 is the lower Carbon Reflector  
 4206 4 -1.75 -7 9 -4202 imp:n=1  
 C Cell 4207 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4207 5 -7.92 (4202:15:-9) (-4203 -10 11) imp:n=4  
 C Cell 4208 is the void at the top of the fuel element  
 4208 9 -0.001205 -4202 -15 8 imp:n=1  
 C  
 C Fuel Element D-3  
 C  
 C Cell 4211 is the central Zirconium rod  
 4211 1 -6.51 -4211 -4 5 imp:n=4  
 C Cell 4212 is the fuel area of the fuel rod  
 4212 421 0.09690183 4211 -4212 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4213 is the upper Samarium/aluminum poison disk  
 4213 3 -5.27 4 -6 -4212 imp:n=4  
 C Cell 4214 is the lower Samarium/aluminum poison disk  
 4214 3 -5.27 -5 7 -4212 imp:n=4  
 C Cell 4215 is the upper Carbon reflector

4215 4 -1.75 -8 6 -4212 imp:n=1  
 C Cell 4216 is the lower Carbon Reflector  
 4216 4 -1.75 -7 9 -4212 imp:n=1  
 C Cell 4217 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4217 5 -7.92 (4212:15:-9) (-4213 -10 11) imp:n=4  
 C Cell 4218 is the void at the top of the fuel element  
 4218 9 -0.001205 -4212 -15 8 imp:n=1  
 C  
 C Fuel Element D-4  
 C  
 C Cell 4221 is the central Zirconium rod  
 4221 1 -6.51 -4221 -4 5 imp:n=4  
 C Cell 4222 is the fuel area of the fuel rod  
 4222 422 0.09690183 4221 -4222 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4223 is the upper Samarium/aluminum poison disk  
 4223 3 -5.27 4 -6 -4222 imp:n=4  
 C Cell 4224 is the lower Samarium/aluminum poison disk  
 4224 3 -5.27 -5 7 -4222 imp:n=4  
 C Cell 4225 is the upper Carbon reflector  
 4225 4 -1.75 -8 6 -4222 imp:n=1  
 C Cell 4226 is the lower Carbon Reflector  
 4226 4 -1.75 -7 9 -4222 imp:n=1  
 C Cell 4227 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4227 5 -7.92 (4222:15:-9) (-4223 -10 11) imp:n=4  
 C Cell 4228 is the void at the top of the fuel element  
 4228 9 -0.001205 -4222 -15 8 imp:n=1  
 C  
 C Fuel Element D-5  
 C  
 C Cell 4231 is the central Zirconium rod  
 4231 1 -6.51 -4231 -4 5 imp:n=4  
 C Cell 4232 is the fuel area of the fuel rod  
 4232 423 0.09690183 4231 -4232 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4233 is the upper Samarium/aluminum poison disk  
 4233 3 -5.27 4 -6 -4232 imp:n=4  
 C Cell 4234 is the lower Samarium/aluminum poison disk  
 4234 3 -5.27 -5 7 -4232 imp:n=4  
 C Cell 4235 is the upper Carbon reflector  
 4235 4 -1.75 -8 6 -4232 imp:n=1  
 C Cell 4236 is the lower Carbon Reflector  
 4236 4 -1.75 -7 9 -4232 imp:n=1  
 C Cell 4237 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4237 5 -7.92 (4232:15:-9) (-4233 -10 11) imp:n=4

C Cell 4238 is the void at the top of the fuel element  
4238 9 -0.001205 -4232 -15 8 imp:n=1  
C  
C Fuel Element D-6  
C  
C Cell 4241 is the central Zirconium rod  
4241 1 -6.51 -4241 -4 5 imp:n=4  
C Cell 4242 is the fuel area of the fuel rod  
4242 424 0.09690183 4241 -4242 -4 5 vol=382.3638538 imp:n=16  
C Cell 4243 is the upper Samarium/aluminum poison disk  
4243 3 -5.27 4 -6 -4242 imp:n=4  
C Cell 4244 is the lower Samarium/aluminum poison disk  
4244 3 -5.27 -5 7 -4242 imp:n=4  
C Cell 4245 is the upper Carbon reflector  
4245 4 -1.75 -8 6 -4242 imp:n=1  
C Cell 4246 is the lower Carbon Reflector  
4246 4 -1.75 -7 9 -4242 imp:n=1  
C Cell 4247 is the Stainless Steel cladding of the fuel element  
C and support structure  
4247 5 -7.92 (4242:15:-9) (-4243 -10 11) imp:n=4  
C Cell 4248 is the void at the top of the fuel element  
4248 9 -0.001205 -4242 -15 8 imp:n=1  
C  
C Fuel Element D-8  
C  
C Cell 4261 is the central Zirconium rod  
4261 1 -6.51 -4261 -4 5 imp:n=4  
C Cell 4262 is the fuel area of the fuel rod  
4262 426 0.09690183 4261 -4262 -4 5 vol=382.3638538 imp:n=16  
C Cell 4263 is the upper Samarium/aluminum poison disk  
4263 3 -5.27 4 -6 -4262 imp:n=4  
C Cell 4264 is the lower Samarium/aluminum poison disk  
4264 3 -5.27 -5 7 -4262 imp:n=4  
C Cell 4265 is the upper Carbon reflector  
4265 4 -1.75 -8 6 -4262 imp:n=1  
C Cell 4266 is the lower Carbon Reflector  
4266 4 -1.75 -7 9 -4262 imp:n=1  
C Cell 4267 is the Stainless Steel cladding of the fuel element  
C and support structure  
4267 5 -7.92 (4262:15:-9) (-4263 -10 11) imp:n=4  
C Cell 4268 is the void at the top of the fuel element  
4268 9 -0.001205 -4262 -15 8 imp:n=1  
C  
C Fuel Element D-9  
C  
C Cell 4281 is the central Zirconium rod

4281 1 -6.51 -4281 -4 5 imp:n=4  
 C Cell 4282 is the fuel area of the fuel rod  
 4282 428 0.09690183 4281 -4282 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4283 is the upper Samarium/aluminum poison disk  
 4283 3 -5.27 4 -6 -4282 imp:n=4  
 C Cell 4284 is the lower Samarium/aluminum poison disk  
 4284 3 -5.27 -5 7 -4282 imp:n=4  
 C Cell 4285 is the upper Carbon reflector  
 4285 4 -1.75 -8 6 -4282 imp:n=1  
 C Cell 4286 is the lower Carbon Reflector  
 4286 4 -1.75 -7 9 -4282 imp:n=1  
 C Cell 4287 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4287 5 -7.92 (4282:15:-9) (-4283 -10 11) imp:n=4  
 C Cell 4288 is the void at the top of the fuel element  
 4288 9 -0.001205 -4282 -15 8 imp:n=1  
 C  
 C Fuel Element D-10  
 C  
 C Cell 4291 is the central Zirconium rod  
 4291 1 -6.51 -4291 -4 5 imp:n=4  
 C Cell 4292 is the fuel area of the fuel rod  
 4292 429 0.09690183 4291 -4292 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4293 is the upper Samarium/aluminum poison disk  
 4293 3 -5.27 4 -6 -4292 imp:n=4  
 C Cell 4294 is the lower Samarium/aluminum poison disk  
 4294 3 -5.27 -5 7 -4292 imp:n=4  
 C Cell 4295 is the upper Carbon reflector  
 4295 4 -1.75 -8 6 -4292 imp:n=1  
 C Cell 4296 is the lower Carbon Reflector  
 4296 4 -1.75 -7 9 -4292 imp:n=1  
 C Cell 4297 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4297 5 -7.92 (4292:15:-9) (-4293 -10 11) imp:n=4  
 C Cell 4298 is the void at the top of the fuel element  
 4298 9 -0.001205 -4292 -15 8 imp:n=1  
 C  
 C Fuel Element D-11  
 C  
 C Cell 4301 is the central Zirconium rod  
 4301 1 -6.51 -4301 -4 5 imp:n=4  
 C Cell 4302 is the fuel area of the fuel rod  
 4302 430 0.09690183 4301 -4302 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4303 is the upper Samarium/aluminum poison disk  
 4303 3 -5.27 4 -6 -4302 imp:n=4  
 C Cell 4304 is the lower Samarium/aluminum poison disk

4304 3 -5.27 -5 7 -4302 imp:n=4  
 C Cell 4305 is the upper Carbon reflector  
 4305 4 -1.75 -8 6 -4302 imp:n=1  
 C Cell 4306 is the lower Carbon Reflector  
 4306 4 -1.75 -7 9 -4302 imp:n=1  
 C Cell 4307 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4307 5 -7.92 (4302:15:-9) (-4303 -10 11) imp:n=4  
 C Cell 4308 is the void at the top of the fuel element  
 4308 9 -0.001205 -4302 -15 8 imp:n=1  
 C  
 C Fuel Element D-12  
 C  
 C Cell 4311 is the central Zirconium rod  
 4311 1 -6.51 -4311 -4 5 imp:n=4  
 C Cell 4312 is the fuel area of the fuel rod  
 4312 431 0.09690183 4311 -4312 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4313 is the upper Samarium/aluminum poison disk  
 4313 3 -5.27 4 -6 -4312 imp:n=4  
 C Cell 4314 is the lower Samarium/aluminum poison disk  
 4314 3 -5.27 -5 7 -4312 imp:n=4  
 C Cell 4315 is the upper Carbon reflector  
 4315 4 -1.75 -8 6 -4312 imp:n=1  
 C Cell 4316 is the lower Carbon Reflector  
 4316 4 -1.75 -7 9 -4312 imp:n=1  
 C Cell 4317 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4317 5 -7.92 (4312:15:-9) (-4313 -10 11) imp:n=4  
 C Cell 4318 is the void at the top of the fuel element  
 4318 9 -0.001205 -4312 -15 8 imp:n=1  
 C  
 C Fuel Element D-14  
 C  
 C Cell 4331 is the central Zirconium rod  
 4331 1 -6.51 -4331 -4 5 imp:n=4  
 C Cell 4332 is the fuel area of the fuel rod  
 4332 433 0.09690183 4331 -4332 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4333 is the upper Samarium/aluminum poison disk  
 4333 3 -5.27 4 -6 -4332 imp:n=4  
 C Cell 4334 is the lower Samarium/aluminum poison disk  
 4334 3 -5.27 -5 7 -4332 imp:n=4  
 C Cell 4335 is the upper Carbon reflector  
 4335 4 -1.75 -8 6 -4332 imp:n=1  
 C Cell 4336 is the lower Carbon Reflector  
 4336 4 -1.75 -7 9 -4332 imp:n=1  
 C Cell 4337 is the Stainless Steel cladding of the fuel element

C and support structure  
 4337 5 -7.92 (4332:15:-9) (-4333 -10 11) imp:n=4  
 C Cell 4338 is the void at the top of the fuel element  
 4338 9 -0.001205 -4332 -15 8 imp:n=1  
 C  
 C Fuel Element D-15  
 C  
 C Cell 4341 is the central Zirconium rod  
 4341 1 -6.51 -4341 -4 5 imp:n=4  
 C Cell 4342 is the fuel area of the fuel rod  
 4342 434 0.09690183 4341 -4342 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4343 is the upper Samarium/aluminum poison disk  
 4343 3 -5.27 4 -6 -4342 imp:n=4  
 C Cell 4344 is the lower Samarium/aluminum poison disk  
 4344 3 -5.27 -5 7 -4342 imp:n=4  
 C Cell 4345 is the upper Carbon reflector  
 4345 4 -1.75 -8 6 -4342 imp:n=1  
 C Cell 4346 is the lower Carbon Reflector  
 4346 4 -1.75 -7 9 -4342 imp:n=1  
 C Cell 4347 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4347 5 -7.92 (4342:15:-9) (-4343 -10 11) imp:n=4  
 C Cell 4348 is the void at the top of the fuel element  
 4348 9 -0.001205 -4342 -15 8 imp:n=1  
 C  
 C Fuel Element D-16  
 C  
 C Cell 4351 is the central Zirconium rod  
 4351 1 -6.51 -4351 -4 5 imp:n=4  
 C Cell 4352 is the fuel area of the fuel rod  
 4352 435 0.09690183 4351 -4352 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4353 is the upper Samarium/aluminum poison disk  
 4353 3 -5.27 4 -6 -4352 imp:n=4  
 C Cell 4354 is the lower Samarium/aluminum poison disk  
 4354 3 -5.27 -5 7 -4352 imp:n=4  
 C Cell 4355 is the upper Carbon reflector  
 4355 4 -1.75 -8 6 -4352 imp:n=1  
 C Cell 4356 is the lower Carbon Reflector  
 4356 4 -1.75 -7 9 -4352 imp:n=1  
 C Cell 4357 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4357 5 -7.92 (4352:15:-9) (-4353 -10 11) imp:n=4  
 C Cell 4358 is the void at the top of the fuel element  
 4358 9 -0.001205 -4352 -15 8 imp:n=1  
 C  
 C Fuel Element D-17

C  
 C Cell 4361 is the central Zirconium rod  
 4361 1 -6.51 -4361 -4 5 imp:n=4  
 C Cell 4362 is the fuel area of the fuel rod  
 4362 436 0.09690183 4361 -4362 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4363 is the upper Samarium/aluminum poison disk  
 4363 3 -5.27 4 -6 -4362 imp:n=4  
 C Cell 4364 is the lower Samarium/aluminum poison disk  
 4364 3 -5.27 -5 7 -4362 imp:n=4  
 C Cell 4365 is the upper Carbon reflector  
 4365 4 -1.75 -8 6 -4362 imp:n=1  
 C Cell 4366 is the lower Carbon Reflector  
 4366 4 -1.75 -7 9 -4362 imp:n=1  
 C Cell 4367 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4367 5 -7.92 (4362:15:-9) (-4363 -10 11) imp:n=4  
 C Cell 4368 is the void at the top of the fuel element  
 4368 9 -0.001205 -4362 -15 8 imp:n=1  
 C  
 C Fuel Element D-18  
 C  
 C Cell 4371 is the central Zirconium rod  
 4371 1 -6.51 -4371 -4 5 imp:n=4  
 C Cell 4372 is the fuel area of the fuel rod  
 4372 437 0.09690183 4371 -4372 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4373 is the upper Samarium/aluminum poison disk  
 4373 3 -5.27 4 -6 -4372 imp:n=4  
 C Cell 4374 is the lower Samarium/aluminum poison disk  
 4374 3 -5.27 -5 7 -4372 imp:n=4  
 C Cell 4375 is the upper Carbon reflector  
 4375 4 -1.75 -8 6 -4372 imp:n=1  
 C Cell 4376 is the lower Carbon Reflector  
 4376 4 -1.75 -7 9 -4372 imp:n=1  
 C Cell 4377 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4377 5 -7.92 (4372:15:-9) (-4373 -10 11) imp:n=4  
 C Cell 4378 is the void at the top of the fuel element  
 4378 9 -0.001205 -4372 -15 8 imp:n=1  
 C  
 C Fuel Element E-1  
 C  
 C Cell 4381 is the central Zirconium rod  
 4381 1 -6.51 -4381 -4 5 imp:n=4  
 C Cell 4382 is the fuel area of the fuel rod  
 4382 438 0.09690183 4381 -4382 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4383 is the upper Samarium/aluminum poison disk

4383 3 -5.27 4 -6 -4382 imp:n=4  
 C Cell 4384 is the lower Samarium/aluminum poison disk  
 4384 3 -5.27 -5 7 -4382 imp:n=4  
 C Cell 4385 is the upper Carbon reflector  
 4385 4 -1.75 -8 6 -4382 imp:n=1  
 C Cell 4386 is the lower Carbon Reflector  
 4386 4 -1.75 -7 9 -4382 imp:n=1  
 C Cell 4387 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4387 5 -7.92 (4382:15:-9) (-4383 -10 11) imp:n=4  
 C Cell 4388 is the void at the top of the fuel element  
 4388 9 -0.001205 -4382 -15 8 imp:n=1  
 C  
 C Fuel Element E-2  
 C  
 C Cell 4391 is the central Zirconium rod  
 4391 1 -6.51 -4391 -4 5 imp:n=4  
 C Cell 4392 is the fuel area of the fuel rod  
 4392 439 0.09690183 4391 -4392 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4393 is the upper Samarium/aluminum poison disk  
 4393 3 -5.27 4 -6 -4392 imp:n=4  
 C Cell 4394 is the lower Samarium/aluminum poison disk  
 4394 3 -5.27 -5 7 -4392 imp:n=4  
 C Cell 4395 is the upper Carbon reflector  
 4395 4 -1.75 -8 6 -4392 imp:n=1  
 C Cell 4396 is the lower Carbon Reflector  
 4396 4 -1.75 -7 9 -4392 imp:n=1  
 C Cell 4397 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4397 5 -7.92 (4392:15:-9) (-4393 -10 11) imp:n=4  
 C Cell 4398 is the void at the top of the fuel element  
 4398 9 -0.001205 -4392 -15 8 imp:n=1  
 C  
 C Fuel Element E-3  
 C  
 C Cell 4401 is the central Zirconium rod  
 4401 1 -6.51 -4401 -4 5 imp:n=4  
 C Cell 4402 is the fuel area of the fuel rod  
 4402 440 0.09690183 4401 -4402 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4403 is the upper Samarium/aluminum poison disk  
 4403 3 -5.27 4 -6 -4402 imp:n=4  
 C Cell 4404 is the lower Samarium/aluminum poison disk  
 4404 3 -5.27 -5 7 -4402 imp:n=4  
 C Cell 4405 is the upper Carbon reflector  
 4405 4 -1.75 -8 6 -4402 imp:n=1  
 C Cell 4406 is the lower Carbon Reflector

4406 4 -1.75 -7 9 -4402 imp:n=1  
 C Cell 4407 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4407 5 -7.92 (4402:15:-9) (-4403 -10 11) imp:n=4  
 C Cell 4408 is the void at the top of the fuel element  
 4408 9 -0.001205 -4402 -15 8 imp:n=1  
 C  
 C Fuel Element E-4  
 C  
 C Cell 4411 is the central Zirconium rod  
 4411 1 -6.51 -4411 -4 5 imp:n=4  
 C Cell 4412 is the fuel area of the fuel rod  
 4412 441 0.09690183 4411 -4412 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4413 is the upper Samarium/aluminum poison disk  
 4413 3 -5.27 4 -6 -4412 imp:n=4  
 C Cell 4414 is the lower Samarium/aluminum poison disk  
 4414 3 -5.27 -5 7 -4412 imp:n=4  
 C Cell 4415 is the upper Carbon reflector  
 4415 4 -1.75 -8 6 -4412 imp:n=1  
 C Cell 4416 is the lower Carbon Reflector  
 4416 4 -1.75 -7 9 -4412 imp:n=1  
 C Cell 4417 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4417 5 -7.92 (4412:15:-9) (-4413 -10 11) imp:n=4  
 C Cell 4418 is the void at the top of the fuel element  
 4418 9 -0.001205 -4412 -15 8 imp:n=1  
 C  
 C Fuel Element E-5  
 C  
 C Cell 4421 is the central Zirconium rod  
 4421 1 -6.51 -4421 -4 5 imp:n=4  
 C Cell 4422 is the fuel area of the fuel rod  
 4422 442 0.09690183 4421 -4422 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4423 is the upper Samarium/aluminum poison disk  
 4423 3 -5.27 4 -6 -4422 imp:n=4  
 C Cell 4424 is the lower Samarium/aluminum poison disk  
 4424 3 -5.27 -5 7 -4422 imp:n=4  
 C Cell 4425 is the upper Carbon reflector  
 4425 4 -1.75 -8 6 -4422 imp:n=1  
 C Cell 4426 is the lower Carbon Reflector  
 4426 4 -1.75 -7 9 -4422 imp:n=1  
 C Cell 4427 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4427 5 -7.92 (4422:15:-9) (-4423 -10 11) imp:n=4  
 C Cell 4428 is the void at the top of the fuel element  
 4428 9 -0.001205 -4422 -15 8 imp:n=1

C  
C Fuel Element E-6  
C  
C Cell 4431 is the central Zirconium rod  
4431 1 -6.51 -4431 -4 5 imp:n=4  
C Cell 4432 is the fuel area of the fuel rod  
4432 443 0.09690183 4431 -4432 -4 5 vol=382.3638538 imp:n=16  
C Cell 4433 is the upper Samarium/aluminum poison disk  
4433 3 -5.27 4 -6 -4432 imp:n=4  
C Cell 4434 is the lower Samarium/aluminum poison disk  
4434 3 -5.27 -5 7 -4432 imp:n=4  
C Cell 4435 is the upper Carbon reflector  
4435 4 -1.75 -8 6 -4432 imp:n=1  
C Cell 4436 is the lower Carbon Reflector  
4436 4 -1.75 -7 9 -4432 imp:n=1  
C Cell 4437 is the Stainless Steel cladding of the fuel element  
C and support structure  
4437 5 -7.92 (4432:15:-9) (-4433 -10 11) imp:n=4  
C Cell 4438 is the void at the top of the fuel element  
4438 9 -0.001205 -4432 -15 8 imp:n=1  
C  
C Fuel Element E-7  
C  
C Cell 4441 is the central Zirconium rod  
4441 1 -6.51 -4441 -4 5 imp:n=4  
C Cell 4442 is the fuel area of the fuel rod  
4442 444 0.09690183 4441 -4442 -4 5 vol=382.3638538 imp:n=16  
C Cell 4443 is the upper Samarium/aluminum poison disk  
4443 3 -5.27 4 -6 -4442 imp:n=4  
C Cell 4444 is the lower Samarium/aluminum poison disk  
4444 3 -5.27 -5 7 -4442 imp:n=4  
C Cell 4445 is the upper Carbon reflector  
4445 4 -1.75 -8 6 -4442 imp:n=1  
C Cell 4446 is the lower Carbon Reflector  
4446 4 -1.75 -7 9 -4442 imp:n=1  
C Cell 4447 is the Stainless Steel cladding of the fuel element  
C and support structure  
4447 5 -7.92 (4442:15:-9) (-4443 -10 11) imp:n=4  
C Cell 4448 is the void at the top of the fuel element  
4448 9 -0.001205 -4442 -15 8 imp:n=1  
C  
C Fuel Element E-8  
C  
C Cell 4451 is the central Zirconium rod  
4451 1 -6.51 -4451 -4 5 imp:n=4  
C Cell 4452 is the fuel area of the fuel rod

4452 445 0.09690183 4451 -4452 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4453 is the upper Samarium/aluminum poison disk  
 4453 3 -5.27 4 -6 -4452 imp:n=4  
 C Cell 4454 is the lower Samarium/aluminum poison disk  
 4454 3 -5.27 -5 7 -4452 imp:n=4  
 C Cell 4455 is the upper Carbon reflector  
 4455 4 -1.75 -8 6 -4452 imp:n=1  
 C Cell 4456 is the lower Carbon Reflector  
 4456 4 -1.75 -7 9 -4452 imp:n=1  
 C Cell 4457 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4457 5 -7.92 (4452:15:-9) (-4453 -10 11) imp:n=4  
 C Cell 4458 is the void at the top of the fuel element  
 4458 9 -0.001205 -4452 -15 8 imp:n=1  
 C  
 C Fuel Element E-9  
 C  
 C Cell 4461 is the central Zirconium rod  
 4461 1 -6.51 -4461 -4 5 imp:n=4  
 C Cell 4462 is the fuel area of the fuel rod  
 4462 446 0.09690183 4461 -4462 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4463 is the upper Samarium/aluminum poison disk  
 4463 3 -5.27 4 -6 -4462 imp:n=4  
 C Cell 4464 is the lower Samarium/aluminum poison disk  
 4464 3 -5.27 -5 7 -4462 imp:n=4  
 C Cell 4465 is the upper Carbon reflector  
 4465 4 -1.75 -8 6 -4462 imp:n=1  
 C Cell 4466 is the lower Carbon Reflector  
 4466 4 -1.75 -7 9 -4462 imp:n=1  
 C Cell 4467 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4467 5 -7.92 (4462:15:-9) (-4463 -10 11) imp:n=4  
 C Cell 4468 is the void at the top of the fuel element  
 4468 9 -0.001205 -4462 -15 8 imp:n=1  
 C  
 C Fuel Element E-10  
 C  
 C Cell 4471 is the central Zirconium rod  
 4471 1 -6.51 -4471 -4 5 imp:n=4  
 C Cell 4472 is the fuel area of the fuel rod  
 4472 447 0.09690183 4471 -4472 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4473 is the upper Samarium/aluminum poison disk  
 4473 3 -5.27 4 -6 -4472 imp:n=4  
 C Cell 4474 is the lower Samarium/aluminum poison disk  
 4474 3 -5.27 -5 7 -4472 imp:n=4  
 C Cell 4475 is the upper Carbon reflector

4475 4 -1.75 -8 6 -4472 imp:n=1  
 C Cell 4476 is the lower Carbon Reflector  
 4476 4 -1.75 -7 9 -4472 imp:n=1  
 C Cell 4477 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4477 5 -7.92 (4472:15:-9) (-4473 -10 11) imp:n=4  
 C Cell 4478 is the void at the top of the fuel element  
 4478 9 -0.001205 -4472 -15 8 imp:n=1  
 C  
 C Fuel Element E-11  
 C  
 C Cell 4481 is the central Zirconium rod  
 4481 1 -6.51 -4481 -4 5 imp:n=4  
 C Cell 4482 is the fuel area of the fuel rod  
 4482 448 0.09690183 4481 -4482 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4483 is the upper Samarium/aluminum poison disk  
 4483 3 -5.27 4 -6 -4482 imp:n=4  
 C Cell 4484 is the lower Samarium/aluminum poison disk  
 4484 3 -5.27 -5 7 -4482 imp:n=4  
 C Cell 4485 is the upper Carbon reflector  
 4485 4 -1.75 -8 6 -4482 imp:n=1  
 C Cell 4486 is the lower Carbon Reflector  
 4486 4 -1.75 -7 9 -4482 imp:n=1  
 C Cell 4487 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4487 5 -7.92 (4482:15:-9) (-4483 -10 11) imp:n=4  
 C Cell 4488 is the void at the top of the fuel element  
 4488 9 -0.001205 -4482 -15 8 imp:n=1  
 C  
 C Fuel Element E-12  
 C  
 C Cell 4491 is the central Zirconium rod  
 4491 1 -6.51 -4491 -4 5 imp:n=4  
 C Cell 4492 is the fuel area of the fuel rod  
 4492 449 0.09690183 4491 -4492 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4493 is the upper Samarium/aluminum poison disk  
 4493 3 -5.27 4 -6 -4492 imp:n=4  
 C Cell 4494 is the lower Samarium/aluminum poison disk  
 4494 3 -5.27 -5 7 -4492 imp:n=4  
 C Cell 4495 is the upper Carbon reflector  
 4495 4 -1.75 -8 6 -4492 imp:n=1  
 C Cell 4496 is the lower Carbon Reflector  
 4496 4 -1.75 -7 9 -4492 imp:n=1  
 C Cell 4497 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4497 5 -7.92 (4492:15:-9) (-4493 -10 11) imp:n=4

C Cell 4498 is the void at the top of the fuel element  
4498 9 -0.001205 -4492 -15 8 imp:n=1  
C  
C Fuel Element E-13  
C  
C Cell 4501 is the central Zirconium rod  
4501 1 -6.51 -4501 -4 5 imp:n=4  
C Cell 4502 is the fuel area of the fuel rod  
4502 450 0.09690183 4501 -4502 -4 5 vol=382.3638538 imp:n=16  
C Cell 4503 is the upper Samarium/aluminum poison disk  
4503 3 -5.27 4 -6 -4502 imp:n=4  
C Cell 4504 is the lower Samarium/aluminum poison disk  
4504 3 -5.27 -5 7 -4502 imp:n=4  
C Cell 4505 is the upper Carbon reflector  
4505 4 -1.75 -8 6 -4502 imp:n=1  
C Cell 4506 is the lower Carbon Reflector  
4506 4 -1.75 -7 9 -4502 imp:n=1  
C Cell 4507 is the Stainless Steel cladding of the fuel element  
C and support structure  
4507 5 -7.92 (4502:15:-9) (-4503 -10 11) imp:n=4  
C Cell 4508 is the void at the top of the fuel element  
4508 9 -0.001205 -4502 -15 8 imp:n=1  
C  
C Fuel Element E-14  
C  
C Cell 4511 is the central Zirconium rod  
4511 1 -6.51 -4511 -4 5 imp:n=4  
C Cell 4512 is the fuel area of the fuel rod  
4512 451 0.09690183 4511 -4512 -4 5 vol=382.3638538 imp:n=16  
C Cell 4513 is the upper Samarium/aluminum poison disk  
4513 3 -5.27 4 -6 -4512 imp:n=4  
C Cell 4514 is the lower Samarium/aluminum poison disk  
4514 3 -5.27 -5 7 -4512 imp:n=4  
C Cell 4515 is the upper Carbon reflector  
4515 4 -1.75 -8 6 -4512 imp:n=1  
C Cell 4516 is the lower Carbon Reflector  
4516 4 -1.75 -7 9 -4512 imp:n=1  
C Cell 4517 is the Stainless Steel cladding of the fuel element  
C and support structure  
4517 5 -7.92 (4512:15:-9) (-4513 -10 11) imp:n=4  
C Cell 4518 is the void at the top of the fuel element  
4518 9 -0.001205 -4512 -15 8 imp:n=1  
C  
C Fuel Element E-15  
C  
C Cell 4521 is the central Zirconium rod

4521 1 -6.51 -4521 -4 5 imp:n=4  
 C Cell 4522 is the fuel area of the fuel rod  
 4522 452 0.09690183 4521 -4522 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4523 is the upper Samarium/aluminum poison disk  
 4523 3 -5.27 4 -6 -4522 imp:n=4  
 C Cell 4524 is the lower Samarium/aluminum poison disk  
 4524 3 -5.27 -5 7 -4522 imp:n=4  
 C Cell 4525 is the upper Carbon reflector  
 4525 4 -1.75 -8 6 -4522 imp:n=1  
 C Cell 4526 is the lower Carbon Reflector  
 4526 4 -1.75 -7 9 -4522 imp:n=1  
 C Cell 4527 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4527 5 -7.92 (4522:15:-9) (-4523 -10 11) imp:n=4  
 C Cell 4528 is the void at the top of the fuel element  
 4528 9 -0.001205 -4522 -15 8 imp:n=1  
 C  
 C Fuel Element E-16  
 C  
 C Cell 4531 is the central Zirconium rod  
 4531 1 -6.51 -4531 -4 5 imp:n=4  
 C Cell 4532 is the fuel area of the fuel rod  
 4532 453 0.09690183 4531 -4532 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4533 is the upper Samarium/aluminum poison disk  
 4533 3 -5.27 4 -6 -4532 imp:n=4  
 C Cell 4534 is the lower Samarium/aluminum poison disk  
 4534 3 -5.27 -5 7 -4532 imp:n=4  
 C Cell 4535 is the upper Carbon reflector  
 4535 4 -1.75 -8 6 -4532 imp:n=1  
 C Cell 4536 is the lower Carbon Reflector  
 4536 4 -1.75 -7 9 -4532 imp:n=1  
 C Cell 4537 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4537 5 -7.92 (4532:15:-9) (-4533 -10 11) imp:n=4  
 C Cell 4538 is the void at the top of the fuel element  
 4538 9 -0.001205 -4532 -15 8 imp:n=1  
 C  
 C Fuel Element E-17  
 C  
 C Cell 4541 is the central Zirconium rod  
 4541 1 -6.51 -4541 -4 5 imp:n=4  
 C Cell 4542 is the fuel area of the fuel rod  
 4542 454 0.09690183 4541 -4542 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4543 is the upper Samarium/aluminum poison disk  
 4543 3 -5.27 4 -6 -4542 imp:n=4  
 C Cell 4544 is the lower Samarium/aluminum poison disk

4544 3 -5.27 -5 7 -4542 imp:n=4  
 C Cell 4545 is the upper Carbon reflector  
 4545 4 -1.75 -8 6 -4542 imp:n=1  
 C Cell 4546 is the lower Carbon Reflector  
 4546 4 -1.75 -7 9 -4542 imp:n=1  
 C Cell 4547 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4547 5 -7.92 (4542:15:-9) (-4543 -10 11) imp:n=4  
 C Cell 4548 is the void at the top of the fuel element  
 4548 9 -0.001205 -4542 -15 8 imp:n=1  
 C  
 C Fuel Element E-18  
 C  
 C Cell 4551 is the central Zirconium rod  
 4551 1 -6.51 -4551 -4 5 imp:n=4  
 C Cell 4552 is the fuel area of the fuel rod  
 4552 455 0.09690183 4551 -4552 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4553 is the upper Samarium/aluminum poison disk  
 4553 3 -5.27 4 -6 -4552 imp:n=4  
 C Cell 4554 is the lower Samarium/aluminum poison disk  
 4554 3 -5.27 -5 7 -4552 imp:n=4  
 C Cell 4555 is the upper Carbon reflector  
 4555 4 -1.75 -8 6 -4552 imp:n=1  
 C Cell 4556 is the lower Carbon Reflector  
 4556 4 -1.75 -7 9 -4552 imp:n=1  
 C Cell 4557 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4557 5 -7.92 (4552:15:-9) (-4553 -10 11) imp:n=4  
 C Cell 4558 is the void at the top of the fuel element  
 4558 9 -0.001205 -4552 -15 8 imp:n=1  
 C  
 C Fuel Element E-19  
 C  
 C Cell 4561 is the central Zirconium rod  
 4561 1 -6.51 -4561 -4 5 imp:n=4  
 C Cell 4562 is the fuel area of the fuel rod  
 4562 456 0.09690183 4561 -4562 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4563 is the upper Samarium/aluminum poison disk  
 4563 3 -5.27 4 -6 -4562 imp:n=4  
 C Cell 4564 is the lower Samarium/aluminum poison disk  
 4564 3 -5.27 -5 7 -4562 imp:n=4  
 C Cell 4565 is the upper Carbon reflector  
 4565 4 -1.75 -8 6 -4562 imp:n=1  
 C Cell 4566 is the lower Carbon Reflector  
 4566 4 -1.75 -7 9 -4562 imp:n=1  
 C Cell 4567 is the Stainless Steel cladding of the fuel element

C and support structure  
 4567 5 -7.92 (4562:15:-9) (-4563 -10 11) imp:n=4  
 C Cell 4568 is the void at the top of the fuel element  
 4568 9 -0.001205 -4562 -15 8 imp:n=1  
 C  
 C Fuel Element E-20  
 C  
 C Cell 4571 is the central Zirconium rod  
 4571 1 -6.51 -4571 -4 5 imp:n=4  
 C Cell 4572 is the fuel area of the fuel rod  
 4572 457 0.09690183 4571 -4572 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4573 is the upper Samarium/aluminum poison disk  
 4573 3 -5.27 4 -6 -4572 imp:n=4  
 C Cell 4574 is the lower Samarium/aluminum poison disk  
 4574 3 -5.27 -5 7 -4572 imp:n=4  
 C Cell 4575 is the upper Carbon reflector  
 4575 4 -1.75 -8 6 -4572 imp:n=1  
 C Cell 4576 is the lower Carbon Reflector  
 4576 4 -1.75 -7 9 -4572 imp:n=1  
 C Cell 4577 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4577 5 -7.92 (4572:15:-9) (-4573 -10 11) imp:n=4  
 C Cell 4578 is the void at the top of the fuel element  
 4578 9 -0.001205 -4572 -15 8 imp:n=1  
 C  
 C Fuel Element E-21  
 C  
 C Cell 4581 is the central Zirconium rod  
 4581 1 -6.51 -4581 -4 5 imp:n=4  
 C Cell 4582 is the fuel area of the fuel rod  
 4582 458 0.09690183 4581 -4582 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4583 is the upper Samarium/aluminum poison disk  
 4583 3 -5.27 4 -6 -4582 imp:n=4  
 C Cell 4584 is the lower Samarium/aluminum poison disk  
 4584 3 -5.27 -5 7 -4582 imp:n=4  
 C Cell 4585 is the upper Carbon reflector  
 4585 4 -1.75 -8 6 -4582 imp:n=1  
 C Cell 4586 is the lower Carbon Reflector  
 4586 4 -1.75 -7 9 -4582 imp:n=1  
 C Cell 4587 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4587 5 -7.92 (4582:15:-9) (-4583 -10 11) imp:n=4  
 C Cell 4588 is the void at the top of the fuel element  
 4588 9 -0.001205 -4582 -15 8 imp:n=1  
 C  
 C Fuel Element E-22

C  
C Cell 4591 is the central Zirconium rod  
4591 1 -6.51 -4591 -4 5 imp:n=4  
C Cell 4592 is the fuel area of the fuel rod  
4592 459 0.09690183 4591 -4592 -4 5 vol=382.3638538 imp:n=16  
C Cell 4593 is the upper Samarium/aluminum poison disk  
4593 3 -5.27 4 -6 -4592 imp:n=4  
C Cell 4594 is the lower Samarium/aluminum poison disk  
4594 3 -5.27 -5 7 -4592 imp:n=4  
C Cell 4595 is the upper Carbon reflector  
4595 4 -1.75 -8 6 -4592 imp:n=1  
C Cell 4596 is the lower Carbon Reflector  
4596 4 -1.75 -7 9 -4592 imp:n=1  
C Cell 4597 is the Stainless Steel cladding of the fuel element  
C and support structure  
4597 5 -7.92 (4592:15:-9) (-4593 -10 11) imp:n=4  
C Cell 4598 is the void at the top of the fuel element  
4598 9 -0.001205 -4592 -15 8 imp:n=1  
C  
C Fuel Element E-23 Core Exposure Tube Location  
C  
C Fuel Element E-24  
C  
C Cell 4611 is the central Zirconium rod  
4611 1 -6.51 -4611 -4 5 imp:n=4  
C Cell 4592 is the fuel area of the fuel rod  
4612 461 0.09690183 4611 -4612 -4 5 vol=382.3638538 imp:n=16  
C Cell 4613 is the upper Samarium/aluminum poison disk  
4613 3 -5.27 4 -6 -4612 imp:n=4  
C Cell 4614 is the lower Samarium/aluminum poison disk  
4614 3 -5.27 -5 7 -4612 imp:n=4  
C Cell 4615 is the upper Carbon reflector  
4615 4 -1.75 -8 6 -4612 imp:n=1  
C Cell 4616 is the lower Carbon Reflector  
4616 4 -1.75 -7 9 -4612 imp:n=1  
C Cell 4617 is the Stainless Steel cladding of the fuel element  
C and support structure  
4617 5 -7.92 (4612:15:-9) (-4613 -10 11) imp:n=4  
C Cell 4618 is the void at the top of the fuel element  
4618 9 -0.001205 -4612 -15 8 imp:n=1  
C  
C Fuel Element F-1  
C  
C Cell 4621 is the central Zirconium rod  
4621 1 -6.51 -4621 -4 5 imp:n=4  
C Cell 4622 is the fuel area of the fuel rod

4622 462 0.09690183 4621 -4622 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4623 is the upper Samarium/aluminum poison disk  
 4623 3 -5.27 4 -6 -4622 imp:n=4  
 C Cell 4624 is the lower Samarium/aluminum poison disk  
 4624 3 -5.27 -5 7 -4622 imp:n=4  
 C Cell 4625 is the upper Carbon reflector  
 4625 4 -1.75 -8 6 -4622 imp:n=1  
 C Cell 4626 is the lower Carbon Reflector  
 4626 4 -1.75 -7 9 -4622 imp:n=1  
 C Cell 4627 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4627 5 -7.92 (4622:15:-9) (-4623 -10 11) imp:n=4  
 C Cell 4628 is the void at the top of the fuel element  
 4628 9 -0.001205 -4622 -15 8 imp:n=1  
 C  
 C Fuel Element F-2  
 C  
 C Cell 4631 is the central Zirconium rod  
 4631 1 -6.51 -4631 -4 5 imp:n=4  
 C Cell 4632 is the fuel area of the fuel rod  
 4632 463 0.09690183 4631 -4632 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4633 is the upper Samarium/aluminum poison disk  
 4633 3 -5.27 4 -6 -4632 imp:n=4  
 C Cell 4634 is the lower Samarium/aluminum poison disk  
 4634 3 -5.27 -5 7 -4632 imp:n=4  
 C Cell 4635 is the upper Carbon reflector  
 4635 4 -1.75 -8 6 -4632 imp:n=1  
 C Cell 4636 is the lower Carbon Reflector  
 4636 4 -1.75 -7 9 -4632 imp:n=1  
 C Cell 4637 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4637 5 -7.92 (4632:15:-9) (-4633 -10 11) imp:n=4  
 C Cell 4638 is the void at the top of the fuel element  
 4638 9 -0.001205 -4632 -15 8 imp:n=1  
 C  
 C Fuel Element F-3  
 C  
 C Cell 4641 is the central Zirconium rod  
 4641 1 -6.51 -4641 -4 5 imp:n=4  
 C Cell 4642 is the fuel area of the fuel rod  
 4642 464 0.09690183 4641 -4642 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4643 is the upper Samarium/aluminum poison disk  
 4643 3 -5.27 4 -6 -4642 imp:n=4  
 C Cell 4644 is the lower Samarium/aluminum poison disk  
 4644 3 -5.27 -5 7 -4642 imp:n=4  
 C Cell 4645 is the upper Carbon reflector

4645 4 -1.75 -8 6 -4642 imp:n=1  
 C Cell 4646 is the lower Carbon Reflector  
 4646 4 -1.75 -7 9 -4642 imp:n=1  
 C Cell 4647 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4647 5 -7.92 (4642:15:-9) (-4643 -10 11) imp:n=4  
 C Cell 4648 is the void at the top of the fuel element  
 4648 9 -0.001205 -4642 -15 8 imp:n=1  
 C  
 C Fuel Element F-4  
 C  
 C Cell 4651 is the central Zirconium rod  
 4651 1 -6.51 -4651 -4 5 imp:n=4  
 C Cell 4652 is the fuel area of the fuel rod  
 4652 465 0.09690183 4651 -4652 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4653 is the upper Samarium/aluminum poison disk  
 4653 3 -5.27 4 -6 -4652 imp:n=4  
 C Cell 4654 is the lower Samarium/aluminum poison disk  
 4654 3 -5.27 -5 7 -4652 imp:n=4  
 C Cell 4655 is the upper Carbon reflector  
 4655 4 -1.75 -8 6 -4652 imp:n=1  
 C Cell 4656 is the lower Carbon Reflector  
 4656 4 -1.75 -7 9 -4652 imp:n=1  
 C Cell 4657 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4657 5 -7.92 (4652:15:-9) (-4653 -10 11) imp:n=4  
 C Cell 4658 is the void at the top of the fuel element  
 4658 9 -0.001205 -4652 -15 8 imp:n=1  
 C  
 C Fuel Element F-5  
 C  
 C Cell 4661 is the central Zirconium rod  
 4661 1 -6.51 -4661 -4 5 imp:n=4  
 C Cell 4662 is the fuel area of the fuel rod  
 4662 466 0.09690183 4661 -4662 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4663 is the upper Samarium/aluminum poison disk  
 4663 3 -5.27 4 -6 -4662 imp:n=4  
 C Cell 4664 is the lower Samarium/aluminum poison disk  
 4664 3 -5.27 -5 7 -4662 imp:n=4  
 C Cell 4665 is the upper Carbon reflector  
 4665 4 -1.75 -8 6 -4662 imp:n=1  
 C Cell 4666 is the lower Carbon Reflector  
 4666 4 -1.75 -7 9 -4662 imp:n=1  
 C Cell 4667 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4667 5 -7.92 (4662:15:-9) (-4663 -10 11) imp:n=4

C Cell 4668 is the void at the top of the fuel element  
4668 9 -0.001205 -4662 -15 8 imp:n=1  
C  
C Fuel Element F-6  
C  
C Cell 4671 is the central Zirconium rod  
4671 1 -6.51 -4671 -4 5 imp:n=4  
C Cell 4672 is the fuel area of the fuel rod  
4672 467 0.09690183 4671 -4672 -4 5 vol=382.3638538 imp:n=16  
C Cell 4673 is the upper Samarium/aluminum poison disk  
4673 3 -5.27 4 -6 -4672 imp:n=4  
C Cell 4674 is the lower Samarium/aluminum poison disk  
4674 3 -5.27 -5 7 -4672 imp:n=4  
C Cell 4675 is the upper Carbon reflector  
4675 4 -1.75 -8 6 -4672 imp:n=1  
C Cell 4676 is the lower Carbon Reflector  
4676 4 -1.75 -7 9 -4672 imp:n=1  
C Cell 4677 is the Stainless Steel cladding of the fuel element  
C and support structure  
4677 5 -7.92 (4672:15:-9) (-4673 -10 11) imp:n=4  
C Cell 4678 is the void at the top of the fuel element  
4678 9 -0.001205 -4672 -15 8 imp:n=1  
C  
C Fuel Element F-7  
C  
C Cell 4681 is the central Zirconium rod  
4681 1 -6.51 -4681 -4 5 imp:n=4  
C Cell 4682 is the fuel area of the fuel rod  
4682 468 0.09690183 4681 -4682 -4 5 vol=382.3638538 imp:n=16  
C Cell 4683 is the upper Samarium/aluminum poison disk  
4683 3 -5.27 4 -6 -4682 imp:n=4  
C Cell 4684 is the lower Samarium/aluminum poison disk  
4684 3 -5.27 -5 7 -4682 imp:n=4  
C Cell 4685 is the upper Carbon reflector  
4685 4 -1.75 -8 6 -4682 imp:n=1  
C Cell 4686 is the lower Carbon Reflector  
4686 4 -1.75 -7 9 -4682 imp:n=1  
C Cell 4687 is the Stainless Steel cladding of the fuel element  
C and support structure  
4687 5 -7.92 (4682:15:-9) (-4683 -10 11) imp:n=4  
C Cell 4688 is the void at the top of the fuel element  
4688 9 -0.001205 -4682 -15 8 imp:n=1  
C  
C Fuel Element F-8  
C  
C Cell 4691 is the central Zirconium rod

4691 1 -6.51 -4691 -4 5 imp:n=4  
 C Cell 4692 is the fuel area of the fuel rod  
 4692 469 0.09690183 4691 -4692 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4693 is the upper Samarium/aluminum poison disk  
 4693 3 -5.27 4 -6 -4692 imp:n=4  
 C Cell 4694 is the lower Samarium/aluminum poison disk  
 4694 3 -5.27 -5 7 -4692 imp:n=4  
 C Cell 4695 is the upper Carbon reflector  
 4695 4 -1.75 -8 6 -4692 imp:n=1  
 C Cell 4696 is the lower Carbon Reflector  
 4696 4 -1.75 -7 9 -4692 imp:n=1  
 C Cell 4697 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4697 5 -7.92 (4692:15:-9) (-4693 -10 11) imp:n=4  
 C Cell 4698 is the void at the top of the fuel element  
 4698 9 -0.001205 -4692 -15 8 imp:n=1  
 C  
 C Fuel Element F-9 Empty  
 C  
 C Fuel Element F-10  
 C  
 C Cell 4711 is the central Zirconium rod  
 4711 1 -6.51 -4711 -4 5 imp:n=4  
 C Cell 4712 is the fuel area of the fuel rod  
 4712 471 0.09690183 4711 -4712 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4713 is the upper Samarium/aluminum poison disk  
 4713 3 -5.27 4 -6 -4712 imp:n=4  
 C Cell 4714 is the lower Samarium/aluminum poison disk  
 4714 3 -5.27 -5 7 -4712 imp:n=4  
 C Cell 4715 is the upper Carbon reflector  
 4715 4 -1.75 -8 6 -4712 imp:n=1  
 C Cell 4716 is the lower Carbon Reflector  
 4716 4 -1.75 -7 9 -4712 imp:n=1  
 C Cell 4717 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4717 5 -7.92 (4712:15:-9) (-4713 -10 11) imp:n=4  
 C Cell 4718 is the void at the top of the fuel element  
 4718 9 -0.001205 -4712 -15 8 imp:n=1  
 C  
 C Fuel Element F-11  
 C  
 C Cell 4721 is the central Zirconium rod  
 4721 1 -6.51 -4721 -4 5 imp:n=4  
 C Cell 4722 is the fuel area of the fuel rod  
 4722 472 0.09690183 4721 -4722 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4723 is the upper Samarium/aluminum poison disk

4723 3 -5.27 4 -6 -4722 imp:n=4  
 C Cell 4724 is the lower Samarium/aluminum poison disk  
 4724 3 -5.27 -5 7 -4722 imp:n=4  
 C Cell 4725 is the upper Carbon reflector  
 4725 4 -1.75 -8 6 -4722 imp:n=1  
 C Cell 4726 is the lower Carbon Reflector  
 4726 4 -1.75 -7 9 -4722 imp:n=1  
 C Cell 4727 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4727 5 -7.92 (4722:15:-9) (-4723 -10 11) imp:n=4  
 C Cell 4728 is the void at the top of the fuel element  
 4728 9 -0.001205 -4722 -15 8 imp:n=1  
 C  
 C Fuel Element F-12  
 C  
 C Cell 4731 is the central Zirconium rod  
 4731 1 -6.51 -4731 -4 5 imp:n=4  
 C Cell 4732 is the fuel area of the fuel rod  
 4732 473 0.09690183 4731 -4732 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4733 is the upper Samarium/aluminum poison disk  
 4733 3 -5.27 4 -6 -4732 imp:n=4  
 C Cell 4734 is the lower Samarium/aluminum poison disk  
 4734 3 -5.27 -5 7 -4732 imp:n=4  
 C Cell 4735 is the upper Carbon reflector  
 4735 4 -1.75 -8 6 -4732 imp:n=1  
 C Cell 4736 is the lower Carbon Reflector  
 4736 4 -1.75 -7 9 -4732 imp:n=1  
 C Cell 4737 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4737 5 -7.92 (4732:15:-9) (-4733 -10 11) imp:n=4  
 C Cell 4738 is the void at the top of the fuel element  
 4738 9 -0.001205 -4732 -15 8 imp:n=1  
 C  
 C Fuel Element F-13  
 C  
 C Cell 4741 is the central Zirconium rod  
 4741 1 -6.51 -4741 -4 5 imp:n=4  
 C Cell 4742 is the fuel area of the fuel rod  
 4742 474 0.09690183 4741 -4742 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4743 is the upper Samarium/aluminum poison disk  
 4743 3 -5.27 4 -6 -4742 imp:n=4  
 C Cell 4744 is the lower Samarium/aluminum poison disk  
 4744 3 -5.27 -5 7 -4742 imp:n=4  
 C Cell 4745 is the upper Carbon reflector  
 4745 4 -1.75 -8 6 -4742 imp:n=1  
 C Cell 4746 is the lower Carbon Reflector

4746 4 -1.75 -7 9 -4742 imp:n=1  
 C Cell 4747 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4747 5 -7.92 (4742:15:-9) (-4743 -10 11) imp:n=4  
 C Cell 4748 is the void at the top of the fuel element  
 4748 9 -0.001205 -4742 -15 8 imp:n=1  
 C  
 C Fuel Element F-14  
 C  
 C Cell 4751 is the central Zirconium rod  
 4751 1 -6.51 -4751 -4 5 imp:n=4  
 C Cell 4752 is the fuel area of the fuel rod  
 4752 475 0.09690183 4751 -4752 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4753 is the upper Samarium/aluminum poison disk  
 4753 3 -5.27 4 -6 -4752 imp:n=4  
 C Cell 4754 is the lower Samarium/aluminum poison disk  
 4754 3 -5.27 -5 7 -4752 imp:n=4  
 C Cell 4755 is the upper Carbon reflector  
 4755 4 -1.75 -8 6 -4752 imp:n=1  
 C Cell 4756 is the lower Carbon Reflector  
 4756 4 -1.75 -7 9 -4752 imp:n=1  
 C Cell 4757 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4757 5 -7.92 (4752:15:-9) (-4753 -10 11) imp:n=4  
 C Cell 4758 is the void at the top of the fuel element  
 4758 9 -0.001205 -4752 -15 8 imp:n=1  
 C  
 C Fuel Element F-15  
 C  
 C Cell 4761 is the central Zirconium rod  
 4761 1 -6.51 -4761 -4 5 imp:n=4  
 C Cell 4762 is the fuel area of the fuel rod  
 4762 476 0.09690183 4761 -4762 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4763 is the upper Samarium/aluminum poison disk  
 4763 3 -5.27 4 -6 -4762 imp:n=4  
 C Cell 4764 is the lower Samarium/aluminum poison disk  
 4764 3 -5.27 -5 7 -4762 imp:n=4  
 C Cell 4765 is the upper Carbon reflector  
 4765 4 -1.75 -8 6 -4762 imp:n=1  
 C Cell 4766 is the lower Carbon Reflector  
 4766 4 -1.75 -7 9 -4762 imp:n=1  
 C Cell 4767 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4767 5 -7.92 (4762:15:-9) (-4763 -10 11) imp:n=4  
 C Cell 4768 is the void at the top of the fuel element  
 4768 9 -0.001205 -4762 -15 8 imp:n=1

C  
C Fuel Element F-16  
C  
C Cell 4771 is the central Zirconium rod  
4771 1 -6.51 -4771 -4 5 imp:n=4  
C Cell 4772 is the fuel area of the fuel rod  
4772 477 0.09690183 4771 -4772 -4 5 vol=382.3638538 imp:n=16  
C Cell 4773 is the upper Samarium/aluminum poison disk  
4773 3 -5.27 4 -6 -4772 imp:n=4  
C Cell 4774 is the lower Samarium/aluminum poison disk  
4774 3 -5.27 -5 7 -4772 imp:n=4  
C Cell 4775 is the upper Carbon reflector  
4775 4 -1.75 -8 6 -4772 imp:n=1  
C Cell 4776 is the lower Carbon Reflector  
4776 4 -1.75 -7 9 -4772 imp:n=1  
C Cell 4777 is the Stainless Steel cladding of the fuel element  
C and support structure  
4777 5 -7.92 (4772:15:-9) (-4773 -10 11) imp:n=4  
C Cell 4778 is the void at the top of the fuel element  
4778 9 -0.001205 -4772 -15 8 imp:n=1  
C  
C Fuel Element F-17  
C  
C Cell 4781 is the central Zirconium rod  
4781 1 -6.51 -4781 -4 5 imp:n=4  
C Cell 4782 is the fuel area of the fuel rod  
4782 478 0.09690183 4781 -4782 -4 5 vol=382.3638538 imp:n=16  
C Cell 4783 is the upper Samarium/aluminum poison disk  
4783 3 -5.27 4 -6 -4782 imp:n=4  
C Cell 4784 is the lower Samarium/aluminum poison disk  
4784 3 -5.27 -5 7 -4782 imp:n=4  
C Cell 4785 is the upper Carbon reflector  
4785 4 -1.75 -8 6 -4782 imp:n=1  
C Cell 4786 is the lower Carbon Reflector  
4786 4 -1.75 -7 9 -4782 imp:n=1  
C Cell 4787 is the Stainless Steel cladding of the fuel element  
C and support structure  
4787 5 -7.92 (4782:15:-9) (-4783 -10 11) imp:n=4  
C Cell 4788 is the void at the top of the fuel element  
4788 9 -0.001205 -4782 -15 8 imp:n=1  
C  
C Fuel Element F-18  
C Cell 4791 is the central Zirconium rod  
4791 1 -6.51 -4791 -4 5 imp:n=4  
C Cell 4792 is the fuel area of the fuel rod  
4792 479 0.09690183 4791 -4792 -4 5 vol=382.3638538 imp:n=16

C Cell 4793 is the upper Samarium/aluminum poison disk  
 4793 3 -5.27 4 -6 -4792 imp:n=4  
 C Cell 4794 is the lower Samarium/aluminum poison disk  
 4794 3 -5.27 -5 7 -4792 imp:n=4  
 C Cell 4795 is the upper Carbon reflector  
 4795 4 -1.75 -8 6 -4792 imp:n=1  
 C Cell 4796 is the lower Carbon Reflector  
 4796 4 -1.75 -7 9 -4792 imp:n=1  
 C Cell 4797 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4797 5 -7.92 (4792:15:-9) (-4793 -10 11) imp:n=4  
 C Cell 4798 is the void at the top of the fuel element  
 4798 9 -0.001205 -4792 -15 8 imp:n=1  
 C  
 C Fuel Element F-19  
 C  
 C Cell 4801 is the central Zirconium rod  
 4801 1 -6.51 -4801 -4 5 imp:n=4  
 C Cell 4802 is the fuel area of the fuel rod  
 4802 480 0.09690183 4801 -4802 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4803 is the upper Samarium/aluminum poison disk  
 4803 3 -5.27 4 -6 -4802 imp:n=4  
 C Cell 4804 is the lower Samarium/aluminum poison disk  
 4804 3 -5.27 -5 7 -4802 imp:n=4  
 C Cell 4805 is the upper Carbon reflector  
 4805 4 -1.75 -8 6 -4802 imp:n=1  
 C Cell 4806 is the lower Carbon Reflector  
 4806 4 -1.75 -7 9 -4802 imp:n=1  
 C Cell 4807 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4807 5 -7.92 (4802:15:-9) (-4803 -10 11) imp:n=4  
 C Cell 4808 is the void at the top of the fuel element  
 4808 9 -0.001205 -4802 -15 8 imp:n=1  
 C  
 C Fuel Element F-20  
 C  
 C Cell 4811 is the central Zirconium rod  
 4811 1 -6.51 -4811 -4 5 imp:n=4  
 C Cell 4812 is the fuel area of the fuel rod  
 4812 481 0.09690183 4811 -4812 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4813 is the upper Samarium/aluminum poison disk  
 4813 3 -5.27 4 -6 -4812 imp:n=4  
 C Cell 4814 is the lower Samarium/aluminum poison disk  
 4814 3 -5.27 -5 7 -4812 imp:n=4  
 C Cell 4815 is the upper Carbon reflector  
 4815 4 -1.75 -8 6 -4812 imp:n=1

C Cell 4816 is the lower Carbon Reflector  
 4816 4 -1.75 -7 9 -4812 imp:n=1  
 C Cell 4817 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4817 5 -7.92 (4812:15:-9) (-4813 -10 11) imp:n=4  
 C Cell 4818 is the void at the top of the fuel element  
 4818 9 -0.001205 -4812 -15 8 imp:n=1  
 C  
 C Fuel Element F-21  
 C  
 C Cell 4821 is the central Zirconium rod  
 4821 1 -6.51 -4821 -4 5 imp:n=4  
 C Cell 4822 is the fuel area of the fuel rod  
 4822 482 0.09690183 4821 -4822 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4823 is the upper Samarium/aluminum poison disk  
 4823 3 -5.27 4 -6 -4822 imp:n=4  
 C Cell 4824 is the lower Samarium/aluminum poison disk  
 4824 3 -5.27 -5 7 -4822 imp:n=4  
 C Cell 4825 is the upper Carbon reflector  
 4825 4 -1.75 -8 6 -4822 imp:n=1  
 C Cell 4826 is the lower Carbon Reflector  
 4826 4 -1.75 -7 9 -4822 imp:n=1  
 C Cell 4827 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4827 5 -7.92 (4822:15:-9) (-4823 -10 11) imp:n=4  
 C Cell 4828 is the void at the top of the fuel element  
 4828 9 -0.001205 -4822 -15 8 imp:n=1  
 C  
 C Fuel Element F-22  
 C  
 C Cell 4831 is the central Zirconium rod  
 4831 1 -6.51 -4831 -4 5 imp:n=4  
 C Cell 4832 is the fuel area of the fuel rod  
 4832 483 0.09690183 4831 -4832 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4833 is the upper Samarium/aluminum poison disk  
 4833 3 -5.27 4 -6 -4832 imp:n=4  
 C Cell 4834 is the lower Samarium/aluminum poison disk  
 4834 3 -5.27 -5 7 -4832 imp:n=4  
 C Cell 4835 is the upper Carbon reflector  
 4835 4 -1.75 -8 6 -4832 imp:n=1  
 C Cell 4836 is the lower Carbon Reflector  
 4836 4 -1.75 -7 9 -4832 imp:n=1  
 C Cell 4837 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4837 5 -7.92 (4832:15:-9) (-4833 -10 11) imp:n=4  
 C Cell 4838 is the void at the top of the fuel element

4838 9 -0.001205 -4832 -15 8 imp:n=1  
 C  
 C Fuel Element F-23  
 C  
 C Cell 4841 is the central Zirconium rod  
 4841 1 -6.51 -4841 -4 5 imp:n=4  
 C Cell 4842 is the fuel area of the fuel rod  
 4842 484 0.09690183 4841 -4842 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4843 is the upper Samarium/aluminum poison disk  
 4843 3 -5.27 4 -6 -4842 imp:n=4  
 C Cell 4844 is the lower Samarium/aluminum poison disk  
 4844 3 -5.27 -5 7 -4842 imp:n=4  
 C Cell 4845 is the upper Carbon reflector  
 4845 4 -1.75 -8 6 -4842 imp:n=1  
 C Cell 4846 is the lower Carbon Reflector  
 4846 4 -1.75 -7 9 -4842 imp:n=1  
 C Cell 4847 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4847 5 -7.92 (4842:15:-9) (-4843 -10 11) imp:n=4  
 C Cell 4848 is the void at the top of the fuel element  
 4848 9 -0.001205 -4842 -15 8 imp:n=1  
 C  
 C Fuel Element F-24  
 C  
 C Cell 4851 is the central Zirconium rod  
 4851 1 -6.51 -4851 -4 5 imp:n=4  
 C Cell 4852 is the fuel area of the fuel rod  
 4852 485 0.09690183 4851 -4852 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4853 is the upper Samarium/aluminum poison disk  
 4853 3 -5.27 4 -6 -4852 imp:n=4  
 C Cell 4854 is the lower Samarium/aluminum poison disk  
 4854 3 -5.27 -5 7 -4852 imp:n=4  
 C Cell 4855 is the upper Carbon reflector  
 4855 4 -1.75 -8 6 -4852 imp:n=1  
 C Cell 4856 is the lower Carbon Reflector  
 4856 4 -1.75 -7 9 -4852 imp:n=1  
 C Cell 4857 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4857 5 -7.92 (4852:15:-9) (-4853 -10 11) imp:n=4  
 C Cell 4858 is the void at the top of the fuel element  
 4858 9 -0.001205 -4852 -15 8 imp:n=1  
 C  
 C Fuel Element F-25  
 C  
 C Cell 4861 is the central Zirconium rod  
 4861 1 -6.51 -4861 -4 5 imp:n=4

C Cell 4862 is the fuel area of the fuel rod  
 4862 486 0.09690183 4861 -4862 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4863 is the upper Samarium/aluminum poison disk  
 4863 3 -5.27 4 -6 -4862 imp:n=4  
 C Cell 4864 is the lower Samarium/aluminum poison disk  
 4864 3 -5.27 -5 7 -4862 imp:n=4  
 C Cell 4865 is the upper Carbon reflector  
 4865 4 -1.75 -8 6 -4862 imp:n=1  
 C Cell 4866 is the lower Carbon Reflector  
 4866 4 -1.75 -7 9 -4862 imp:n=1  
 C Cell 4867 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4867 5 -7.92 (4862:15:-9) (-4863 -10 11) imp:n=4  
 C Cell 4868 is the void at the top of the fuel element  
 4868 9 -0.001205 -4862 -15 8 imp:n=1  
 C  
 C Fuel Element F-26  
 C  
 C Cell 4871 is the central Zirconium rod  
 4871 1 -6.51 -4871 -4 5 imp:n=4  
 C Cell 4872 is the fuel area of the fuel rod  
 4872 487 0.09690183 4871 -4872 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4873 is the upper Samarium/aluminum poison disk  
 4873 3 -5.27 4 -6 -4872 imp:n=4  
 C Cell 4874 is the lower Samarium/aluminum poison disk  
 4874 3 -5.27 -5 7 -4872 imp:n=4  
 C Cell 4875 is the upper Carbon reflector  
 4875 4 -1.75 -8 6 -4872 imp:n=1  
 C Cell 4876 is the lower Carbon Reflector  
 4876 4 -1.75 -7 9 -4872 imp:n=1  
 C Cell 4877 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4877 5 -7.92 (4872:15:-9) (-4873 -10 11) imp:n=4  
 C Cell 4878 is the void at the top of the fuel element  
 4878 9 -0.001205 -4872 -15 8 imp:n=1  
 C  
 C Fuel Element F-27  
 C  
 C Cell 4881 is the central Zirconium rod  
 4881 1 -6.51 -4881 -4 5 imp:n=4  
 C Cell 4882 is the fuel area of the fuel rod  
 4882 488 0.09690183 4881 -4882 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4883 is the upper Samarium/aluminum poison disk  
 4883 3 -5.27 4 -6 -4882 imp:n=4  
 C Cell 4884 is the lower Samarium/aluminum poison disk  
 4884 3 -5.27 -5 7 -4882 imp:n=4

C Cell 4885 is the upper Carbon reflector  
 4885 4 -1.75 -8 6 -4882 imp:n=1  
 C Cell 4886 is the lower Carbon Reflector  
 4886 4 -1.75 -7 9 -4882 imp:n=1  
 C Cell 4887 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4887 5 -7.92 (4882:15:-9) (-4883 -10 11) imp:n=4  
 C Cell 4888 is the void at the top of the fuel element  
 4888 9 -0.001205 -4882 -15 8 imp:n=1  
 C  
 C Fuel Element F-28  
 C  
 C Cell 4891 is the central Zirconium rod  
 4891 1 -6.51 -4891 -4 5 imp:n=4  
 C Cell 4892 is the fuel area of the fuel rod  
 4892 489 0.09690183 4891 -4892 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4893 is the upper Samarium/aluminum poison disk  
 4893 3 -5.27 4 -6 -4892 imp:n=4  
 C Cell 4894 is the lower Samarium/aluminum poison disk  
 4894 3 -5.27 -5 7 -4892 imp:n=4  
 C Cell 4895 is the upper Carbon reflector  
 4895 4 -1.75 -8 6 -4892 imp:n=1  
 C Cell 4896 is the lower Carbon Reflector  
 4896 4 -1.75 -7 9 -4892 imp:n=1  
 C Cell 4897 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4897 5 -7.92 (4892:15:-9) (-4893 -10 11) imp:n=4  
 C Cell 4898 is the void at the top of the fuel element  
 4898 9 -0.001205 -4892 -15 8 imp:n=1  
 C  
 C Fuel Element F-29  
 C  
 C Cell 4901 is the central Zirconium rod  
 4901 1 -6.51 -4901 -4 5 imp:n=4  
 C Cell 4902 is the fuel area of the fuel rod  
 4902 490 0.09690183 4901 -4902 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4903 is the upper Samarium/aluminum poison disk  
 4903 3 -5.27 4 -6 -4902 imp:n=4  
 C Cell 4904 is the lower Samarium/aluminum poison disk  
 4904 3 -5.27 -5 7 -4902 imp:n=4  
 C Cell 4905 is the upper Carbon reflector  
 4905 4 -1.75 -8 6 -4902 imp:n=1  
 C Cell 4906 is the lower Carbon Reflector  
 4906 4 -1.75 -7 9 -4902 imp:n=1  
 C Cell 4907 is the Stainless Steel cladding of the fuel element  
 C and support structure

4907 5 -7.92 (4902:15:-9) (-4903 -10 11) imp:n=4  
 C Cell 4908 is the void at the top of the fuel element  
 4908 9 -0.001205 -4902 -15 8 imp:n=1  
 C  
 C Fuel Element F-30  
 C  
 C Cell 4911 is the central Zirconium rod  
 4911 1 -6.51 -4911 -4 5 imp:n=4  
 C Cell 4912 is the fuel area of the fuel rod  
 4912 491 0.09690183 4911 -4912 -4 5 vol=382.3638538 imp:n=16  
 C Cell 4913 is the upper Samarium/aluminum poison disk  
 4913 3 -5.27 4 -6 -4912 imp:n=4  
 C Cell 4914 is the lower Samarium/aluminum poison disk  
 4914 3 -5.27 -5 7 -4912 imp:n=4  
 C Cell 4915 is the upper Carbon reflector  
 4915 4 -1.75 -8 6 -4912 imp:n=1  
 C Cell 4916 is the lower Carbon Reflector  
 4916 4 -1.75 -7 9 -4912 imp:n=1  
 C Cell 4917 is the Stainless Steel cladding of the fuel element  
 C and support structure  
 4917 5 -7.92 (4912:15:-9) (-4913 -10 11) imp:n=4  
 C Cell 4918 is the void at the top of the fuel element  
 4918 9 -0.001205 -4912 -15 8 imp:n=1  
 c  
 c -----  
 c Exposure room 1  
 c -----  
 c  
 c Cell 702 is the wood lining of the exposure room  
 702 11 -0.650 -555 601 -602 603 604 -630  
 (610: -611: 612: -613: -614: 615)  
 ((-519 558 -551 604):  
 (-519 559 551 -630)):  
 (-551 565 603 519 -555 604):  
 (551 -555 519 569 603 -630):  
 (551 -555 519 568 -602 -630):  
 (-551 564 -602 519 -555 604)  
 imp:n=1  
 c Cell 703 is the masonite/gadolinium lining of the exposure room  
 703 12 -1.30 -610 611 -612 613 614 -615  
 (620: -621: 622: -623: -624: 625)  
 ((558 -551):(559 551))  
 imp:n=1  
 c Cell 704 defines the interior volume of the exposure room  
 704 9 -0.001205 -620 621 -622 623 624 -625  
 ((558 -551):(559 551)) #706 imp:n=1

c Cell 706 is the cadmium curtain  
706 15 -8.69 558 -3002 -620 -3001 3003 imp:n=1  
c Cell 707 is the air gap between the wood and concrete on ceiling  
707 9 -0.001205 (-555 601 -602 603 630 -605)  
(-519 559):  
(568 519 -602 -555 630 -605):  
(569 519 603 -555 630 -605)  
imp:n=1  
c  
c -----  
c Exposure room 2  
c -----  
c  
c Cell 710 is the wood lining of the exposure room  
710 11 -0.650 554 -651 -652 653 654 -655  
(-660: 661: 662: -663: -664: 665)  
((516 556 -551 654):  
(516 557 551 -655)):  
(-551 563 653 -516 554 654):  
(551 554 -516 567 653 -655):  
(551 554 -516 566 -652 -655):  
(-551 562 -652 -516 554 654) imp:n=1  
c Cell 711 is the masonite/gadolinium lining of the exposure room  
711 12 -1.30 660 -661 -662 663 664 -665  
(-670: 671: 672: -673: -674: 675)  
((556 -551):(557 551)) imp:n=1  
c Cell 712 defines the interior volume of the exposure room  
712 9 -0.001205 670 -671 -672 673 674 -675 ((556 -551):(557 551)) imp:n=1  
c Cell 713 is the lead shield  
c  
c -----  
c Control rod guide tubes  
c -----  
c  
c Control rod A-1  
c  
358 7 0.059195  
-503 1013 -53 1033  
imp:n=1  
c Air in guide tube A-1  
362 9 -0.001205  
-503 502 1004 -1013  
imp:n=1  
c  
c Control rod D-1  
c

359 7 0.059195  
 -503 1039 -73 1033  
 imp:n=1  
 c Air in guide tube D-1  
 363 9 -0.001205  
 -503 502 1024 -1039  
 imp:n=1  
 c  
 c Control rod D-7  
 c  
 360 7 0.059195  
 -503 1053 -79 1033  
 imp:n=1  
 c Air in guide tube D-7  
 364 9 -0.001205  
 -503 502 1044 -1053  
 imp:n=1  
 c  
 c Control rod D-13  
 c  
 361 7 0.059195  
 -503 1073 -85 1033  
 imp:n=1  
 c Air in guide tube D-13  
 365 9 -0.001205  
 -503 502 1064 -1073  
 imp:n=1  
 c  
 c -----  
 c Core exposure tube  
 c -----  
 c Located at Core position E-23  
 c Terminated at surface 1078; actual exposure tube serpentines to  
 c surface of pool to prevent radiation streaming  
 c -----  
 656 7 0.059195  
 -113 851 -1087 9  
 imp:n=1  
 1658 9 -0.001205  
 -851 9 -1087  
 imp:n=1  
 1659 7 0.059195  
 -9 11 -113  
 imp:n=1  
 C Surface cards

150 cz 13.93063  
 151 cz 17.90192  
 152 cz 22.00000

c -----  
 C Surfaces 1 thru 15 define a fuel element at position B1  
 c -----

c  
 C Dimensions from reactor plans sheet T3S210D170  
 c

4	pz	21.081125		\$ Top of fuel area
5	pz	-17.018875		\$ Bottom of fuel area
6	pz	21.119125		\$ Top of upper Samarium wafer
7	pz	-17.056875		\$ Bottom of lower Samarium wafer
8	pz	29.859125		\$ Top of upper carbon reflector
9	pz	-25.796875		\$ Bottom of lower carbon reflector
10	pz	31.4325		\$ Top of cladding can
11	pz	-27.066875		\$ Bottom of cladding can
13	pz	39.0017		\$ Top of fuel element
14	pz	-31.4325		\$ Bottom of fuel element
15	pz	30.189325		\$ Top of void

c  
 c -----  
 C Upper Grid Plate  
 c -----

50	PZ	33.3375		\$ Top surface of plate
51	PZ	31.4325		\$ Bottom surface of plate
52	CZ	23.6601		\$ Exterior edge of plate

c A Ring

c  
 c  
 c B Ring

54	C/Z	-4.05384	0.0	1.91135	\$ Core position B1
55	C/Z	-2.02692	3.510534	1.91135	\$ Core position B2
56	C/Z	2.02692	3.510534	1.91135	\$ Core position B3
57	C/Z	4.05384	0.0	1.91135	\$ Core position B4
58	C/Z	2.02692	-3.510534	1.91135	\$ Core position B5
59	C/Z	-2.02692	-3.510534	1.91135	\$ Core position B6

c  
 c C Ring

60	C/Z	-7.98068	0.0	1.91135	\$ Core position C1
61	C/Z	-6.91134	3.99034	1.91135	\$ Core position C2
63	C/Z	-3.99034	6.91134	1.91135	\$ Core position C3
64	C/Z	0.0	7.98068	1.91135	\$ Core position C4

65	C/Z	3.99034	6.91134	1.91135	\$ Core position C5
66	C/Z	6.91134	3.99034	1.91135	\$ Core position C6
67	C/Z	7.98068	0.0	1.91135	\$ Core position C7
68	C/Z	6.91134	-3.99034	1.91135	\$ Core position C8
69	C/Z	3.99034	-6.91134	1.91135	\$ Core position C9
70	C/Z	0.0	-7.98068	1.91135	\$ Core position C10
71	C/Z	-3.99034	-6.91134	1.91135	\$ Core position C11
72	C/Z	-6.91134	-3.99034	1.91135	\$ Core position C12

c

c D Ring

c

74	C/Z	-11.22528	4.085336	1.91135	\$ Core position D2
75	C/Z	-9.15035	7.678736	1.91135	\$ Core position D3
76	C/Z	-5.97281	10.344912	1.91135	\$ Core position D4
77	C/Z	-2.073656	11.76401	1.91135	\$ Core position D5
78	C/Z	2.073656	11.76401	1.91135	\$ Core position D6
80	C/Z	9.15035	7.678674	1.91135	\$ Core position D8
81	C/Z	11.225276	4.085336	1.91135	\$ Core position D9
82	C/Z	11.94562	0.0	1.91135	\$ Core position D10
83	C/Z	11.225276	-4.085336	1.91135	\$ Core position D11
84	C/Z	9.15035	-7.678674	1.91135	\$ Core position D12
86	C/Z	2.07366	-11.76401	1.91135	\$ Core position D14
87	C/Z	-2.07366	-11.76401	1.91135	\$ Core position D15
88	C/Z	-5.97281	-10.344912	1.91135	\$ Core position D16
89	C/Z	-9.15035	-7.678674	1.91135	\$ Core position D17
90	C/Z	-11.22528	-4.085336	1.91135	\$ Core position D18

c

c E Ring

c

91	C/Z	-15.91564	0.0	1.91135	\$ Core position E1
92	C/Z	-15.372842	4.118864	1.91135	\$ Core position E2
93	C/Z	-13.782802	7.95782	1.91135	\$ Core position E3
94	C/Z	-11.253978	11.253978	1.91135	\$ Core position E4
95	C/Z	-7.95782	13.782802	1.91135	\$ Core position E5
96	C/Z	-4.118864	15.372842	1.91135	\$ Core position E6
97	C/Z	0.0	15.91564	1.91135	\$ Core position E7
98	C/Z	4.118864	15.372842	1.91135	\$ Core position E8
99	C/Z	7.95782	13.782802	1.91135	\$ Core position E9
100	C/Z	11.25398	11.253978	1.91135	\$ Core position E10
101	C/Z	13.782802	7.95782	1.91135	\$ Core position E11
102	C/Z	15.372842	4.118864	1.91135	\$ Core position E12
103	C/Z	15.91564	0.0	1.91135	\$ Core position E13
104	C/Z	15.372842	-4.118864	1.91135	\$ Core position E14
105	C/Z	13.782802	-7.95782	1.91135	\$ Core position E15
106	C/Z	11.253978	-11.253978	1.91135	\$ Core position E16
107	C/Z	7.95782	-13.782802	1.91135	\$ Core position E17

108 C/Z 4.118864 -15.372842 1.91135 \$ Core position E18  
 109 C/Z 0.0 -15.91564 1.91135 \$ Core position E19  
 110 C/Z -4.118864 -15.372842 1.91135 \$ Core position E20  
 111 C/Z -7.95782 -13.782802 1.91135 \$ Core position E21  
 112 C/Z -11.25398 -11.25398 1.91135 \$ Core position E22  
 113 C/Z -13.78208 -7.95782 1.91135 \$ Core position E23  
 114 C/Z -15.372842 -4.118864 1.91135 \$ Core position E24

c

c F Ring

c

115 C/Z -19.8882 0.0 1.91335 \$ Core position F1  
 116 C/Z -19.45259 4.134866 1.91135 \$ Core position F2  
 117 C/Z -18.167858 8.08863 1.91135 \$ Core position F3  
 118 C/Z -16.08963 11.69035 1.91135 \$ Core position F4  
 119 C/Z -13.292074 14.77899 1.91135 \$ Core position F5  
 120 C/Z -9.9441 17.223232 1.91135 \$ Core position F6  
 121 C/Z -6.14553 18.915634 1.91135 \$ Core position F7  
 122 C/Z -2.078228 19.915634 1.91135 \$ Core position F8  
 123 C/Z 2.078228 19.915634 1.91135 \$ Core position F9  
 124 C/Z 6.14553 18.915634 1.91135 \$ Core position F10  
 125 C/Z 9.9441 17.223232 1.91135 \$ Core position F11  
 126 C/Z 13.292074 14.77899 1.91135 \$ Core position F12  
 127 C/Z 16.08963 11.69035 1.91135 \$ Core position F13  
 128 C/Z 18.167858 8.08863 1.91135 \$ Core position F14  
 129 C/Z 19.45259 4.134866 1.91135 \$ Core position F15  
 130 C/Z 19.8882 0.0 1.91135 \$ Core position F16  
 131 C/Z 19.45259 -4.134866 1.91135 \$ Core position F17  
 132 C/Z 18.167858 -8.08863 1.91135 \$ Core position F18  
 133 C/Z 16.08963 -11.69035 1.91135 \$ Core position F19  
 134 C/Z 13.292074 -14.77899 1.91135 \$ Core position F20  
 135 C/Z 9.9441 -17.223232 1.91135 \$ Core position F21  
 136 C/Z 6.14553 -18.915634 1.91135 \$ Core position F22  
 137 C/Z 2.078228 -19.915634 1.91135 \$ Core position F23  
 138 C/Z -2.078338 -19.915634 1.91135 \$ Core position F24  
 139 C/Z -6.14553 -18.915634 1.91135 \$ Core position F25  
 140 C/Z -9.9441 -17.223232 1.91135 \$ Core position F26  
 141 C/Z -13.292074 -14.77899 1.91135 \$ Core position F27  
 142 C/Z -16.08963 -11.69035 1.91135 \$ Core position F28  
 143 C/Z -18.167858 -8.08864 1.91135 \$ Core position F29  
 144 C/Z -19.45259 -4.134866 1.91135 \$ Core position F30

C 145 C/Z 1.13665 \$ External neutron source position

c

c -----

C Lower Grid Plate

c -----

c

200	PZ	-31.4325			\$ Top surface of plate
201	PZ	-33.3375			\$ Bottom surface of plate
202	CZ	21.115			\$ Exterior edge of plate
c					
C					
C	-----				
C	Adding additional fuel elements				
c	-----				
C					
C	Fuel Element B-1				
C					
4011	c/z	-4.05384	0.0	0.31	\$ Central Zirconium Rod
4012	c/z	-4.05384	0.0	1.814	\$ Interior of cladding
4013	c/z	-4.05384	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element B-2				
C					
4021	c/z	-2.02692	3.510534	0.31	\$ Central Zirconium Rod
4022	c/z	-2.02692	3.510534	1.814	\$ Interior of cladding
4023	c/z	-2.02692	3.510534	1.865	\$ Exterior of cladding
C					
C	Fuel Element B-3				
C					
4031	c/z	2.02692	3.510534	0.31	\$ Central Zirconium Rod
4032	c/z	2.02692	3.510534	1.814	\$ Interior of cladding
4033	c/z	2.02692	3.510534	1.865	\$ Exterior of cladding
C					
C	Fuel Element B-4				
C					
4041	c/z	4.05384	0.0	0.31	\$ Central Zirconium Rod
4042	c/z	4.05384	0.0	1.814	\$ Interior of cladding
4043	c/z	4.05384	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element B-5				
C					
4051	c/z	2.02692	-3.510534	0.31	\$ Central Zirconium Rod
4052	c/z	2.02692	-3.510534	1.814	\$ Interior of cladding
4053	c/z	2.02692	-3.510534	1.865	\$ Exterior of cladding
C					
C	Fuel Element B-6				
C					
4061	c/z	-2.02692	-3.510534	0.31	\$ Central Zirconium Rod
4062	c/z	-2.02692	-3.510534	1.814	\$ Interior of cladding
4063	c/z	-2.02692	-3.510534	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-1				

C					
4071	c/z	-7.98068	0.0	0.31	\$ Central Zirconium Rod
4072	c/z	-7.98068	0.0	1.814	\$ Interior of cladding
4073	c/z	-7.98068	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-2				
C					
4081	c/z	-6.91134	3.99034	0.31	\$ Central Zirconium Rod
4082	c/z	-6.91134	3.99034	1.814	\$ Interior of cladding
4083	c/z	-6.91134	3.99034	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-3				
C					
4091	c/z	-3.99034	6.91134	0.31	\$ Central Zirconium Rod
4092	c/z	-3.99034	6.91134	1.814	\$ Interior of cladding
4093	c/z	-3.99034	6.91134	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-4				
C					
4101	c/z	0.0	7.98068	0.31	\$ Central Zirconium Rod
4102	c/z	0.0	7.98068	1.814	\$ Interior of cladding
4103	c/z	0.0	7.98068	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-5				
C					
4111	c/z	3.99034	6.91134	0.31	\$ Central Zirconium Rod
4112	c/z	3.99034	6.91134	1.814	\$ Interior of cladding
4113	c/z	3.99034	6.91134	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-6				
C					
4121	c/z	6.91134	3.99034	0.31	\$ Central Zirconium Rod
4122	c/z	6.91134	3.99034	1.814	\$ Interior of cladding
4123	c/z	6.91134	3.99034	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-7				
C					
4131	c/z	7.98068	0.0	0.31	\$ Central Zirconium Rod
4132	c/z	7.98068	0.0	1.814	\$ Interior of cladding
4133	c/z	7.98068	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element C-8				
C					
4141	c/z	6.91134	-3.99034	0.31	\$ Central Zirconium Rod
4142	c/z	6.91134	-3.99034	1.814	\$ Interior of cladding
4143	c/z	6.91134	-3.99034	1.865	\$ Exterior of cladding

C  
C Fuel Element C-9  
C  
4151 c/z 3.99034 -6.91134 0.31 \$ Central Zirconium Rod  
4152 c/z 3.99034 -6.91134 1.814 \$ Interior of cladding  
4153 c/z 3.99034 -6.91134 1.865 \$ Exterior of cladding  
C  
C Fuel Element C-10  
C  
4161 c/z 0.0 -7.98068 0.31 \$ Central Zirconium Rod  
4162 c/z 0.0 -7.98068 1.814 \$ Interior of cladding  
4163 c/z 0.0 -7.98068 1.865 \$ Exterior of cladding  
C  
C Fuel Element C-11  
C  
4171 c/z -3.99034 -6.91134 0.31 \$ Central Zirconium Rod  
4172 c/z -3.99034 -6.91134 1.814 \$ Interior of cladding  
4173 c/z -3.99034 -6.91134 1.865 \$ Exterior of cladding  
C  
C Fuel Element C-12  
C  
4181 c/z -6.91134 -3.99034 0.31 \$ Central Zirconium Rod  
4182 c/z -6.91134 -3.99034 1.814 \$ Interior of cladding  
4183 c/z -6.91134 -3.99034 1.865 \$ Exterior of cladding  
C  
C Fuel Element D-2  
C  
4201 c/z -11.22528 4.085336 0.31 \$ Central Zirconium Rod  
4202 c/z -11.22528 4.085336 1.814 \$ Interior of cladding  
4203 c/z -11.22528 4.085336 1.865 \$ Exterior of cladding  
C  
C Fuel Element D-3  
C  
4211 c/z -9.15035 7.678736 0.31 \$ Central Zirconium Rod  
4212 c/z -9.15035 7.678736 1.814 \$ Interior of cladding  
4213 c/z -9.15035 7.678736 1.865 \$ Exterior of cladding  
C  
C Fuel Element D-4  
C  
4221 c/z -5.97281 10.344912 0.31 \$ Central Zirconium Rod  
4222 c/z -5.97281 10.344912 1.814 \$ Interior of cladding  
4223 c/z -5.97281 10.344912 1.865 \$ Exterior of cladding  
C  
C Fuel Element D-5  
C  
4231 c/z -2.073656 11.76401 0.31 \$ Central Zirconium Rod

4232	c/z	-2.073656	11.76401	1.814	\$ Interior of cladding
4233	c/z	-2.073656	11.76401	1.865	\$ Exterior of cladding
C					
C Fuel Element D-6					
C					
4241	c/z	2.073656	11.76401	0.31	\$ Central Zirconium Rod
4242	c/z	2.073656	11.76401	1.814	\$ Interior of cladding
4243	c/z	2.073656	11.76401	1.865	\$ Exterior of cladding
C					
C Fuel Element D-8					
C					
4261	c/z	9.15035	7.678674	0.31	\$ Central Zirconium Rod
4262	c/z	9.15035	7.678674	1.814	\$ Interior of cladding
4263	c/z	9.15035	7.678674	1.865	\$ Exterior of cladding
C					
C Fuel Element D-9					
C					
4281	c/z	11.225276	4.085336	0.31	\$ Central Zirconium Rod
4282	c/z	11.225276	4.085336	1.814	\$ Interior of cladding
4283	c/z	11.225276	4.085336	1.865	\$ Exterior of cladding
C					
C Fuel Element D-10					
C					
4291	c/z	11.94562	0.0	0.31	\$ Central Zirconium Rod
4292	c/z	11.94562	0.0	1.814	\$ Interior of cladding
4293	c/z	11.94562	0.0	1.865	\$ Exterior of cladding
C					
C Fuel Element D-11					
C					
4301	c/z	11.225276	-4.085336	0.31	\$ Central Zirconium Rod
4302	c/z	11.225276	-4.085336	1.814	\$ Interior of cladding
4303	c/z	11.225276	-4.085336	1.865	\$ Exterior of cladding
C					
C Fuel Element D-12					
C					
4311	c/z	9.15035	-7.678674	0.31	\$ Central Zirconium Rod
4312	c/z	9.15035	-7.678674	1.814	\$ Interior of cladding
4313	c/z	9.15035	-7.678674	1.865	\$ Exterior of cladding
C					
C Fuel Element D-14					
C					
4331	c/z	2.07366	-11.76401	0.31	\$ Central Zirconium Rod
4332	c/z	2.07366	-11.76401	1.814	\$ Interior of cladding
4333	c/z	2.07366	-11.76401	1.865	\$ Exterior of cladding
C					
C Fuel Element D-15					

C					
4341	c/z	-2.07366	-11.76401	0.31	\$ Central Zirconium Rod
4342	c/z	-2.07366	-11.76401	1.814	\$ Interior of cladding
4343	c/z	-2.07366	-11.76401	1.865	\$ Exterior of cladding
C					
C	Fuel Element D-16				
C					
4351	c/z	-5.97281	-10.344912	0.31	\$ Central Zirconium Rod
4352	c/z	-5.97281	-10.344912	1.814	\$ Interior of cladding
4353	c/z	-5.97281	-10.344912	1.865	\$ Exterior of cladding
C					
C	Fuel Element D-17				
C					
4361	c/z	-9.15035	-7.678674	0.31	\$ Central Zirconium Rod
4362	c/z	-9.15035	-7.678674	1.814	\$ Interior of cladding
4363	c/z	-9.15035	-7.678674	1.865	\$ Exterior of cladding
C					
C	Fuel Element D-18				
C					
4371	c/z	-11.22528	-4.085336	0.31	\$ Central Zirconium Rod
4372	c/z	-11.22528	-4.085336	1.814	\$ Interior of cladding
4373	c/z	-11.22528	-4.085336	1.865	\$ Exterior of cladding
C					
C	Fuel Element E-1				
C					
4381	c/z	-15.91564	0.0	0.31	\$ Central Zirconium Rod
4382	c/z	-15.91564	0.0	1.814	\$ Interior of cladding
4383	c/z	-15.91564	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element E-2				
C					
4391	c/z	-15.372842	4.118864	0.31	\$ Central Zirconium Rod
4392	c/z	-15.372842	4.118864	1.814	\$ Interior of cladding
4393	c/z	-15.372842	4.118864	1.865	\$ Exterior of cladding
C					
C	Fuel Element E-3				
C					
4401	c/z	-13.782802	7.95782	0.31	\$ Central Zirconium Rod
4402	c/z	-13.782802	7.95782	1.814	\$ Interior of cladding
4403	c/z	-13.782802	7.95782	1.865	\$ Exterior of cladding
C					
C	Fuel Element E-4				
C					
C					
4411	c/z	-11.253978	11.253978	0.31	\$ Central Zirconium Rod
4412	c/z	-11.253978	11.253978	1.814	\$ Interior of cladding

4413	c/z	-11.253978	11.253978	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-5
C					
4421	c/z	-7.95782	13.782802	0.31	\$ Central Zirconium Rod
4422	c/z	-7.95782	13.782802	1.814	\$ Interior of cladding
4423	c/z	-7.95782	13.782802	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-6
C					
4431	c/z	-4.118864	15.372842	0.31	\$ Central Zirconium Rod
4432	c/z	-4.118864	15.372842	1.814	\$ Interior of cladding
4433	c/z	-4.118864	15.372842	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-7
C					
4441	c/z	0.0	15.91564	0.31	\$ Central Zirconium Rod
4442	c/z	0.0	15.91564	1.814	\$ Interior of cladding
4443	c/z	0.0	15.91564	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-8
C					
4451	c/z	4.118864	15.372842	0.31	\$ Central Zirconium Rod
4452	c/z	4.118864	15.372842	1.814	\$ Interior of cladding
4453	c/z	4.118864	15.372842	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-9
C					
4461	c/z	7.95782	13.782802	0.31	\$ Central Zirconium Rod
4462	c/z	7.95782	13.782802	1.814	\$ Interior of cladding
4463	c/z	7.95782	13.782802	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-10
C					
4471	c/z	11.25398	11.253978	0.31	\$ Central Zirconium Rod
4472	c/z	11.25398	11.253978	1.814	\$ Interior of cladding
4473	c/z	11.25398	11.253978	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-11
C					
4481	c/z	13.782802	7.95782	0.31	\$ Central Zirconium Rod
4482	c/z	13.782802	7.95782	1.814	\$ Interior of cladding
4483	c/z	13.782802	7.95782	1.865	\$ Exterior of cladding
C					

C	Fuel Element E-12
C	
4491	c/z 15.372842 4.118864 0.31 \$ Central Zirconium Rod
4492	c/z 15.372842 4.118864 1.814 \$ Interior of cladding
4493	c/z 15.372842 4.118864 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-13
C	
4501	c/z 15.91564 0.0 0.31 \$ Central Zirconium Rod
4502	c/z 15.91564 0.0 1.814 \$ Interior of cladding
4503	c/z 15.91564 0.0 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-14
C	
4511	c/z 15.372842 -4.118864 0.31 \$ Central Zirconium Rod
4512	c/z 15.372842 -4.118864 1.814 \$ Interior of cladding
4513	c/z 15.372842 -4.118864 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-15
C	
4521	c/z 13.782802 -7.95782 0.31 \$ Central Zirconium Rod
4522	c/z 13.782802 -7.95782 1.814 \$ Interior of cladding
4523	c/z 13.782802 -7.95782 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-16
C	
4531	c/z 11.253978 -11.253978 0.31 \$ Central Zirconium Rod
4532	c/z 11.253978 -11.253978 1.814 \$ Interior of cladding
4533	c/z 11.253978 -11.253978 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-17
C	
4541	c/z 7.95782 -13.782802 0.31 \$ Central Zirconium Rod
4542	c/z 7.95782 -13.782802 1.814 \$ Interior of cladding
4543	c/z 7.95782 -13.782802 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-18
C	
4551	c/z 4.118864 -15.372842 0.31 \$ Central Zirconium Rod
4552	c/z 4.118864 -15.372842 1.814 \$ Interior of cladding
4553	c/z 4.118864 -15.372842 1.865 \$ Exterior of cladding
C	
C	Fuel Element E-19
C	
4561	c/z 0.0 -15.91564 0.31 \$ Central Zirconium Rod
4562	c/z 0.0 -15.91564 1.814 \$ Interior of cladding

4563	c/z	0.0	-15.91564	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-20
C					
4571	c/z	-4.118864	-15.372842	0.31	\$ Central Zirconium Rod
4572	c/z	-4.118864	-15.372842	1.814	\$ Interior of cladding
4573	c/z	-4.118864	-15.372842	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-21
C					
4581	c/z	-7.95782	-13.782802	0.31	\$ Central Zirconium Rod
4582	c/z	-7.95782	-13.782802	1.814	\$ Interior of cladding
4583	c/z	-7.95782	-13.782802	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-22
C					
4591	c/z	-11.25398	-11.25398	0.31	\$ Central Zirconium Rod
4592	c/z	-11.25398	-11.25398	1.814	\$ Interior of cladding
4593	c/z	-11.25398	-11.25398	1.865	\$ Exterior of cladding
C					
C					Fuel Element E-24
C					
4611	c/z	-15.372842	-4.118864	0.31	\$ Central Zirconium Rod
4612	c/z	-15.372842	-4.118864	1.814	\$ Interior of cladding
4613	c/z	-15.372842	-4.118864	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-1
C					
4621	c/z	-19.8882	0.0	0.31	\$ Central Zirconium Rod
4622	c/z	-19.8882	0.0	1.814	\$ Interior of cladding
4623	c/z	-19.8882	0.0	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-2
C					
4631	c/z	-19.45259	4.134866	0.31	\$ Central Zirconium Rod
4632	c/z	-19.45259	4.134866	1.814	\$ Interior of cladding
4633	c/z	-19.45259	4.134866	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-3
C					
4641	c/z	-18.167858	8.08863	0.31	\$ Central Zirconium Rod
4642	c/z	-18.167858	8.08863	1.814	\$ Interior of cladding
4643	c/z	-18.167858	8.08863	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-4
C					

4651	c/z	-16.08963	11.69035	0.31	\$ Central Zirconium Rod
4652	c/z	-16.08963	11.69035	1.814	\$ Interior of cladding
4653	c/z	-16.08963	11.69035	1.865	\$ Exterior of cladding
C					
C Fuel Element F-5					
C					
4661	c/z	-13.292074	14.77899	0.31	\$ Central Zirconium Rod
4662	c/z	-13.292074	14.77899	1.814	\$ Interior of cladding
4663	c/z	-13.292074	14.77899	1.865	\$ Exterior of cladding
C					
C Fuel Element F-6					
C					
4671	c/z	-9.9441	17.223232	0.31	\$ Central Zirconium Rod
4672	c/z	-9.9441	17.223232	1.814	\$ Interior of cladding
4673	c/z	-9.9441	17.223232	1.865	\$ Exterior of cladding
C					
C Fuel Element F-7					
C					
4681	c/z	-6.14553	18.915634	0.31	\$ Central Zirconium Rod
4682	c/z	-6.14553	18.915634	1.814	\$ Interior of cladding
4683	c/z	-6.14553	18.915634	1.865	\$ Exterior of cladding
C					
C Fuel Element F-8					
C					
4691	c/z	-2.078228	19.915634	0.31	\$ Central Zirconium Rod
4692	c/z	-2.078228	19.915634	1.814	\$ Interior of cladding
4693	c/z	-2.078228	19.915634	1.865	\$ Exterior of cladding
C					
C Fuel Element F-10					
C					
4711	c/z	6.14553	18.915634	0.31	\$ Central Zirconium Rod
4712	c/z	6.14553	18.915634	1.814	\$ Interior of cladding
4713	c/z	6.14553	18.915634	1.865	\$ Exterior of cladding
C					
C Fuel Element F-11					
C					
4721	c/z	9.9441	17.223232	0.31	\$ Central Zirconium Rod
4722	c/z	9.9441	17.223232	1.814	\$ Interior of cladding
4723	c/z	9.9441	17.223232	1.865	\$ Exterior of cladding
C					
C Fuel Element F-12					
C					
4731	c/z	13.292074	14.77899	0.31	\$ Central Zirconium Rod
4732	c/z	13.292074	14.77899	1.814	\$ Interior of cladding
4733	c/z	13.292074	14.77899	1.865	\$ Exterior of cladding
C					

C	Fuel Element F-13				
C					
4741	c/z	16.08963	11.69035	0.31	\$ Central Zirconium Rod
4742	c/z	16.08963	11.69035	1.814	\$ Interior of cladding
4743	c/z	16.08963	11.69035	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-14				
C					
4751	c/z	18.167858	8.08863	0.31	\$ Central Zirconium Rod
4752	c/z	18.167858	8.08863	1.814	\$ Interior of cladding
4753	c/z	18.167858	8.08863	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-15				
C					
4761	c/z	19.45259	4.134866	0.31	\$ Central Zirconium Rod
4762	c/z	19.45259	4.134866	1.814	\$ Interior of cladding
4763	c/z	19.45259	4.134866	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-16				
C					
4771	c/z	19.8882	0.0	0.31	\$ Central Zirconium Rod
4772	c/z	19.8882	0.0	1.814	\$ Interior of cladding
4773	c/z	19.8882	0.0	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-17				
C					
4781	c/z	19.45259	-4.134866	0.31	\$ Central Zirconium Rod
4782	c/z	19.45259	-4.134866	1.814	\$ Interior of cladding
4783	c/z	19.45259	-4.134866	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-18				
C					
4791	c/z	18.167858	-8.08863	0.31	\$ Central Zirconium Rod
4792	c/z	18.167858	-8.08863	1.814	\$ Interior of cladding
4793	c/z	18.167858	-8.08863	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-19				
C					
4801	c/z	16.08963	-11.69035	0.31	\$ Central Zirconium Rod
4802	c/z	16.08963	-11.69035	1.814	\$ Interior of cladding
4803	c/z	16.08963	-11.69035	1.865	\$ Exterior of cladding
C					
C	Fuel Element F-20				
C					
4811	c/z	13.292074	-14.77899	0.31	\$ Central Zirconium Rod
4812	c/z	13.292074	-14.77899	1.814	\$ Interior of cladding

4813	c/z	13.292074	-14.77899	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-21
C					
4821	c/z	9.9441	-17.223232	0.31	\$ Central Zirconium Rod
4822	c/z	9.9441	-17.223232	1.814	\$ Interior of cladding
4823	c/z	9.9441	-17.223232	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-22
C					
4831	c/z	6.14553	-18.915634	0.31	\$ Central Zirconium Rod
4832	c/z	6.14553	-18.915634	1.814	\$ Interior of cladding
4833	c/z	6.14553	-18.915634	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-23
C					
4841	c/z	2.078228	-19.915634	0.31	\$ Central Zirconium Rod
4842	c/z	2.078228	-19.915634	1.814	\$ Interior of cladding
4843	c/z	2.078228	-19.915634	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-24
C					
4851	c/z	-2.078338	-19.915634	0.31	\$ Central Zirconium Rod
4852	c/z	-2.078338	-19.915634	1.814	\$ Interior of cladding
4853	c/z	-2.078338	-19.915634	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-25
C					
4861	c/z	-6.14553	-18.915634	0.31	\$ Central Zirconium Rod
4862	c/z	-6.14553	-18.915634	1.814	\$ Interior of cladding
4863	c/z	-6.14553	-18.915634	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-26
C					
4871	c/z	-9.9441	-17.223232	0.31	\$ Central Zirconium Rod
4872	c/z	-9.9441	-17.223232	1.814	\$ Interior of cladding
4873	c/z	-9.9441	-17.223232	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-27
C					
4881	c/z	-13.292074	-14.77899	0.31	\$ Central Zirconium Rod
4882	c/z	-13.292074	-14.77899	1.814	\$ Interior of cladding
4883	c/z	-13.292074	-14.77899	1.865	\$ Exterior of cladding
C					
C					Fuel Element F-28
C					

4891	c/z	-16.08963	-11.69035	0.31	\$ Central Zirconium Rod
4892	c/z	-16.08963	-11.69035	1.814	\$ Interior of cladding
4893	c/z	-16.08963	-11.69035	1.865	\$ Exterior of cladding
C					
C Fuel Element F-29					
C					
4901	c/z	-18.167858	-8.08864	0.31	\$ Central Zirconium Rod
4902	c/z	-18.167858	-8.08864	1.814	\$ Interior of cladding
4903	c/z	-18.167858	-8.08864	1.865	\$ Exterior of cladding
C					
C Fuel Element F-30					
C					
4911	c/z	-19.45259	-4.134866	0.31	\$ Central Zirconium Rod
4912	c/z	-19.45259	-4.134866	1.814	\$ Interior of cladding
4913	c/z	-19.45259	-4.134866	1.865	\$ Exterior of cladding
C					
c A Ring					
c					
203	CZ	1.92405			\$ Core position A1
c					
c B Ring					
c					
204	C/Z	-4.05384	0.0	0.79375	\$ Core position B1
205	C/Z	-2.02692	3.510534	0.79375	\$ Core position B2
206	C/Z	2.02692	3.510534	0.79375	\$ Core position B3
207	C/Z	4.05384	0.0	0.79375	\$ Core position B4
208	C/Z	2.02692	-3.510534	0.79375	\$ Core position B5
209	C/Z	-2.02692	-3.510534	0.79375	\$ Core position B6
c					
c C Ring					
c					
210	C/Z	-7.98068	0.0	0.79375	\$ Core position C1
211	C/Z	-6.91134	3.99034	0.79375	\$ Core position C2
213	C/Z	-3.99034	6.91134	0.79375	\$ Core position C3
214	C/Z	0.0	7.98068	0.79375	\$ Core position C4
215	C/Z	3.99034	6.91134	0.79375	\$ Core position C5
216	C/Z	6.91134	3.99034	0.79375	\$ Core position C6
217	C/Z	7.98068	0.0	0.79375	\$ Core position C7
218	C/Z	6.91134	-3.99034	0.79375	\$ Core position C8
219	C/Z	3.99034	-6.91134	0.79375	\$ Core position C9
220	C/Z	0.0	-7.98068	0.79375	\$ Core position C10
221	C/Z	-3.99034	-6.91134	0.79375	\$ Core position C11
222	C/Z	-6.91134	-3.99034	0.79375	\$ Core position C12
c					
c D Ring					
c					

223	C/Z	-11.94562	0.0	1.92405	\$ Core position D1
224	C/Z	-11.22528	4.085336	0.79375	\$ Core position D2
225	C/Z	-9.15035	7.678736	0.79375	\$ Core position D3
226	C/Z	-5.97281	10.344912	0.79375	\$ Core position D4
227	C/Z	-2.073656	11.76401	0.79375	\$ Core position D5
228	C/Z	2.073656	11.76401	0.79375	\$ Core position D6
229	C/Z	5.97281	10.344912	1.92405	\$ Core position D7
230	C/Z	9.15035	7.678674	0.79375	\$ Core position D8
231	C/Z	11.225276	4.085336	0.79375	\$ Core position D9
232	C/Z	11.94562	0.0	0.79375	\$ Core position D10
233	C/Z	11.225276	-4.085336	0.79375	\$ Core position D11
234	C/Z	9.15035	-7.678674	0.79375	\$ Core position D12
235	C/Z	5.97281	-10.344912	1.92405	\$ Core position D13
236	C/Z	2.07366	-11.76401	0.79375	\$ Core position D14
237	C/Z	-2.07366	-11.76401	0.79375	\$ Core position D15
238	C/Z	-5.97281	-10.344912	0.79375	\$ Core position D16
239	C/Z	-9.15035	-7.678674	0.79375	\$ Core position D17
240	C/Z	-11.22528	-4.085336	0.79375	\$ Core position D18

c

c E Ring

c

241	C/Z	-15.91564	0.0	0.79375	\$ Core position E1
242	C/Z	-15.372842	4.118864	0.79375	\$ Core position E2
243	C/Z	-13.782802	7.95782	0.79375	\$ Core position E3
244	C/Z	-11.253978	11.253978	0.79375	\$ Core position E4
245	C/Z	-7.95782	13.782802	0.79375	\$ Core position E5
246	C/Z	-4.118864	15.372842	0.79375	\$ Core position E6
247	C/Z	0.0	15.91564	0.79375	\$ Core position E7
248	C/Z	4.118864	15.372842	0.79375	\$ Core position E8
249	C/Z	7.95782	13.782802	0.79375	\$ Core position E9
250	C/Z	11.25398	11.253978	0.79375	\$ Core position E10
251	C/Z	13.782802	7.95782	0.79375	\$ Core position E11
252	C/Z	15.372842	4.118864	0.79375	\$ Core position E12
253	C/Z	15.91564	0.0	0.79375	\$ Core position E13
254	C/Z	15.372842	-4.118864	0.79375	\$ Core position E14
255	C/Z	13.782802	-7.95782	0.79375	\$ Core position E15
256	C/Z	11.253978	-11.253978	0.79375	\$ Core position E16
257	C/Z	7.95782	-13.782802	0.79375	\$ Core position E17
258	C/Z	4.118864	-15.372842	0.79375	\$ Core position E18
259	C/Z	0.0	-15.91564	0.79375	\$ Core position E19
260	C/Z	-4.118864	-15.372842	0.79375	\$ Core position E20
261	C/Z	-7.95782	-13.782802	0.79375	\$ Core position E21
262	C/Z	-11.25398	-11.25398	0.79375	\$ Core position E22
263	C/Z	-13.78208	-7.95782	0.79375	\$ Core position E23
264	C/Z	-15.372842	-4.118864	0.79375	\$ Core position E24

c

c F Ring

c

265	C/Z	-19.8882	0.0	0.79375	\$ Core position F1
266	C/Z	-19.45259	4.134866	0.79375	\$ Core position F2
267	C/Z	-18.167858	8.08863	0.79375	\$ Core position F3
268	C/Z	-16.08963	11.69035	0.79375	\$ Core position F4
269	C/Z	-13.292074	14.77899	0.79375	\$ Core position F5
270	C/Z	-9.9441	17.223232	0.79375	\$ Core position F6
271	C/Z	-6.14553	18.915634	0.79375	\$ Core position F7
272	C/Z	-2.078228	19.915634	0.79375	\$ Core position F8
273	C/Z	2.078228	19.915634	0.79375	\$ Core position F9
274	C/Z	6.14553	18.915634	0.79375	\$ Core position F10
275	C/Z	9.9441	17.223232	0.79375	\$ Core position F11
276	C/Z	13.292074	14.77899	0.79375	\$ Core position F12
277	C/Z	16.08963	11.69035	0.79375	\$ Core position F13
278	C/Z	18.167858	8.08863	0.79375	\$ Core position F14
279	C/Z	19.45259	4.134866	0.79375	\$ Core position F15
280	C/Z	19.8882	0.0	0.79375	\$ Core position F16
281	C/Z	19.45259	-4.134866	0.79375	\$ Core position F17
282	C/Z	18.167858	-8.08863	0.79375	\$ Core position F18
283	C/Z	16.08963	-11.69035	0.79375	\$ Core position F19
284	C/Z	13.292074	-14.77899	0.79375	\$ Core position F20
285	C/Z	9.9441	-17.223232	0.79375	\$ Core position F21
286	C/Z	6.14553	-18.915634	0.79375	\$ Core position F22
287	C/Z	2.078228	-19.915634	0.79375	\$ Core position F23
288	C/Z	-2.078338	-19.915634	0.79375	\$ Core position F24
289	C/Z	-6.14553	-18.915634	0.79375	\$ Core position F25
290	C/Z	-9.9441	-17.223232	0.79375	\$ Core position F26
291	C/Z	-13.292074	-14.77899	0.79375	\$ Core position F27
292	C/Z	-16.08963	-11.69035	0.79375	\$ Core position F28
293	C/Z	-18.167858	-8.08864	0.79375	\$ Core position F29
294	C/Z	-19.45259	-4.134866	0.79375	\$ Core position F30
1033	pz	-62.865			

c

c Control rods

c

c -----

c Control rod A1

c Dimensions from drawing T3S 250 D 136, converted from inches to cm

c

1001	cz	1.50745	\$ Exterior of B4C section
1002	cz	1.5875	\$ Interior of cladding
1003	cz	1.65862	\$ Exterior of cladding
1004	cz	0.79375	\$ exterior of top extension
1006	pz	-18.923875	\$ bottom of control rod
1008	pz	-18.288875	\$ bottom of A1 follower

1009	pz	59.181125		\$ top of poison section
1010	pz	20.446125		\$ top of Al follower
1011	pz	21.081125		\$ bottom of poison
1012	pz	63.296125		\$ top of cladding
1013	cz	1.75655		\$ interior of CR guide

c

c -----

c Control rod D1

C Dimensions from AFRRR TR94-1, converted from inches to cm

c

1021	c/z	-11.94562	0.0	0.3175	\$ zirconium center rod
1022	c/z	-11.94562	0.0	1.42875	\$ Interior of cladding
1023	c/z	-11.94562	0.0	1.47955	\$ Exterior of cladding
1024	c/z	-11.94562	0.0	0.79375	\$ exterior of top extension
1025	c/z	-11.94562	0.0	1.37668	\$ Fuel follower exterior
1026	pz	-20.511875			\$ bottom of control rod
1027	pz	72.834125			\$ top of upper void
1028	pz	-18.606875			\$ bottom of fuel follower
1029	pz	59.181125			\$ top of poison section/bottom of poison void
1030	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1031	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1032	pz	76.974125			\$ top of cladding
1037	c/z	-11.94562	0.0	1.34874	\$ Poison section exterior
1034	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1035	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1036	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1039	c/z	-11.94562	0.0	1.60655	\$ interior of CR guide

c

c -----

c Control rod D7

C Dimensions from AFRRR TR94-1, converted from inches to cm

c

1041	c/z	5.97281	10.344912	0.3175	\$ zirconium center rod
1042	c/z	5.97281	10.344912	1.42875	\$ Interior of cladding
1043	c/z	5.97281	10.344912	1.47955	\$ Exterior of cladding
1044	c/z	5.97281	10.344912	0.79375	\$ exterior of top extension
1045	c/z	5.97281	10.344912	1.37668	\$ Fuel follower exterior
1046	pz	-20.511875			\$ bottom of control rod
1047	pz	72.834125			\$ top of upper void
1048	pz	-18.606875			\$ bottom of fuel follower
1049	pz	59.181125			\$ top of poison section/bottom of poison void
1050	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1051	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1052	pz	76.974125			\$ top of cladding
1053	c/z	5.97281	10.344912	1.60655	\$ interior of CR guide
1058	c/z	5.97281	10.344912	1.34874	\$ Poison section exterior
1054	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform

1055 pz 59.499125 \$ top of poison gap/bottom of upper Magnaform  
 1056 pz 60.769125 \$ bottom of upper void/top of upper Magnaform  
 1059 c/z 5.97281 10.344912 1.60655 \$ interior of CR guide

c -----

c Control rod D13

C Dimensions from AFRRR TR94-1, converted from inches to cm

c -----

1061 c/z 5.97281 -10.344912 0.3175 \$ zirconium center rod  
 1062 c/z 5.97281 -10.344912 1.42875 \$ Interior of cladding  
 1063 c/z 5.97281 -10.344912 1.47955 \$ Exterior of cladding  
 1064 c/z 5.97281 -10.344912 0.79375 \$ exterior of top extension  
 1065 c/z 5.97281 -10.344912 1.37668 \$ Fuel follower exterior  
 1066 pz -20.511875 \$ bottom of control rod  
 1067 pz 72.834125 \$ top of upper void  
 1068 pz -18.606875 \$ bottom of fuel follower  
 1069 pz 59.181125 \$ top of poison section/bottom of poison void  
 1070 pz 18.541125 \$ top of fuel follower/bottom of fuel void  
 1071 pz 21.081125 \$ bottom of poison/top of lower Magnaform  
 1072 pz 76.974125 \$ top of cladding  
 1073 c/z 5.97281 -10.344912 1.60655 \$ interior of CR guide  
 1074 pz 19.811125 \$ top of fuel gap/bottom of lower Magnaform  
 1075 pz 59.499125 \$ top of poison gap/bottom of upper Magnaform  
 1076 pz 60.769125 \$ bottom of upper void/top of upper Magnaform  
 1078 c/z 5.97281 -10.344912 1.34874 \$ Poison section exterior  
 1079 c/z 5.97281 -10.344912 1.60655 \$ interior of CR guide

c

53 CZ 1.92405 \$ Core position A1  
 73 C/Z -11.94562 0.0 1.92405 \$ Core position D1  
 79 C/Z 5.97281 10.344912 1.92405 \$ Core position D7  
 85 C/Z 5.97281 -10.344912 1.92405 \$ Core position D13

c

c -----

c Core shroud and support structure

c -----

c

1080 cz 24.28875 \$ interior of core shroud  
 1081 cz 24.765 \$ exterior of core shroud  
 1082 cz 44.1325 \$ interior of core support  
 1083 cz 45.72 \$ exterior of core support  
 1088 cz 22.70125 \$ interior of shroud support  
 1084 pz -38.3375 \$ bottom of core shroud  
 1085 pz 40.30625 \$ top of core shroud  
 1087 pz 184.70625 \$ top of shroud support

c -----

c Reactor pool

c Dimensions read manually from drawing T3B200J100

c and converted from inches to centimeters

c -----  
500 pz -73.66 \$ bottom of reactor pool  
501 pz 116.84 \$ Projection shelf  
502 pz 502.92 \$ pool water surface  
503 pz 553.72 \$ reactor room floor  
504 c/z 0.0 89.662 114.3 \$ left tank wing  
505 c/z 0.0 -89.662 114.3 \$ right tank wing  
506 px 114.3 \$ tank edge--ER 2  
507 px -114.3 \$ tank edge--ER 1  
508 c/z 140.97 0.0 26.67 \$ ER 1 penetration  
509 c/z 140.97 0.0 60.96 \$ above ER 1 penetration  
510 c/z -140.97 0.0 26.67 \$ ER 2 penetration  
511 c/z -140.97 0.0 60.96 \$ above ER 2 penetration

c  
c surfaces 512 and 515 are the penetration walls above ER 2

c  
512 p 114.3 67.31 116.84 140.97 60.96 116.84 114.3 67.31 502.92  
515 p 114.3 -67.31 116.84 140.97 -60.96 116.84 114.3 -67.31 502.92

c  
c surfaces 513 and 514 are the penetration walls in ER 2

c  
513 p 114.3 33.02 116.84 140.97 26.67 116.84 114.3 33.02 502.92  
514 p 114.3 -33.02 116.84 140.97 -26.67 116.84 114.3 -33.02 502.92  
516 px 140.97

c  
c surfaces 517 and 518 are the penetration walls in ER 1

c  
517 p -114.3 33.02 116.84 -140.97 26.67 116.84 -114.3 33.02 502.92  
518 p -114.3 -33.02 116.84 -140.97 -26.67 116.84 -114.3 -33.02 502.92  
519 px -140.97  
520 py 89.662  
521 py -89.662

c  
c surfaces 522 and 523 are the penetration walls above ER 1

c  
522 p -114.3 67.31 116.84 -140.97 60.96 116.84 -114.3 67.31 502.92  
523 p -114.3 -67.31 116.84 -140.97 -60.96 116.84 -114.3 -67.31 502.92

c -----  
c Reactor tank lining  
c thicknesses from Safety Analysis Report, dated January 2000  
c bottom and tank shelf thickness .5 inch (1.27 cm)  
c Exposure room protusion thickness .25 inch (0.635 cm)  
c Other tank wall thickness .375 inch (0.9525 cm)

c -----  
550 pz -74.93 \$ bottom of reactor pool

551 pz 115.57 \$ Projection shelf  
552 c/z 0.0 89.662 115.2525 \$ left tank wing  
553 c/z 0.0 -89.662 115.2525 \$ right tank wing  
554 px 115.2525 \$ tank edge--ER 2  
555 px -115.2525 \$ tank edge--ER 1  
556 c/z 140.97 0.0 27.305 \$ ER 1 penetration  
557 c/z 140.97 0.0 61.595 \$ above ER 1 penetration  
558 c/z -140.97 0.0 27.305 \$ ER 2 penetration  
559 c/z -140.97 0.0 61.595 \$ above ER 2 penetration  
c  
c surfaces 562 and 563 are the penetration walls in ER 2  
c  
562 p 114.3 33.665 115.2525 140.97 27.3 115.2525 114.3 33.655 -74.93  
563 p 114.3 -33.665 115.2525 140.97 -27.3 115.2525 114.3 -33.655 -74.93  
c  
c surfaces 564 and 565 are the penetration walls in ER 1  
c  
564 p -114.3 33.665 115.2525 -140.97 27.3 115.2525 -114.3 33.655 -74.93  
565 p -114.3 -33.665 115.2525 -140.97 -27.3 115.2525 -114.3 -33.655 -74.93  
c  
c surfaces 566 and 567 are the penetration walls above ER 2  
c  
566 p 114.3 67.945 116.84 140.97 61.595 116.84 114.3 67.945 502.92  
567 p 114.3 -67.945 116.84 140.97 -61.595 116.84 114.3 -67.945 502.92  
c  
c surfaces 568 and 569 are the penetration walls above ER 1  
c  
568 p -114.3 67.945 116.84 -140.97 61.595 116.84 -114.3 67.945 502.92  
569 p -114.3 -67.945 116.84 -140.97 -61.595 116.84 -114.3 -67.945 502.92  
c  
c -----  
c Exposure room 1  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Exposure room walls  
c -----  
c Surface 555 forms wall of exposure room  
601 px -785.8125 \$ wall furthest from reactor pool  
602 py 335.28 \$ left wall  
603 py -335.28 \$ right wall  
604 pz -153.035 \$ exposure room floor  
605 pz 187.96 \$ exposure room ceiling  
c -----

c Wood lining of exposure room

c -----  
610 px -145.7325 \$ wall nearest reactor pool  
611 px -755.3325 \$ wall furthest from reactor pool  
612 py 304.8 \$ left wall  
613 py -304.8 \$ right wall  
614 pz -122.555 \$ exposure room floor  
615 pz 147.32 \$ exposure room ceiling

c -----  
c masonite lining of exposure room

c -----  
620 px -146.3675 \$ wall nearest reactor pool  
621 px -754.6975 \$ wall furthest from reactor pool  
622 py 304.165 \$ left wall  
623 py -304.165 \$ right wall  
624 pz -121.92 \$ exposure room floor  
625 pz 146.685 \$ exposure room ceiling

c -----  
630 pz 177.8 \$ bottom of ceiling air gap

c -----  
c Exposure room 2

c -----  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters

C -----  
c Exposure room walls

c -----  
c Surface 554 defines exterior wall of exposure room 2  
651 px 541.9725 \$ wall furthest from reactor pool  
652 py 228.6 \$ right wall  
653 py -228.6 \$ left wall  
654 pz -112.395 \$ exposure room floor  
655 pz 193.04 \$ exposure room ceiling

c -----  
c Wood lining of exposure room

c -----  
660 px 145.7325 \$ wall nearest reactor pool  
661 px 511.4925 \$ wall furthest from reactor pool  
662 py 198.12 \$ right wall  
663 py -198.12 \$ left wall  
664 pz -81.915 \$ exposure room floor  
665 pz 162.56 \$ exposure room ceiling

c -----  
c masonite lining of exposure room  
c -----  
670 px 146.3675 \$ wall nearest reactor pool  
671 px 510.8575 \$ wall furthest from reactor pool  
672 py 197.485 \$ right wall  
673 py -197.485 \$ left wall  
674 pz -81.28 \$ exposure room floor  
675 pz 161.925 \$ exposure room ceiling  
c -----  
c Concrete surrounding the reactor pool and exposure rooms  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Dimensions are approximations. Actual region surrounding the reactor  
c varies from floor to floor of the facility and is a combination of  
c concrete and backfilled soil  
c -----  
800 pz -334.01 \$ soil surface  
802 px -831.5325 \$ beyond ER 1  
803 px 836.6125 \$ beyond ER 2  
804 py 599.12 \$ right of ER 1  
805 py -721.04 \$ left of ER 1  
806 py -502.92 \$ right of ER 2  
807 py 350.52 \$ left of ER 2  
850 px 0.0  
c -----  
c Core exposure tube  
c -----  
c Located at Core position E-23  
c -----  
851 C/Z -13.78208 -7.95782 1.814  
c -----  
c Cadmium shielding of reactor tank protrusion in exposure room 1  
c -----  
c  
3001 c/z -140.97 0.0 27.4066  
3002 pz 30.48  
3003 pz -30.48  
C Data cards  
c -----

```

c Burnup cards
c -----
BURN TIME=43
PFRAC=1.0
POWER=1.0
MAT = 401 402 403 404 405 406 407 408 409 410
      411 412 413 414 415 416 417 418 419 420
      421 422 423 424 425 426 428 429 430
      431 432 433 434 435 436 437 438 439 440
      441 442 443 444 445 446 447 448 449 450
      451 452 453 454 455 456 457 458 459
      461 462 463 464 465 466 467 468 469
      471 472 473 474 475 476 477 478 479 480
      481 482 483 484 485 486 487 488 489 490
      491
BOPT = 1 0 1
c -----
C Material cards
c -----
c
C Material 1 is Zirconium
c
m1 40000.60c 0.99994 $ Zr
    72000.60c 0.00006 $ Hf
c
C Material 401 is the UZrH fuel in element B-1
c
m401 1001.60 0.05859804 $ H 0.05859804
      6000.60c 0.00148274 $ O 0.00148274
      40000.60 0.03555136 $ Zr 0.03555136
      92234.61c 0.00000192 $ U-234 0.00000192
      92235.61c 0.00025605 $ U-235 0.00025605
      92236.61c 0.00000283 $ U-236 0.00000283
      92238.61c 0.00100676 $ U-238 0.00100676
      72000.60c 2.1330816e-6 $ Hf 2.1330816e-6
mt401 h/zr.60t zr/h.60t
c
C Material 3 is the Samarium/aluminum burnable poison wafer
c 1% wt of Samarium Oxide, per Volkov, et al, 1960
c
m3 13027.60c 0.99 $ Al
    62147.66c 0.004312 $ Sm-247
    62149.66c 0.004312 $ Sm-149
    8016.60c 0.001376 $ O
c
C Material 4 is the Carbon reflector layer

```

c  
m4 6000.60c 1 \$ C  
mt4 grph.60t  
c  
C Material 5 is the stainless steel 304 cladding  
c  
m5 24050.60 0.000778 \$ Cr-50  
24052.60 0.015003 \$ Cr-52  
24053.60 0.001701 \$ Cr-53  
26056.60 0.05673 \$ Fe-56  
28058.60 0.007939 \$ Ni  
25055.60 0.001697 \$ Mn  
c  
C Material 6 is boron carbide  
c  
m6 5010.60c 0.02095 \$ B-10  
5011.60c 0.08431 \$ B-11  
6000.60c 0.02632 \$ C  
c  
C Material m7 is 6061 aluminum alloy  
c  
m7 13027.60c 0.058693 \$ Al-27  
26056.60c 0.000502 \$ Fe-56  
c  
c Material m8 is water  
c  
m8 1001.60c -0.111894 \$ H  
8016.60c -0.888106 \$ O  
mt8 lwtr.60t  
c  
c Material m9 is air  
c  
m9 6000.60c -0.000124 \$ C  
7014.60c -0.755268 \$ N  
8016.60c -0.231781 \$ O  
18000.35d -0.012827 \$ Ar  
c  
c Material m419 is the fuel in the fuel follower control rods  
c  
m419 1001.60 0.05777811 \$ H  
6000.60c 0.00152383 \$ C  
40000.60 0.03511576 \$ Sm  
92234.61c 0.00000198 \$ U-234  
92235.61c 0.00037003 \$ U-235  
92236.61c 0.00000290 \$ U-236  
92238.61c 0.00147347 \$ U-238

72000.60c 2.1069456e-6 \$ Hf  
 mt419 h/zr.60t  
 zr/h.60t  
 c  
 c Material m425 is the fuel in the fuel follower control rods  
 c  
 m425 1001.60 0.05777811 \$ H  
 6000.60c 0.00152383 \$ C  
 40000.60 0.03511576 \$ Sm  
 92234.61c 0.00000198 \$ U-234  
 92235.61c 0.00037003 \$ U-235  
 92236.61c 0.00000290 \$ U-236  
 92238.61c 0.00147347 \$ U-238  
 72000.60c 2.1069456e-6 \$ Hf  
 mt425 h/zr.60t  
 zr/h.60t  
 c  
 c Material m432 is the fuel in the fuel follower control rods  
 c  
 m432 1001.60 0.05777811 \$ H  
 6000.60c 0.00152383 \$ C  
 40000.60 0.03511576 \$ Sm  
 92234.61c 0.00000198 \$ U-234  
 92235.61c 0.00037003 \$ U-235  
 92236.61c 0.00000290 \$ U-236  
 92238.61c 0.00147347 \$ U-238  
 72000.60c 2.1069456e-6 \$ Hf  
 mt432 h/zr.60t  
 zr/h.60t  
 c  
 c Material m11 is wood (pine)  
 c  
 m11 1001.60c 0.476191 \$ H  
 6000.60c 0.285714 \$ C  
 8016.60c 0.238095 \$ O-16  
 c  
 c Material m12 is masonite/gadolinium  
 c  
 m12 1001.60c 0.47144526 \$ H  
 6000.60c 0.28284630 \$ C  
 8016.60c 0.23570844 \$ O-16  
 64000 0.01 \$ Gd  
 c  
 c material 13 is ORNL composition concrete  
 c  
 m13 1001.60c 0.00453 \$ H-1

8016.60c	0.5126	\$ O-16
11023.62c	0.01527	\$ Na-23
13027.60c	0.03555	\$ Al-27
14000.60c	0.36036	\$ Si
20000.60c	0.05791	\$ Ca
26000.50c	0.01378	\$ Fe

c

c material 15 is the cadmium shielding in exposure room 1  
c gadolinium paint on interior of shield is approximated by  
c including 0.2% by weight of gadolinium

c

m15	48000	-99.8	\$ Cd
	64000	-0.2	\$ Gd

c

C Material 402 is the UZrH fuel in element B-2

c

m402	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt402 h/zr.60t zr/h.60t

c

C Material 403 is the UZrH fuel in element B-3

c

m403	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt403 h/zr.60t zr/h.60t

c

C Material 404 is the UZrH fuel in element B-4

c

m404	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283

92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt404 h/zr.60t zr/h.60t

c

C Material 405 is the UZrH fuel in element B-5

c

m405 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt405 h/zr.60t zr/h.60t

c

C Material 406 is the UZrH fuel in element B-6

c

m406 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt406 h/zr.60t zr/h.60t

c

C Material 407 is the UZrH fuel in element C-1

c

m407 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt407 h/zr.60t zr/h.60t

c

C Material 408 is the UZrH fuel in element C-2

c

m408 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192

92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt408 h/zr.60t zr/h.60t

c

C Material 409 is the UZrH fuel in element C-3

c

m409 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt409 h/zr.60t zr/h.60t

c

C Material 410 is the UZrH fuel in element C-4

c

m410 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt410 h/zr.60t zr/h.60t

c

C Material 411 is the UZrH fuel in element C-5

c

m411 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt411 h/zr.60t zr/h.60t

c

C Material 412 is the UZrH fuel in element C-6

c

m412 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274

40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt412 h/zr.60t zr/h.60t

c

C Material 413 is the UZrH fuel in element C-7

c

m413 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt413 h/zr.60t zr/h.60t

c

C Material 414 is the UZrH fuel in element C-8

c

m414 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt414 h/zr.60t zr/h.60t

c

C Material 415 is the UZrH fuel in element C-9

c

m415 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt415 h/zr.60t zr/h.60t

c

C Material 416 is the UZrH fuel in element C-10

c

m416 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt416 h/zr.60t zr/h.60t

c

C Material 417 is the UZrH fuel in element C-11

c

m417 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt417 h/zr.60t zr/h.60t

c

C Material 418 is the UZrH fuel in element C-12

c

m418 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt418 h/zr.60t zr/h.60t

c

C Material 420 is the UZrH fuel in element D-2

c

m420 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt420 h/zr.60t zr/h.60t

c

C Material 421 is the UZrH fuel in element D-3

c

m421	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt421 h/zr.60t zr/h.60t

c

C Material 422 is the UZrH fuel in element D-4

c

m422	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt422 h/zr.60t zr/h.60t

c

C Material 423 is the UZrH fuel in element D-5

c

m423	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt423 h/zr.60t zr/h.60t

c

C Material 424 is the UZrH fuel in element D-6

c

m424	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt424 h/zr.60t zr/h.60t

c

C Material 426 is the UZrH fuel in element D-8

c

m426	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt426 h/zr.60t zr/h.60t

c

C Material 428 is the UZrH fuel in element D-9

c

m428	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt428 h/zr.60t zr/h.60t

c

C Material 429 is the UZrH fuel in element D-10

c

m429	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt429 h/zr.60t zr/h.60t

c

C Material 420 is the UZrH fuel in element D-11

c

m430	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	

92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt430 h/zr.60t zr/h.60t

c

C Material 431 is the UZrH fuel in element D-12

c

m431 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt431 h/zr.60t zr/h.60t

c

C Material 433 is the UZrH fuel in element D-14

c

m433 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt433 h/zr.60t zr/h.60t

c

C Material 434 is the UZrH fuel in element D-15

c

m434 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt434 h/zr.60t zr/h.60t

c

C Material 435 is the UZrH fuel in element D-16

c

m435 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192

92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt435 h/zr.60t zr/h.60t

c

C Material 436 is the UZrH fuel in element D-17

c

m436 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt436 h/zr.60t zr/h.60t

c

C Material 437 is the UZrH fuel in element D-18

c

m437 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt437 h/zr.60t zr/h.60t

c

C Material 438 is the UZrH fuel in element E-1

c

m438 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt438 h/zr.60t zr/h.60t

c

C Material 439 is the UZrH fuel in element E-2

c

m439 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274

40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt439 h/zr.60t zr/h.60t

c

C Material 440 is the UZrH fuel in element E-3

c

m440 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt440 h/zr.60t zr/h.60t

c

C Material 441 is the UZrH fuel in element E-4

c

m441 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt441 h/zr.60t zr/h.60t

c

C Material 442 is the UZrH fuel in element E-5

c

m442 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt442 h/zr.60t zr/h.60t

c

C Material 443 is the UZrH fuel in element E-6

c

m443 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt443 h/zr.60t zr/h.60t

c

C Material 444 is the UZrH fuel in element E-7

c

m444 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt444 h/zr.60t zr/h.60t

c

C Material 445 is the UZrH fuel in element E-8

c

m445 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt445 h/zr.60t zr/h.60t

c

C Material 446 is the UZrH fuel in element E-9

c

m446 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt446 h/zr.60t zr/h.60t

c

C Material 447 is the UZrH fuel in element E-10

c

m447	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt447 h/zr.60t zr/h.60t

c

C Material 448 is the UZrH fuel in element E-11

c

m448	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt448 h/zr.60t zr/h.60t

c

C Material 449 is the UZrH fuel in element E-12

c

m449	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt449 h/zr.60t zr/h.60t

c

C Material 450 is the UZrH fuel in element E-13

c

m450	1001.60	0.05859804	\$ H	0.05859804
	6000.60c	0.00148274	\$ O	0.00148274
	40000.60	0.03555136	\$ Zr	0.03555136
	92234.61c	0.00000192	\$ U-234	0.00000192
	92235.61c	0.00025605	\$ U-235	0.00025605
	92236.61c	0.00000283	\$ U-236	0.00000283
	92238.61c	0.00100676	\$ U-238	0.00100676
	72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6

mt450 h/zr.60t zr/h.60t

c

C Material 451 is the UZrH fuel in element E-14

c

m451	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt451 h/zr.60t zr/h.60t

c

C Material 452 is the UZrH fuel in element E-15

c

m452	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt452 h/zr.60t zr/h.60t

c

C Material 453 is the UZrH fuel in element E-16

c

m453	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt453 h/zr.60t zr/h.60t

c

C Material 454 is the UZrH fuel in element E-17

c

m454	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	

92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt454 h/zr.60t zr/h.60t

c

C Material 455 is the UZrH fuel in element E-18

c

m455 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt455 h/zr.60t zr/h.60t

c

C Material 456 is the UZrH fuel in element E-19

c

m456 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt456 h/zr.60t zr/h.60t

c

C Material 457 is the UZrH fuel in element E-20

c

m457 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt457 h/zr.60t zr/h.60t

c

C Material 458 is the UZrH fuel in element E-21

c

m458 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192

92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt458 h/zr.60t zr/h.60t

c

C Material 459 is the UZrH fuel in element E-22

c

m459 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt459 h/zr.60t zr/h.60t

c

C Material 461 is the UZrH fuel in element E-24

c

m461 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt461 h/zr.60t zr/h.60t

c

C Material 462 is the UZrH fuel in element F-1

c

m462 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt462 h/zr.60t zr/h.60t

c

C Material 463 is the UZrH fuel in element F-2

c

m463 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274

40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt463 h/zr.60t zr/h.60t

c

C Material 464 is the UZrH fuel in element F-3

c

m464 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt464 h/zr.60t zr/h.60t

c

C Material 465 is the UZrH fuel in element F-4

c

m465 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt465 h/zr.60t zr/h.60t

c

C Material 466 is the UZrH fuel in element F-5

c

m466 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt466 h/zr.60t zr/h.60t

c

C Material 467 is the UZrH fuel in element F-6

c

m467 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt467 h/zr.60t zr/h.60t

c

C Material 468 is the UZrH fuel in element F-7

c

m468 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt468 h/zr.60t zr/h.60t

c

C Material 469 is the UZrH fuel in element F-8

c

m469 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt469 h/zr.60t zr/h.60t

c

C Material 471 is the UZrH fuel in element F-10

c

m471 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt471 h/zr.60t zr/h.60t

c

C Material 472 is the UZrH fuel in element F-11

c

m472 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt472 h/zr.60t zr/h.60t

c

C Material 473 is the UZrH fuel in element F-12

c

m473 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt473 h/zr.60t zr/h.60t

c

C Material 474 is the UZrH fuel in element F-13

c

m474 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt474 h/zr.60t zr/h.60t

c

C Material 475 is the UZrH fuel in element F-14

c

m475 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt475 h/zr.60t zr/h.60t

c

C Material 476 is the UZrH fuel in element F-15

c

m476	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt476 h/zr.60t zr/h.60t

c

C Material 477 is the UZrH fuel in element F-16

c

m477	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt477 h/zr.60t zr/h.60t

c

C Material 478 is the UZrH fuel in element F-17

c

m478	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	
92238.61c	0.00100676	\$ U-238	0.00100676	
72000.60c	2.1330816e-6	\$ Hf	2.1330816e-6	

mt478 h/zr.60t zr/h.60t

c

C Material 479 is the UZrH fuel in element F-18

c

m479	1001.60	0.05859804	\$ H	0.05859804
6000.60c	0.00148274	\$ O	0.00148274	
40000.60	0.03555136	\$ Zr	0.03555136	
92234.61c	0.00000192	\$ U-234	0.00000192	
92235.61c	0.00025605	\$ U-235	0.00025605	
92236.61c	0.00000283	\$ U-236	0.00000283	

92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt479 h/zr.60t zr/h.60t

c

C Material 480 is the UZrH fuel in element F-19

c

m480 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt480 h/zr.60t zr/h.60t

c

C Material 481 is the UZrH fuel in element F-20

c

m481 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt481 h/zr.60t zr/h.60t

c

C Material 482 is the UZrH fuel in element F-21

c

m482 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt482 h/zr.60t zr/h.60t

c

C Material 483 is the UZrH fuel in element F-22

c

m483 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192

92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt483 h/zr.60t zr/h.60t

c

C Material 484 is the UZrH fuel in element F-23

c

m484 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt484 h/zr.60t zr/h.60t

c

C Material 485 is the UZrH fuel in element F-24

c

m485 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt485 h/zr.60t zr/h.60t

c

C Material 486 is the UZrH fuel in element F-25

c

m486 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6  
mt486 h/zr.60t zr/h.60t

c

C Material 487 is the UZrH fuel in element F-26

c

m487 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274

40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt487 h/zr.60t zr/h.60t

c

C Material 488 is the UZrH fuel in element F-27

c

m488 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt488 h/zr.60t zr/h.60t

c

C Material 489 is the UZrH fuel in element F-28

c

m489 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt489 h/zr.60t zr/h.60t

c

C Material 490 is the UZrH fuel in element F-29

c

m490 1001.60 0.05859804 \$ H 0.05859804  
6000.60c 0.00148274 \$ O 0.00148274  
40000.60 0.03555136 \$ Zr 0.03555136  
92234.61c 0.00000192 \$ U-234 0.00000192  
92235.61c 0.00025605 \$ U-235 0.00025605  
92236.61c 0.00000283 \$ U-236 0.00000283  
92238.61c 0.00100676 \$ U-238 0.00100676  
72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt490 h/zr.60t zr/h.60t

c

C Material 491 is the UZrH fuel in element F-30

c

m491 1001.60 0.05859804 \$ H 0.05859804  
 6000.60c 0.00148274 \$ O 0.00148274  
 40000.60 0.03555136 \$ Zr 0.03555136  
 92234.61c 0.00000192 \$ U-234 0.00000192  
 92235.61c 0.00025605 \$ U-235 0.00025605  
 92236.61c 0.00000283 \$ U-236 0.00000283  
 92238.61c 0.00100676 \$ U-238 0.00100676  
 72000.60c 2.1330816e-6 \$ Hf 2.1330816e-6

mt491 h/zr.60t zr/h.60t

c  
 c -----  
 C Criticality control cards  
 c -----  
 c

Kcode 10000 1.0 50 500

c -----  
 c No source in A-1, E-23, or F-9  
 c sources in D-1, D-7, and D-13 offset to ensure they remain in active  
 c fuel region regardless of Control Rod position (below 37 cm inserted)  
 c -----

Ksrc	-3.23559	0.0	0.0	-1.20867	3.510534	0.0
	2.84517	3.510534	0.0	4.87209	0.0	0.0
	2.84517	-3.510534	0.0	-1.20867	-3.510534	0.0
	-7.16243	0.0	0.0	-6.09309	3.99034	0.0
	-3.17209	6.91134	0.0	0.81825	7.98068	0.0
	4.80859	6.91134	0.0	7.72959	3.99034	0.0
	8.79893	0.0	0.0	7.72959	-3.99034	0.0
	4.80859	-6.91134	0.0	0.81825	-7.98068	0.0
	-3.17209	-6.91134	0.0	-6.09309	-3.99034	0.0
	-10.40703	4.085336	0.0	-8.3321	7.678736	0.0
	-5.15456	10.344912	0.0	-1.255406	11.76401	0.0
	2.891906	11.76401	0.0	9.9686	7.678674	0.0
	12.043526	4.085336	0.0	12.76387	0.0	0.0
	12.043526	-4.085336	0.0	9.9686	-7.678674	0.0
	2.89191	-11.76401	0.0	-1.25541	-11.76401	0.0
	-5.15456	-10.344912	0.0	-8.3321	-7.678674	0.0
	-10.40703	-4.085336	0.0	-15.09739	0.0	0.0
	-14.554592	4.118864	0.0	-12.964552	7.95782	0.0
	-10.435728	11.253978	0.0	-7.13957	13.782802	0.0
	-3.300614	15.372842	0.0	0.81825	15.91564	0.0
	4.937114	15.372842	0.0	8.77607	13.782802	0.0
	12.07223	11.253978	0.0	14.601052	7.95782	0.0
	16.191092	4.118864	0.0	16.73389	0.0	0.0
	15.191092	-4.118864	0.0	14.600332	-7.95782	0.0
	12.072228	-11.253978	0.0	8.77607	-13.782802	0.0
	4.937114	-15.372842	0.0	0.81825	-15.91564	0.0

-3.300614 -15.372842 0.0 -7.13957 -13.782802 0.0  
 -10.43573 -11.25398 0.0 -14.554592 -4.118864 0.0  
 -19.06995 0.0 0.0 -18.63434 4.134866 0.0  
 -17.349608 8.08863 0.0 -15.27138 11.69035 0.0  
 -12.473824 14.77899 0.0 -9.12585 17.223232 0.0  
 -5.32728 18.915634 0.0 -1.259978 19.915634 0.0  
 6.96378 18.915634 0.0 10.76235 17.223232 0.0  
 14.110324 14.77899 0.0 16.90788 11.69035 0.0  
 18.986108 8.08863 0.0 20.27084 4.134866 0.0  
 20.70645 0.0 0.0 20.27084 -4.134866 0.0  
 18.986108 -8.08863 0.0 16.090788 -11.69035 0.0  
 14.110324 -14.77899 0.0 10.76235 -17.223232 0.0  
 6.96378 -18.915634 0.0 2.896478 -19.915634 0.0  
 -21.259978 -19.915634 0.0 -5.32728 -18.915634 0.0  
 -9.12585 -17.223232 0.0 -12.473824 -14.77899 0.0  
 -15.27138 -11.69035 0.0 -17.349608 -8.08864 0.0  
 -18.63434 -4.134866 0.0  
 -11.12737 0.0 -17.0 6.79106 10.344912 -17.0  
 6.79106 -10.344912 -17.0

mode n

F14:n 4012  
 F24:n 4022  
 F34:n 4032  
 F44:n 4042  
 F54:n 4052  
 F64:n 4062  
 F74:n 4072  
 F84:n 4082  
 F94:n 4092  
 F104:n 4102  
 F114:n 4112  
 F124:n 4122  
 F134:n 4132  
 F144:n 4142  
 F154:n 4152  
 F164:n 4162  
 F174:n 4172  
 F184:n 4182  
 F194:n 1121  
 F204:n 4202  
 F214:n 4212  
 F224:n 4222  
 F234:n 4232  
 F244:n 4242  
 F254:n 1131  
 F264:n 4262

F284:n 4282  
F294:n 4292  
F304:n 4302  
F314:n 4312  
F324:n 1141  
F334:n 4332  
F344:n 4342  
F354:n 4352  
F364:n 4362  
F374:n 4372  
F384:n 4382  
F394:n 4392  
F404:n 4402  
F414:n 4412  
F424:n 4422  
F434:n 4432  
F444:n 4442  
F454:n 4452  
F464:n 4462  
F474:n 4472  
F484:n 4482  
F494:n 4492  
F504:n 4502  
F514:n 4512  
F524:n 4522  
F534:n 4532  
F544:n 4542  
F554:n 4552  
F564:n 4562  
F574:n 4572  
F584:n 4582  
F594:n 4592  
F614:n 4612  
F624:n 4622  
F634:n 4632  
F644:n 4642  
F654:n 4652  
F664:n 4662  
F674:n 4672  
F684:n 4682  
F694:n 4692  
F714:n 4712  
F724:n 4722  
F734:n 4732  
F744:n 4742  
F754:n 4752

F764:n 4762  
F774:n 4772  
F784:n 4782  
F794:n 4792  
F804:n 4802  
F814:n 4812  
F824:n 4822  
F834:n 4832  
F844:n 4842  
F854:n 4852  
F864:n 4862  
F874:n 4872  
F884:n 4882  
F894:n 4892  
F904:n 4902  
F914:n 4912  
print

e14 1e-12 120i 2.5 \$ energy bins  
e24 1e-10 120i 2.5 \$ energy bins  
e34 1e-12 120i 2.5 \$ energy bins  
e44 1e-10 120i 2.5 \$ energy bins  
e54 1e-10 120i 2.5 \$ energy bins  
e64 1e-10 120i 2.5 \$ energy bins  
e74 1e-10 120i 2.5 \$ energy bins  
e84 1e-10 120i 2.5 \$ energy bins  
e94 1e-10 120i 2.5 \$ energy bins  
e104 1e-10 120i 2.5 \$ energy bins  
e114 1e-10 120i 2.5 \$ energy bins  
e124 1e-10 120i 2.5 \$ energy bins  
e134 1e-10 120i 2.5 \$ energy bins  
e144 1e-10 120i 2.5 \$ energy bins  
e154 1e-10 120i 2.5 \$ energy bins  
e164 1e-10 120i 2.5 \$ energy bins  
e174 1e-10 120i 2.5 \$ energy bins  
e184 1e-10 120i 2.5 \$ energy bins  
e194 1e-10 120i 2.5 \$ energy bins  
e204 1e-10 120i 2.5 \$ energy bins  
print

## Appendix 3—Core Position 750 with Phantoms

Presented below is the MCNP source file for the AFRRRI TRIGA reactor in core

position 750, modified to include phantoms for dose calculations in exposure room 2.

```
c AFRRRI TRIGA Mark-F Reactor and supporting exposure facilities
c Core position 750
C Cell cards
c -----
c Control rod A1
c -----
C cell 1110 is the air gap surrounding the B4C poison section
1110 9 -0.001205 1001 -1002 1011 -1009 imp:n,p=1
C cell 1111 is the air follower
1111 9 -0.001205 -1002 1008 -1010 imp:n,p=1
c cell 1112 is a stainless steel spacer between the poison section
c and the air follower
1112 5 -7.92 1010 -1011 -1002 imp:n,p=1
C cell 1113 is the B4C poison section
1113 6 0.135714 -1001 1011 -1009 imp:n,p=1
C cell 1115 is the cladding
1115 5 -7.92 (1002:-1008: 1009) (-1003 1006 -1012):
(-1004 -503 1012) imp:n,p=1
c -----
c Control rod D1
c -----
C cell 1120 is the zirconium center rod of the fuel follower section
1120 1 -6.51 -1021 1028 -1030 imp:n,p=1
C cell 1121 is the fuel follower section
1121 10 0.09626819 1021 -1025 1028 -1030 imp:n,p=1
C cell 1122 is the lower Magnaform
1122 5 -7.92 -1022 1034 -1031 imp:n,p=1
C cell 1123 is the B4C poison section
1123 6 0.135714 -1037 1031 -1029 imp:n,p=1
C cell 1124 is the void at the top of the fuel element
1124 9 -0.001205 -1022 1036 -1027 imp:n,p=1
C cell 1125 is the cladding
1125 5 -7.92 (1022:-1028: 1027)
(-1023 1026 -1032):
(-1024 -503 1032)
imp:n,p=1
c cell 1126 is the fuel follower gap
1126 9 -0.001205 1025 -1022 1028 -1030 imp:n,p=1
c cell 1127 is the fuel follower/clad void
1127 9 -0.001205 1030 -1034 -1022 imp:n,p=1
```

c cell 1128 is the poison section/clad gap  
1128 9 -0.001205 1031 -1029 1037 -1022 imp:n,p=1  
c cell 1129 is the poison section void  
1129 9 -0.001205 1029 -1035 -1022 imp:n,p=1  
c cell 1152 is the upper Magnaform  
1152 5 -7.92 1035 -1036 -1022 imp:n,p=1  
c -----  
c Control rod D7  
c -----  
C cell 1130 is the zirconium center rod of the fuel follower section  
1130 1 -6.51 -1041 1048 -1050 imp:n,p=1  
C cell 1131 is the fuel follower section  
1131 10 0.09626819 1041 -1045 1048 -1050 imp:n,p=1  
C cell 1132 is the lower Magnaform  
1132 5 -7.92 -1042 1054 -1051 imp:n,p=1  
C cell 1133 is the B4C poison section  
1133 6 0.135714 -1058 1051 -1049 imp:n,p=1  
C cell 1134 is the void at the top of the fuel element  
1134 9 -0.001205 -1042 1056 -1047 imp:n,p=1  
C cell 1135 is the cladding  
1135 5 -7.92 (1042:-1048: 1047)  
(-1043 1046 -1052):  
(-1044 -503 1052)  
imp:n,p=1  
c cell 1136 is the fuel follower gap  
1136 9 -0.001205 1045 -1042 1048 -1050 imp:n,p=1  
c cell 1137 is the fuel follower/clad void  
1137 9 -0.001205 1050 -1054 -1042 imp:n,p=1  
c cell 1138 is the poison section/clad gap  
1138 9 -0.001205 1051 -1049 1058 -1042 imp:n,p=1  
c cell 1139 is the poison section void  
1139 9 -0.001205 1049 -1055 -1042 imp:n,p=1  
c cell 1153 is the upper Magnaform  
1153 5 -7.92 1055 -1056 -1042 imp:n,p=1  
c -----  
c Control rod D13  
c -----  
C cell 1140 is the zirconium center rod of the fuel follower section  
1140 1 -6.51 -1061 1068 -1070 imp:n,p=1  
C cell 1141 is the fuel follower section  
1141 10 0.09626819 1061 -1065 1068 -1070 imp:n,p=1  
C cell 1142 is the lower Magnaform  
1142 5 -7.92 -1062 1074 -1071 imp:n,p=1  
C cell 1143 is the B4C poison section  
1143 6 0.135714 -1078 1071 -1069 imp:n,p=1  
C cell 1144 is the void at the top of the fuel element

```

1144 9 -0.001205 -1062 1076 -1067          imp:n,p=1
C   cell 1145 is the cladding
1145 5 -7.92 (1062:-1068: 1067)
      (-1063 1066 -1072):
      (-1064 -503 1072)
                                     imp:n,p=1
c   cell 1146 is the fuel follower gap
1146 9 -0.001205 1065 -1062 1068 -1070      imp:n,p=1
c   cell 1147 is the fuel follower/clad void
1147 9 -0.001205 1070 -1074 -1062          imp:n,p=1
c   cell 1148 is the poison section/clad gap
1148 9 -0.001205 1071 -1069 1078 -1062      imp:n,p=1
c   cell 1149 is the poison section void
1149 9 -0.001205 1069 -1075 -1062          imp:n,p=1
c   cell 1143 is the upper Magnaform
1150 5 -7.92 1075 -1076 -1062              imp:n,p=1
C   -----
C   Cells 501 thru 508 define a fuel element to fill cell 401's universe
c   -----
C
C   Cell 501 is the central Zirconium rod
501 1 -6.51 -1 -4 5                          u=1 imp:n,p=1
C   Cell 502 is the fuel area of the fuel rod
502 2 0.09690183 1 -2 -4 5                  u=1 imp:n,p=1
C   Cell 503 is the upper Samarium/aluminum poison disk
503 3 -5.27 4 -6 -2                          u=1 imp:n,p=1
C   Cell 504 is the lower Samarium/aluminum poison disk
504 3 -5.27 -5 7 -2                          u=1 imp:n,p=1
C   Cell 505 is the upper Carbon reflector
505 4 -1.75 -8 6 -2                          u=1 imp:n,p=1
C   Cell 506 is the lower Carbon Reflector
506 4 -1.75 -7 9 -2                          u=1 imp:n,p=1
C   Cell 507 is the Stainless Steel cladding of the fuel element
C   and support structure
507 5 -7.92 2:15:-9                          u=1 imp:n,p=1
C   Cell 508 is the void at the top of the fuel element
508 9 -0.001205 -2 -15 8                    u=1 imp:n,p=1
C   Cell 401 creates a universe for the fuel element to be replicated later
401 0 (-3 -10 11)                            fill=1 imp:n,p=1
c
C   -----
c   Cell 202 is the lower grid plate
c   -----
202 7 0.059195
    -200 201 -202 203 204 205 206 207 208 209
    210 211 213 214 215 216 217 218 219

```

220 221 222 223 224 225 226 227 228 229  
230 231 232 233 234 235 236 237 238 239  
240 241 242 243 244 245 246 247 248 249  
250 251 252 253 254 255 256 257 258 259  
260 261 262 263 264 265 266 267 268 269  
270 271 272 273 274 275 276 277 278 279  
280 281 282 283 284 285 286 287 288 289  
290 291 292 293 294

imp:n,p=1

C -----

c Cell 301 is the lower plenum region

c -----

301 8 -1.0

-11 200 -202 203 204 205 206 207 208 209  
210 211 213 214 215 216 217 218 219  
220 221 222 223 224 225 226 227 228 229  
230 231 232 233 234 235 236 237 238 239  
240 241 242 243 244 245 246 247 248 249  
250 251 252 253 254 255 256 257 258 259  
260 261 262 263 264 265 266 267 268 269  
270 271 272 274 275 276 277 278 279  
280 281 282 283 284 285 286 287 288 289  
290 291 292 293 294

imp:n,p=1

C -----

c Cell 300 is the reactor pool inside the support structure

c -----

300 8 -1.0 ((11: -201: 202:-203:-223:-229:-235)

(10: -11: -203:-223:-229:-235: 152)

(13: -51: 52: -53: -73: -79: -85)

223 229 203 235 (113 201)

(-1080 1084 -1085):

(-1088 -1087 1085 203 223 229 235 (113 201))):

(-201 203 223 229 235 1084 -1080)

imp:n,p=1

c -----

C -----

c core shroud and support structure

c -----

c -----

c cell 350 is the core shroud

350 7 0.059195 1080 -1081 1084 -1085 imp:n,p=1

c cell 351 is the core support

351 7 0.059195 1082 -1083 1087 -503 imp:n,p=1

c cell 353 is the shroud support extension

353 7 0.059195 1088 -1081 1085 -1087 imp:n,p=1

c Cell 352 is the reactor pool  
352 8 -1.0 (((500 -502 1083 (-504:-505)):  
(-506 507 -520 521 500 -502):  
(500 -501 -508):  
(500 -501 -510):  
(501 -502 -509):  
(501 -502 -511):  
(501 -502 -516 506 -512 -515):  
(501 -502 519 -507 -522 -523):  
(500 -501 -516 506 -513 -514):  
(500 -501 519 -507 -517 -518)))  
(((-502 1083 1087):  
(-1087 1084 1081)):  
(-1084 1033 203 235 223 229):  
(-1033 500))  
imp:n,p=1  
c Cell 354 is the air in the tank above the water level  
354 9 -0.001205 ((502 -503 (-504:-505)):  
(-506 507 -520 521 502 -503):  
(502 -503 -516 506 -512 -515):  
(502 -503 519 -507 -522 -523):  
(502 -503 -519 -511):  
(502 -503 516 -509)) 1083  
imp:n,p=1  
c Cell 355 is the reactor tank lining  
355 7 0.059195 (-500 550 (-552: -553)):  
(-554 555 -520 521 550 -500):  
(550 -500 -556 516):  
(550 -500 -558 -519):  
(550 -500 -516 554 -562 -563):  
(550 -500 519 -507 -564 -565):  
551 -501 ((516 508 -557):  
(513 506 -516 -566):  
(514 506 -516 -567)):  
551 -501((-519 510 -559):  
(517 -507 519 -568):  
(518 -507 519 -569)):  
(500 -503)((505 -553 -521):  
(504 -552 520)):  
500 -551 ((513 506 -554 -520):  
(514 506 -554 521):  
(517 -507 555 -520):  
(518 -507 555 521):  
((516 508 -556):  
(506 -516 513 -562):  
(506 -516 514 -563)):

```

((-519 510 -558):
(-507 519 517 -564):
(-507 519 518 -565)))
(501 -503(((512 506 -554 -520):
(515 506 -554 521)):
(-520 568 -507 555):
(521 569 -507 555):
((516 509 -557):
(506 -516 512 -566):
(506 -516 515 -567))):
((-519 511 -559):
(-507 519 522 -568):
(-507 519 523 -569))))):
(506 -554 -501 551 -520 566):
(506 -554 -501 551 567 521):
(-501 551 555 -507 -520 568):
(-501 551 555 -507 521 569)

```

imp:n,p=4

c Cell 356 is the air inside the top of the core support structure

356 9 -0.001205 502 -503 -1082

223

229

235

203

imp:n,p=1

c Cell 357 is the water inside the core support

357 8 -1.0 -1082 1087 -502

223

229

235

203

imp:n,p=1

c

c -----

c control rod support structure

c -----

c

c cell 304 holds control rod A1

304 8 -1.0 (-1006:1003:

(1012 1004))

(-1013 1033 -502) imp:n,p=1

c cell 305 holds control rod D1

305 8 -1.0 (-1026:1023:

(1032 1024))

(-1039 1033 -502) imp:n,p=1

c cell 306 holds control rod D7

306 8 -1.0 (-1046:1043:  
(1052 1044))  
(-1053 1033 -502) imp:n,p=1  
c cell 307 holds control rod D13

307 8 -1.0 (-1066:1063:  
(1072 1064))  
(-1073 1033 -502) imp:n,p=1  
c Cell 150 is the water filled region in rings B thru D

150 8 -1.0 (-10 11 203 223 229 235 -150)  
( 3: 10: -11)  
402003 403003 404003 405003 406003 407003 408003 409003 410003  
411003 412003 413003 414003 415003 416003 417003 418003 420003  
421003 422003 423003 424003 426003 428003 429003 430003 431003  
433003 434003 435003 436003 437003  
imp:n,p=1  
c Cell 151 is a water filled torus in ring E

151 8 -1.0 -10 11 150 -151  
438003 439003 440003 441003 442003 443003 444003 445003 446003  
447003 448003 449003 450003 451003 452003 453003 454003 455003  
456003 457003 458003 459003 461003 113  
imp:n,p=1  
c Cell 152 is a water filled torus in ring F

152 8 -1.0 -10 11 151 -152  
462003 463003 464003 465003 466003 467003 468003 469003  
471003 472003 473003 474003 475003 476003 477003 478003 479003  
480003 481003 482003 483003 484003 485003 486003 487003 488003  
489003 490003 491003  
imp:n,p=1  
c  
c -----  
c Cell 900 is the concrete surrounding the reactor  
c -----  
900 13 -2.25 ((-503 800 802 -850 -804 805):  
(-503 800 850 -803 806 -807))  
(503: -550: (564 519 -555 -551):  
(565 519 -555 -551):  
(554 -516 563 -551):  
(554 -516 562 -551):  
(556 516 -551):  
(558 -551 -519):  
(552 520):  
(553 -521):  
(551 519 568 -555):  
(551 519 569 -555):  
(-519 559 551):  
(551 554 566 -516):

(551 554 567 -516):  
 (516 551 557))  
 ((555: -601: 602: -603: -604: 605):  
 (555 519 -564 -565 -551):  
 (-519 -558 -551):  
 (-519 -559 551):  
 (-555 519 -568 -569 551):  
 (-555 -564 -565 519 -551))  
 ((-554: 651: 652: -653: -654: 655):  
 (554 -516 -562 -563 -551):  
 (516 -556 -551):  
 (516 -557 551):  
 (554 -516 -566 -567 551):  
 (554 -562 -563 -516 -551))

imp:n,p=4

C -----  
 c Cell 901 is the outside world

c -----  
 901 0 (503: -800: -802: 850: 804: -805)  
 (503: -800: -850: 803: -806: 807)

imp:n,p=0

c -----  
 C Cell 201 is the top grid plate

c -----  
 C

201 7 0.059195  
 -50 51 -52 53 54 55 56 57 58 59  
 60 61 63 64 65 66 67 68 69  
 70 71 72 73 74 75 76 77 78 79  
 80 81 82 83 84 85 86 87 88 89  
 90 91 92 93 94 95 96 97 98 99  
 100 101 102 103 104 105 106 107 108 109  
 110 111 112 113 114 115 116 117 118 119  
 120 121 122 123 124 125 126 127 128 129  
 130 131 132 133 134 135 136 137 138 139  
 140 141 142 143 144 imp:n,p=1

c -----  
 C cell 302 is the water in the upper plenum region

c -----  
 c  
 302 8 -1.0  
 -13 50 -52 53 204 205 206 207 208 209  
 210 211 213 214 215 216 217 218 219  
 220 221 222 73 224 225 226 227 228 79

230	231	232	233	234	85	236	237	238	239	
240	241	242	243	244	245	246	247	248	249	
250	251	252	253	254	255	256	257	258	259	
260	261	262	113	264	265	266	267	268	269	
270	271	272		274	275	276	277	278	279	
280	281	282	283	284	285	286	287	288	289	
290	291	292	293	294						imp:n,p=1
601	8	-1.0	-50	204	10	-54				imp:n,p=1 \$ B1
602	8	-1.0	-50	205	10	-55				imp:n,p=1 \$ B2
603	8	-1.0	-50	206	10	-56				imp:n,p=1 \$ B3
604	8	-1.0	-50	207	10	-57				imp:n,p=1 \$ B4
605	8	-1.0	-50	208	10	-58				imp:n,p=1 \$ B5
606	8	-1.0	-50	209	10	-59				imp:n,p=1 \$ B6
607	8	-1.0	-50	210	10	-60				imp:n,p=1 \$ C1
608	8	-1.0	-50	211	10	-61				imp:n,p=1 \$ C2
609	8	-1.0	-50	213	10	-63				imp:n,p=1 \$ C3
610	8	-1.0	-50	214	10	-64				imp:n,p=1 \$ C4
611	8	-1.0	-50	215	10	-65				imp:n,p=1 \$ C5
612	8	-1.0	-50	216	10	-66				imp:n,p=1 \$ C6
613	8	-1.0	-50	217	10	-67				imp:n,p=1 \$ C7
614	8	-1.0	-50	218	10	-68				imp:n,p=1 \$ C8
615	8	-1.0	-50	219	10	-69				imp:n,p=1 \$ C9
616	8	-1.0	-50	220	10	-70				imp:n,p=1 \$ C10
617	8	-1.0	-50	221	10	-71				imp:n,p=1 \$ C11
618	8	-1.0	-50	222	10	-72				imp:n,p=1 \$ C12
619	8	-1.0	-50	224	10	-74				imp:n,p=1 \$ D2
620	8	-1.0	-50	225	10	-75				imp:n,p=1 \$ D3
621	8	-1.0	-50	226	10	-76				imp:n,p=1 \$ D4
622	8	-1.0	-50	227	10	-77				imp:n,p=1 \$ D5
623	8	-1.0	-50	228	10	-78				imp:n,p=1 \$ D6
624	8	-1.0	-50	230	10	-80				imp:n,p=1 \$ D8
625	8	-1.0	-50	231	10	-81				imp:n,p=1 \$ D9
626	8	-1.0	-50	232	10	-82				imp:n,p=1 \$ D20
627	8	-1.0	-50	233	10	-83				imp:n,p=1 \$ D11
628	8	-1.0	-50	234	10	-84				imp:n,p=1 \$ D12
629	8	-1.0	-50	236	10	-86				imp:n,p=1 \$ D14
630	8	-1.0	-50	237	10	-87				imp:n,p=1 \$ D15
631	8	-1.0	-50	238	10	-88				imp:n,p=1 \$ D16
632	8	-1.0	-50	239	10	-89				imp:n,p=1 \$ D17
633	8	-1.0	-50	240	10	-90				imp:n,p=1 \$ D18
634	8	-1.0	-50	241	10	-91				imp:n,p=1 \$ E1
635	8	-1.0	-50	242	10	-92				imp:n,p=1 \$ E2
636	8	-1.0	-50	243	10	-93				imp:n,p=1 \$ E3
637	8	-1.0	-50	244	10	-94				imp:n,p=1 \$ E4
638	8	-1.0	-50	245	10	-95				imp:n,p=1 \$ E5
639	8	-1.0	-50	246	10	-96				imp:n,p=1 \$ E6

640	8 -1.0	-50	247	10 -97	imp:n,p=1 \$ E7
641	8 -1.0	-50	248	10 -98	imp:n,p=1 \$ E8
642	8 -1.0	-50	249	10 -99	imp:n,p=1 \$ E9
643	8 -1.0	-50	250	10 -100	imp:n,p=1 \$ E10
644	8 -1.0	-50	251	10 -101	imp:n,p=1 \$ E11
645	8 -1.0	-50	252	10 -102	imp:n,p=1 \$ E12
646	8 -1.0	-50	253	10 -103	imp:n,p=1 \$ E13
647	8 -1.0	-50	254	10 -104	imp:n,p=1 \$ E14
648	8 -1.0	-50	255	10 -105	imp:n,p=1 \$ E15
649	8 -1.0	-50	256	10 -106	imp:n,p=1 \$ E16
650	8 -1.0	-50	257	10 -107	imp:n,p=1 \$ E17
651	8 -1.0	-50	258	10 -108	imp:n,p=1 \$ E18
652	8 -1.0	-50	259	10 -109	imp:n,p=1 \$ E19
653	8 -1.0	-50	260	10 -110	imp:n,p=1 \$ E20
654	8 -1.0	-50	261	10 -111	imp:n,p=1 \$ E21
655	8 -1.0	-50	262	10 -112	imp:n,p=1 \$ E22
657	8 -1.0	-50	264	10 -114	imp:n,p=1 \$ E24
658	8 -1.0	-50	265	10 -115	imp:n,p=1 \$ F1
659	8 -1.0	-50	266	10 -116	imp:n,p=1 \$ F2
660	8 -1.0	-50	267	10 -117	imp:n,p=1 \$ F3
661	8 -1.0	-50	268	10 -118	imp:n,p=1 \$ F4
662	8 -1.0	-50	269	10 -119	imp:n,p=1 \$ F5
663	8 -1.0	-50	270	10 -120	imp:n,p=1 \$ F6
664	8 -1.0	-50	271	10 -121	imp:n,p=1 \$ F7
665	8 -1.0	-50	272	10 -122	imp:n,p=1 \$ F8
666	8 -1.0	-50		10 -123	imp:n,p=1 \$ F9
667	8 -1.0	-50	274	10 -124	imp:n,p=1 \$ F10
668	8 -1.0	-50	275	10 -125	imp:n,p=1 \$ F11
669	8 -1.0	-50	276	10 -126	imp:n,p=1 \$ F12
670	8 -1.0	-50	277	10 -127	imp:n,p=1 \$ F13
671	8 -1.0	-50	278	10 -128	imp:n,p=1 \$ F14
672	8 -1.0	-50	279	10 -129	imp:n,p=1 \$ F15
673	8 -1.0	-50	280	10 -130	imp:n,p=1 \$ F16
674	8 -1.0	-50	281	10 -131	imp:n,p=1 \$ F17
675	8 -1.0	-50	282	10 -132	imp:n,p=1 \$ F18
676	8 -1.0	-50	283	10 -133	imp:n,p=1 \$ F19
677	8 -1.0	-50	284	10 -134	imp:n,p=1 \$ F20
678	8 -1.0	-50	285	10 -135	imp:n,p=1 \$ F21
679	8 -1.0	-50	286	10 -136	imp:n,p=1 \$ F22
680	8 -1.0	-50	287	10 -137	imp:n,p=1 \$ F23
681	8 -1.0	-50	288	10 -138	imp:n,p=1 \$ F24
682	8 -1.0	-50	289	10 -139	imp:n,p=1 \$ F25
683	8 -1.0	-50	290	10 -140	imp:n,p=1 \$ F26
684	8 -1.0	-50	291	10 -141	imp:n,p=1 \$ F27
685	8 -1.0	-50	292	10 -142	imp:n,p=1 \$ F28
686	8 -1.0	-50	293	10 -143	imp:n,p=1 \$ F29

687	8	-1.0	-50	294	10	-144	imp:n,p=1 \$ F30
54	5	-7.92	-54	-10	51:	(-204 -13 10)	imp:n,p=1 \$ B1
55	5	-7.92	-55	-10	51:	(-205 -13 10)	imp:n,p=1 \$ B2
56	5	-7.92	-56	-10	51:	(-206 -13 10)	imp:n,p=1 \$ B3
57	5	-7.92	-57	-10	51:	(-207 -13 10)	imp:n,p=1 \$ B4
58	5	-7.92	-58	-10	51:	(-208 -13 10)	imp:n,p=1 \$ B5
59	5	-7.92	-59	-10	51:	(-209 -13 10)	imp:n,p=1 \$ B6
60	5	-7.92	-60	-10	51:	(-210 -13 10)	imp:n,p=1 \$ C1
61	5	-7.92	-61	-10	51:	(-211 -13 10)	imp:n,p=1 \$ C2
63	5	-7.92	-63	-10	51:	(-213 -13 10)	imp:n,p=1 \$ C3
64	5	-7.92	-64	-10	51:	(-214 -13 10)	imp:n,p=1 \$ C4
65	5	-7.92	-65	-10	51:	(-215 -13 10)	imp:n,p=1 \$ C5
66	5	-7.92	-66	-10	51:	(-216 -13 10)	imp:n,p=1 \$ C6
67	5	-7.92	-67	-10	51:	(-217 -13 10)	imp:n,p=1 \$ C7
68	5	-7.92	-68	-10	51:	(-218 -13 10)	imp:n,p=1 \$ C8
69	5	-7.92	-69	-10	51:	(-219 -13 10)	imp:n,p=1 \$ C9
70	5	-7.92	-70	-10	51:	(-220 -13 10)	imp:n,p=1 \$ C10
71	5	-7.92	-71	-10	51:	(-221 -13 10)	imp:n,p=1 \$ C11
72	5	-7.92	-72	-10	51:	(-222 -13 10)	imp:n,p=1 \$ C12
74	5	-7.92	-74	-10	51:	(-224 -13 10)	imp:n,p=1 \$ D2
75	5	-7.92	-75	-10	51:	(-225 -13 10)	imp:n,p=1 \$ D3
76	5	-7.92	-76	-10	51:	(-226 -13 10)	imp:n,p=1 \$ D4
77	5	-7.92	-77	-10	51:	(-227 -13 10)	imp:n,p=1 \$ D5
78	5	-7.92	-78	-10	51:	(-228 -13 10)	imp:n,p=1 \$ D6
80	5	-7.92	-80	-10	51:	(-230 -13 10)	imp:n,p=1 \$ D8
81	5	-7.92	-81	-10	51:	(-231 -13 10)	imp:n,p=1 \$ D9
82	5	-7.92	-82	-10	51:	(-232 -13 10)	imp:n,p=1 \$ D10
83	5	-7.92	-83	-10	51:	(-233 -13 10)	imp:n,p=1 \$ D11
84	5	-7.92	-84	-10	51:	(-234 -13 10)	imp:n,p=1 \$ D12
86	5	-7.92	-86	-10	51:	(-236 -13 10)	imp:n,p=1 \$ D14
87	5	-7.92	-87	-10	51:	(-237 -13 10)	imp:n,p=1 \$ D15
88	5	-7.92	-88	-10	51:	(-238 -13 10)	imp:n,p=1 \$ D16
89	5	-7.92	-89	-10	51:	(-239 -13 10)	imp:n,p=1 \$ D17
90	5	-7.92	-90	-10	51:	(-240 -13 10)	imp:n,p=1 \$ D18
91	5	-7.92	-91	-10	51:	(-241 -13 10)	imp:n,p=1 \$ E1
92	5	-7.92	-92	-10	51:	(-242 -13 10)	imp:n,p=1 \$ E2
93	5	-7.92	-93	-10	51:	(-243 -13 10)	imp:n,p=1 \$ E3
94	5	-7.92	-94	-10	51:	(-244 -13 10)	imp:n,p=1 \$ E4
95	5	-7.92	-95	-10	51:	(-245 -13 10)	imp:n,p=1 \$ E5
96	5	-7.92	-96	-10	51:	(-246 -13 10)	imp:n,p=1 \$ E6
97	5	-7.92	-97	-10	51:	(-247 -13 10)	imp:n,p=1 \$ E7
98	5	-7.92	-98	-10	51:	(-248 -13 10)	imp:n,p=1 \$ E8
99	5	-7.92	-99	-10	51:	(-249 -13 10)	imp:n,p=1 \$ E9
100	5	-7.92	-100	-10	51:	(-250 -13 10)	imp:n,p=1 \$ E10
101	5	-7.92	-101	-10	51:	(-251 -13 10)	imp:n,p=1 \$ E11
102	5	-7.92	-102	-10	51:	(-252 -13 10)	imp:n,p=1 \$ E12

103	5	-7.92	-103	-10	51:(-253 -13 10)	imp:n,p=1 \$ E13
104	5	-7.92	-104	-10	51:(-254 -13 10)	imp:n,p=1 \$ E14
105	5	-7.92	-105	-10	51:(-255 -13 10)	imp:n,p=1 \$ E15
106	5	-7.92	-106	-10	51:(-256 -13 10)	imp:n,p=1 \$ E16
107	5	-7.92	-107	-10	51:(-257 -13 10)	imp:n,p=1 \$ E17
108	5	-7.92	-108	-10	51:(-258 -13 10)	imp:n,p=1 \$ E18
109	5	-7.92	-109	-10	51:(-259 -13 10)	imp:n,p=1 \$ E19
110	5	-7.92	-110	-10	51:(-260 -13 10)	imp:n,p=1 \$ E20
111	5	-7.92	-111	-10	51:(-261 -13 10)	imp:n,p=1 \$ E21
112	5	-7.92	-112	-10	51:(-262 -13 10)	imp:n,p=1 \$ E22
114	5	-7.92	-114	-10	51:(-264 -13 10)	imp:n,p=1 \$ E24
115	5	-7.92	-115	-10	51:(-265 -13 10)	imp:n,p=1 \$ F1
116	5	-7.92	-116	-10	51:(-266 -13 10)	imp:n,p=1 \$ F2
117	5	-7.92	-117	-10	51:(-267 -13 10)	imp:n,p=1 \$ F3
118	5	-7.92	-118	-10	51:(-268 -13 10)	imp:n,p=1 \$ F4
119	5	-7.92	-119	-10	51:(-269 -13 10)	imp:n,p=1 \$ F5
120	5	-7.92	-120	-10	51:(-270 -13 10)	imp:n,p=1 \$ F6
121	5	-7.92	-121	-10	51:(-271 -13 10)	imp:n,p=1 \$ F7
122	5	-7.92	-122	-10	51:(-272 -13 10)	imp:n,p=1 \$ F8
124	5	-7.92	-124	-10	51:(-274 -13 10)	imp:n,p=1 \$ F9
125	5	-7.92	-125	-10	51:(-275 -13 10)	imp:n,p=1 \$ F10
126	5	-7.92	-126	-10	51:(-276 -13 10)	imp:n,p=1 \$ F11
127	5	-7.92	-127	-10	51:(-277 -13 10)	imp:n,p=1 \$ F12
128	5	-7.92	-128	-10	51:(-278 -13 10)	imp:n,p=1 \$ F13
129	5	-7.92	-129	-10	51:(-279 -13 10)	imp:n,p=1 \$ F14
130	5	-7.92	-130	-10	51:(-280 -13 10)	imp:n,p=1 \$ F15
131	5	-7.92	-131	-10	51:(-281 -13 10)	imp:n,p=1 \$ F16
132	5	-7.92	-132	-10	51:(-282 -13 10)	imp:n,p=1 \$ F17
133	5	-7.92	-133	-10	51:(-283 -13 10)	imp:n,p=1 \$ F18
134	5	-7.92	-134	-10	51:(-284 -13 10)	imp:n,p=1 \$ F19
135	5	-7.92	-135	-10	51:(-285 -13 10)	imp:n,p=1 \$ F20
136	5	-7.92	-136	-10	51:(-286 -13 10)	imp:n,p=1 \$ F21
137	5	-7.92	-137	-10	51:(-287 -13 10)	imp:n,p=1 \$ F22
138	5	-7.92	-138	-10	51:(-288 -13 10)	imp:n,p=1 \$ F24
139	5	-7.92	-139	-10	51:(-289 -13 10)	imp:n,p=1 \$ F25
140	5	-7.92	-140	-10	51:(-290 -13 10)	imp:n,p=1 \$ F26
141	5	-7.92	-141	-10	51:(-291 -13 10)	imp:n,p=1 \$ F27
142	5	-7.92	-142	-10	51:(-292 -13 10)	imp:n,p=1 \$ F28
143	5	-7.92	-143	-10	51:(-293 -13 10)	imp:n,p=1 \$ F29
144	5	-7.92	-144	-10	51:(-294 -13 10)	imp:n,p=1 \$ F30

c

C -----

c Cells in bottom plate

c

c

204	5	-7.92	201	-11 -204	imp:n,p=1 \$ B1
-----	---	-------	-----	----------	-----------------

205	5	-7.92	201	-11	-205	imp:n,p=1 \$ B2
206	5	-7.92	201	-11	-206	imp:n,p=1 \$ B3
207	5	-7.92	201	-11	-207	imp:n,p=1 \$ B4
208	5	-7.92	201	-11	-208	imp:n,p=1 \$ B5
209	5	-7.92	201	-11	-209	imp:n,p=1 \$ B6
210	5	-7.92	201	-11	-210	imp:n,p=1 \$ C1
211	5	-7.92	201	-11	-211	imp:n,p=1 \$ C2
213	5	-7.92	201	-11	-213	imp:n,p=1 \$ C3
214	5	-7.92	201	-11	-214	imp:n,p=1 \$ C4
215	5	-7.92	201	-11	-215	imp:n,p=1 \$ C5
216	5	-7.92	201	-11	-216	imp:n,p=1 \$ C6
217	5	-7.92	201	-11	-217	imp:n,p=1 \$ C7
218	5	-7.92	201	-11	-218	imp:n,p=1 \$ C8
219	5	-7.92	201	-11	-219	imp:n,p=1 \$ C9
220	5	-7.92	201	-11	-220	imp:n,p=1 \$ C10
221	5	-7.92	201	-11	-221	imp:n,p=1 \$ C11
222	5	-7.92	201	-11	-222	imp:n,p=1 \$ C12
224	5	-7.92	201	-11	-224	imp:n,p=1 \$ D2
225	5	-7.92	201	-11	-225	imp:n,p=1 \$ D3
226	5	-7.92	201	-11	-226	imp:n,p=1 \$ D4
227	5	-7.92	201	-11	-227	imp:n,p=1 \$ D5
228	5	-7.92	201	-11	-228	imp:n,p=1 \$ D6
230	5	-7.92	201	-11	-230	imp:n,p=1 \$ D8
231	5	-7.92	201	-11	-231	imp:n,p=1 \$ D9
232	5	-7.92	201	-11	-232	imp:n,p=1 \$ D10
233	5	-7.92	201	-11	-233	imp:n,p=1 \$ D11
234	5	-7.92	201	-11	-234	imp:n,p=1 \$ D12
236	5	-7.92	201	-11	-236	imp:n,p=1 \$ D14
237	5	-7.92	201	-11	-237	imp:n,p=1 \$ D15
238	5	-7.92	201	-11	-238	imp:n,p=1 \$ D16
239	5	-7.92	201	-11	-239	imp:n,p=1 \$ D17
240	5	-7.92	201	-11	-240	imp:n,p=1 \$ D18
241	5	-7.92	201	-11	-241	imp:n,p=1 \$ E1
242	5	-7.92	201	-11	-242	imp:n,p=1 \$ E2
243	5	-7.92	201	-11	-243	imp:n,p=1 \$ E3
244	5	-7.92	201	-11	-244	imp:n,p=1 \$ E4
245	5	-7.92	201	-11	-245	imp:n,p=1 \$ E5
246	5	-7.92	201	-11	-246	imp:n,p=1 \$ E6
247	5	-7.92	201	-11	-247	imp:n,p=1 \$ E7
248	5	-7.92	201	-11	-248	imp:n,p=1 \$ E8
249	5	-7.92	201	-11	-249	imp:n,p=1 \$ E9
250	5	-7.92	201	-11	-250	imp:n,p=1 \$ E10
251	5	-7.92	201	-11	-251	imp:n,p=1 \$ E11
252	5	-7.92	201	-11	-252	imp:n,p=1 \$ E12
253	5	-7.92	201	-11	-253	imp:n,p=1 \$ E13
254	5	-7.92	201	-11	-254	imp:n,p=1 \$ E14

255	5	-7.92	201	-11	-255	imp:n,p=1	\$ E15
256	5	-7.92	201	-11	-256	imp:n,p=1	\$ E16
257	5	-7.92	201	-11	-257	imp:n,p=1	\$ E17
258	5	-7.92	201	-11	-258	imp:n,p=1	\$ E18
259	5	-7.92	201	-11	-259	imp:n,p=1	\$ E19
260	5	-7.92	201	-11	-260	imp:n,p=1	\$ E20
261	5	-7.92	201	-11	-261	imp:n,p=1	\$ E21
262	5	-7.92	201	-11	-262	imp:n,p=1	\$ E22
263	7	0.059195	201	-11	-263	imp:n,p=1	\$ E23
264	5	-7.92	201	-11	-264	imp:n,p=1	\$ E24
265	5	-7.92	201	-11	-265	imp:n,p=1	\$ F1
266	5	-7.92	201	-11	-266	imp:n,p=1	\$ F2
267	5	-7.92	201	-11	-267	imp:n,p=1	\$ F3
268	5	-7.92	201	-11	-268	imp:n,p=1	\$ F4
269	5	-7.92	201	-11	-269	imp:n,p=1	\$ F5
270	5	-7.92	201	-11	-270	imp:n,p=1	\$ F6
271	5	-7.92	201	-11	-271	imp:n,p=1	\$ F7
272	5	-7.92	201	-11	-272	imp:n,p=1	\$ F8
273	8	-1.00	201	-14	-273	imp:n,p=1	\$ F9
274	5	-7.92	201	-11	-274	imp:n,p=1	\$ F10
275	5	-7.92	201	-11	-275	imp:n,p=1	\$ F11
276	5	-7.92	201	-11	-276	imp:n,p=1	\$ F12
277	5	-7.92	201	-11	-277	imp:n,p=1	\$ F13
278	5	-7.92	201	-11	-278	imp:n,p=1	\$ F14
279	5	-7.92	201	-11	-279	imp:n,p=1	\$ F15
280	5	-7.92	201	-11	-280	imp:n,p=1	\$ F16
281	5	-7.92	201	-11	-281	imp:n,p=1	\$ F17
282	5	-7.92	201	-11	-282	imp:n,p=1	\$ F18
283	5	-7.92	201	-11	-283	imp:n,p=1	\$ F19
284	5	-7.92	201	-11	-284	imp:n,p=1	\$ F20
285	5	-7.92	201	-11	-285	imp:n,p=1	\$ F21
286	5	-7.92	201	-11	-286	imp:n,p=1	\$ F22
287	5	-7.92	201	-11	-287	imp:n,p=1	\$ F23
288	5	-7.92	201	-11	-288	imp:n,p=1	\$ F24
289	5	-7.92	201	-11	-289	imp:n,p=1	\$ F25
290	5	-7.92	201	-11	-290	imp:n,p=1	\$ F26
291	5	-7.92	201	-11	-291	imp:n,p=1	\$ F27
292	5	-7.92	201	-11	-292	imp:n,p=1	\$ F28
293	5	-7.92	201	-11	-293	imp:n,p=1	\$ F29
294	5	-7.92	201	-11	-294	imp:n,p=1	\$ F30

C

C

-----  
 Adding additional fuel elements

c

C

C Ring B

C  
 402 Like 401 but trcl ( 2.02692 3.510534 0.0) \$ Core position B2  
 403 Like 401 but trcl ( 6.08076 3.510534 0.0) \$ Core position B3  
 404 Like 401 but trcl ( 8.10768 0.0 0.0) \$ Core position B4  
 405 Like 401 but trcl ( 6.08076 -3.510534 0.0) \$ Core position B5  
 406 Like 401 but trcl ( 2.02692 -3.510534 0.0) \$ Core position B6

C  
 C Ring C

C  
 407 Like 401 but trcl ( -3.92684 0.0 0.0) \$ Core position C1  
 408 Like 401 but trcl ( -2.85750 3.99034 0.0) \$ Core position C2  
 409 Like 401 but trcl ( -0.06350 6.91134 0.0) \$ Core position C3  
 410 Like 401 but trcl ( 4.05384 7.98068 0.0) \$ Core position C4  
 411 Like 401 but trcl ( 8.04418 6.91134 0.0) \$ Core position C5  
 412 Like 401 but trcl ( 10.96518 3.99034 0.0) \$ Core position C6  
 413 Like 401 but trcl ( 12.03452 0.0 0.0) \$ Core position C7  
 414 Like 401 but trcl ( 10.96518 -3.99034 0.0) \$ Core position C8  
 415 Like 401 but trcl ( 8.04418 -6.91134 0.0) \$ Core position C9  
 416 Like 401 but trcl ( 4.05384 -7.98068 0.0) \$ Core position C10  
 417 Like 401 but trcl ( -0.06350 -6.91134 0.0) \$ Core position C11  
 418 Like 401 but trcl ( -2.85750 -3.99034 0.0) \$ Core position C12

c  
 C Ring D

c  
 420 Like 401 but trcl ( -7.17144 4.085336 0.0) \$ Core position D2  
 421 Like 401 but trcl ( -5.09651 7.678736 0.0) \$ Core position D3  
 422 Like 401 but trcl ( -1.91897 10.344912 0.0) \$ Core position D4  
 423 Like 401 but trcl ( 1.980184 11.76401 0.0) \$ Core position D5  
 424 Like 401 but trcl ( 6.127496 11.76401 0.0) \$ Core position D6  
 c Core position D7  
 426 Like 401 but trcl ( 13.20419 7.678736 0.0) \$ Core position D8  
 428 Like 401 but trcl ( 15.20419 4.085336 0.0) \$ Core position D9  
 429 Like 401 but trcl ( 15.99946 0.0 0.0) \$ Core position D10  
 430 Like 401 but trcl ( 15.279116 -4.085336 0.0) \$ Core position D11  
 431 Like 401 but trcl ( 13.20419 -7.678736 0.0) \$ Core position D12  
 c Core position D13  
 433 Like 401 but trcl ( 6.127496 -11.76401 0.0) \$ Core position D14  
 434 Like 401 but trcl ( 1.980184 -11.76401 0.0) \$ Core position D15  
 435 Like 401 but trcl ( -1.91897 -10.344912 0.0) \$ Core position D16  
 436 Like 401 but trcl ( -5.09651 -7.678736 0.0) \$ Core position D17  
 437 Like 401 but trcl ( -7.17144 -4.085336 0.0) \$ Core position D18

c  
 C Ring E

c  
 438 Like 401 but trcl (-11.8618 0.0 0.0) \$ Core position E1  
 439 Like 401 but trcl (-11.319002 4.118864 0.0) \$ Core position E2

440 Like 401 but trcl ( -9.728962 7.95782 0.0) \$ Core position E3  
 441 Like 401 but trcl ( -7.200138 11.253978 0.0) \$ Core position E4  
 442 Like 401 but trcl ( -3.92198 13.782802 0.0) \$ Core position E5  
 443 Like 401 but trcl ( -0.065024 15.372842 0.0) \$ Core position E6  
 444 Like 401 but trcl ( 4.05384 15.91564 0.0) \$ Core position E7  
 445 Like 401 but trcl ( 8.172704 15.372842 0.0) \$ Core position E8  
 446 Like 401 but trcl ( 12.01166 13.782802 0.0) \$ Core position E9  
 447 Like 401 but trcl ( 15.30782 11.253978 0.0) \$ Core position E10  
 448 Like 401 but trcl ( 17.836642 7.95782 0.0) \$ Core position E11  
 449 Like 401 but trcl ( 19.426682 4.118864 0.0) \$ Core position E12  
 450 Like 401 but trcl ( 19.96948 0.0 0.0) \$ Core position E13  
 451 Like 401 but trcl ( 19.426682 -4.118864 0.0) \$ Core position E14  
 452 Like 401 but trcl ( 17.836642 -7.95782 0.0) \$ Core position E15  
 453 Like 401 but trcl ( 15.30782 -11.253978 0.0) \$ Core position E16  
 454 Like 401 but trcl ( 12.01166 -13.782802 0.0) \$ Core position E17  
 455 Like 401 but trcl ( 8.172704 -15.372842 0.0) \$ Core position E18  
 456 Like 401 but trcl ( 4.05384 -15.91564 0.0) \$ Core position E19  
 457 Like 401 but trcl ( -0.065024 -15.372842 0.0) \$ Core position E20  
 458 Like 401 but trcl ( -3.92198 -13.782802 0.0) \$ Core position E21  
 459 Like 401 but trcl ( -7.200138 -11.253978 0.0) \$ Core position E22  
 461 Like 401 but trcl ( -11.319002 -4.118864 0.0) \$ Core position E24

c

C Ring F

c

462 Like 401 but trcl ( -15.83436 0.0 0.0) \$ Core position F1  
 463 Like 401 but trcl ( -15.39875 4.134866 0.0) \$ Core position F2  
 464 Like 401 but trcl ( -14.114018 8.08863 0.0) \$ Core position F3  
 465 Like 401 but trcl ( -12.03579 11.69035 0.0) \$ Core position F4  
 466 Like 401 but trcl ( -9.238234 14.77899 0.0) \$ Core position F5  
 467 Like 401 but trcl ( -5.89026 17.223232 0.0) \$ Core position F6  
 468 Like 401 but trcl ( -2.09169 18.915634 0.0) \$ Core position F7  
 469 Like 401 but trcl ( 1.975612 19.915634 0.0) \$ Core position F8  
 471 Like 401 but trcl ( 10.19937 18.915634 0.0) \$ Core position F10  
 472 Like 401 but trcl ( 13.99794 17.223232 0.0) \$ Core position F11  
 473 Like 401 but trcl ( 17.345914 14.77899 0.0) \$ Core position F12  
 474 Like 401 but trcl ( 20.14347 11.69035 0.0) \$ Core position F13  
 475 Like 401 but trcl ( 22.221698 8.08863 0.0) \$ Core position F14  
 476 Like 401 but trcl ( 23.50643 4.134866 0.0) \$ Core position F15  
 477 Like 401 but trcl ( 23.94204 0.0 0.0) \$ Core position F16  
 478 Like 401 but trcl ( 20.14347 -11.69035 0.0) \$ Core position F17  
 479 Like 401 but trcl ( 22.221698 -8.08863 0.0) \$ Core position F18  
 480 Like 401 but trcl ( 23.50643 -4.134866 0.0) \$ Core position F19  
 481 Like 401 but trcl ( 17.345914 -14.77899 0.0) \$ Core position F20  
 482 Like 401 but trcl ( 13.99794 -17.223232 0.0) \$ Core position F21  
 483 Like 401 but trcl ( 10.19937 -18.915634 0.0) \$ Core position F22  
 484 Like 401 but trcl ( 6.132068 -19.915634 0.0) \$ Core position F23

485 Like 401 but trcl ( 1.975612 -19.915634 0.0) \$ Core position F24  
 486 Like 401 but trcl (-2.09169 -18.915634 0.0) \$ Core position F25  
 487 Like 401 but trcl (-5.89026 -17.223232 0.0) \$ Core position F26  
 488 Like 401 but trcl (-9.238234 -14.77899 0.0) \$ Core position F27  
 489 Like 401 but trcl (-12.03579 -11.69035 0.0) \$ Core position F28  
 490 Like 401 but trcl (-14.114018 -8.08863 0.0) \$ Core position F29  
 491 Like 401 but trcl (-15.39875 -4.134866 0.0) \$ Core position F30

c

c -----

c Exposure room 1

c -----

c

c Cell 702 is the wood lining of the exposure room

702 11 -0.650 -555 601 -602 603 604 -630  
 (610: -611: 612: -613: -614: 615)  
 ((-519 558 -551 604):  
 (-519 559 551 -630)):  
 (-551 565 603 519 -555 604):  
 (551 -555 519 569 603 -630):  
 (551 -555 519 568 -602 -630):  
 (-551 564 -602 519 -555 604)

imp:n,p=1

c Cell 703 is the masonite/gadolinium lining of the exposure room

703 12 -1.30 -610 611 -612 613 614 -615  
 (620: -621: 622: -623: -624: 625)  
 ((558 -551):(559 551))

imp:n,p=1

c Cell 704 defines the interior volume of the exposure room

704 9 -0.001205 -620 621 -622 623 624 -625  
 ((558 -551):(559 551)) imp:n,p=1

c Cell 705 is the lead shield

c Cell 706 is the cadmium curtain

c Cell 707 is the air gap between the wood and concrete on ceiling

707 9 -0.001205 (-555 601 -602 603 630 -605)  
 (-519 559):  
 (568 519 -602 -555 630 -605):  
 (569 519 603 -555 630 -605)

imp:n,p=1

c

c -----

c Exposure room 2

c -----

c

c Cell 710 is the wood lining of the exposure room

710 11 -0.650 554 -651 -652 653 654 -655  
 (-660: 661: 662: -663: -664: 665)

((516 556 -551 654):  
 (516 557 551 -655)):  
 (-551 563 653 -516 554 654):  
 (551 554 -516 567 653 -655):  
 (551 554 -516 566 -652 -655):  
 (-551 562 -652 -516 554 654) imp:n,p=8  
 c Cell 711 is the masonite/gadolinium lining of the exposure room  
 711 12 -1.30 660 -661 -662 663 664 -665  
 (-670: 671: 672: -673: -674: 675)  
 ((556 -551):(557 551)) imp:n,p=24  
 c Cell 712 defines the interior volume of the exposure room  
 712 9 -0.001205 670 -671 -672 673 674 -675 ((556 -551):(557 551))  
 (2001: -2002: 2003) (2001: -2002: 2004) (2001: -2002: 2005)  
 (2001: -2002: 2006) (2001: -2002: 2007) (2001: -2002: 2008)  
 (2001: -2002: 2009)  
 imp:n,p=75  
 c Cell 713 is the lead shield  
 c  
 c -----  
 c Control rod guide tubes  
 c -----  
 c  
 c Control rod A-1  
 c  
 358 7 0.059195  
 -503 1013 -53 1033  
 imp:n,p=1  
 c Air in guide tube A-1  
 362 9 -0.001205  
 -503 502 1004 -1013  
 imp:n,p=1  
 c  
 c Control rod D-1  
 c  
 359 7 0.059195  
 -503 1039 -73 1033  
 imp:n,p=1  
 c Air in guide tube D-1  
 363 9 -0.001205  
 -503 502 1024 -1039  
 imp:n,p=1  
 c  
 c Control rod D-7  
 c  
 360 7 0.059195  
 -503 1053 -79 1033

imp:n,p=1  
 c Air in guide tube D-7  
 364 9 -0.001205  
 -503 502 1044 -1053  
 imp:n,p=1  
 c  
 c Control rod D-13  
 c  
 361 7 0.059195  
 -503 1073 -85 1033  
 imp:n,p=1  
 c Air in guide tube D-13  
 365 9 -0.001205  
 -503 502 1064 -1073  
 imp:n,p=1  
 c  
 c -----  
 c Core exposure tube  
 c -----  
 c Located at Core position E-23  
 c Terminated at surface 1078; actual exposure tube serpentines to  
 c surface of pool to prevent radiation streaming  
 c -----  
 656 7 0.059195  
 -113 851 -1087 9  
 imp:n,p=1  
 1658 9 -0.001205  
 -851 9 -1087  
 imp:n,p=1  
 1659 7 0.059195  
 -9 11 -113  
 imp:n,p=1  
 c  
 c -----  
 c Phantoms in exposure room 2  
 c -----  
 2001 14 -1.19 -2001 2002 -2003 imp:n,p=250  
 2002 14 -1.19 -2001 2002 -2004 imp:n,p=250  
 2003 14 -1.19 -2001 2002 -2005 imp:n,p=250  
 2004 14 -1.19 -2001 2002 -2006 imp:n,p=250  
 2005 14 -1.19 -2001 2002 -2007 imp:n,p=250  
 2006 14 -1.19 -2001 2002 -2008 imp:n,p=250  
 2007 14 -1.19 -2001 2002 -2009 imp:n,p=250  
 c -----  
 C Surface cards

150 cz 13.93063  
 151 cz 17.90192  
 152 cz 22.00000

c -----  
 C Surfaces 1 thru 15 define a fuel element at position B1  
 c -----

c  
 C Dimensions from reactor plans sheet T3S210D170  
 c

1	c/z	-4.05384	0.0	0.31	\$ Central Zirconium Rod
2	c/z	-4.05384	0.0	1.814	\$ Interior of cladding
3	c/z	-4.05384	0.0	1.865	\$ Exterior of cladding
4	pz	21.081125			\$ Top of fuel area
5	pz	-17.018875			\$ Bottom of fuel area
6	pz	21.119125			\$ Top of upper Samarium wafer
7	pz	-17.056875			\$ Bottom of lower Samarium wafer
8	pz	29.859125			\$ Top of upper carbon reflector
9	pz	-25.796875			\$ Bottom of lower carbon reflector
10	pz	31.4325			\$ Top of cladding can
11	pz	-27.066875			\$ Bottom of cladding can
13	pz	39.0017			\$ Top of fuel element
14	pz	-31.4325			\$ Bottom of fuel element
15	pz	30.189325			\$ Top of void

c  
 c -----  
 C Upper Grid Plate  
 c -----

50	PZ	33.3375			\$ Top surface of plate
51	PZ	31.4325			\$ Bottom surface of plate
52	CZ	23.6601			\$ Exterior edge of plate

c A Ring

c  
 c  
 c B Ring

54	C/Z	-4.05384	0.0	1.91135	\$ Core position B1
55	C/Z	-2.02692	3.510534	1.91135	\$ Core position B2
56	C/Z	2.02692	3.510534	1.91135	\$ Core position B3
57	C/Z	4.05384	0.0	1.91135	\$ Core position B4
58	C/Z	2.02692	-3.510534	1.91135	\$ Core position B5
59	C/Z	-2.02692	-3.510534	1.91135	\$ Core position B6

c  
 c C Ring

60	C/Z	-7.98068	0.0	1.91135	\$ Core position C1
----	-----	----------	-----	---------	---------------------

61	C/Z	-6.91134	3.99034	1.91135	\$ Core position C2
63	C/Z	-3.99034	6.91134	1.91135	\$ Core position C3
64	C/Z	0.0	7.98068	1.91135	\$ Core position C4
65	C/Z	3.99034	6.91134	1.91135	\$ Core position C5
66	C/Z	6.91134	3.99034	1.91135	\$ Core position C6
67	C/Z	7.98068	0.0	1.91135	\$ Core position C7
68	C/Z	6.91134	-3.99034	1.91135	\$ Core position C8
69	C/Z	3.99034	-6.91134	1.91135	\$ Core position C9
70	C/Z	0.0	-7.98068	1.91135	\$ Core position C10
71	C/Z	-3.99034	-6.91134	1.91135	\$ Core position C11
72	C/Z	-6.91134	-3.99034	1.91135	\$ Core position C12

c

c D Ring

c

74	C/Z	-11.22528	4.085336	1.91135	\$ Core position D2
75	C/Z	-9.15035	7.678736	1.91135	\$ Core position D3
76	C/Z	-5.97281	10.344912	1.91135	\$ Core position D4
77	C/Z	-2.073656	11.76401	1.91135	\$ Core position D5
78	C/Z	2.073656	11.76401	1.91135	\$ Core position D6
80	C/Z	9.15035	7.678674	1.91135	\$ Core position D8
81	C/Z	11.225276	4.085336	1.91135	\$ Core position D9
82	C/Z	11.94562	0.0	1.91135	\$ Core position D10
83	C/Z	11.225276	-4.085336	1.91135	\$ Core position D11
84	C/Z	9.15035	-7.678674	1.91135	\$ Core position D12
86	C/Z	2.07366	-11.76401	1.91135	\$ Core position D14
87	C/Z	-2.07366	-11.76401	1.91135	\$ Core position D15
88	C/Z	-5.97281	-10.344912	1.91135	\$ Core position D16
89	C/Z	-9.15035	-7.678674	1.91135	\$ Core position D17
90	C/Z	-11.22528	-4.085336	1.91135	\$ Core position D18

c

c E Ring

c

91	C/Z	-15.91564	0.0	1.91135	\$ Core position E1
92	C/Z	-15.372842	4.118864	1.91135	\$ Core position E2
93	C/Z	-13.782802	7.95782	1.91135	\$ Core position E3
94	C/Z	-11.253978	11.253978	1.91135	\$ Core position E4
95	C/Z	-7.95782	13.782802	1.91135	\$ Core position E5
96	C/Z	-4.118864	15.372842	1.91135	\$ Core position E6
97	C/Z	0.0	15.91564	1.91135	\$ Core position E7
98	C/Z	4.118864	15.372842	1.91135	\$ Core position E8
99	C/Z	7.95782	13.782802	1.91135	\$ Core position E9
100	C/Z	11.25398	11.253978	1.91135	\$ Core position E10
101	C/Z	13.782802	7.95782	1.91135	\$ Core position E11
102	C/Z	15.372842	4.118864	1.91135	\$ Core position E12
103	C/Z	15.91564	0.0	1.91135	\$ Core position E13
104	C/Z	15.372842	-4.118864	1.91135	\$ Core position E14

105 C/Z 13.782802 -7.95782 1.91135 \$ Core position E15  
 106 C/Z 11.253978 -11.253978 1.91135 \$ Core position E16  
 107 C/Z 7.95782 -13.782802 1.91135 \$ Core position E17  
 108 C/Z 4.118864 -15.372842 1.91135 \$ Core position E18  
 109 C/Z 0.0 -15.91564 1.91135 \$ Core position E19  
 110 C/Z -4.118864 -15.372842 1.91135 \$ Core position E20  
 111 C/Z -7.95782 -13.782802 1.91135 \$ Core position E21  
 112 C/Z -11.25398 -11.25398 1.91135 \$ Core position E22  
 113 C/Z -13.78208 -7.95782 1.91135 \$ Core position E23  
 114 C/Z -15.372842 -4.118864 1.91135 \$ Core position E24

c

c F Ring

c

115 C/Z -19.8882 0.0 1.91335 \$ Core position F1  
 116 C/Z -19.45259 4.134866 1.91135 \$ Core position F2  
 117 C/Z -18.167858 8.08863 1.91135 \$ Core position F3  
 118 C/Z -16.08963 11.69035 1.91135 \$ Core position F4  
 119 C/Z -13.292074 14.77899 1.91135 \$ Core position F5  
 120 C/Z -9.9441 17.223232 1.91135 \$ Core position F6  
 121 C/Z -6.14553 18.915634 1.91135 \$ Core position F7  
 122 C/Z -2.078228 19.915634 1.91135 \$ Core position F8  
 123 C/Z 2.078228 19.915634 1.91135 \$ Core position F9  
 124 C/Z 6.14553 18.915634 1.91135 \$ Core position F10  
 125 C/Z 9.9441 17.223232 1.91135 \$ Core position F11  
 126 C/Z 13.292074 14.77899 1.91135 \$ Core position F12  
 127 C/Z 16.08963 11.69035 1.91135 \$ Core position F13  
 128 C/Z 18.167858 8.08863 1.91135 \$ Core position F14  
 129 C/Z 19.45259 4.134866 1.91135 \$ Core position F15  
 130 C/Z 19.8882 0.0 1.91135 \$ Core position F16  
 131 C/Z 19.45259 -4.134866 1.91135 \$ Core position F17  
 132 C/Z 18.167858 -8.08863 1.91135 \$ Core position F18  
 133 C/Z 16.08963 -11.69035 1.91135 \$ Core position F19  
 134 C/Z 13.292074 -14.77899 1.91135 \$ Core position F20  
 135 C/Z 9.9441 -17.223232 1.91135 \$ Core position F21  
 136 C/Z 6.14553 -18.915634 1.91135 \$ Core position F22  
 137 C/Z 2.078228 -19.915634 1.91135 \$ Core position F23  
 138 C/Z -2.078338 -19.915634 1.91135 \$ Core position F24  
 139 C/Z -6.14553 -18.915634 1.91135 \$ Core position F25  
 140 C/Z -9.9441 -17.223232 1.91135 \$ Core position F26  
 141 C/Z -13.292074 -14.77899 1.91135 \$ Core position F27  
 142 C/Z -16.08963 -11.69035 1.91135 \$ Core position F28  
 143 C/Z -18.167858 -8.08864 1.91135 \$ Core position F29  
 144 C/Z -19.45259 -4.134866 1.91135 \$ Core position F30

C 145 C/Z 1.13665 \$ External neutron source position

c

c -----

C Lower Grid Plate  
c -----  
c  
200 PZ -31.4325 \$ Top surface of plate  
201 PZ -33.3375 \$ Bottom surface of plate  
202 CZ 21.115 \$ Exterior edge of plate  
c  
c A Ring  
c  
203 CZ 1.92405 \$ Core position A1  
c  
c B Ring  
c  
204 C/Z -4.05384 0.0 0.79375 \$ Core position B1  
205 C/Z -2.02692 3.510534 0.79375 \$ Core position B2  
206 C/Z 2.02692 3.510534 0.79375 \$ Core position B3  
207 C/Z 4.05384 0.0 0.79375 \$ Core position B4  
208 C/Z 2.02692 -3.510534 0.79375 \$ Core position B5  
209 C/Z -2.02692 -3.510534 0.79375 \$ Core position B6  
c  
c C Ring  
c  
210 C/Z -7.98068 0.0 0.79375 \$ Core position C1  
211 C/Z -6.91134 3.99034 0.79375 \$ Core position C2  
213 C/Z -3.99034 6.91134 0.79375 \$ Core position C3  
214 C/Z 0.0 7.98068 0.79375 \$ Core position C4  
215 C/Z 3.99034 6.91134 0.79375 \$ Core position C5  
216 C/Z 6.91134 3.99034 0.79375 \$ Core position C6  
217 C/Z 7.98068 0.0 0.79375 \$ Core position C7  
218 C/Z 6.91134 -3.99034 0.79375 \$ Core position C8  
219 C/Z 3.99034 -6.91134 0.79375 \$ Core position C9  
220 C/Z 0.0 -7.98068 0.79375 \$ Core position C10  
221 C/Z -3.99034 -6.91134 0.79375 \$ Core position C11  
222 C/Z -6.91134 -3.99034 0.79375 \$ Core position C12  
c  
c D Ring  
c  
223 C/Z -11.94562 0.0 1.92405 \$ Core position D1  
224 C/Z -11.22528 4.085336 0.79375 \$ Core position D2  
225 C/Z -9.15035 7.678736 0.79375 \$ Core position D3  
226 C/Z -5.97281 10.344912 0.79375 \$ Core position D4  
227 C/Z -2.073656 11.76401 0.79375 \$ Core position D5  
228 C/Z 2.073656 11.76401 0.79375 \$ Core position D6  
229 C/Z 5.97281 10.344912 1.92405 \$ Core position D7  
230 C/Z 9.15035 7.678674 0.79375 \$ Core position D8  
231 C/Z 11.225276 4.085336 0.79375 \$ Core position D9

232	C/Z	11.94562	0.0	0.79375	\$ Core position D10
233	C/Z	11.225276	-4.085336	0.79375	\$ Core position D11
234	C/Z	9.15035	-7.678674	0.79375	\$ Core position D12
235	C/Z	5.97281	-10.344912	1.92405	\$ Core position D13
236	C/Z	2.07366	-11.76401	0.79375	\$ Core position D14
237	C/Z	-2.07366	-11.76401	0.79375	\$ Core position D15
238	C/Z	-5.97281	-10.344912	0.79375	\$ Core position D16
239	C/Z	-9.15035	-7.678674	0.79375	\$ Core position D17
240	C/Z	-11.22528	-4.085336	0.79375	\$ Core position D18

c

c E Ring

c

241	C/Z	-15.91564	0.0	0.79375	\$ Core position E1
242	C/Z	-15.372842	4.118864	0.79375	\$ Core position E2
243	C/Z	-13.782802	7.95782	0.79375	\$ Core position E3
244	C/Z	-11.253978	11.253978	0.79375	\$ Core position E4
245	C/Z	-7.95782	13.782802	0.79375	\$ Core position E5
246	C/Z	-4.118864	15.372842	0.79375	\$ Core position E6
247	C/Z	0.0	15.91564	0.79375	\$ Core position E7
248	C/Z	4.118864	15.372842	0.79375	\$ Core position E8
249	C/Z	7.95782	13.782802	0.79375	\$ Core position E9
250	C/Z	11.25398	11.253978	0.79375	\$ Core position E10
251	C/Z	13.782802	7.95782	0.79375	\$ Core position E11
252	C/Z	15.372842	4.118864	0.79375	\$ Core position E12
253	C/Z	15.91564	0.0	0.79375	\$ Core position E13
254	C/Z	15.372842	-4.118864	0.79375	\$ Core position E14
255	C/Z	13.782802	-7.95782	0.79375	\$ Core position E15
256	C/Z	11.253978	-11.253978	0.79375	\$ Core position E16
257	C/Z	7.95782	-13.782802	0.79375	\$ Core position E17
258	C/Z	4.118864	-15.372842	0.79375	\$ Core position E18
259	C/Z	0.0	-15.91564	0.79375	\$ Core position E19
260	C/Z	-4.118864	-15.372842	0.79375	\$ Core position E20
261	C/Z	-7.95782	-13.782802	0.79375	\$ Core position E21
262	C/Z	-11.25398	-11.25398	0.79375	\$ Core position E22
263	C/Z	-13.78208	-7.95782	0.79375	\$ Core position E23
264	C/Z	-15.372842	-4.118864	0.79375	\$ Core position E24

c

c F Ring

c

265	C/Z	-19.8882	0.0	0.79375	\$ Core position F1
266	C/Z	-19.45259	4.134866	0.79375	\$ Core position F2
267	C/Z	-18.167858	8.08863	0.79375	\$ Core position F3
268	C/Z	-16.08963	11.69035	0.79375	\$ Core position F4
269	C/Z	-13.292074	14.77899	0.79375	\$ Core position F5
270	C/Z	-9.9441	17.223232	0.79375	\$ Core position F6
271	C/Z	-6.14553	18.915634	0.79375	\$ Core position F7

272	C/Z	-2.078228	19.915634	0.79375	\$ Core position F8
273	C/Z	2.078228	19.915634	0.79375	\$ Core position F9
274	C/Z	6.14553	18.915634	0.79375	\$ Core position F10
275	C/Z	9.9441	17.223232	0.79375	\$ Core position F11
276	C/Z	13.292074	14.77899	0.79375	\$ Core position F12
277	C/Z	16.08963	11.69035	0.79375	\$ Core position F13
278	C/Z	18.167858	8.08863	0.79375	\$ Core position F14
279	C/Z	19.45259	4.134866	0.79375	\$ Core position F15
280	C/Z	19.8882	0.0	0.79375	\$ Core position F16
281	C/Z	19.45259	-4.134866	0.79375	\$ Core position F17
282	C/Z	18.167858	-8.08863	0.79375	\$ Core position F18
283	C/Z	16.08963	-11.69035	0.79375	\$ Core position F19
284	C/Z	13.292074	-14.77899	0.79375	\$ Core position F20
285	C/Z	9.9441	-17.223232	0.79375	\$ Core position F21
286	C/Z	6.14553	-18.915634	0.79375	\$ Core position F22
287	C/Z	2.078228	-19.915634	0.79375	\$ Core position F23
288	C/Z	-2.078338	-19.915634	0.79375	\$ Core position F24
289	C/Z	-6.14553	-18.915634	0.79375	\$ Core position F25
290	C/Z	-9.9441	-17.223232	0.79375	\$ Core position F26
291	C/Z	-13.292074	-14.77899	0.79375	\$ Core position F27
292	C/Z	-16.08963	-11.69035	0.79375	\$ Core position F28
293	C/Z	-18.167858	-8.08864	0.79375	\$ Core position F29
294	C/Z	-19.45259	-4.134866	0.79375	\$ Core position F30
1033	pz	-62.865			

c

c Control rods

c

c -----

c Control rod A1

c Dimensions from drawing T3S 250 D 136, converted from inches to cm

c

c -----

1001	cz	1.50745		\$ Exterior of B4C section
1002	cz	1.5875		\$ Interior of cladding
1003	cz	1.65862		\$ Exterior of cladding
1004	cz	0.79375		\$ exterior of top extension
1006	pz	-18.923875		\$ bottom of control rod
1008	pz	-18.288875		\$ bottom of A1 follower
1009	pz	59.181125		\$ top of poison section
1010	pz	20.446125		\$ top of A1 follower
1011	pz	21.081125		\$ bottom of poison
1012	pz	63.296125		\$ top of cladding
1013	cz	1.75655		\$ interior of CR guide

c

c -----

c Control rod D1

C Dimensions from AFRR1 TR94-1, converted from inches to cm

c -----					
1021	c/z	-11.94562	0.0	0.3175	\$ zirconium center rod
1022	c/z	-11.94562	0.0	1.42875	\$ Interior of cladding
1023	c/z	-11.94562	0.0	1.47955	\$ Exterior of cladding
1024	c/z	-11.94562	0.0	0.79375	\$ exterior of top extension
1025	c/z	-11.94562	0.0	1.37668	\$ Fuel follower exterior
1026	pz	-20.511875			\$ bottom of control rod
1027	pz	72.834125			\$ top of upper void
1028	pz	-18.606875			\$ bottom of fuel follower
1029	pz	59.181125			\$ top of poison section/bottom of poison void
1030	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1031	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1032	pz	76.974125			\$ top of cladding
1037	c/z	-11.94562	0.0	1.34874	\$ Poison section exterior
1034	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1035	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1036	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1039	c/z	-11.94562	0.0	1.60655	\$ interior of CR guide

c -----  
c Control rod D7  
C Dimensions from AFRRI TR94-1, converted from inches to cm

c -----					
1041	c/z	5.97281	10.344912	0.3175	\$ zirconium center rod
1042	c/z	5.97281	10.344912	1.42875	\$ Interior of cladding
1043	c/z	5.97281	10.344912	1.47955	\$ Exterior of cladding
1044	c/z	5.97281	10.344912	0.79375	\$ exterior of top extension
1045	c/z	5.97281	10.344912	1.37668	\$ Fuel follower exterior
1046	pz	-20.511875			\$ bottom of control rod
1047	pz	72.834125			\$ top of upper void
1048	pz	-18.606875			\$ bottom of fuel follower
1049	pz	59.181125			\$ top of poison section/bottom of poison void
1050	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1051	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1052	pz	76.974125			\$ top of cladding
1053	c/z	5.97281	10.344912	1.60655	\$ interior of CR guide
1058	c/z	5.97281	10.344912	1.34874	\$ Poison section exterior
1054	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1055	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1056	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1059	c/z	5.97281	10.344912	1.60655	\$ interior of CR guide

c -----  
c Control rod D13  
C Dimensions from AFRRI TR94-1, converted from inches to cm

c -----					
1061	c/z	5.97281	-10.344912	0.3175	\$ zirconium center rod
1062	c/z	5.97281	-10.344912	1.42875	\$ Interior of cladding

1063	c/z	5.97281	-10.344912	1.47955	\$ Exterior of cladding
1064	c/z	5.97281	-10.344912	0.79375	\$ exterior of top extension
1065	c/z	5.97281	-10.344912	1.37668	\$ Fuel follower exterior
1066	pz	-20.511875			\$ bottom of control rod
1067	pz	72.834125			\$ top of upper void
1068	pz	-18.606875			\$ bottom of fuel follower
1069	pz	59.181125			\$ top of poison section/bottom of poison void
1070	pz	18.541125			\$ top of fuel follower/bottom of fuel void
1071	pz	21.081125			\$ bottom of poison/top of lower Magnaform
1072	pz	76.974125			\$ top of cladding
1073	c/z	5.97281	-10.344912	1.60655	\$ interior of CR guide
1074	pz	19.811125			\$ top of fuel gap/bottom of lower Magnaform
1075	pz	59.499125			\$ top of poison gap/bottom of upper Magnaform
1076	pz	60.769125			\$ bottom of upper void/top of upper Magnaform
1078	c/z	5.97281	-10.344912	1.34874	\$ Poison section exterior
1079	c/z	5.97281	-10.344912	1.60655	\$ interior of CR guide
c					
53	CZ	1.92405			\$ Core position A1
73	C/Z	-11.94562	0.0	1.92405	\$ Core position D1
79	C/Z	5.97281	10.344912	1.92405	\$ Core position D7
85	C/Z	5.97281	-10.344912	1.92405	\$ Core position D13
c					
-----					
c Core shroud and support structure					
-----					
c					
1080	cz	24.28875			\$ interior of core shroud
1081	cz	24.765			\$ exterior of core shroud
1082	cz	44.1325			\$ interior of core support
1083	cz	45.72			\$ exterior of core support
1088	cz	22.70125			\$ interior of shroud support
1084	pz	-38.3375			\$ bottom of core shroud
1085	pz	40.30625			\$ top of core shroud
1087	pz	184.70625			\$ top of shroud support
-----					
c Reactor pool					
c Dimensions read manually from drawing T3B200J100					
c and converted from inches to centimeters					
-----					
500	pz	-73.66			\$ bottom of reactor pool
501	pz	116.84			\$ Projection shelf
502	pz	502.92			\$ pool water surface
503	pz	553.72			\$ reactor room floor
504	c/z	-140.97	89.662	114.3	\$ left tank wing
505	c/z	-140.97	-89.662	114.3	\$ right tank wing
506	px	-26.67			\$ tank edge--ER 2

507 px -255.27 \$ tank edge--ER 1  
 508 c/z 0.0 0.0 26.67 \$ ER 1 penetration  
 509 c/z 0.0 0.0 60.96 \$ above ER 2 penetration  
 510 c/z -281.94 0.0 26.67 \$ ER 2 penetration  
 511 c/z -281.94 0.0 60.96 \$ above ER 1 penetration  
 c  
 c surfaces 512 and 515 are the penetration walls above ER 2  
 c  
 512 p -26.67 67.31 116.84 0.0 60.96 116.84 -26.73 67.31 502.92  
 515 p -26.67 -67.31 116.84 0.0 -60.96 116.84 -26.73 -67.31 502.92  
 c  
 c surfaces 513 and 514 are the penetration walls in ER 2  
 c  
 513 p -26.73 33.02 116.84 0.0 26.67 116.84 -26.73 33.02 502.92  
 514 p -26.73 -33.02 116.84 0.0 -26.67 116.84 -26.73 -33.02 502.92  
 516 px 0.0  
 c  
 c surfaces 517 and 518 are the penetration walls in ER 1  
 c  
 517 p -255.27 33.02 116.84 -281.94 26.67 116.84 -255.27 33.02 502.92  
 518 p -255.27 -33.02 116.84 -281.94 -26.67 116.84 -255.27 -33.02 502.92  
 519 px -281.94  
 520 py 89.662  
 521 py -89.662  
 c  
 c surfaces 522 and 523 are the penetration walls above ER 1  
 c  
 522 p -255.27 67.31 116.84 -281.94 60.96 116.84 -255.27 67.31 502.92  
 523 p -255.27 -67.31 116.84 -281.94 -60.96 116.84 -255.27 -67.31 502.92  
 c -----  
 c Reactor tank lining  
 c thicknesses from Safety Analysis Report, dated January 2000  
 c bottom and tank shelf thickness .5 inch (1.27 cm)  
 c Exposure room protusion thickness .25 inch (0.635 cm)  
 c Other tank wall thickness .375 inch (0.9525 cm)  
 c -----  
 550 pz -74.93 \$ bottom of reactor pool  
 551 pz 115.57 \$ Projection shelf  
 552 c/z -140.97 89.662 115.2525 \$ left tank wing  
 553 c/z -140.97 -89.662 115.2525 \$ right tank wing  
 554 px -25.7175 \$ tank edge--ER 2  
 555 px -256.2225 \$ tank edge--ER 1  
 556 c/z 0.0 0.0 27.305 \$ ER 1 penetration  
 557 c/z 0.0 0.0 61.595 \$ above ER 1 penetration  
 558 c/z -281.94 0.0 27.305 \$ ER 2 penetration  
 559 c/z -281.94 0.0 61.595 \$ above ER 2 penetration

c  
c surfaces 562 and 563 are the penetration walls in ER 2  
c  
562 p -26.67 33.665 115.2525 0.0 27.3 115.2525 -26.67 33.655 -74.93  
563 p -26.67 -33.665 115.2525 0.0 -27.3 115.2525 -26.67 -33.655 -74.93  
c  
c surfaces 564 and 565 are the penetration walls in ER 1  
c  
564 p -255.27 33.665 115.2525 -281.94 27.3 115.2525 -255.27 33.655 -74.93  
565 p -255.27 -33.665 115.2525 -281.94 -27.3 115.2525 -255.27 -33.655 -74.93  
c  
c surfaces 566 and 567 are the penetration walls above ER 2  
c  
566 p -26.67 67.945 116.84 0.0 61.595 116.84 -26.67 67.945 502.92  
567 p -26.67 -67.945 116.84 0.0 -61.595 116.84 -26.67 -67.945 502.92  
c  
c surfaces 568 and 569 are the penetration walls above ER 1  
c  
568 p -255.27 67.945 116.84 -281.94 61.595 116.84 -255.27 67.945 502.92  
569 p -255.27 -67.945 116.84 -281.94 -61.595 116.84 -255.27 -67.945 502.92  
c  
c -----  
c Exposure room 1  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Exposure room walls  
c -----  
c Surface 555 forms wall of exposure room  
601 px -926.7825 \$ wall furthest from reactor pool  
602 py 335.28 \$ left wall  
603 py -335.28 \$ right wall  
604 pz -153.035 \$ exposure room floor  
605 pz 187.96 \$ exposure room ceiling  
c -----  
c Wood lining of exposure room  
c -----  
610 px -286.7025 \$ wall nearest reactor pool  
611 px -896.3025 \$ wall furthest from reactor pool  
612 py 304.8 \$ left wall  
613 py -304.8 \$ right wall  
614 pz -122.555 \$ exposure room floor  
615 pz 147.32 \$ exposure room ceiling  
c -----

c masonite lining of exposure room  
c -----  
620 px -287.3375 \$ wall nearest reactor pool  
621 px -895.6675 \$ wall furthest from reactor pool  
622 py 304.165 \$ left wall  
623 py -304.165 \$ right wall  
624 pz -121.92 \$ exposure room floor  
625 pz 146.685 \$ exposure room ceiling  
c -----  
630 pz 177.8 \$ bottom of ceiling air gap  
c  
c -----  
c Exposure room 2  
c -----  
c  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Exposure room walls  
c -----  
c Surface 554 defines exterior wall of exposure room 2  
651 px 401.0025 \$ wall furthest from reactor pool  
652 py 228.6 \$ right wall  
653 py -228.6 \$ left wall  
654 pz -112.395 \$ exposure room floor  
655 pz 193.04 \$ exposure room ceiling  
c -----  
c Wood lining of exposure room  
c -----  
660 px 4.7625 \$ wall nearest reactor pool  
661 px 370.5225 \$ wall furthest from reactor pool  
662 py 198.12 \$ right wall  
663 py -198.12 \$ left wall  
664 pz -81.915 \$ exposure room floor  
665 pz 162.56 \$ exposure room ceiling  
c -----  
c masonite lining of exposure room  
c -----  
670 px 5.3975 \$ wall nearest reactor pool  
671 px 369.8875 \$ wall furthest from reactor pool  
672 py 197.485 \$ right wall  
673 py -197.485 \$ left wall  
674 pz -81.28 \$ exposure room floor  
675 pz 161.925 \$ exposure room ceiling

c -----  
c Concrete surrounding the reactor pool and exposure rooms  
C -----  
c Dimensions from Safety Analysis Report January 2000  
c and "Plan Exposure Room Level" sheet S-1, July 1960  
c dimensions converted from feet/inches to centimeters  
C -----  
c Dimensions are approximations. Actual region surrounding the reactor  
c varies from floor to floor of the facility and is a combination of  
c concrete and backfilled soil  
c -----  
800 pz -334.01 \$ soil surface  
802 px -972.5025 \$ beyond ER 1  
803 px 695.6425 \$ beyond ER 2  
804 py 599.12 \$ right of ER 1  
805 py -721.04 \$ left of ER 1  
806 py -502.92 \$ right of ER 2  
807 py 350.52 \$ left of ER 2  
850 px -140.97  
c -----  
c Core exposure tube  
c -----  
c Located at Core position E-23  
c -----  
851 C/Z -13.78208 -7.95782 1.814  
c -----  
c Surfaces to define volumes for mouse phantoms  
c -----  
c  
2001 pz 3.81  
2002 pz -3.81  
2003 c/z 50.0 0 1.27  
2004 c/z 100.0 0 1.27  
2005 c/z 150.0 0 1.27  
2006 c/z 200.0 0 1.27  
2007 c/z 250.0 0 1.27  
2008 c/z 300.0 0 1.27  
2009 c/z 350.0 0 1.27  
c -----  
C Data cards  
c -----  
C Material cards

```

c -----
c
C   Material 1 is Zirconium
c
m1  40000.60c  0.99994  $ Zr
    72000.60c  0.00006  $ Hf
c
C   Material 2 is the UZrH fuel
c
m2  1001.60    0.05859804 $ H    0.05859804
    6000.60c   0.00148274 $ O    0.00148274
    40000.60   0.03555136 $ Zr   0.03555136
    92234.61c  0.00000192 $ U-234 0.00000192
    92235.61c  0.00025605 $ U-235 0.00025605
    92236.61c  0.00000283 $ U-236 0.00000283
    92238.61c  0.00100676 $ U-238 0.00100676
    72000.60c  2.1330816e-6 $ Hf   2.1330816e-6
mt2  h/zr.60t zr/h.60t
c
C   Material 3 is the Samarium/aluminum burnable poison wafer
c   1% wt of Samarium, per Volkov, et al, 1960
c
m3  13027.60c  0.99    $ Al
    62147.66c  0.004312 $ Sm-247
    62149.66c  0.004312 $ Sm-149
    8016.60c   0.001376 $ O
c
C   Material 4 is the Carbon reflector layer
c
m4  6000.60c  1      $ C
mt4  grph.60t
c
C   Material 5 is the stainless steel 304 cladding
c
m5  24050.60  0.000778  $ Cr-50
    24052.60  0.015003  $ Cr-52
    24053.60  0.001701  $ Cr-53
    26056.60  0.05673   $ Fe-56
    28058.60  0.007939   $ Ni
    25055.60  0.001697   $ Mn
c
C   Material 6 is boron carbide
c
m6  5010.60c  0.02095  $ B-10
    5011.60c  0.08431  $ B-11
    6000.60c  0.02632  $ C

```

c  
C Material m7 is 6061 aluminum alloy  
c  
m7 13027.60c 0.058693 \$ Al-27  
26056.60c 0.000502 \$ Fe-56  
c  
c Material m8 is water  
c  
m8 1001.60c -0.111894 \$ H  
8016.60c -0.888106 \$ O  
mt8 lwtr.60t  
c  
c Material m9 is air  
c  
m9 6000.60c -0.000124 \$ C  
7014.60c -0.755268 \$ N  
8016.60c -0.231781 \$ O  
18000.35d -0.012827 \$ Ar  
c  
c Material m10 is the fuel in the fuel follower control rods  
c  
m10 1001.60 0.05777811 \$ H  
6000.60c 0.00152383 \$ C  
40000.60 0.03511576 \$ Sm  
92234.61c 0.00000198 \$ U-234  
92235.61c 0.00037003 \$ U-235  
92236.61c 0.00000290 \$ U-236  
92238.61c 0.00147347 \$ U-238  
72000.60c 2.1069456e-6 \$ Hf  
mt10 h/zr.60t  
zr/h.60t  
c  
c Material m11 is wood (pine)  
c  
m11 1001.60c 0.476191 \$ H  
6000.60c 0.285714 \$ C  
8016.60c 0.238095 \$ O-16  
c  
c Material m12 is masonite/gadolinium  
c  
m12 1001 0.47144526 \$ H  
6000 0.28284630 \$ C  
8016 0.23570844 \$ O-16  
64000 0.01 \$ Gd  
c  
c material 13 is ORNL composition concrete

c  
m13 1001 0.00453 \$ H-1  
8016 0.5126 \$ O-16  
11023 0.01527 \$ Na-23  
13027 0.03555 \$ Al-27  
14000 0.36036 \$ Si  
20000 0.05791 \$ Ca  
26000 0.01378 \$ Fe

c  
c material 14 is Lucite

c  
m14 1001 -0.080538 \$ H-1  
6000 -0.599848 \$ C  
8016 -0.319614 \$ O-16

c  
C -----  
Criticality control cards

c  
Kcode 20000 1.0 50 500

c  
c -----  
c No source in A-1, E-23, or F-9  
c sources in D-1, D-7, and D-13 offset to ensure they remain in active  
c fuel region regardless of Control Rod position (below 37 cm inserted)

c  
Ksrc -----  
-3.23559 0.0 0.0 -1.20867 3.510534 0.0  
2.84517 3.510534 0.0 4.87209 0.0 0.0  
2.84517 -3.510534 0.0 -1.20867 -3.510534 0.0  
-7.16243 0.0 0.0 -6.09309 3.99034 0.0  
-3.17209 6.91134 0.0 0.81825 7.98068 0.0  
4.80859 6.91134 0.0 7.72959 3.99034 0.0  
8.79893 0.0 0.0 7.72959 -3.99034 0.0  
4.80859 -6.91134 0.0 0.81825 -7.98068 0.0  
-3.17209 -6.91134 0.0 -6.09309 -3.99034 0.0  
-10.40703 4.085336 0.0 -8.3321 7.678736 0.0  
-5.15456 10.344912 0.0 -1.255406 11.76401 0.0  
2.891906 11.76401 0.0 9.9686 7.678674 0.0  
12.043526 4.085336 0.0 12.76387 0.0 0.0  
12.043526 -4.085336 0.0 9.9686 -7.678674 0.0  
2.89191 -11.76401 0.0 -1.25541 -11.76401 0.0  
-5.15456 -10.344912 0.0 -8.3321 -7.678674 0.0  
-10.40703 -4.085336 0.0 -15.09739 0.0 0.0  
-14.554592 4.118864 0.0 -12.964552 7.95782 0.0  
-10.435728 11.253978 0.0 -7.13957 13.782802 0.0  
-3.300614 15.372842 0.0 0.81825 15.91564 0.0  
4.937114 15.372842 0.0 8.77607 13.782802 0.0  
12.07223 11.253978 0.0 14.601052 7.95782 0.0

```

16.191092  4.118864  0.0  16.73389  0.0  0.0
15.191092 -4.118864  0.0  14.600332 -7.95782  0.0
12.072228 -11.253978 0.0  8.77607 -13.782802 0.0
4.937114 -15.372842 0.0  0.81825 -15.91564 0.0
-3.300614 -15.372842 0.0 -7.13957 -13.782802 0.0
-10.43573 -11.25398 0.0 -14.554592 -4.118864 0.0
-19.06995  0.0  0.0 -18.63434  4.134866 0.0
-17.349608 8.08863 0.0 -15.27138 11.69035 0.0
-12.473824 14.77899 0.0 -9.12585 17.223232 0.0
-5.32728 18.915634 0.0 -1.259978 19.915634 0.0
6.96378 18.915634 0.0 10.76235 17.223232 0.0
14.110324 14.77899 0.0 16.90788 11.69035 0.0
18.986108 8.08863 0.0 20.27084 4.134866 0.0
20.70645 0.0 0.0 20.27084 -4.134866 0.0
18.986108 -8.08863 0.0 16.090788 -11.69035 0.0
14.110324 -14.77899 0.0 10.76235 -17.223232 0.0
6.96378 -18.915634 0.0 2.896478 -19.915634 0.0
-21.259978 -19.915634 0.0 -5.32728 -18.915634 0.0
-9.12585 -17.223232 0.0 -12.473824 -14.77899 0.0
-15.27138 -11.69035 0.0 -17.349608 -8.08864 0.0
-18.63434 -4.134866 0.0
-11.12737 0.0 -17.0 6.79106 10.344912 -17.0
6.79106 -10.344912 -17.0

```

mode n p

phys:p

```

F14:n 2001
F24:p 2001
F34:n 2002
F44:p 2002
F54:n 2003
F64:p 2003
F74:n 2004
F84:p 2004
F94:n 2005
F104:p 2005
F114:n 2006
F124:p 2006
F134:n 2007
F144:p 2007
F154:n 2001
F164:p 2001
F174:n 2002
F184:p 2002
e14 1e-12 200i 2.5 $ energy bins
e24 1e-10 200i 20.0 $ energy bins
e34 1e-12 200i 2.5 $ energy bins

```

e44 1e-10 200i 20.0 \$ energy bins  
print

## Glossary

**AFRRI**—Armed Forces Radiobiology Research Institute

**CT**—Computerized Tomography

**ENDF**—Evaluated Nuclear Data File

**FSAR**—Final Safety Analysis Report

**MCNP**—Monte Carlo N-Particle

**MCNPX**—Monte Carlo N-Particle Extended

**MRI**—Magnetic Resonance Imaging

**NCTRIGA**—Natural Convection Thermal-hydraulics - **TRIGA** pins

**TORT**—Three Dimensional Oak Ridge Discrete Ordinates Neutron/Photon  
Transport Code

**TRIGA**—Training, Research, Isotope production, General Atomic

**VISED**—VISual EDitor

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