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Title: DEVELOPMENT OF SYSTEMS ANALYSIS PROGRAM FOR SPACE REACTOR STUDIES

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An overall systems design code was developed to model an advanced in-core thermionic energy conversion based nuclear reactor system for space applications at power levels of 10 to 50 kWe. The purpose of this work was to provide the overall shell for the systems code and to also provide the detailed neutronic analysis section of the code. The design code that was developed is to be used to evaluate a reactor system based upon a single cell thermionic fuel element which uses advanced technology to enhance the performance of single cell thermionic fuel elements.

A literature survey provided information concerning how other organizations performed system studies on similar space reactor designs.

DEVELOPMENT OF SYSTEMS ANALYSIS PROGRAM FOR SPACE REACTOR STUDIES

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DEVELOPMENT OF SYSTEMS ANALYSIS PROGRAM FOR SPACE REACTOR STUDIES

I. INTRODUCTION

An overall systems design code was developed to model an advanced in-core thermionic energy conversion based nuclear reactor system for space applications at power levels of 10 to 50 kWe. In the U.S., the Thermionic Fuel Element Verification Program [Samuelson 1990] has been highly successful in developing a feasible and reliable system for use in high power space applications using a multi-cell arrangement. In the Soviet Union, the 10 kWe single cell in-core thermionic reactor units (TOPAZ) have undergone extensive development, including space-based testing of two units [Wetch 1990]. The design code that was developed is to be used to evaluate a reactor system based upon a single cell thermionic fuel element which uses advanced technology to enhance the performance of single cell thermionic fuel elements.

II. SPACE REACTOR ANALYSIS OVERVIEW

2.1 Advanced Thermionic Initiative Reactor

The Advanced Thermionic Initiative (ATI) Reactor is a design in the research stage of development by the U.S. Air Force. There are several efforts underway to establish new or advanced technical concepts for application in the ATI reactor. The work at OSU is intended to provide a tool that

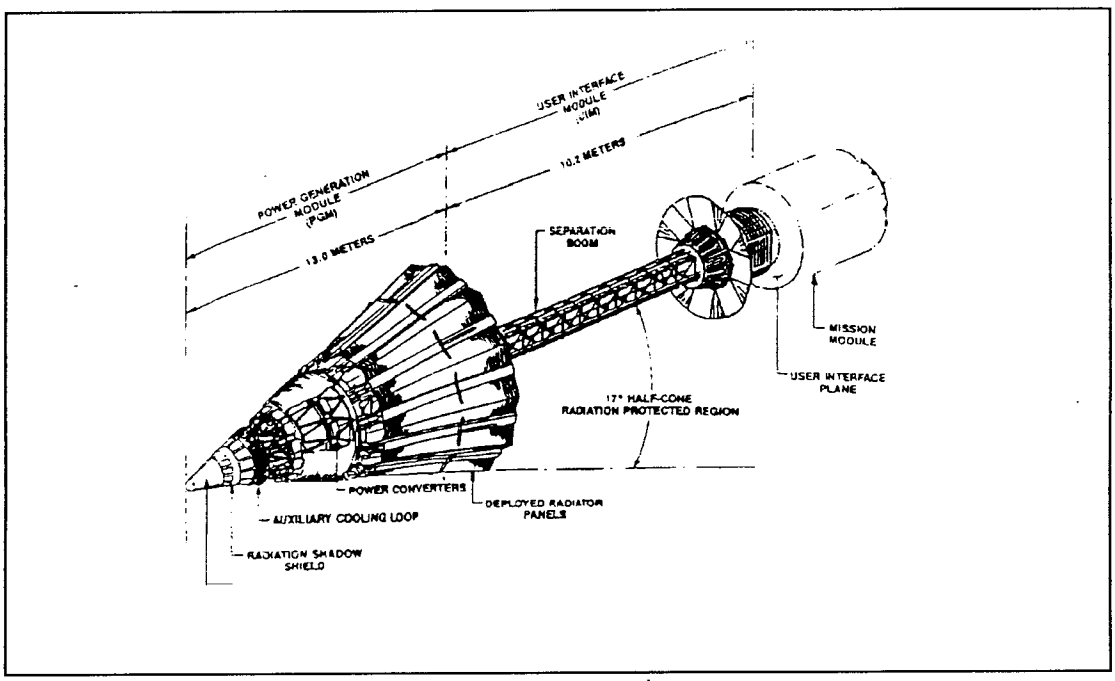

Figure 1 Deployed Space Reactor View

allows the user to bring together the results of the various research efforts to assess their impact on the overall system performance.

An overall view of a deployed space reactor is provided in Figure 1 [Truscello]. The small cone at the far left of

the view is the structure that holds reactor and the radiation shield. The shield between the reactor and the payload protects the payload from radiation damage. In addition, the boom between the reactor and the payload provides the distance necessary to reduce the radiation at the payload and the requirement for the shield thickness.

The reactor core is made up of Thermionic Fuel Elements (TFEs), along with their coolant channels that are equally spaced in a hexagonal pattern throughout a zirconium hydride cylindrical block. The zirconium hydride block provides the moderating material which makes this a relatively thermalized reactor. A cross sectional view of the core midplane shown in Figure 2. The core is surrounded on the sides by a reflector material (BeO or Be) to decrease the critical core size by decreasing neutron leakage. The top

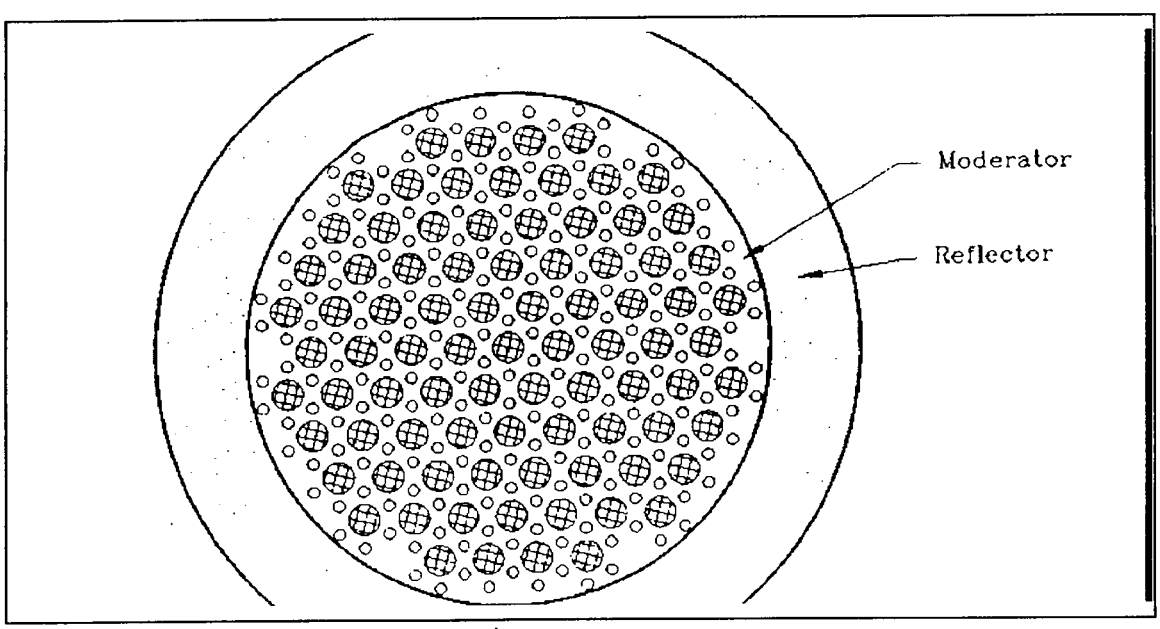

Figure 2 ATI Horizontal View

and bottom are surrounded by as much reflector material as the design will allow considering the electrical connections with the TFEs.

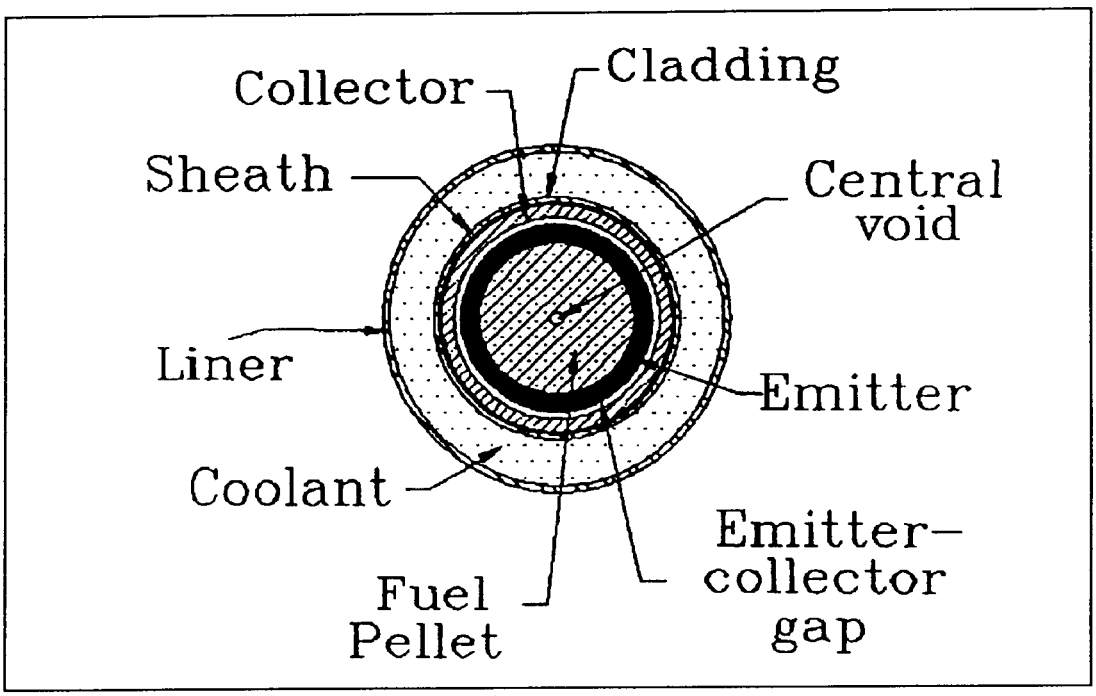

Figure 3 TFE Horizontal View

A cross sectional view of a single cell thermionic fuel element (TFE) with its coolant channel is shown in Figure 3. The TFE consists of:

1. a central void to remove fission gas products
2. uranium oxide fuel to generate heat
3. emitter material made of tungsten which emits electrons
4. emitter/collector gap filled with cesium vapor for electron transport
5. collector material made of molybdenum or tungsten to collect the electrons
6. insulator sheath made of diamond or Al^2O^3 to electrically insulate the collector
7. cladding made of Kovar

8. coolant channel with NaK coolant
9. a liner made of stainless steel that contains the TFE's coolant channel within the overall core material

Considering the low power levels for which the reactor will be designed, another important variable that is part of the design analysis is the potential addition of driver fuel elements. Driver fuel elements are small fuel rods without the thermionic capabilities and hence without the extra non-fissionable material. The use of driver fuel elements can enable smaller reactor designs to be critical where, if the reactor was only made of TFEs designed to run at full power, it would not attain criticality. There is also the option of using enough TFEs to obtain criticality and then downrating the required electrical power from each TFE to obtain the desired total core power.

2.2 The Thermionic Process

In order to develop a system analysis capability, one first needs to understand the purpose and mechanisms within the system to comprehend the required parametric studies that will be required of the final product. Therefore a detailed examination of the thermionic process will be necessary.

Thermionic converters are devices that directly convert heat into electricity without moving parts. As illustrated in Figure 4, electrons are thermionically emitted from a hot

metallic electrode, called the emitter, traverse a gap, and then enter a cooler metallic electrode, called the collector. The voltage developed between the two electrodes causes the electrons to flow through an electrical impedance external to the thermionic converter, delivering electrical power to the load.

Thermodynamically, thermionic converters are heat engines in which electrons are the working fluid. As such, the electrons also transport heat from the emitter to the collector and thus heat must be rejected to a coolant.

Temperature profiles typical of converters on which extensive testing has been conducted are shown in Figure 5. The collector and emitter temperatures are chosen to optimize overall system performance. Since the energy conversion efficiency increases with increasing emitter temperature, T_E, it is chosen to be as high as practical,

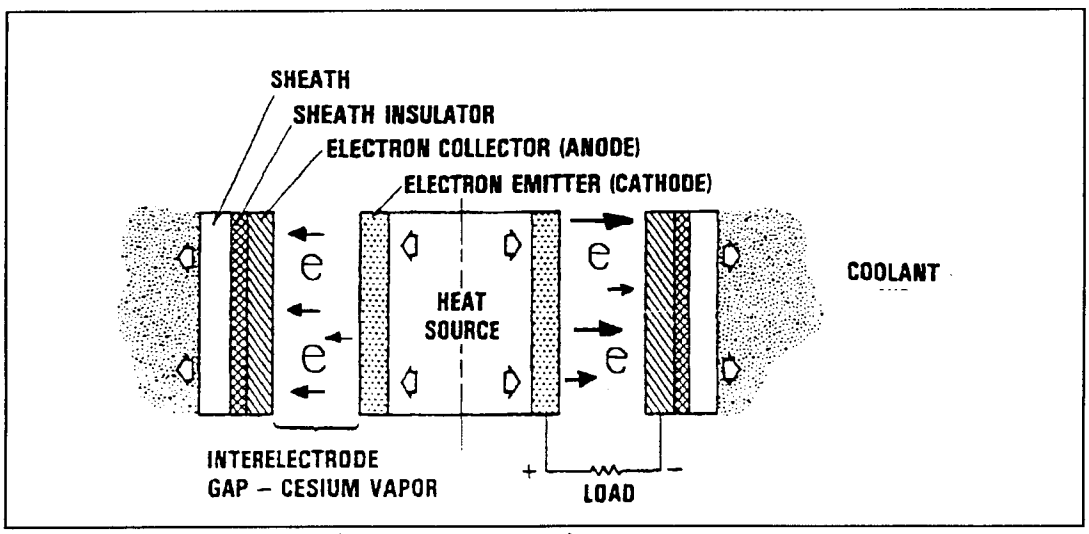

Figure 4 Thermionic Process Diagram

consistent with the properties of the heater and emitter materials, and the desired lifetime for the device operation. For long term operation the range of practicality for T_E is 1600 to 2000 K. If the heat source is a nuclear fuel, the peak temperature occurs in the center of the fuel pellet, and is about 700 K hotter than the emitter. The collector temperature, T_C, has a strong influence on the space system heat-rejection-radiator mass and size. The lower the collector temperature, the higher the thermionic efficiency, as well as the heavier the radiator. This is because the radiator, which operates at approximately the collector temperature, rejects heat via radiation. This heat removal rate increases as a function of T^4. Therefore, the higher the collector temperature, the smaller the space radiator needed to remove the same amount of waste heat. The balance usually optimizes at about 1000 to 1100 K, or the highest possible value consistent with high conversion efficiency.[Angrist] Note that all components of the power system except the fuel and emitter

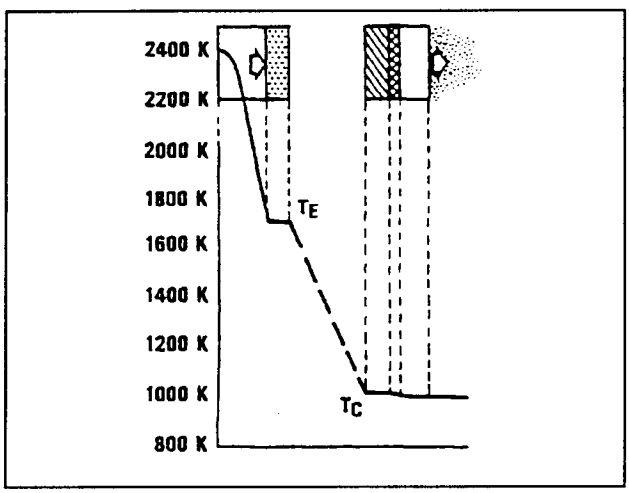

Figure 5 Typical Temperature Profile

operate at temperatures at or below the collector temperature.

A typical current-voltage characteristic of a thermionic converter and a motive diagram showing the electron potentials within the thermionic converter are shown in Figure 6 (a). In this example 0.6 volt is produced by the converter electrodes. This potential is created by the difference between the emitter and collector work functions (Φ_E, Φ_C) and the various efficiency loss mechanisms in the real-life application of the thermionic process. One function of the cesium is the creation of ionized cesium plasma (neutral plasma) that allows the electrons to traverse the gap without having to overcome an electronic space charge that would otherwise exist. This occurs when the energy dissipated internally in the

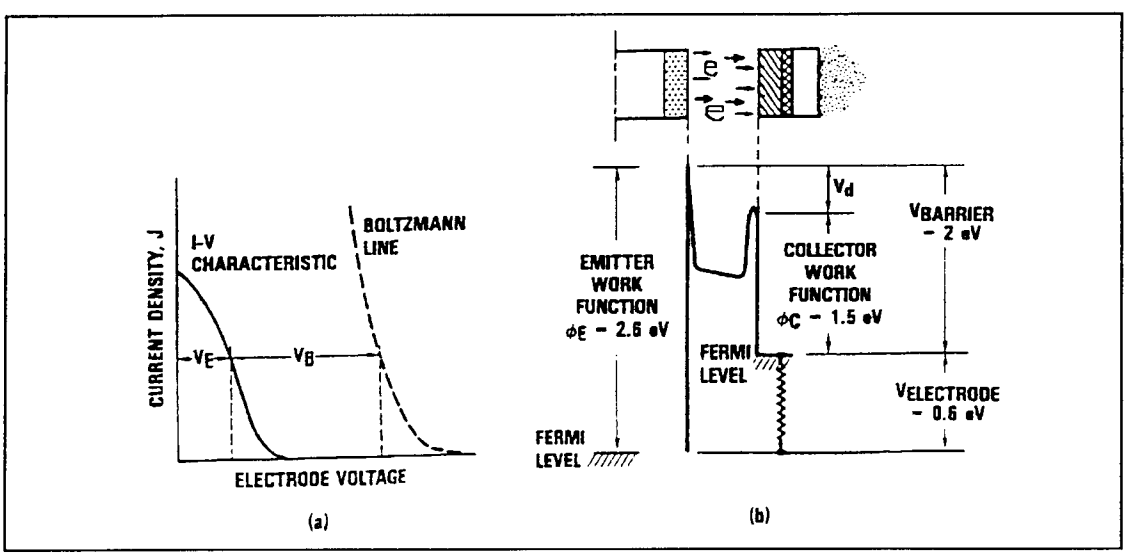

Figure 6 Thermionic Process Diagrams

interelectrode gas by collisional processes heats the electrons in the gas to a sufficiently high temperature so that the ionized gas maintains a neutral plasma. If a neutral plasma did not exist, then the barrier for the electrons to leave the emitter would be significantly higher (i.e. electrons in the plasma would create a negative charge, repelling further ingress of electrons). The neutral plasma state is referred to as the ignited mode of the thermionic device, and the remaining discussion of the thermionic process will be limited to the ignited mode. If outside of this condition (i.e. the temperature difference , T_E-T_C, is not high enough to ignite the plasma) the thermionic efficiencies are significantly lower than in the ignited mode operation. This is part of the difficulty of operating single-cell TFEs, because the longer the cell the more difficult it is to maintain an ignited mode of operation along the entire length. There are several transition regions and changing mechanisms involved in the various stages of the thermionic process. The most desired mode is the ignited case and the goal is to maintain the process in this mode, therefore the remaining discussion is limited to ignited mode processes.

To be moved from the emitter into the gap, an electron must overcome the energy barrier known as the emitter work function(Φ_E). A similar barrier, V_B, exists on the collector. This voltage barrier consists of the collector

work function (Φ_C), and the arc drop, V_D, required to generate a cesium plasma. Returning to the motive diagram, the output voltage of the electrodes, V_E, is

$$V_E = \Phi_E - V_B$$

$$\text{where} \quad V_B = \Phi_C + V_D$$

The electrical power produced per centimeter of electrode length, P_E , is

$$P_E = J\ V_E$$

where J, the net current density in A/cm^2 from the emitter to the collector, is calculated using statistical electron theory. This is done using the Richardson/Dushman equation

$$J = AT_E^2 \exp(-(V_E+V_B)/kT_E),$$

where A=120 A/cm^2-K^2, and k=(11,600)$^{-1}$eV/K is the Boltzmann constant divided by the electronic charge. As V_B goes to zero, the maximum efficiency, shown as the Boltzmann Line in Figure 6 (a), is obtained.

The total heat that must be supplied to the emitter is

$$q_E = q_{ec} + q_r + q_{el},$$

where q_{ec}= emitter electron cooling = $J(\Phi_E + 2kT_E)$

q_r = heat removed by radiation = $\sigma\mathcal{E}(T_E^4 - T_C^4)$

q_{el} = heat conducted down the emitter lead

σ = 5.67*10^{-12} W/cm^{2}K^4 = Stefan-Boltzmann constant, and

$\mathcal{E}$ = net thermal emissivity of the electrode system,

$\approx$ 0.1 - 0.2.

The energy conversion efficiency is, therefore,

$$\eta = JV_E/q_E = P/Q$$

The preceding thermionic discussion is a top level view of the process that was reviewed to help understand the required parametric study capability requirements. Another thermionic performance characteristic that will be of concern is the losses in efficiency due to ohmic losses that the electrons experience traveling the length of the TFE and the electronic leads attached to the TFEs. These losses are important factors that regulate the optimization of the length of the TFEs.

2.3 System Model Requirements

The system analysis program is to be used to verify the design and to conduct detailed parametric studies on a system wide basis. The requirements of the systems analysis program are:

1. Evaluate core criticality and power distribution.
2. Interfacing with a power conversion code to determine thermionic performance.
3. Radiation shielding analysis.
4. Heat rejection system calculations.

An overall system program was developed that could manage all of the system variables and feed the appropriate variables to system modules that perform specific calculations. This interrelationship is depicted in Figure

7. The specific modules that were planned included neutronic, thermionic/thermal performance, shielding analysis, and heat rejection performance. The results from these modules would need to be shared and fed back into the overall description. Once the systems analysis program was operational, the program would be used for parametric studies.

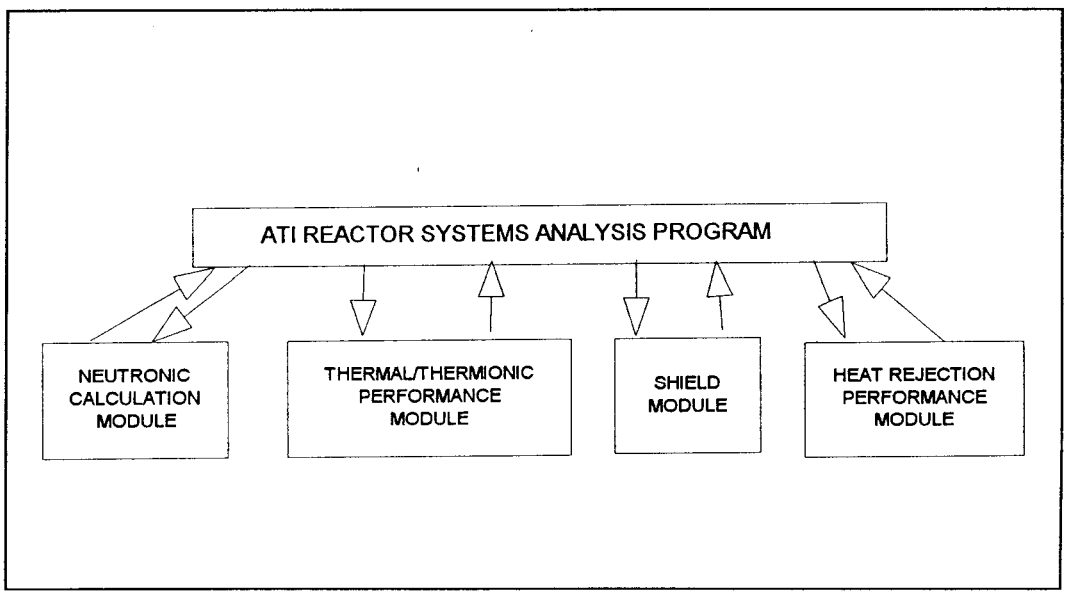

Figure 7 Systems Code Interactions

2.4 Neutronic Model Requirements

The nuclear analysis module was required to perform a variety of nuclear design calculations. Foremost is an accurate determination of k effective. The k effective calculation should also be able to model launch configurations. This includes the adequate shutdown margin calculations for normal configurations, water immersion,

water flooding, and sand burial. Industry standard neutron transport codes were required to obtain reasonable accuracy.

In the effort to develop the neutronic module, a list of the input parameters that would need to be accessible for parametric studies and a list of output variables was determined. The resulting list is shown in Table 1. The system program will likely require additional parameters, but an effort was made to include all the reactor parameters that would be needed for the neutronic calculations as well as the other modules in the program.

Table 1 Neutronic Model Input/Output List

ATI Reactor Parameters	Neutron-ic	Thermal/ thermion ic	Shield	Heat reject-ion
Core				
pitch/diameter ratio	input			
radius	input		*	
height				
fueled region	input		*	
rod top	input		*	
moderator material	input		*	
Radial reflector				
radius	input		*	
height	input		*	
material	input		*	
Top reflector				
radius	input		*	
height	input		*	
material	input		*	
# TFEs	output	*		
# Driver rods	output	*		

* expected shared variable for module not yet developed

Table 1 Neutronic Model Input/Output List (cont.)

ATI Reactor Parameters	Neutron-ic	Thermal/ thermion ic	Shield	Heat reject-ion
Thermionic Fuel Element (for each rod in the core)				
void radius	input	*		
fuel radius/material/temp	input	*		
emitter radius/material/temp	input	*		
gap radius/material/temp	input	*		
collector radius/material/temp	input	*		
sheath radius/material/temp	input	*		
cladding radius/material/temp	input	*		
coolant radius/material/temp	input	*		
liner radius/material/temp	input	*		
Driver Rod (for each rod in the core)				
fuel radius/material/temp	input	*		
gap radius/material/temp	input	*		
cladding radius/material/temp	input	*		
coolant radius/material/temp	input	*		
liner radius/material/temp	input	*		
Region Outside Reactor material/temp	input			
Material (for all materials)				
atomic number (specify isotopes)	input			
density	input			
K effective	output			
Reactor mass	output		*	
U235 mass	output			
% heat generated in each rod	output	*		*
% heat TFEs/total heat	output	*		*

* expected shared variable for module not yet developed

III. REVIEW OF LITERATURE

An investigation was made of how other attempts at this type of system analysis have been accomplished in the past. The investigation centered on the neutronic analysis requirements with the overall system program interactions as a secondary concern.

3.1 RSMASS

A simple mathematical model (RSMASS) has been developed to provide rapid estimates of reactor and shield masses for space-based reactor power systems [Marshal 1986]. Approximations were used rather than correlations or detailed calculations to estimate the reactor fuel mass and the masses of the moderator, structure, reflector, pressure vessel, miscellaneous components, and the reactor shield. The fuel mass is determined either by neutronic limits, specific power limits, or fuel burnup limits--whichever yields the largest mass.

RSMASS requires the reactor power and energy, 24 reactor parameters, and 20 shield parameters to be specified. This parametric approach is intended to provide mass estimates for a very broad range of reactor types.

It was determined not to apply the same type of calculations to the system analysis program under development in this project. The desired sensitivity studies that are needed could not be achieved with the few

parameters that are input to this type of program. In addition, the results would be highly questionable outside the range for which the formulas would apply.

3.2 Development of a Thermionic Reactor Space Power System

Development of a Thermionic Reactor Space Power System is a report summarizing 17 months of effort conducted in the early 1970's on the design of an in-core thermionic reactor system [General Atomic, 1973]. The method used in this study was to analyze four reference designs in detail in order to develop the data to observe parametric trends.

For most of the calculations, an 11 broad group structure was used for neutron cross sections. Some adjustment of the energy groups was made to adequately treat the various types of reactions in the resolved and unresolved resonance range and in the fission source range. The general procedure followed was to run separate neutron cross section group development code for the core region and the radial reflector. As stated in the report, "None of the resonance absorption treatments presently available in the GGC-5 are adequate to treat the core region lattice. ... In the calculations actually done, most of this complexity was necessarily ignored." The two-dimensional calculations were done in r-z and r-θ geometry. Because of the limitations of computer memory and budget, only portions of the reactor core were represented in various models. The models

developed had to be analyzed and modified on an individual basis for each parameter change in order to determine if the current model was actually sensitive to the parameter being examined.

It was determined that this work performed a similar level of detail as the ATI system program developed for this project, but a substantial amount of work and various models of each specific core that had to be created for each parametric study. Therefore using similar analysis techniques would not be used in this project.

3.3 SP-100 Reactor and Shield Design

The COROPT-S [Deane 1992] code was the primary tool used to investigate the mass impact of the initial design options for the SP-100 reactor system. The code has modules that determine the size and evaluate the key design limiting performance characteristics of the major components of the reactor, shield, primary heat transport and reactor instrumentation and control subsystems. The code provides initial design definition data that meet the specified design requirements and constraints. Selected variables, which have been defined to be independent, may be floated during an optimization run to determine the minimum mass system. Some system level interface parameters, such as mass flow rate and the secondary side pressure drop are held constant as are system-level parameters such as cone angle

and power level. These parameters are optimized in a sensitivity mode by manual iteration with a computer code which performs the heat balance for the system. Additional coding includes: 1) a code which was used for the nuclear assembly test fuel pin design review analysis, 2) a model for the radial reflector, and 3) an integrated reactor and shield neutronics model. The code used for the fuel pin design review includes the nitrogen balance model, helium generation in the UN due to neutron absorption in the nitrogen, and fission gas release and swelling models which have been calibrated to the available SP-100 fuel test data. The neutronics-model uses a one neutron group and one gamma diffusion group approximation to improve the capability to perform trade-offs between the reactor and shield subsystems. Verification and calibration of the one group model were done using MCNP for k effective and TWODANT for the shield.

IV. NEUTRONIC ANALYSIS

There are several methods that are available for this type of analysis. A review of these methods revealed that in many of the codes there were assumptions made in the development stages. These assumptions were required to enable the codes to run in reasonable amounts of time, given the computer capabilities during development (the 1960's or earlier). This causes concern, for it was difficult to identify when one is outside the bounds imposed by assumptions made during the development stage of the programs. A reasonable question to ask is if these limitations in computer capabilities still exist and do they need to be accounted for in the current system code development. Given the increase in the speed of computers and the reduction in cost of these machines, the first approach taken in this project is the brute force method.

The brute force method is the Monte Carlo Neutron and Photon Transport Code (MCNP) developed at Los Alamos National Lab [RSIC]. This code was originally designed to run on Cray computer systems and is written in FORTRAN. MCNP has since been downloaded and compiled on personal computers at Oregon State University. This enables MCNP to be incorporated into a systems code.

4.1 General MCNP Information

Monte Carlo methods are very different from deterministic transport methods. Deterministic methods, the most common of which is the discrete ordinates method, solve the transport equation for the average particle behavior. By contrast, Monte Carlo does not solve an explicit equation, but rather obtains answers by simulating individual particles and recording some aspects (called tallies) of their average behavior. The average behavior of particles in the physical system is then inferred (using the central limit theorem) from the average behavior of the simulated particles. Not only are Monte Carlo and deterministic methods very different ways of solving a problem, even what constitutes a solution is different. Deterministic methods typically give fairly complete information, whereas Monte Carlo supplies information only about specific tallies requested by the user.

Monte Carlo methods can be used to theoretically duplicate a statistical process (such as the interaction of nuclear particles with materials) and is particularly useful for complex problems that cannot be modeled by computer codes of deterministic methods. The individual probabilistic events that comprise a process are simulated sequentially, and the probability distributions governing these events are statistically sampled to describe the total phenomenon. The statistical sampling process is based on

the selection of random numbers - analogous to throwing dice in a gambling casino - hence the name "Monte Carlo'. In particle transport, it consists of actually following each of many particles from a source throughout its life to its death in some terminal category (absorption, escape, etc.). Probability distributions are randomly sampled from the transport data to determine the outcome of each step of its life [MCNP manual]. This is depicted in Figure 8, which shows a sample of the path of a neutron through a medium. The following numbered statements refer to the interaction at that number's location in Figure 8.

1. Neutron scatter, photon production
2. Photon capture
3. Fission, photon production
4. Neutron leakage
5. Neutron capture
6. Photon scatter
7. Photon leakage

In the above example, each of the interactions would be added to the tally, assuming the user had requested the code to gather these reactions in a tally bin for that type of interaction. If enough source particles are introduced into the model, the tallies will describe the average behavior

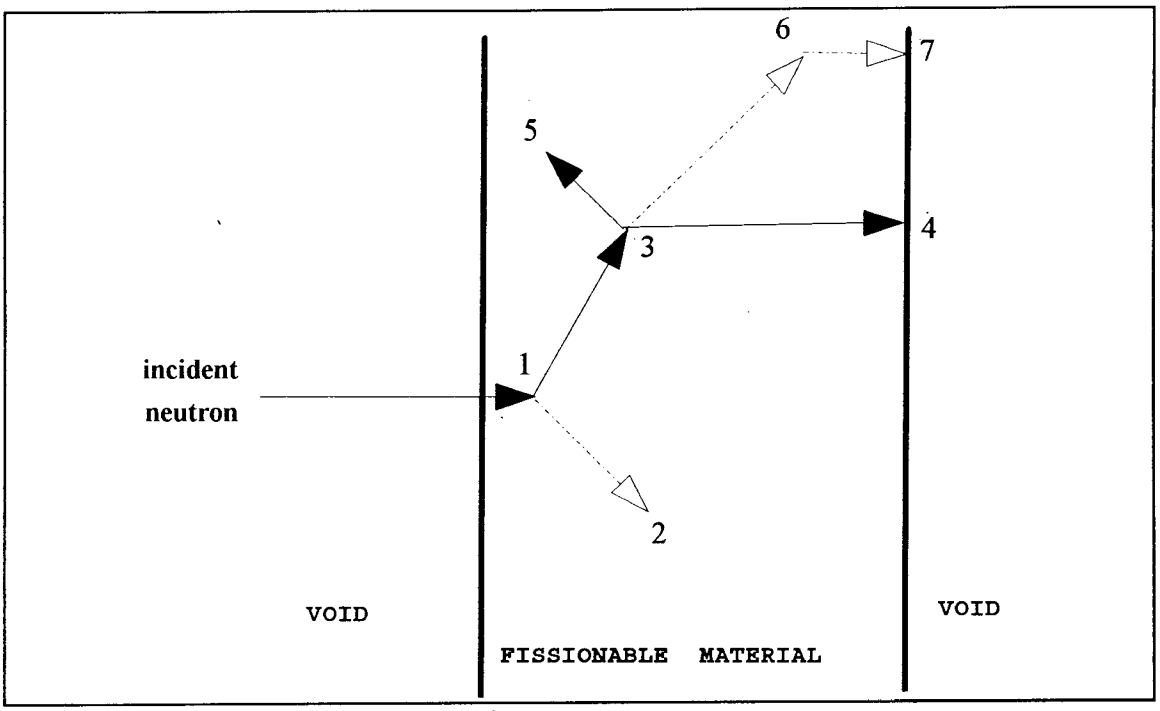

Figure 8 Neutron Interaction Example

one can expect of the real life situation with equivalent source particles.

4.2 MCNP Geometry

The geometry of MCNP treats an arbitrary three-dimensional configuration of user-defined materials in geometric cells bounded by first- and second-degree surfaces. The cells are defined by the intersections, unions, and complements of the regions bounded by the surfaces. Surfaces are defined by supplying coefficients to the analytic surface equations, or for the certain types of surfaces by supplying known points on the surfaces.

MCNP has a more general combinational geometry than is available most other codes. Rather than combining several predefined geometrical bodies as in a more conventional combinatorial geometry scheme, MCNP gives the user the added flexibility of defining geometrical regions from all the first and second degree surfaces of analytical geometry and elliptical tori, and then of combining them with Boolean operators. The code does extensive internal checking to find input errors.

Using the cell specifications, MCNP tracks particles through the geometry. MCNP knows all of the bounding surfaces of a cell and calculates the intersection of a particle's trajectory with each bounding surface and finds the minimum positive distance to an intersection. If the distance to the next collision is greater than this minimum distance then the particle leaves the current cell. At the appropriate surface intersection, MCNP finds the correct cell that the particle will enter by checking the sense of the intersection point for each surface listed for the cell. When a complete match is found, MCNP has found the correct cell on the other side and the transport continues.

4.3 Description of ATI MCNP Model

The input to MCNP describes a heterogeneous core that is a spatially complete description of the core. The only simplification in the core geometry model is in the

connections on the ends of the TFEs. These sections are modeled as a homogeneous mixture of the elements present in these sections. This 3-dimensional heterogeneous model uses a reflective midplane, a reflective vertical plane and a reflective horizontal plane to reduce the size of the problem. This is a technique used in MCNP to have a partial model simulate the results of a full model. In this case, having a reflective plane implies that the core is assumed fully symmetric about the plane (i.e. the 1/8 section that is completely modeled is the same as the other seven 1/8

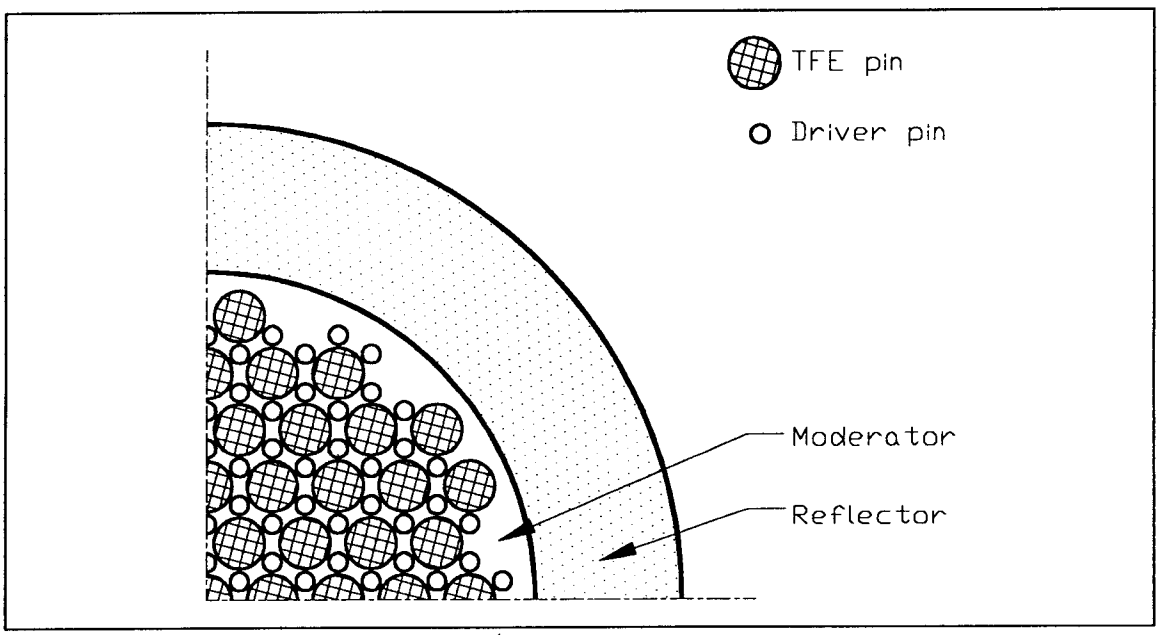

Figure 9 ATI MCNP Model 1/4 Core

sections). Figure 9 shows a simplified, horizontal cross section view of the model. The model view is simplified in that each TFE is actually represented by nine embedded cylinders for each material in the TFE. A typical input

deck thus has 300 to 400 cell descriptions and approximately the same number of surface descriptions. A sample of a typical input deck is included as Appendix B.

V. SYSTEMS CODE

A review of the extensive MCNP input deck in Appendix B demonstrates the need for a preprocessor for MCNP. For example, to analyze a different pitch to diameter ratio would require an experienced MCNP user at least four to five days of work. This would not be an acceptable use of time in the conduct of parametric studies. Another factor is the uncertainty of the model if it is manually developed each time and subject to human errors. The same preprocessor that builds the MCNP input decks also needs the ability to handle all of the system data, and to have the capability to serve as a preprocessor and postprocessor for the other modules in the system code.

5.1 First Attempt

The input for MCNP is extensive and labor intensive, but it also is based on rather simple relationships. Therefore an attempt was made to develop a MCNP preprocessor in the Quattro Pro (QPRO) spreadsheet environment utilizing the macro capabilities of QPRO. A macro is a sequence of recorded keystrokes or commands that QPRO executes automatically [Borland 1991].

Three weeks of effort produced a QPRO macro that would build an ATI reactor MCNP input deck. The list of variables for parametric studies was, for the most variables, available to the user. Two weeks later, a modification to

the input development was determined necessary. The entire algorithm seemed to collapse when a small change was attempted. The macros used for the preprocessor were rather lengthy and difficult to debug when problems arose. It was obvious that this method was stretched beyond its usefulness to create an MCNP input deck, and that to add additional features by various programmers would likely lead to trouble. Therefore, a new programming environment was needed.

5.2 Investigation of Object Oriented Programming

Object orientation represents a major shift from traditional methods of software construction. Traditional methods apply active procedures to passive data. Object orientation changes the focus of the programming process from the procedures to *objects*. Objects are self-contained modules that include both the data and the procedures that act on the data. Objects that have a common use are grouped together in a *class*, and new classes can be created that inherit the procedures and data from classes already built, enabling the programmer to reuse existing classes and to program only the differences.

5.3 MCNP in OOP Environment

In MCNP, a cell describes a region where geometry, position, and composition are defined. An object may also

be defined in terms of its geometry, position, and composition. Therefore, a direct correlation can be made between objects and cells. It is also possible that each object may contain one or more interior objects. In fact, a complex assembly of objects can be visualized as a hierarchy of progressively interior objects. In order to develop the basis of the programming for the MCNP preprocessor, the following rules were developed.

1. Objects have boundaries which contain one or more cells.
2. Objects may have interior objects.
3. If the boundaries of a cell or interior object are incompletely specified then they share that boundary of the object outside it.
4. If an object contains interior objects then its cells must exclude their boundaries.
5. The set of all objects, the universe, is itself an object with all other objects interior to it.
6. The universe is the only object which has no exterior object.

Once the problem is specified as an object hierarchy to the MCNP processor, every detail of the problem description may be accessed by the outermost object. This object, the universe, is the set of all objects.

5.4 Resulting Program

The base for the system program was successfully developed in the Object Oriented Programming (OOP) environment called SmallTalk [Digittalk 1986]. While in the

main code (Smalltalk environment), any of the parameters that make up the core can be modified by the user through windows that display the current core description, also a graphical representation of the core can be viewed by the user. The main code can then arrange the data into an input deck for MCNP, and run MCNP.

One of the windows available to the user is a tree that displays the hierarchy of objects in the universe, as seen by the code. This is displayed in Figure 10, which is the exact view as seen on the computer screen by the user. The universe consists of objects internal to it. The first level down is the "void outside the reactor", inside of this is the "reactor". The reactor consists of the "reflector", which surrounds the "core". The core contains the individual TFES

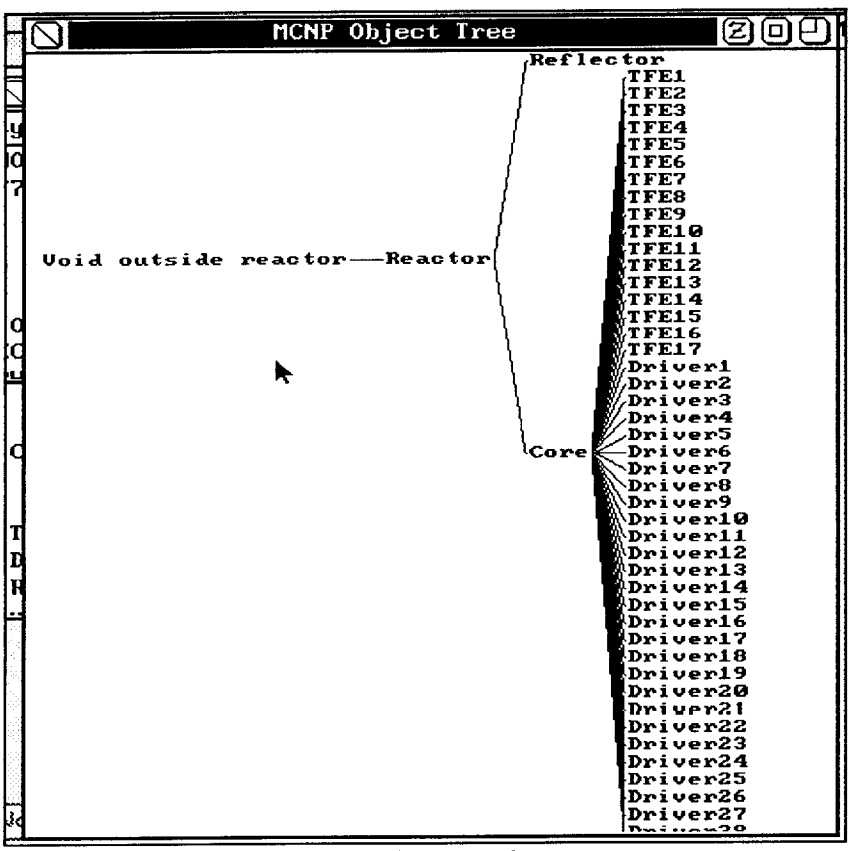

Figure 10 Tree of Object Hierarchy

and Driver rods. Figure 11 shows the window that allows the user to modify the main core parameters. The parameters that can be modified are shown with a box surrounding the value, while the parameters that are calculated as a result of user input are displayed without a box. Further details of the program's features are provided in the manual in Appendix A.

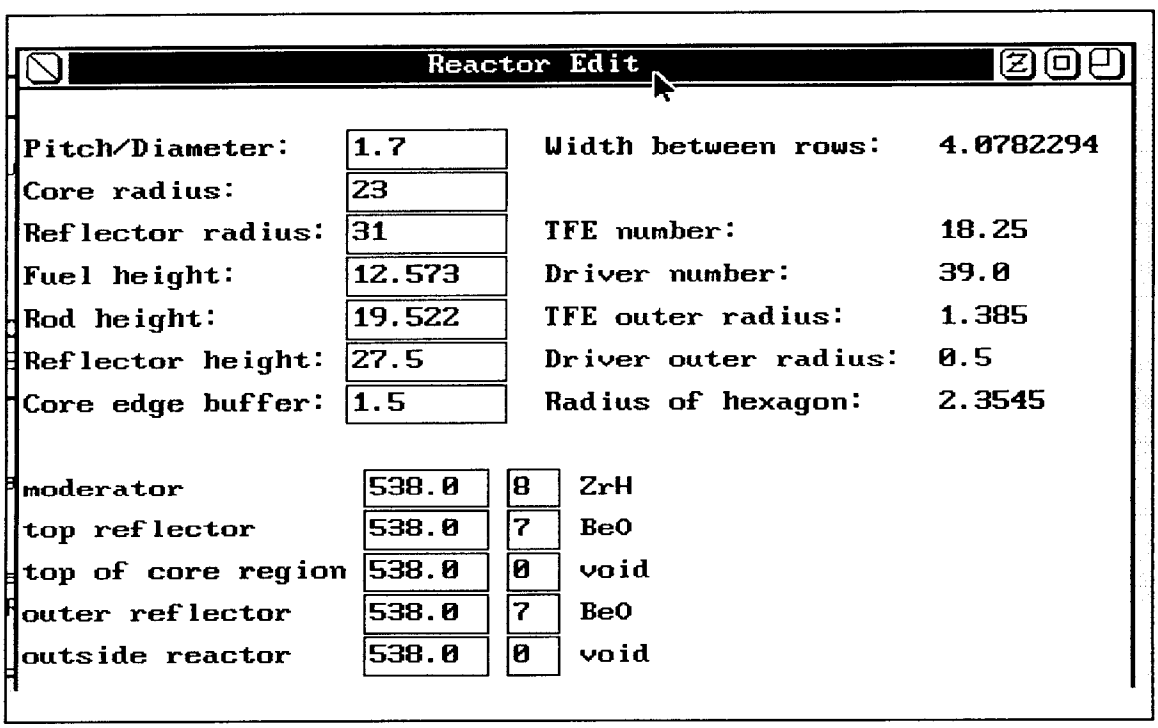

Figure 11 Reactor Edit Window

Two examples that demonstrate the usefulness of the this programming environment are to change of the pitch-to-diameter ratio of the reactor and to change the variables of an individual rod within the core. The first example of changing the pitch-to-diameter ratio can be accomplished by changing the appropriate value in the Reactor Edit Window. The results can be seen in Figure 12 and Figure 13. The first case is with a 1.7 pitch-to-diameter ratio and the second case is with a 2.1 pitch-to-diameter ratio. This demonstrates that a task that used to require approximately five days can now be accomplished in a few minutes with this program. In addition, the graphical display provides a useful tool for the reactor designer to view the design.

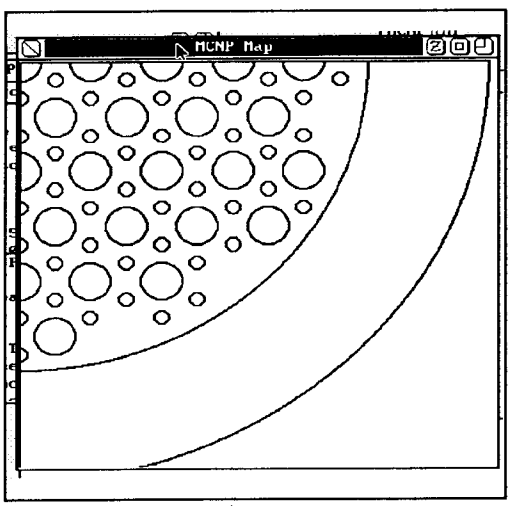

Figure 12 P/D=1.7

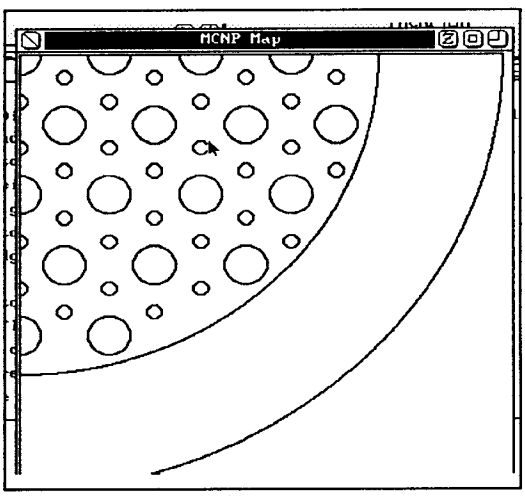

Figure 13 P/D=2.1

The second example demonstrates the capability to modify each individual TFE or Driver rod in the MCNP Map Window as shown in Figure 14. Once a specific location is highlighted, a menu can be accessed that allows the user to remove the rod or to edit the rod's parameters. Figure 15 shows the resulting window from choosing to edit the rod. In the TFE11 Edit Window, the user can modify any of the various parameters that describe the rod.

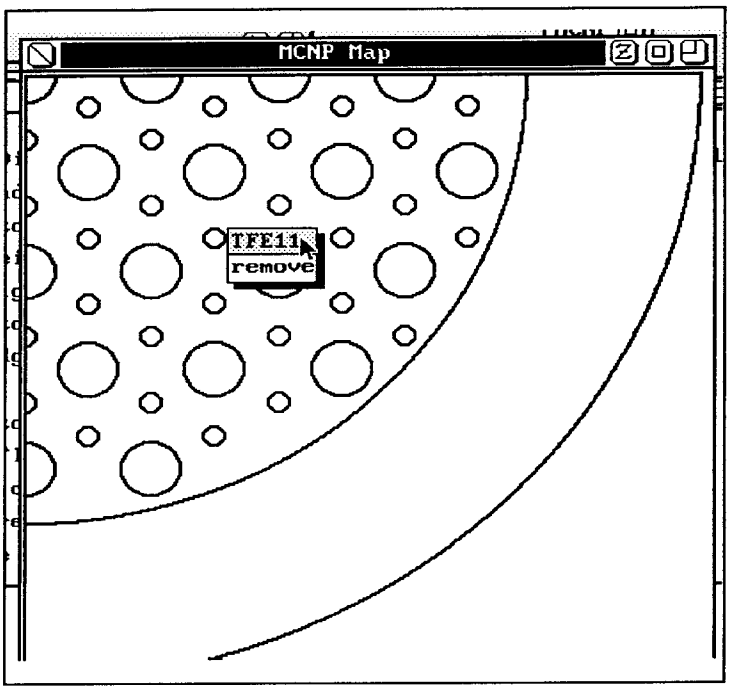

Figure 14 MCNP Map Window - Individual Rod Modification

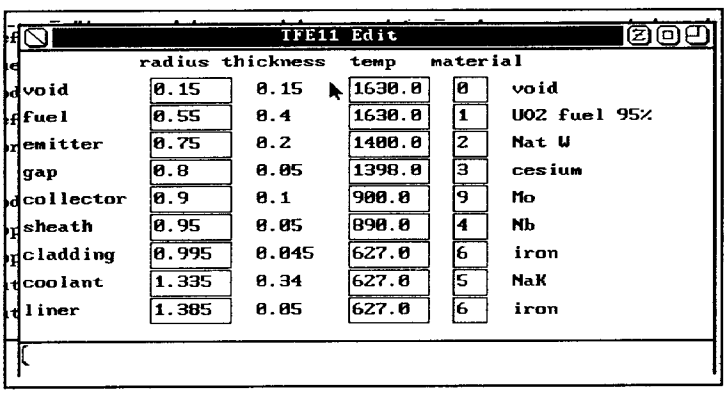

Figure 15 Individual TFE Parameter Window

VI. ANALYSIS RESULTS

During the course of this project, the base reactor configuration was changing due to input from the various research groups involved in the process. Therefore, the following neutronic studies are not analyzing the exact same reactor configuration. These studies were intended investigate individual parameters of interest for other groups involved in this project. The initial analysis of the ATI reactor was to optimize the parameters with respect to k effective. Therefore the following results are an investigation of the effects of various changes on k effective. The overall design optimization will require balancing the k effective changes with thermionic performance, system mass, radiator efficiency, etc.

6.1 Investigation of the Use of Tungsten

Since tungsten has been determined to be the optimal emitter for the long ATI thermionic fuel element, a series of core criticality calculations were performed to assess the effect of using natural tungsten as the emitter and the collector in the thermionic fuel element. Unfortunately, most of the isotopes of tungsten are strong thermal neutron absorbers and this restricts the use of natural tungsten in a thermal reactor. This is due to the thermal neutrons necessary for the nuclear reactions being absorbed by the tungsten. However, one isotope of tungsten, W^{184}, has a

reasonably low thermal neutron absorption cross section. Therefore tungsten enriched in W^{184} may be attractive as an emitter/collector material. The effect of enriched tungsten however will be determined by the degree of thermalization of the neutrons. A fast spectrum reactor will be less effected by the strong thermal neutron absorption of natural tungsten than a more thermalized reactor configuration.

Figure 16 shows the effect on k effective for various W^{184} percentages using two pitch to diameter ratios. For the P/D of 1.01, the core radius was 25 cm and for the P/D of 1.2, the core radius was 30 cm. This resulted in a similar

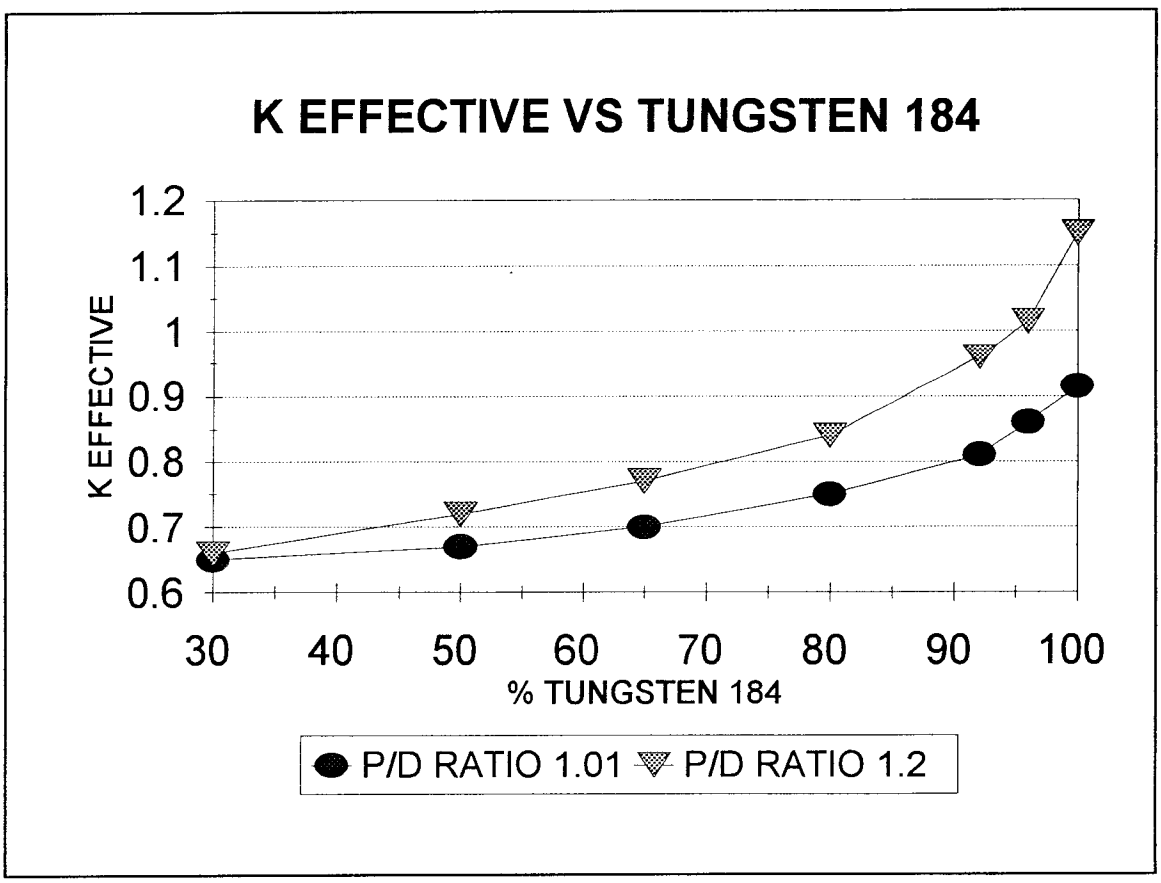

Figure 16 Various Tungsten 184 Percentages

number of TFEs in both cases (approximately 250). It should be noted that this is a neutronic investigation and that the final core design for low power levels will probably have significantly fewer TFEs. As can be seen of Figure 16, the more thermal the reactor, the higher the k effective for similar number of TFEs. Also the more thermal the reactor, the stronger the effect of thermal absorption in natural tungsten.

6.2 Optimizing Pitch-to-Diameter Ratio and Driver Radius

As seen in the previous analysis, driver rods will be required to achieve criticality if natural Tungsten emitters are to be used in the design. This raises the question of what is the optimum driver rod size in combination with the optimum pitch-to-diameter ratio. The goals are to obtain a k effective of at least 1.05, to minimize the amount of power that is being generated in the driver fuel, and to minimize total reactor mass.

In an effort to find the optimum pitch-to-diameter ratio and driver fuel diameter, a series of twenty reactor configurations were analyzed with the ATI Systems Code. This series of reactors all have 85 TFEs and 204 Drivers to provide a comparison of reactors with equivalent power production capabilities while varying the parameters of concern. The ATI Systems Code was used to make the MCNP

input decks and the resulting data was processed in a QPRO spreadsheet.

Figure 17 shows the range in k effective with various driver rod radii and pitch-to-diameter ratios. K effective increases with increasing pitch-to-diameter ratio due to the increase moderation with increasing distance between the fuel pins. This is advantageous up to a p/d ratio of 2.1, but at a p/d ratio of 2.3, the k effective starts to decrease due to the negative effect of the increased fuel-to-fuel distance.

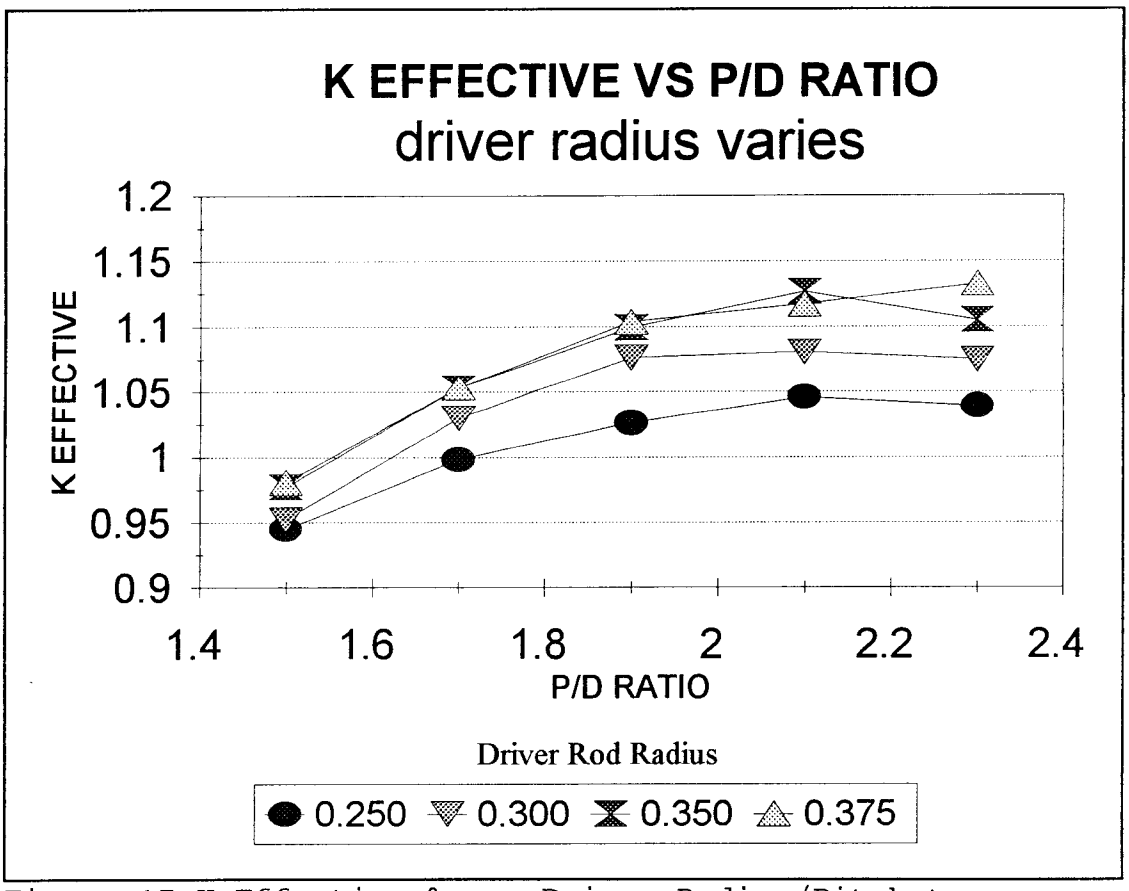

Figure 17 K Effective % vs, Driver Radius/Pitch-to-Diameter Ratio

The second parameter of concern is to maximize the amount of power that is generated by fission in the TFEs. The goal to minimize the power generation in the driver fuel due to the power generated in the driver fuel is 100% waste heat. This is because all the power generated in the driver rods is wasted due to these rods not creating any electrical power. Figure 18 shows the TFE power percentage in comparison to varying the driver radius and pitch-to-diameter ratio. The graph shows that the smaller the driver rod radius, the higher the TFE power percentage.

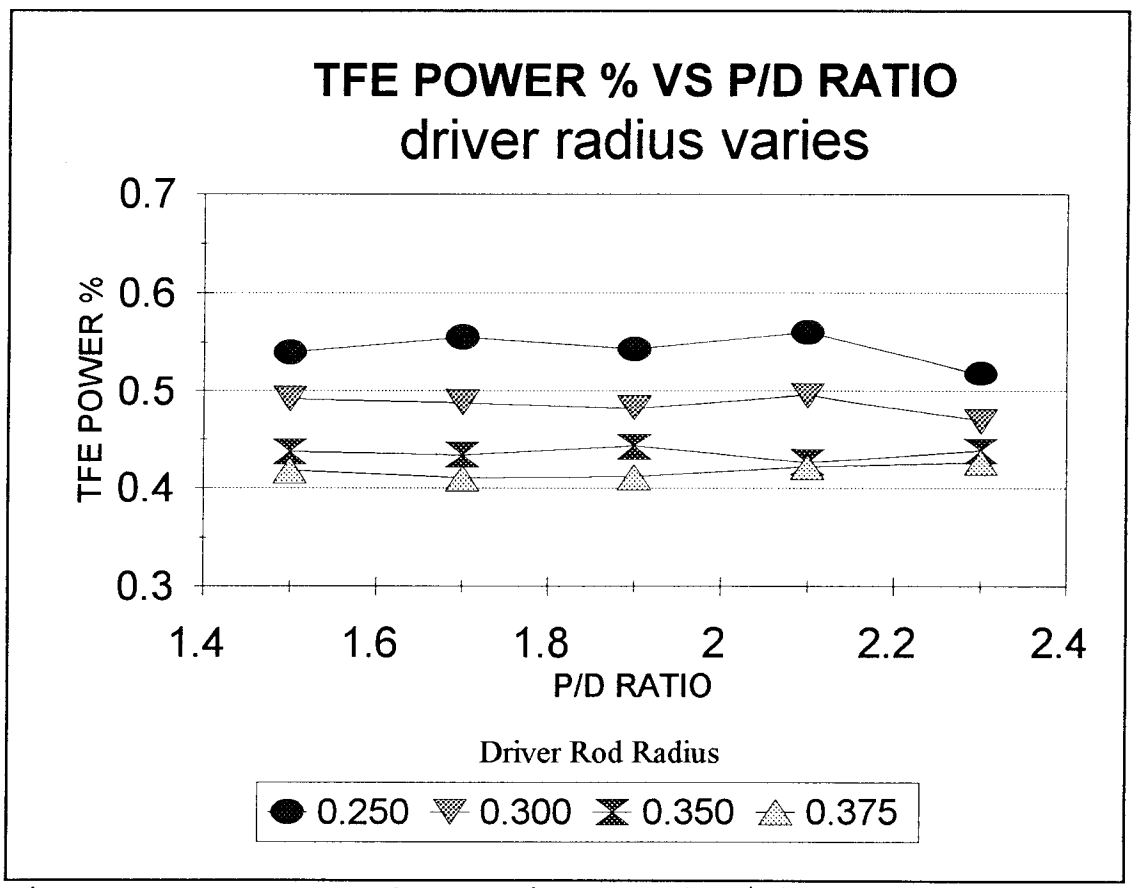

Figure 18 TFE Power % vs Driver Radius/Pitch-to-Diameter Ratio

The third parameter of concern is the reactor mass. Figure 19 shows the reactor mass of the twenty reactors used in this analysis. The main factor controlling the mass is the p/d ratio. This is because the larger the p/d ratio, the larger the resulting reactor core. There is a small difference due to the driver rod radius, but in comparison to the overall reactor mass, the difference is negligible.

A consideration of all the data from the twenty reactors that were analyzed determines the optimum reactor. The reactors with the 0.25 cm radius driver rod never achieved the k effective requirement of 1.05 while the

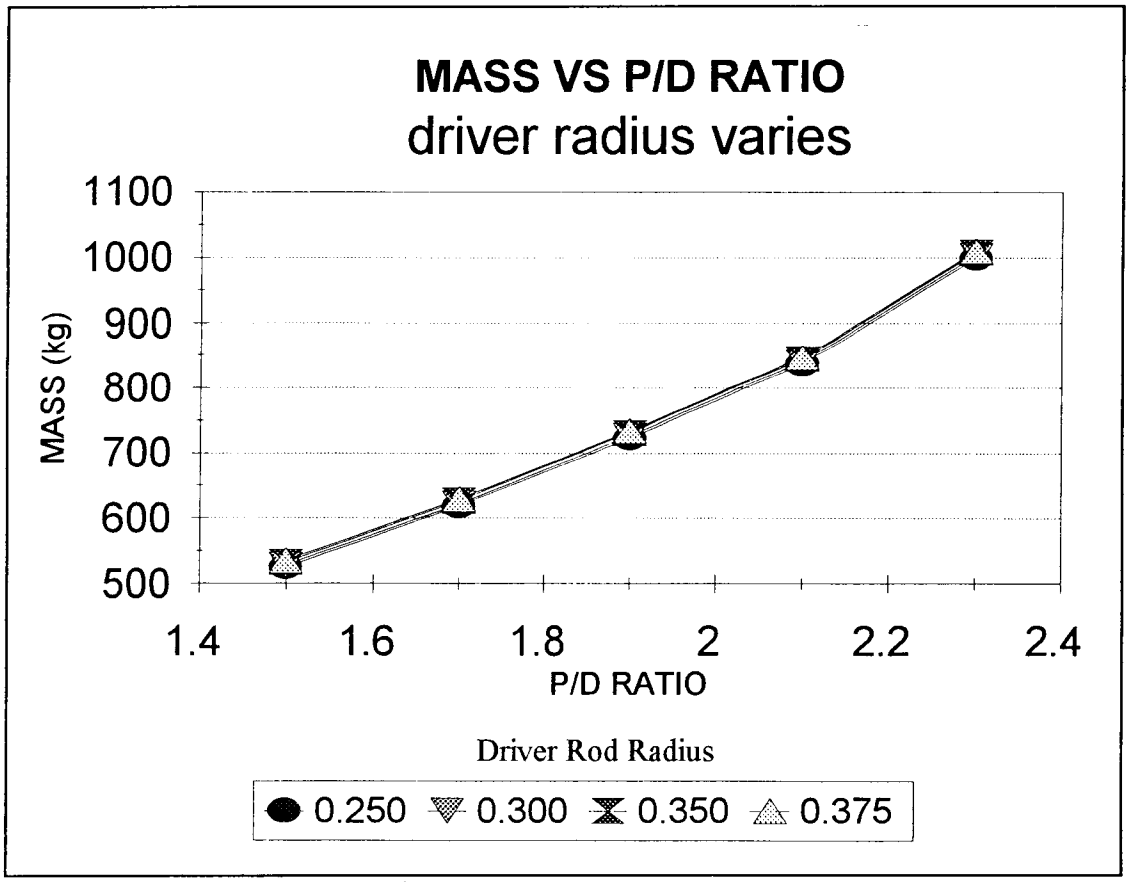

Figure 19 Mass vs P/D Ratio

remaining reactors with p/d ratios greater than 1.9 did meet this requirement. As a result, the optimum reactor must have driver rod radius of at least 0.30 cm. The next goal of maximizing the TFE power percentage is achieved by having the smallest driver rod radius, therefore, of the reactors not already ruled out, the 0.30 cm driver radius is preferable. The last goal of minimizing the reactor mass is achieved by having the smallest p/d ratio. Therefore the reactor with the 0.30 cm driver rod radius and a p/d ratio of 1.9 is the optimum reactor of those that were analyzed.

6.3 Driver Fuel Comparison

Three different driver fuels (UO2, UN, U-10%Mo) were analyzed to determine if there were any neutronic considerations that favor one fuel type over another. The configuration used consisted of 85 TFEs and 204 Driver rods in all cases. Two cores were analyzed for each driver fuel that differed only in the TFE pitch to diameter ratio. This allowed analysis of the effects of increased moderation.

It should be noted that the core configuration analyzed is not a optimized ATI core design, but a simple pattern to allow driver fuel comparisons. The emitter material used was natural tungsten. Also, the UN fuel was analyzed with a very thin rhenium liner that is required to chemically separate the nitrogen from the niobium cladding. The

rhenium is also a high thermal neutron absorber. The use of this liner is similar to the SP-100 UN fuel.

The results of the analysis are shown in Table 2. The results are close, but there are trends. The amount of U-235 increases with driver fuel density while maintaining equivalent K effective values. These results hold true for a thermal reactor where the increased U-235 content in UN and U-10%Mo is offset by increased self shielding. Also, the percentage of core power located in the TFE fuel region decreases with increasing driver density. Therefore, UO2, with the lightest density, is the preferred driver fuel for the ATI core. The UO2 fuel provided the lightest reactors, the smallest fuel loadings, and the highest percentage of power in the TFE fuel regions.

Table 2 Driver Analysis Results

	UO2 Fuel OD=0.6cm density=10.0	UN Fuel OD=0.6cm density=13.2	U-10%Mo Fuel OD=0.5cm density=18.0
TFE p/d=1.7 core dia =48.15cm			
K effective	1.037	1.023	1.036
% Power in TFEs	32.1	30.5	24.5
Reactor Mass (kg)	625	630	627
U-235 Mass (kg)	31.2	35.5	34.3
TFE p/d=1.9 core dia = 53.6cm			
K effective	1.067	1.066	1.068
% Power in TFES	32.5	31.1	26.7
Reactor Mass (kg)	729	734	731
U-235 Mass (kg)	31.2	35.5	34.3

VII. SUMMARY

The resulting systems analysis program for the ATI reactor meets and exceeds the initial goals of the research project. The level of detail in the analysis techniques used for parametric neutronic studies is one of the most accurate techniques currently available. Prior to this program development, MCNP was primarily used for only final design studies. In addition, the use of the OOP environment should aid in the programs ability to be expanded and modified by a variety of different programmers. The description on the reactor as a grouping of objects also provides the ability to feed the appropriate data and results to the various modules within the final systems analysis program.

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APPENDICES

Appendix A Neutronic Module User Manual.

Introduction

This module allows access to the variables in the core, TFE, and driver rods. After modifying these variables, you can build an MCNP input deck with one simple command. This code is written in the Smalltalk/V language. A simple understanding of how to use the mouse, start the program, and open/move windows can be achieved by reviewing the first two chapters in the Smalltalk/V manual.

After a review of the basics of the Smalltalk operating environment, the next step is to have the image file and change.log files for the ATI systems code in place of the files of the same name that are installed with the basic Smalltalk setup. It is these files which start the program in the ATI systems code for which this manual is written.

The details for each individual system will vary depending on how MCNP is compiled and used. The most basic method is to have this program make the desired input decks for MCNP and then to run MCNP outside of this environment. It is also possible to run MCNP inside the Smalltalk environment, but this method varies for each computer.

Initial Screen.

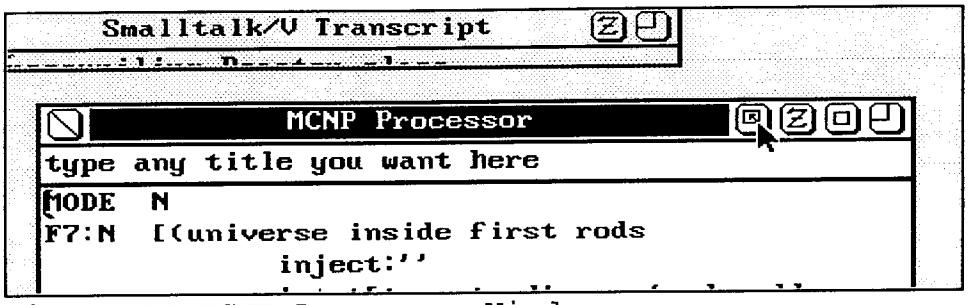

Figure 20 MCNP Processor Window

Figure 20 is the initial window that is used to open menu list to give you access to the other process windows. Move the mouse to the box indicated and click the mouse to bring up the menu shown in the next window.

Main Menu

Figure 21 is the menu list that gives you access the to the various process windows used for reactor analysis. The following figures will be a description of these choices. To choose one of these items, simply highlight your choice with the mouse and click. For example, choose the edit reactor to obtain the following window.

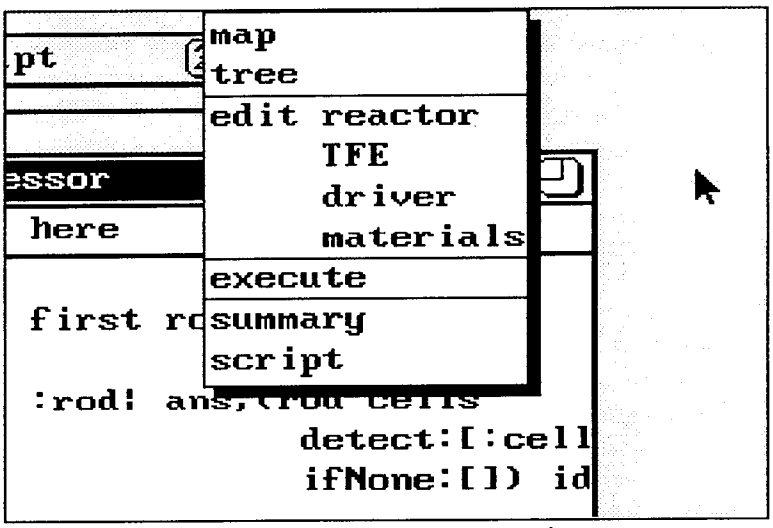

Figure 21 MCNP Processor Choices

Reactor Edit

Figure 22 is the window that allows access to the primary reactor variables. The values that appear in boxes are the ones that you have the capability to change. Simply move the cursor inside the box you want to change and click once. When you see the horizontal bar appear in the box you are in the edit mode. The various edit keys can be used as normal.

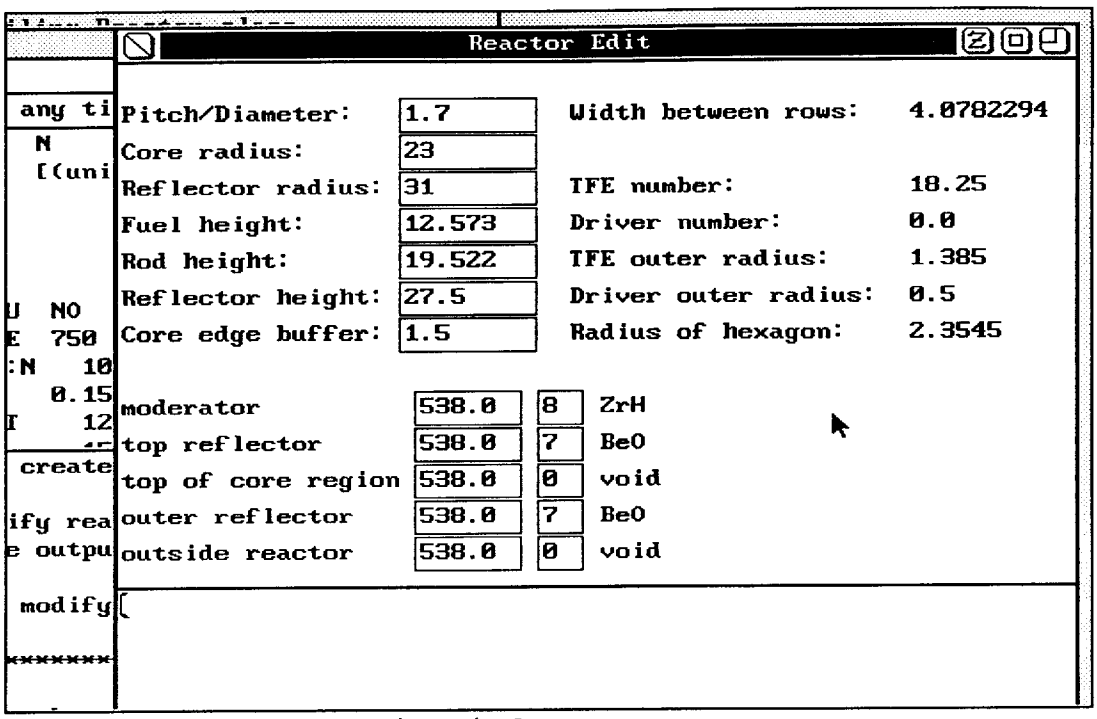

Figure 22 Reactor Edit Window

For example, use the backspace key to delete values to the left of the bar and type the desired number in the box. Use the "enter" when the appropriate value is in the box. If you change the Pitch/Diameter, Core radius or Core Edge buffer, the code recalculates the new core with new rod positions (which also updates the current reactor description). This is evident by the hour glass which appears, indicating to wait while the code works, in addition to new number of calculated rods that is displayed upon completion (assuming your change is large enough to have a core with a different number of rods).

If you change the remaining dimension parameters, the core is not recalculated or updated. Therefore, if you change the Fuel height you also need to update the core to get this change into the current reactor description. An easy way of doing this without really changing the reactor is to change the Core edge buffer from 1.5 to 1.51, this updates the entire reactor description. Future versions should have an update feature in each window.

In the ATI, the moderator region is the cylindrical core region with axial holes for each TFE/driver rod. The bottom part of Reactor Edit window allows you to change the materials that are classified as "Reactor Materials". As can seen in the descriptions, this is the moderator block,

the top reflector region, and outer reflector region (i.e. radial reflector). These regions are intended to model the actual physical material and geometry that is used in the ATI core. The top of core region is modeled as a homogeneous mixture of unfueled region in TFEs, drivers, moderator, and coolant and the material choices should reflect this mixture. The region outside the reactor is normally a void, unless you are conducting accident analysis. If water, sand, etc. is used for the material in this parameter, then a large region outside the reactor is modeled as that material.

To change a material, move to the desired location and change the material number. As will be shown later, you can add, change, and delete materials from the list that you have access to through this numbering scheme. At this point, you would have to know which number represented the material you wanted to change the core materials. Therefore, come back to this window after you understand the material choice method. Note - if you change a material number and the description does not update, close the window and open it again to get the new material description. This also will be fixed in future revisions.

At this time, the temperature input capability does not fully utilized in the neutronic analysis. When and MCNP input deck is generated, the temperatures are also part of input deck, but the results of changing these parameters requires more analysis before this will be utilized in the neutronic analysis. It may be more useful as tracking the temperatures in the thermal module.

TFE Edit

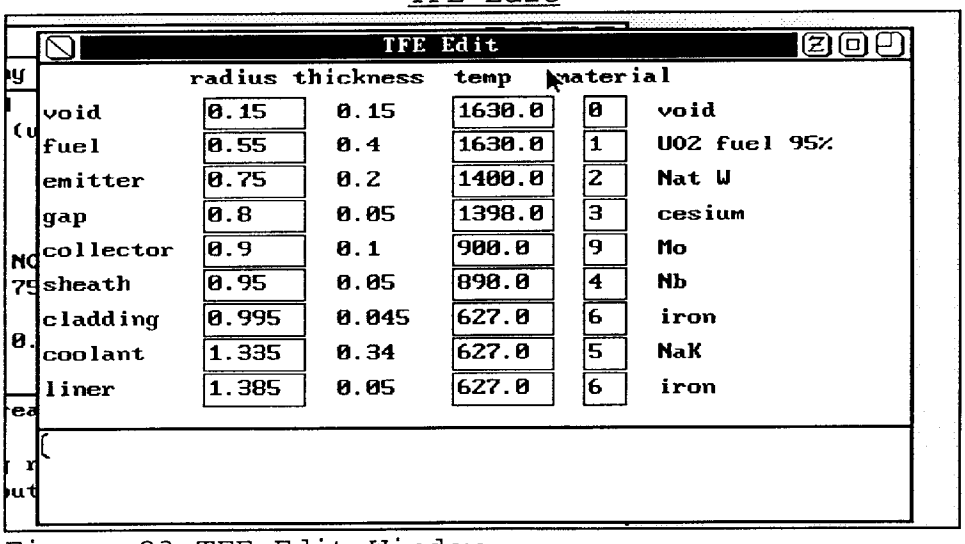

Figure 23 TFE Edit Window

Figure 23 is the window that allows access to the variables that describe the TFE. These variables will be used for each TFE rod each time you create a new reactor. You have access to the dimensions in the same method as in the previous window. When you change one dimension, the thickness is recalculated for the affected layer(s). The materials are modeled as cylindrical heterogeneous sections that are as high as the Fuel height in the Reactor Edit Window. To change the materials, the same method as given the reactor edit section applies to the TFE Edit Window.

Driver Edit

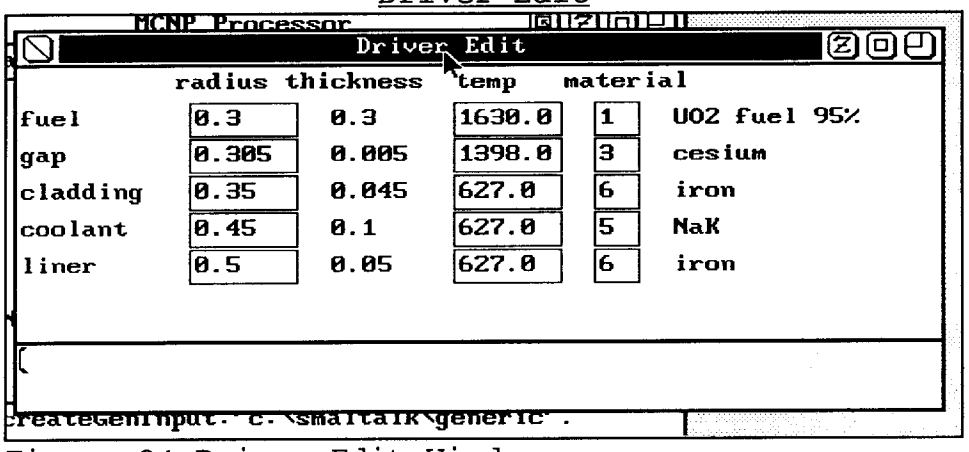

Figure 24 Driver Edit Window

Figure 24 is the window that allows you to edit the driver parameters. The use of this is similar to the TFE Edit Window.

Material Edit

Figure 25 is the window that allows you to make the list of materials and edit materials that you reference in the other windows by the numbers in the first column of this window. Moving around and editing in this window is tricky until you get the hang of it. First of all, what you see is not the whole window. To see the rest of the window press and hold down the right mouse button while moving the mouse across the screen like moving the window reference with your hand (the results of this is shown in Figure 26). To move around within a particular parameter, first click the left mouse button in the parameter of interest and then use the right mouse button as before.

Materials

	description	density	zaid
1	UO2 fuel 95%	10.0	92235 0.95 92238
2	Nat W	18.8	74000 1
3	cesium	0	1001 1
4	Nb	8.4286	41093 1
5	NaK	0.75	11023 -0.78 19000
6	iron	7.87	26000 1
7	BeO	2.96	4009 1 8016 1
8	ZrH	5.6	40000 1 1001 1.84
9	Mo	10.12	42000 1
10	Al2O3	3.56	13027 2 8016 3
11	top rod mix	1.86	42000 -0.329 4009
12	U-10%Mo	18.0	92235 -.873 92238

Figure 25 Materials Edit Window (partial)

Materials

	zaid	sAlphaBeta
1	92235 0.95 92238 0.8	
2	74000 1	
3	1001 1	
4	41093 1	
5	11023 -0.78 19000 -8	
6	26000 1	
7	4009 1 8016 1	BE.05T
8	40000 1 1001 1.84	H/ZR.05T ZR/H.05T
9	42000 1	
10	13027 2 8016 3	
11	42000 -0.329 4009 -8	
12	92235 -.873 92238 -.	

Figure 26 Materials Edit Window (remaining section)

Reactor Display/Graphical Interface

By activating the choice "map", a display of the current reactor is activated as shown in Figure 27. This display shows a horizontal cross section with the core edge, reflector edge and each individual TFE and Driver liner edge within the moderator block.

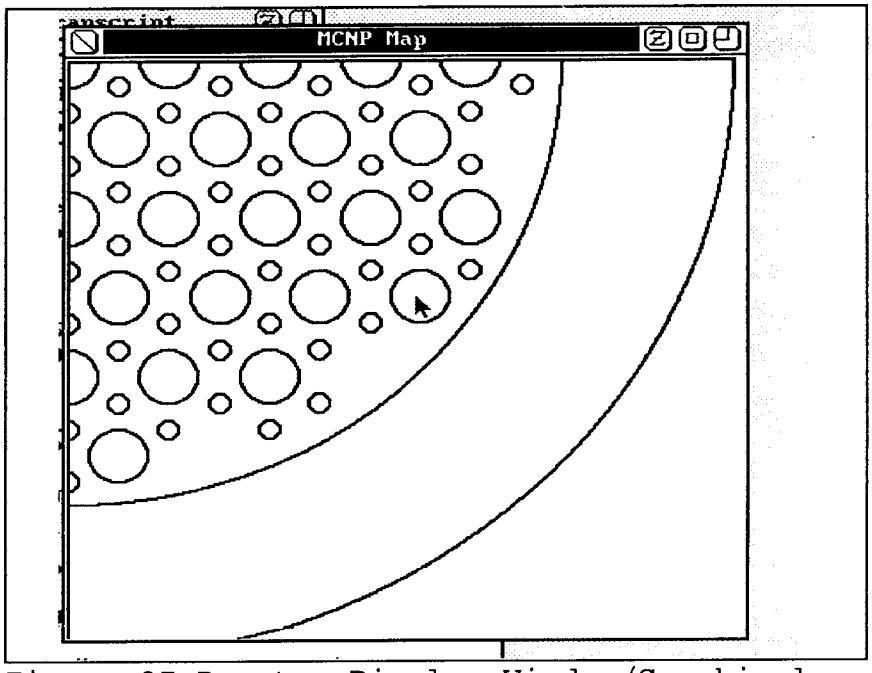

Figure 27 Reactor Display Window/Graphical Interface

This display of the reactor can also be used to modify individual TFE and Driver parameters. By moving the mouse to the desired rod and pressing the left mouse button, you have a menu that allows you to edit just that rod's parameters or to remove it entirely from the core and fill the void with the moderator block material. Examples of this process are shown in Figure 28.

If the right mouse button is pressed you get several choices. Of interest are the "extent", "print upright" and "update". The "extent" changes the size of the reactor. The "print upright" prints the displayed window on the printer. The "update" redraws the reactor to show changes that may have been made after the window was initially opened. Note that you can type notes directly on the screen and they will appear on the printed form. This can be very useful when building and tracking several MCNP input decks.

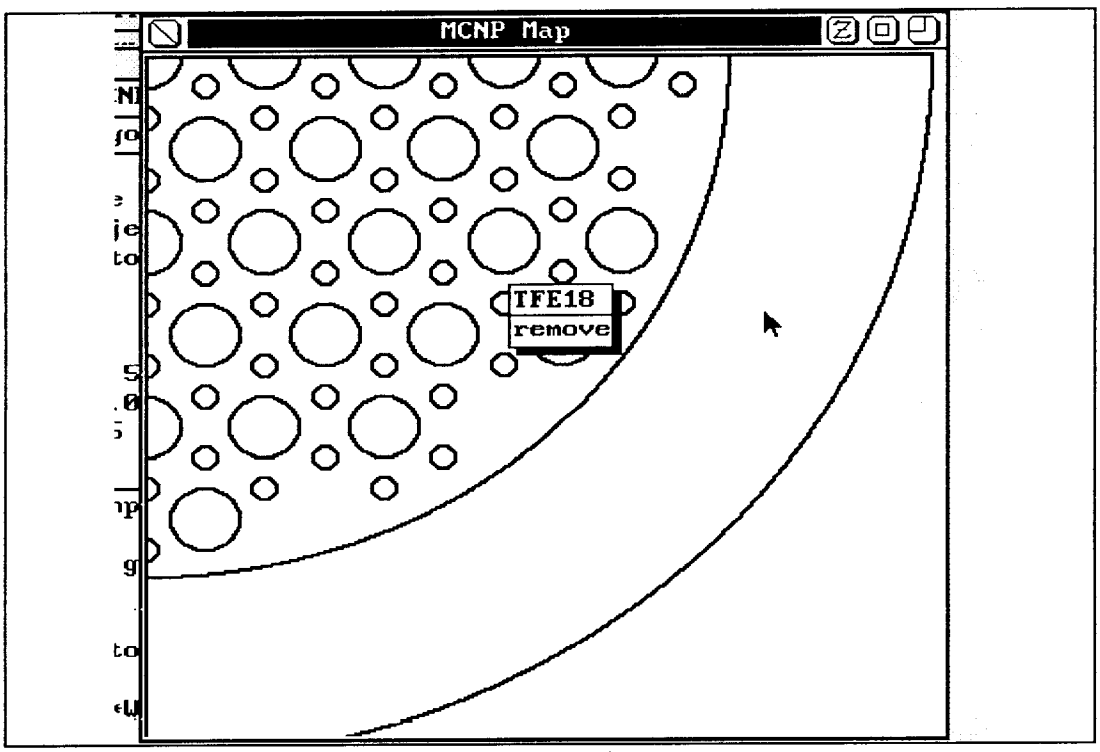

Figure 28 Graphical Interface Window

MCNP Input Control Parameters

The middle section of the MCNP Processor Window (shown in Figure 29) allows the user to modify the control parameters that are attached to the end of the input deck. Refer to the MCNP manual for a description of these parameter.

```
Zoomed text from:    MCNP Processor
MODE   N
F7:N   [(universe inside first rods
            inject:''
            into:[:ans :rod| ans,(rod cells
                                  detect:[:cell|cell description = 'fuel']
                                  ifNone:[]) id printString,' ']) $ heat tall
TOTNU  NO
KCODE  750  1.  5  20
PHYS:N   10.0 0.00001
KSRC   0.15 0.15 0.15
PRINT    120
CTME     150
```

Figure 29 MCNP Input Control Parameters

Creating the MCNP Input Deck

To create the MCNP input deck, you highlight the "create output" section in the lower part of the MCNP Processor Window after filling in the appropriate destination and file name. To highlight the section, hold down the left mouse button while drawing over the area. Then press the right mouse button and choose "do it". The desired MCNP input deck should be built and then filed under the name specified.

Appendix B Sample MCNP Input File

```
type any title you want here
1       0 (-6:-2:-4:5:3) -1 IMP:N=0 TMP=6.9896795E-8 $ outside reactor Void outside reactor
2       0 (-6:-2:-4:5:3) 1 IMP:N=0 TMP=6.9896795E-8 $ infinity Void outside reactor
3       7 -2.96 -7 8 -5 2 4 IMP:N=1 TMP=6.9896795E-8 $ top reflector Reflector
4       7 -2.96 7 -3 -5 6 2 4 IMP:N=1 TMP=6.9896795E-8 $ outer reflector Reflector
5       0 -7 9 -8 2 4 IMP:N=1 TMP=6.9896795E-8 $ top of core region Reflector
6       8 -5.6 18 27 36 45 54 63 72 81 90 99 108 117 126 135 144 153 162  $ moderator Core
       171 180 189 198 207 212 217 222 227 232 237 242 247 252 257 262
       267 272 277 282 287 292 297 302 307 312 317 322 327 332 337 342
       347 352 357 362 367 372 377 382 387 392 397 402 407 412 417 -9
       -7 6 2 4 IMP:N=1 TMP=6.9896795E-8
7       0 -10 -9 6 2 4 IMP:N=1 TMP=1.6399443E-7 VOL=2.2218324E-1 $ void TFE1
8       1 -10.0 10 -11 -9 6 2 4 IMP:N=1 TMP=1.6399443E-7 VOL=2.7649470 $ fuel TFE1
9       2 -18.8 11 -12 -9 6 2 4 IMP:N=1 TMP=1.4417533E-7 VOL=2.5674508 $ emitter TFE1
10      3 0 12 -13 -9 6 2 4 IMP:N=1 TMP=1.4400299E-7 VOL=7.6529784E-1 $ gap TFE1
11      9 -10.12 13 -14 -9 6 2 4 IMP:N=1 TMP=1.0109033E-7 VOL=1.6787178 $ collector TFE1
12      4 -8.4286 14 -15 -9 6 2 4 IMP:N=1 TMP=1.0022863E-7  $ sheath TFE1
       VOL=9.1342001E-1
13      6 -7.87 15 -16 -9 6 2 4 IMP:N=1 TMP=7.7565925E-8 VOL=8.6429282E-1 $ cladding
TFE1
14      5 -0.75 16 -17 -9 6 2 4 IMP:N=1 TMP=7.7565925E-8 VOL=7.8228252 $ coolant TFE1
15      6 -7.87 17 -18 -9 6 2 4 IMP:N=1 TMP=7.7565925E-8 VOL=1.3429742 $ liner TFE1
16      0 -19 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE2
17      1 -10.0 19 -20 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE2
18      2 -18.8 20 -21 -9 6 4 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE2
19      3 0 21 -22 -9 6 4 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE2
20      9 -10.12 22 -23 -9 6 4 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector TFE2
21      4 -8.4286 23 -24 -9 6 4 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath TFE2
22      6 -7.87 24 -25 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding TFE2
23      5 -0.75 25 -26 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE2
24      6 -7.87 26 -27 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE2
25      0 -28 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE3
26      1 -10.0 28 -29 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE3
27      2 -18.8 29 -30 -9 6 4 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE3
28      3 0 30 -31 -9 6 4 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE3
29      9 -10.12 31 -32 -9 6 4 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector TFE3
30      4 -8.4286 32 -33 -9 6 4 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath TFE3
31      6 -7.87 33 -34 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding TFE3
32      5 -0.75 34 -35 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE3
33      6 -7.87 35 -36 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE3
34      0 -37 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE4
35      1 -10.0 37 -38 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE4
36      2 -18.8 38 -39 -9 6 4 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE4
37      3 0 39 -40 -9 6 4 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE4
38      9 -10.12 40 -41 -9 6 4 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector TFE4
39      4 -8.4286 41 -42 -9 6 4 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath TFE4
40      6 -7.87 42 -43 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding TFE4
41      5 -0.75 43 -44 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE4
42      6 -7.87 44 -45 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE4
43      0 -46 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE5
44      1 -10.0 46 -47 -9 6 4 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE5
45      2 -18.8 47 -48 -9 6 4 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE5
46      3 0 48 -49 -9 6 4 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE5
47      9 -10.12 49 -50 -9 6 4 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector TFE5
48      4 -8.4286 50 -51 -9 6 4 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath TFE5
49      6 -7.87 51 -52 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding TFE5
50      5 -0.75 52 -53 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE5
51      6 -7.87 53 -54 -9 6 4 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE5
52      0 -55 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE6
53      1 -10.0 55 -56 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE6
54      2 -18.8 56 -57 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE6
55      3 0 57 -58 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE6
56      9 -10.12 58 -59 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector TFE6
57      4 -8.4286 59 -60 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE6
58      6 -7.87 60 -61 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE6
59      5 -0.75 61 -62 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE6
60      6 -7.87 62 -63 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE6
61      0 -64 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE7
62      1 -10.0 64 -65 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE7
63      2 -18.8 65 -66 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE7
64      3 0 66 -67 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE7
65      9 -10.12 67 -68 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector TFE7
66      4 -8.4286 68 -69 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE7
67      6 -7.87 69 -70 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE7
68      5 -0.75 70 -71 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE7
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69      6 -7.87 71 -72 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE7
70      0 -73 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE8
71      1 -10.0 73 -74 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE8
72      2 -18.8 74 -75 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE8
73      3 0 75 -76 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE8
74      9 -10.12 76 -77 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector TFE8
75      4 -8.4286 77 -78 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE8
76      6 -7.87 78 -79 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE8
77      5 -0.75 79 -80 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE8
78      6 -7.87 80 -81 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE8
79      0 -82 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE9
80      1 -10.0 82 -83 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE9
81      2 -18.8 83 -84 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE9
82      3 0 84 -85 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE9
83      9 -10.12 85 -86 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector TFE9
84      4 -8.4286 86 -87 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE9
85      6 -7.87 87 -88 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE9
86      5 -0.75 88 -89 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE9
87      6 -7.87 89 -90 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE9
88      0 -91 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE10
89      1 -10.0 91 -92 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE10
90      2 -18.8 92 -93 -9 6 2 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE10
91      3 0 93 -94 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE10
92      9 -10.12 94 -95 -9 6 2 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector TFE10
93      4 -8.4286 95 -96 -9 6 2 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath TFE10
94      6 -7.87 96 -97 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding TFE10
95      5 -0.75 97 -98 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE10
96      6 -7.87 98 -99 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE10
97      0 -100 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE11
98      1 -10.0 100 -101 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE11
99      2 -18.8 101 -102 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE11
100     3 0 102 -103 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE11
101     9 -10.12 103 -104 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE11
102     4 -8.4286 104 -105 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE11
103     6 -7.87 105 -106 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE11
104     5 -0.75 106 -107 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE11
105     6 -7.87 107 -108 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE11
106     0 -109 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE12
107     1 -10.0 109 -110 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE12
108     2 -18.8 110 -111 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE12
109     3 0 111 -112 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE12
110     9 -10.12 112 -113 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE12
111     4 -8.4286 113 -114 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE12
112     6 -7.87 114 -115 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE12
113     5 -0.75 115 -116 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE12
114     6 -7.87 116 -117 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE12
115     0 -118 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE13
116     1 -10.0 118 -119 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE13
117     2 -18.8 119 -120 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE13
118     3 0 120 -121 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE13
119     9 -10.12 121 -122 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE13
120     4 -8.4286 122 -123 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE13
121     6 -7.87 123 -124 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE13
122     5 -0.75 124 -125 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE13
123     6 -7.87 125 -126 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE13
124     0 -127 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE14
125     1 -10.0 127 -128 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE14
126     2 -18.8 128 -129 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE14
127     3 0 129 -130 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE14
128     9 -10.12 130 -131 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE14
129     4 -8.4286 131 -132 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE14
130     6 -7.87 132 -133 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE14
131     5 -0.75 133 -134 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE14
132     6 -7.87 134 -135 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE14
133     0 -136 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE15
134     1 -10.0 136 -137 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE15
135     2 -18.8 137 -138 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE15
136     3 0 138 -139 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE15
137     9 -10.12 139 -140 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE15
138     4 -8.4286 140 -141 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE15
139     6 -7.87 141 -142 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE15
140     5 -0.75 142 -143 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE15
141     6 -7.87 143 -144 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE15
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142     0 -145 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE16
143     1 -10.0 145 -146 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE16
144     2 -18.8 146 -147 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE16
145     3 0 147 -148 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE16
146     9 -10.12 148 -149 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE16
147     4 -8.4286 149 -150 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE16
148     6 -7.87 150 -151 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE16
149     5 -0.75 151 -152 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE16
150     6 -7.87 152 -153 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE16
151     0 -154 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE17
152     1 -10.0 154 -155 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE17
153     2 -18.8 155 -156 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE17
154     3 0 156 -157 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE17
155     9 -10.12 157 -158 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE17
156     4 -8.4286 158 -159 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE17
157     6 -7.87 159 -160 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE17
158     5 -0.75 160 -161 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE17
159     6 -7.87 161 -162 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE17
160     0 -163 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE18
161     1 -10.0 163 -164 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE18
162     2 -18.8 164 -165 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE18
163     3 0 165 -166 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE18
164     9 -10.12 166 -167 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE18
165     4 -8.4286 167 -168 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE18
166     6 -7.87 168 -169 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE18
167     5 -0.75 169 -170 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE18
168     6 -7.87 170 -171 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE18
169     0 -172 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=4.4436649E-1 $ void TFE19
170     1 -10.0 172 -173 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=5.5298941 $ fuel TFE19
171     2 -18.8 173 -174 -9 6 2 IMP:N=1 TMP=1.4417533E-7 VOL=5.1349016 $ emitter TFE19
172     3 0 174 -175 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=1.5305957 $ gap TFE19
173     9 -10.12 175 -176 -9 6 2 IMP:N=1 TMP=1.0109033E-7 VOL=3.3574357 $ collector
TFE19
174     4 -8.4286 176 -177 -9 6 2 IMP:N=1 TMP=1.0022863E-7 VOL=1.8268400 $ sheath
TFE19
175     6 -7.87 177 -178 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.7285856 $ cladding
TFE19
176     5 -0.75 178 -179 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=15.645650 $ coolant TFE19
177     6 -7.87 179 -180 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=2.6859485 $ liner TFE19
178     0 -181 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE20
179     1 -10.0 181 -182 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE20
180     2 -18.8 182 -183 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE20
181     3 0 183 -184 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE20
182     9 -10.12 184 -185 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE20
183     4 -8.4286 185 -186 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE20
184     6 -7.87 186 -187 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE20
185     5 -0.75 187 -188 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE20
186     6 -7.87 188 -189 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE20
187     0 -190 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE21
188     1 -10.0 190 -191 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE21
189     2 -18.8 191 -192 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE21
190     3 0 192 -193 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE21
191     9 -10.12 193 -194 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE21
192     4 -8.4286 194 -195 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE21
193     6 -7.87 195 -196 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE21
194     5 -0.75 196 -197 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE21
195     6 -7.87 197 -198 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE21
196     0 -199 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=8.8873298E-1 $ void TFE22
197     1 -10.0 199 -200 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=11.059788 $ fuel TFE22
198     2 -18.8 200 -201 -9 6 IMP:N=1 TMP=1.4417533E-7 VOL=10.269803 $ emitter TFE22
199     3 0 201 -202 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=3.0611913 $ gap TFE22
200     9 -10.12 202 -203 -9 6 IMP:N=1 TMP=1.0109033E-7 VOL=6.7148714 $ collector
TFE22
201     4 -8.4286 203 -204 -9 6 IMP:N=1 TMP=1.0022863E-7 VOL=3.6536800 $ sheath TFE22
202     6 -7.87 204 -205 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.4571713 $ cladding TFE22
203     5 -0.75 205 -206 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=31.291300 $ coolant TFE22
204     6 -7.87 206 -207 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=5.3718971 $ liner TFE22
205     1 -10.0 -208 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver1
206     3 0 208 -209 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver1
207     6 -7.87 209 -210 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver1
208     5 -0.75 210 -211 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver1
```

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209    6 -7.87 211 -212 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver1
210    1 -10.0 -213 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver2
211    3 0 213 -214 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver2
212    6 -7.87 214 -215 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver2
213    5 -0.75 215 -216 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver2
214    6 -7.87 216 -217 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver2
215    1 -10.0 -218 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver3
216    3 0 218 -219 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver3
217    6 -7.87 219 -220 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver3
218    5 -0.75 220 -221 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver3
219    6 -7.87 221 -222 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver3
220    1 -10.0 -223 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver4
221    3 0 223 -224 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver4
222    6 -7.87 224 -225 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver4
223    5 -0.75 225 -226 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver4
224    6 -7.87 226 -227 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver4
225    1 -10.0 -228 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver5
226    3 0 228 -229 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver5
227    6 -7.87 229 -230 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver5
228    5 -0.75 230 -231 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver5
229    6 -7.87 231 -232 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver5
230    1 -10.0 -233 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver6
231    3 0 233 -234 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver6
232    6 -7.87 234 -235 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver6
233    5 -0.75 235 -236 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver6
234    6 -7.87 236 -237 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver6
235    1 -10.0 -238 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver7
236    3 0 238 -239 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver7
237    6 -7.87 239 -240 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver7
238    5 -0.75 240 -241 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver7
239    6 -7.87 241 -242 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver7
240    1 -10.0 -243 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver8
241    3 0 243 -244 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver8
242    6 -7.87 244 -245 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver8
243    5 -0.75 245 -246 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver8
244    6 -7.87 246 -247 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver8
245    1 -10.0 -248 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver9
246    3 0 248 -249 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver9
247    6 -7.87 249 -250 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding Driver9
248    5 -0.75 250 -251 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver9
249    6 -7.87 251 -252 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver9
250    1 -10.0 -253 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver10
251    3 0 253 -254 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver10
252    6 -7.87 254 -255 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver10
253    5 -0.75 255 -256 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver10
254    6 -7.87 256 -257 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver10
255    1 -10.0 -258 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver11
256    3 0 258 -259 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver11
257    6 -7.87 259 -260 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver11
258    5 -0.75 260 -261 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver11
259    6 -7.87 261 -262 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver11
260    1 -10.0 -263 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver12
261    3 0 263 -264 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver12
262    6 -7.87 264 -265 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver12
263    5 -0.75 265 -266 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver12
264    6 -7.87 266 -267 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver12
265    1 -10.0 -268 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver13
266    3 0 268 -269 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver13
267    6 -7.87 269 -270 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver13
268    5 -0.75 270 -271 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver13
269    6 -7.87 271 -272 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver13
270    1 -10.0 -273 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver14
271    3 0 273 -274 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver14
272    6 -7.87 274 -275 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver14
273    5 -0.75 275 -276 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver14
274    6 -7.87 276 -277 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver14
275    1 -10.0 -278 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver15
276    3 0 278 -279 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver15
277    6 -7.87 279 -280 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver15
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278     5 -0.75 280 -281 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver15
279     6 -7.87 281 -282 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver15
280     1 -10.0 -283 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver16
281     3 0 283 -284 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver16
282     6 -7.87 284 -285 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver16
283     5 -0.75 285 -286 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver16
284     6 -7.87 286 -287 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver16
285     1 -10.0 -288 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver17
286     3 0 288 -289 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver17
287     6 -7.87 289 -290 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver17
288     5 -0.75 290 -291 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver17
289     6 -7.87 291 -292 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver17
290     1 -10.0 -293 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver18
291     3 0 293 -294 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver18
292     6 -7.87 294 -295 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver18
293     5 -0.75 295 -296 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver18
294     6 -7.87 296 -297 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver18
295     1 -10.0 -298 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver19
296     3 0 298 -299 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver19
297     6 -7.87 299 -300 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver19
298     5 -0.75 300 -301 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver19
299     6 -7.87 301 -302 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver19
300     1 -10.0 -303 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver20
301     3 0 303 -304 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver20
302     6 -7.87 304 -305 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver20
303     5 -0.75 305 -306 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver20
304     6 -7.87 306 -307 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver20
305     1 -10.0 -308 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver21
306     3 0 308 -309 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver21
307     6 -7.87 309 -310 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver21
308     5 -0.75 310 -311 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver21
309     6 -7.87 311 -312 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver21
310     1 -10.0 -313 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver22
311     3 0 313 -314 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver22
312     6 -7.87 314 -315 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver22
313     5 -0.75 315 -316 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver22
314     6 -7.87 316 -317 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver22
315     1 -10.0 -318 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver23
316     3 0 318 -319 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver23
317     6 -7.87 319 -320 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver23
318     5 -0.75 320 -321 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver23
319     6 -7.87 321 -322 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver23
320     1 -10.0 -323 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver24
321     3 0 323 -324 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver24
322     6 -7.87 324 -325 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver24
323     5 -0.75 325 -326 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver24
324     6 -7.87 326 -327 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver24
325     1 -10.0 -328 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver25
326     3 0 328 -329 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver25
327     6 -7.87 329 -330 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver25
328     5 -0.75 330 -331 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver25
329     6 -7.87 331 -332 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver25
330     1 -10.0 -333 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver26
331     3 0 333 -334 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver26
332     6 -7.87 334 -335 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver26
333     5 -0.75 335 -336 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver26
334     6 -7.87 336 -337 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver26
335     1 -10.0 -338 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver27
336     3 0 338 -339 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver27
337     6 -7.87 339 -340 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver27
338     5 -0.75 340 -341 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver27
339     6 -7.87 341 -342 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver27
340     1 -10.0 -343 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver28
341     3 0 343 -344 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver28
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342    6 -7.87 344 -345 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver28
343    5 -0.75 345 -346 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver28
344    6 -7.87 346 -347 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver28
345    1 -10.0 -348 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver29
346    3 0 348 -349 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver29
347    6 -7.87 349 -350 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver29
348    5 -0.75 350 -351 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver29
349    6 -7.87 351 -352 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver29
350    1 -10.0 -353 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver30
351    3 0 353 -354 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver30
352    6 -7.87 354 -355 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver30
353    5 -0.75 355 -356 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver30
354    6 -7.87 356 -357 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver30
355    1 -10.0 -358 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver31
356    3 0 358 -359 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver31
357    6 -7.87 359 -360 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver31
358    5 -0.75 360 -361 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver31
359    6 -7.87 361 -362 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver31
360    1 -10.0 -363 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver32
361    3 0 363 -364 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver32
362    6 -7.87 364 -365 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver32
363    5 -0.75 365 -366 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver32
364    6 -7.87 366 -367 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver32
365    1 -10.0 -368 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver33
366    3 0 368 -369 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver33
367    6 -7.87 369 -370 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver33
368    5 -0.75 370 -371 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver33
369    6 -7.87 371 -372 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver33
370    1 -10.0 -373 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver34
371    3 0 373 -374 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver34
372    6 -7.87 374 -375 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver34
373    5 -0.75 375 -376 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver34
374    6 -7.87 376 -377 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver34
375    1 -10.0 -378 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver35
376    3 0 378 -379 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver35
377    6 -7.87 379 -380 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver35
378    5 -0.75 380 -381 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver35
379    6 -7.87 381 -382 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver35
380    1 -10.0 -383 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver36
381    3 0 383 -384 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver36
382    6 -7.87 384 -385 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver36
383    5 -0.75 385 -386 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver36
384    6 -7.87 386 -387 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver36
385    1 -10.0 -388 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver37
386    3 0 388 -389 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver37
387    6 -7.87 389 -390 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver37
388    5 -0.75 390 -391 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver37
389    6 -7.87 391 -392 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver37
390    1 -10.0 -393 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver38
391    3 0 393 -394 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver38
392    6 -7.87 394 -395 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver38
393    5 -0.75 395 -396 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver38
394    6 -7.87 396 -397 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver38
395    1 -10.0 -398 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver39
396    3 0 398 -399 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver39
397    6 -7.87 399 -400 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver39
398    5 -0.75 400 -401 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver39
399    6 -7.87 401 -402 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver39
400    1 -10.0 -403 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver40
401    3 0 403 -404 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver40
402    6 -7.87 404 -405 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver40
```

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403     5 -0.75 405 -406 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver40
404     6 -7.87 406 -407 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver40
405     1 -10.0 -408 -9 6 IMP:N=1 TMP=1.6399443E-7 VOL=3.5549319 $ fuel Driver41
406     3 0 408 -409 -9 6 IMP:N=1 TMP=1.4400299E-7 VOL=1.1948521E-1 $ gap Driver41
407     6 -7.87 409 -410 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.1642402 $ cladding
Driver41
408     5 -0.75 410 -411 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=3.1599395 $ coolant Driver41
409     6 -7.87 411 -412 -9 6 IMP:N=1 TMP=7.7565925E-8 VOL=1.8762140 $ liner Driver41
410     1 -10.0 -413 -9 6 2 IMP:N=1 TMP=1.6399443E-7 VOL=1.7774659 $ fuel Driver42
411     3 0 413 -414 -9 6 2 IMP:N=1 TMP=1.4400299E-7 VOL=5.9742606E-2 $ gap Driver42
412     6 -7.87 414 -415 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=0.5821201 $ cladding
Driver42
413     5 -0.75 415 -416 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=1.5799697 $ coolant
Driver42
414     6 -7.87 416 -417 -9 6 2 IMP:N=1 TMP=7.7565925E-8 VOL=9.3810703E-1 $ liner
Driver42

1       SO 1000 $ infinity
*2       PX 0 $ X symmetric plane
3       CZ 31 $ reflector cylinder
*4       PY 0 $ Y symmetric plane
5       PZ 27.5 $ top of core
*6       PZ 0 $ midplane
7       CZ 23 $ cylinder of core
8       PZ 19.522 $ top of rod
9       PZ 12.573 $ top of fuel
10      C/Z 0 1R 0.15 $ TFE1
11      C/Z 0 1R 0.55 $ TFE1
12      C/Z 0 1R 0.75 $ TFE1
13      C/Z 0 1R 0.8 $ TFE1
14      C/Z 0 1R 0.9 $ TFE1
15      C/Z 0 1R 0.95 $ TFE1
16      C/Z 0 1R 0.995 $ TFE1
17      C/Z 0 1R 1.335 $ TFE1
18      C/Z 0 1R 1.385 $ TFE1
19      C/Z 4.709 0 0.15 $ TFE2
20      C/Z 4.709 0 0.55 $ TFE2
21      C/Z 4.709 0 0.75 $ TFE2
22      C/Z 4.709 0 0.8 $ TFE2
23      C/Z 4.709 0 0.9 $ TFE2
24      C/Z 4.709 0 0.95 $ TFE2
25      C/Z 4.709 0 0.995 $ TFE2
26      C/Z 4.709 0 1.335 $ TFE2
27      C/Z 4.709 0 1.385 $ TFE2
28      C/Z 9.418 0 0.15 $ TFE3
29      C/Z 9.418 0 0.55 $ TFE3
30      C/Z 9.418 0 0.75 $ TFE3
31      C/Z 9.418 0 0.8 $ TFE3
32      C/Z 9.418 0 0.9 $ TFE3
33      C/Z 9.418 0 0.95 $ TFE3
34      C/Z 9.418 0 0.995 $ TFE3
35      C/Z 9.418 0 1.335 $ TFE3
36      C/Z 9.418 0 1.385 $ TFE3
37      C/Z 14.127 0 0.15 $ TFE4
38      C/Z 14.127 0 0.55 $ TFE4
39      C/Z 14.127 0 0.75 $ TFE4
40      C/Z 14.127 0 0.8 $ TFE4
41      C/Z 14.127 0 0.9 $ TFE4
42      C/Z 14.127 0 0.95 $ TFE4
43      C/Z 14.127 0 0.995 $ TFE4
44      C/Z 14.127 0 1.335 $ TFE4
45      C/Z 14.127 0 1.385 $ TFE4
46      C/Z 18.836 0 0.15 $ TFE5
47      C/Z 18.836 0 0.55 $ TFE5
48      C/Z 18.836 0 0.75 $ TFE5
49      C/Z 18.836 0 0.8 $ TFE5
50      C/Z 18.836 0 0.9 $ TFE5
51      C/Z 18.836 0 0.95 $ TFE5
52      C/Z 18.836 0 0.995 $ TFE5
53      C/Z 18.836 0 1.335 $ TFE5
54      C/Z 18.836 0 1.385 $ TFE5
55      C/Z 2.3545 4.0782294 0.15 $ TFE6
56      C/Z 2.3545 4.0782294 0.55 $ TFE6
57      C/Z 2.3545 4.0782294 0.75 $ TFE6
58      C/Z 2.3545 4.0782294 0.8 $ TFE6
59      C/Z 2.3545 4.0782294 0.9 $ TFE6
60      C/Z 2.3545 4.0782294 0.95 $ TFE6
61      C/Z 2.3545 4.0782294 0.995 $ TFE6
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62      C/Z 2.3545 4.0782294 1.335 $ TFE6
63      C/Z 2.3545 4.0782294 1.385 $ TFE6
64      C/Z 7.0635 4.0782294 0.15 $ TFE7
65      C/Z 7.0635 4.0782294 0.55 $ TFE7
66      C/Z 7.0635 4.0782294 0.75 $ TFE7
67      C/Z 7.0635 4.0782294 0.8 $ TFE7
68      C/Z 7.0635 4.0782294 0.9 $ TFE7
69      C/Z 7.0635 4.0782294 0.95 $ TFE7
70      C/Z 7.0635 4.0782294 0.995 $ TFE7
71      C/Z 7.0635 4.0782294 1.335 $ TFE7
72      C/Z 7.0635 4.0782294 1.385 $ TFE7
73      C/Z 11.7725 4.0782294 0.15 $ TFE8
74      C/Z 11.7725 4.0782294 0.55 $ TFE8
75      C/Z 11.7725 4.0782294 0.75 $ TFE8
76      C/Z 11.7725 4.0782294 0.8 $ TFE8
77      C/Z 11.7725 4.0782294 0.9 $ TFE8
78      C/Z 11.7725 4.0782294 0.95 $ TFE8
79      C/Z 11.7725 4.0782294 0.995 $ TFE8
80      C/Z 11.7725 4.0782294 1.335 $ TFE8
81      C/Z 11.7725 4.0782294 1.385 $ TFE8
82      C/Z 16.4815 4.0782294 0.15 $ TFE9
83      C/Z 16.4815 4.0782294 0.55 $ TFE9
84      C/Z 16.4815 4.0782294 0.75 $ TFE9
85      C/Z 16.4815 4.0782294 0.8 $ TFE9
86      C/Z 16.4815 4.0782294 0.9 $ TFE9
87      C/Z 16.4815 4.0782294 0.95 $ TFE9
88      C/Z 16.4815 4.0782294 0.995 $ TFE9
89      C/Z 16.4815 4.0782294 1.335 $ TFE9
90      C/Z 16.4815 4.0782294 1.385 $ TFE9
91      C/Z 0 8.1564589 0.15 $ TFE10
92      C/Z 0 8.1564589 0.55 $ TFE10
93      C/Z 0 8.1564589 0.75 $ TFE10
94      C/Z 0 8.1564589 0.8 $ TFE10
95      C/Z 0 8.1564589 0.9 $ TFE10
96      C/Z 0 8.1564589 0.95 $ TFE10
97      C/Z 0 8.1564589 0.995 $ TFE10
98      C/Z 0 8.1564589 1.335 $ TFE10
99      C/Z 0 8.1564589 1.385 $ TFE10
100     C/Z 4.709 8.1564589 0.15 $ TFE11
101     C/Z 4.709 8.1564589 0.55 $ TFE11
102     C/Z 4.709 8.1564589 0.75 $ TFE11
103     C/Z 4.709 8.1564589 0.8 $ TFE11
104     C/Z 4.709 8.1564589 0.9 $ TFE11
105     C/Z 4.709 8.1564589 0.95 $ TFE11
106     C/Z 4.709 8.1564589 0.995 $ TFE11
107     C/Z 4.709 8.1564589 1.335 $ TFE11
108     C/Z 4.709 8.1564589 1.385 $ TFE11
109     C/Z 9.418 8.1564589 0.15 $ TFE12
110     C/Z 9.418 8.1564589 0.55 $ TFE12
111     C/Z 9.418 8.1564589 0.75 $ TFE12
112     C/Z 9.418 8.1564589 0.8 $ TFE12
113     C/Z 9.418 8.1564589 0.9 $ TFE12
114     C/Z 9.418 8.1564589 0.95 $ TFE12
115     C/Z 9.418 8.1564589 0.995 $ TFE12
116     C/Z 9.418 8.1564589 1.335 $ TFE12
117     C/Z 9.418 8.1564589 1.385 $ TFE12
118     C/Z 14.127 8.1564589 0.15 $ TFE13
119     C/Z 14.127 8.1564589 0.55 $ TFE13
120     C/Z 14.127 8.1564589 0.75 $ TFE13
121     C/Z 14.127 8.1564589 0.8 $ TFE13
122     C/Z 14.127 8.1564589 0.9 $ TFE13
123     C/Z 14.127 8.1564589 0.95 $ TFE13
124     C/Z 14.127 8.1564589 0.995 $ TFE13
125     C/Z 14.127 8.1564589 1.335 $ TFE13
126     C/Z 14.127 8.1564589 1.385 $ TFE13
127     C/Z 18.836 8.1564589 0.15 $ TFE14
128     C/Z 18.836 8.1564589 0.55 $ TFE14
129     C/Z 18.836 8.1564589 0.75 $ TFE14
130     C/Z 18.836 8.1564589 0.8 $ TFE14
131     C/Z 18.836 8.1564589 0.9 $ TFE14
132     C/Z 18.836 8.1564589 0.95 $ TFE14
133     C/Z 18.836 8.1564589 0.995 $ TFE14
134     C/Z 18.836 8.1564589 1.335 $ TFE14
135     C/Z 18.836 8.1564589 1.385 $ TFE14
136     C/Z 2.3545 12.234688 0.15 $ TFE15
137     C/Z 2.3545 12.234688 0.55 $ TFE15
138     C/Z 2.3545 12.234688 0.75 $ TFE15
139     C/Z 2.3545 12.234688 0.8 $ TFE15
```

```
140    C/Z 2.3545 12.234688 0.9 $ TFE15
141    C/Z 2.3545 12.234688 0.95 $ TFE15
142    C/Z 2.3545 12.234688 0.995 $ TFE15
143    C/Z 2.3545 12.234688 1.335 $ TFE15
144    C/Z 2.3545 12.234688 1.385 $ TFE15
145    C/Z 7.0635 12.234688 0.15 $ TFE16
146    C/Z 7.0635 12.234688 0.55 $ TFE16
147    C/Z 7.0635 12.234688 0.75 $ TFE16
148    C/Z 7.0635 12.234688 0.8 $ TFE16
149    C/Z 7.0635 12.234688 0.9 $ TFE16
150    C/Z 7.0635 12.234688 0.95 $ TFE16
151    C/Z 7.0635 12.234688 0.995 $ TFE16
152    C/Z 7.0635 12.234688 1.335 $ TFE16
153    C/Z 7.0635 12.234688 1.385 $ TFE16
154    C/Z 11.7725 12.234688 0.15 $ TFE17
155    C/Z 11.7725 12.234688 0.55 $ TFE17
156    C/Z 11.7725 12.234688 0.75 $ TFE17
157    C/Z 11.7725 12.234688 0.8 $ TFE17
158    C/Z 11.7725 12.234688 0.9 $ TFE17
159    C/Z 11.7725 12.234688 0.95 $ TFE17
160    C/Z 11.7725 12.234688 0.995 $ TFE17
161    C/Z 11.7725 12.234688 1.335 $ TFE17
162    C/Z 11.7725 12.234688 1.385 $ TFE17
163    C/Z 16.4815 12.234688 0.15 $ TFE18
164    C/Z 16.4815 12.234688 0.55 $ TFE18
165    C/Z 16.4815 12.234688 0.75 $ TFE18
166    C/Z 16.4815 12.234688 0.8 $ TFE18
167    C/Z 16.4815 12.234688 0.9 $ TFE18
168    C/Z 16.4815 12.234688 0.95 $ TFE18
169    C/Z 16.4815 12.234688 0.995 $ TFE18
170    C/Z 16.4815 12.234688 1.335 $ TFE18
171    C/Z 16.4815 12.234688 1.385 $ TFE18
172    C/Z 0 16.312917 0.15 $ TFE19
173    C/Z 0 16.312917 0.55 $ TFE19
174    C/Z 0 16.312917 0.75 $ TFE19
175    C/Z 0 16.312917 0.8 $ TFE19
176    C/Z 0 16.312917 0.9 $ TFE19
177    C/Z 0 16.312917 0.95 $ TFE19
178    C/Z 0 16.312917 0.995 $ TFE19
179    C/Z 0 16.312917 1.335 $ TFE19
180    C/Z 0 16.312917 1.385 $ TFE19
181    C/Z 4.709 16.312917 0.15 $ TFE20
182    C/Z 4.709 16.312917 0.55 $ TFE20
183    C/Z 4.709 16.312917 0.75 $ TFE20
184    C/Z 4.709 16.312917 0.8 $ TFE20
185    C/Z 4.709 16.312917 0.9 $ TFE20
186    C/Z 4.709 16.312917 0.95 $ TFE20
187    C/Z 4.709 16.312917 0.995 $ TFE20
188    C/Z 4.709 16.312917 1.335 $ TFE20
189    C/Z 4.709 16.312917 1.385 $ TFE20
190    C/Z 9.418 16.312917 0.15 $ TFE21
191    C/Z 9.418 16.312917 0.55 $ TFE21
192    C/Z 9.418 16.312917 0.75 $ TFE21
193    C/Z 9.418 16.312917 0.8 $ TFE21
194    C/Z 9.418 16.312917 0.9 $ TFE21
195    C/Z 9.418 16.312917 0.95 $ TFE21
196    C/Z 9.418 16.312917 0.995 $ TFE21
197    C/Z 9.418 16.312917 1.335 $ TFE21
198    C/Z 9.418 16.312917 1.385 $ TFE21
199    C/Z 2.3545 20.391147 0.15 $ TFE22
200    C/Z 2.3545 20.391147 0.55 $ TFE22
201    C/Z 2.3545 20.391147 0.75 $ TFE22
202    C/Z 2.3545 20.391147 0.8 $ TFE22
203    C/Z 2.3545 20.391147 0.9 $ TFE22
204    C/Z 2.3545 20.391147 0.95 $ TFE22
205    C/Z 2.3545 20.391147 0.995 $ TFE22
206    C/Z 2.3545 20.391147 1.335 $ TFE22
207    C/Z 2.3545 20.391147 1.385 $ TFE22
208    C/Z 0 2.7187411 0.3 $ Driver1
209    C/Z 0 2.7187411 0.305 $ Driver1
210    C/Z 0 2.7187411 0.35 $ Driver1
211    C/Z 0 2.7187411 0.45 $ Driver1
212    C/Z 0 2.7187411 0.5 $ Driver1
213    C/Z 2.3545 1.3592528 0.3 $ Driver2
214    C/Z 2.3545 1.3592528 0.305 $ Driver2
215    C/Z 2.3545 1.3592528 0.35 $ Driver2
216    C/Z 2.3545 1.3592528 0.45 $ Driver2
217    C/Z 2.3545 1.3592528 0.5 $ Driver2
```

```
C/Z 4.709 2.7187411 0.3 $ Driver3
C/Z 4.709 2.7187411 0.305 $ Driver3
C/Z 4.709 2.7187411 0.35 $ Driver3
C/Z 4.709 2.7187411 0.45 $ Driver3
C/Z 4.709 2.7187411 0.5 $ Driver3
C/Z 7.0635 1.3592528 0.3 $ Driver4
C/Z 7.0635 1.3592528 0.305 $ Driver4
C/Z 7.0635 1.3592528 0.35 $ Driver4
C/Z 7.0635 1.3592528 0.45 $ Driver4
C/Z 7.0635 1.3592528 0.5 $ Driver4
C/Z 9.418 2.7187411 0.3 $ Driver5
C/Z 9.418 2.7187411 0.305 $ Driver5
C/Z 9.418 2.7187411 0.35 $ Driver5
C/Z 9.418 2.7187411 0.45 $ Driver5
C/Z 9.418 2.7187411 0.5 $ Driver5
C/Z 11.7725 1.3592528 0.3 $ Driver6
C/Z 11.7725 1.3592528 0.305 $ Driver6
C/Z 11.7725 1.3592528 0.35 $ Driver6
C/Z 11.7725 1.3592528 0.45 $ Driver6
C/Z 11.7725 1.3592528 0.5 $ Driver6
C/Z 14.127 2.7187411 0.3 $ Driver7
C/Z 14.127 2.7187411 0.305 $ Driver7
C/Z 14.127 2.7187411 0.35 $ Driver7
C/Z 14.127 2.7187411 0.45 $ Driver7
C/Z 14.127 2.7187411 0.5 $ Driver7
C/Z 16.4815 1.3592528 0.3 $ Driver8
C/Z 16.4815 1.3592528 0.305 $ Driver8
C/Z 16.4815 1.3592528 0.35 $ Driver8
C/Z 16.4815 1.3592528 0.45 $ Driver8
C/Z 16.4815 1.3592528 0.5 $ Driver8
C/Z 18.836 2.7187411 0.3 $ Driver9
C/Z 18.836 2.7187411 0.305 $ Driver9
C/Z 18.836 2.7187411 0.35 $ Driver9
C/Z 18.836 2.7187411 0.45 $ Driver9
C/Z 18.836 2.7187411 0.5 $ Driver9
C/Z 21.1905 1.3592528 0.3 $ Driver10
C/Z 21.1905 1.3592528 0.305 $ Driver10
C/Z 21.1905 1.3592528 0.35 $ Driver10
C/Z 21.1905 1.3592528 0.45 $ Driver10
C/Z 21.1905 1.3592528 0.5 $ Driver10
C/Z 0 5.4374823 0.3 $ Driver11
C/Z 0 5.4374823 0.305 $ Driver11
C/Z 0 5.4374823 0.35 $ Driver11
C/Z 0 5.4374823 0.45 $ Driver11
C/Z 0 5.4374823 0.5 $ Driver11
C/Z 2.3545 6.7969706 0.3 $ Driver12
C/Z 2.3545 6.7969706 0.305 $ Driver12
C/Z 2.3545 6.7969706 0.35 $ Driver12
C/Z 2.3545 6.7969706 0.45 $ Driver12
C/Z 2.3545 6.7969706 0.5 $ Driver12
C/Z 4.709 5.4374823 0.3 $ Driver13
C/Z 4.709 5.4374823 0.305 $ Driver13
C/Z 4.709 5.4374823 0.35 $ Driver13
C/Z 4.709 5.4374823 0.45 $ Driver13
C/Z 4.709 5.4374823 0.5 $ Driver13
C/Z 7.0635 6.7969706 0.3 $ Driver14
C/Z 7.0635 6.7969706 0.305 $ Driver14
C/Z 7.0635 6.7969706 0.35 $ Driver14
C/Z 7.0635 6.7969706 0.45 $ Driver14
C/Z 7.0635 6.7969706 0.5 $ Driver14
C/Z 9.418 5.4374823 0.3 $ Driver15
C/Z 9.418 5.4374823 0.305 $ Driver15
C/Z 9.418 5.4374823 0.35 $ Driver15
C/Z 9.418 5.4374823 0.45 $ Driver15
C/Z 9.418 5.4374823 0.5 $ Driver15
C/Z 11.7725 6.7969706 0.3 $ Driver16
C/Z 11.7725 6.7969706 0.305 $ Driver16
C/Z 11.7725 6.7969706 0.35 $ Driver16
C/Z 11.7725 6.7969706 0.45 $ Driver16
C/Z 11.7725 6.7969706 0.5 $ Driver16
C/Z 14.127 5.4374823 0.3 $ Driver17
C/Z 14.127 5.4374823 0.305 $ Driver17
C/Z 14.127 5.4374823 0.35 $ Driver17
C/Z 14.127 5.4374823 0.45 $ Driver17
C/Z 14.127 5.4374823 0.5 $ Driver17
C/Z 16.4815 6.7969706 0.3 $ Driver18
C/Z 16.4815 6.7969706 0.305 $ Driver18
C/Z 16.4815 6.7969706 0.35 $ Driver18
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C/Z 16.4815 6.7969706 0.45 $ Driver18
C/Z 16.4815 6.7969706 0.5 $ Driver18
C/Z 18.836 5.4374823 0.3 $ Driver19
C/Z 18.836 5.4374823 0.305 $ Driver19
C/Z 18.836 5.4374823 0.35 $ Driver19
C/Z 18.836 5.4374823 0.45 $ Driver19
C/Z 18.836 5.4374823 0.5 $ Driver19
C/Z 0 10.874964 0.3 $ Driver20
C/Z 0 10.874964 0.305 $ Driver20
C/Z 0 10.874964 0.35 $ Driver20
C/Z 0 10.874964 0.45 $ Driver20
C/Z 0 10.874964 0.5 $ Driver20
C/Z 2.3545 9.5154763 0.3 $ Driver21
C/Z 2.3545 9.5154763 0.305 $ Driver21
C/Z 2.3545 9.5154763 0.35 $ Driver21
C/Z 2.3545 9.5154763 0.45 $ Driver21
C/Z 2.3545 9.5154763 0.5 $ Driver21
C/Z 4.709 10.874964 0.3 $ Driver22
C/Z 4.709 10.874964 0.305 $ Driver22
C/Z 4.709 10.874964 0.35 $ Driver22
C/Z 4.709 10.874964 0.45 $ Driver22
C/Z 4.709 10.874964 0.5 $ Driver22
C/Z 7.0635 9.5154763 0.3 $ Driver23
C/Z 7.0635 9.5154763 0.305 $ Driver23
C/Z 7.0635 9.5154763 0.35 $ Driver23
C/Z 7.0635 9.5154763 0.45 $ Driver23
C/Z 7.0635 9.5154763 0.5 $ Driver23
C/Z 9.418 10.874964 0.3 $ Driver24
C/Z 9.418 10.874964 0.305 $ Driver24
C/Z 9.418 10.874964 0.35 $ Driver24
C/Z 9.418 10.874964 0.45 $ Driver24
C/Z 9.418 10.874964 0.5 $ Driver24
C/Z 11.7725 9.5154763 0.3 $ Driver25
C/Z 11.7725 9.5154763 0.305 $ Driver25
C/Z 11.7725 9.5154763 0.35 $ Driver25
C/Z 11.7725 9.5154763 0.45 $ Driver25
C/Z 11.7725 9.5154763 0.5 $ Driver25
C/Z 14.127 10.874964 0.3 $ Driver26
C/Z 14.127 10.874964 0.305 $ Driver26
C/Z 14.127 10.874964 0.35 $ Driver26
C/Z 14.127 10.874964 0.45 $ Driver26
C/Z 14.127 10.874964 0.5 $ Driver26
C/Z 16.4815 9.5154763 0.3 $ Driver27
C/Z 16.4815 9.5154763 0.305 $ Driver27
C/Z 16.4815 9.5154763 0.35 $ Driver27
C/Z 16.4815 9.5154763 0.45 $ Driver27
C/Z 16.4815 9.5154763 0.5 $ Driver27
C/Z 18.836 10.874964 0.3 $ Driver28
C/Z 18.836 10.874964 0.305 $ Driver28
C/Z 18.836 10.874964 0.35 $ Driver28
C/Z 18.836 10.874964 0.45 $ Driver28
C/Z 18.836 10.874964 0.5 $ Driver28
C/Z 0 13.593705 0.3 $ Driver29
C/Z 0 13.593705 0.305 $ Driver29
C/Z 0 13.593705 0.35 $ Driver29
C/Z 0 13.593705 0.45 $ Driver29
C/Z 0 13.593705 0.5 $ Driver29
C/Z 2.3545 14.953194 0.3 $ Driver30
C/Z 2.3545 14.953194 0.305 $ Driver30
C/Z 2.3545 14.953194 0.35 $ Driver30
C/Z 2.3545 14.953194 0.45 $ Driver30
C/Z 2.3545 14.953194 0.5 $ Driver30
C/Z 4.709 13.593705 0.3 $ Driver31
C/Z 4.709 13.593705 0.305 $ Driver31
C/Z 4.709 13.593705 0.35 $ Driver31
C/Z 4.709 13.593705 0.45 $ Driver31
C/Z 4.709 13.593705 0.5 $ Driver31
C/Z 7.0635 14.953194 0.3 $ Driver32
C/Z 7.0635 14.953194 0.305 $ Driver32
C/Z 7.0635 14.953194 0.35 $ Driver32
C/Z 7.0635 14.953194 0.45 $ Driver32
C/Z 7.0635 14.953194 0.5 $ Driver32
C/Z 9.418 13.593705 0.3 $ Driver33
C/Z 9.418 13.593705 0.305 $ Driver33
C/Z 9.418 13.593705 0.35 $ Driver33
C/Z 9.418 13.593705 0.45 $ Driver33
C/Z 9.418 13.593705 0.5 $ Driver33
C/Z 11.7725 14.953194 0.3 $ Driver34
```

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374     C/Z 11.7725 14.953194 0.305 $ Driver34
375     C/Z 11.7725 14.953194 0.35 $ Driver34
376     C/Z 11.7725 14.953194 0.45 $ Driver34
377     C/Z 11.7725 14.953194 0.5 $ Driver34
378     C/Z 14.127 13.593705 0.3 $ Driver35
379     C/Z 14.127 13.593705 0.305 $ Driver35
380     C/Z 14.127 13.593705 0.35 $ Driver35
381     C/Z 14.127 13.593705 0.45 $ Driver35
382     C/Z 14.127 13.593705 0.5 $ Driver35
383     C/Z 0 19.031188 0.3 $ Driver36
384     C/Z 0 19.031188 0.305 $ Driver36
385     C/Z 0 19.031188 0.35 $ Driver36
386     C/Z 0 19.031188 0.45 $ Driver36
387     C/Z 0 19.031188 0.5 $ Driver36
388     C/Z 2.3545 17.671699 0.3 $ Driver37
389     C/Z 2.3545 17.671699 0.305 $ Driver37
390     C/Z 2.3545 17.671699 0.35 $ Driver37
391     C/Z 2.3545 17.671699 0.45 $ Driver37
392     C/Z 2.3545 17.671699 0.5 $ Driver37
393     C/Z 4.709 19.031188 0.3 $ Driver38
394     C/Z 4.709 19.031188 0.305 $ Driver38
395     C/Z 4.709 19.031188 0.35 $ Driver38
396     C/Z 4.709 19.031188 0.45 $ Driver38
397     C/Z 4.709 19.031188 0.5 $ Driver38
398     C/Z 7.0635 17.671699 0.3 $ Driver39
399     C/Z 7.0635 17.671699 0.305 $ Driver39
400     C/Z 7.0635 17.671699 0.35 $ Driver39
401     C/Z 7.0635 17.671699 0.45 $ Driver39
402     C/Z 7.0635 17.671699 0.5 $ Driver39
403     C/Z 9.418 19.031188 0.3 $ Driver40
404     C/Z 9.418 19.031188 0.305 $ Driver40
405     C/Z 9.418 19.031188 0.35 $ Driver40
406     C/Z 9.418 19.031188 0.45 $ Driver40
407     C/Z 9.418 19.031188 0.5 $ Driver40
408     C/Z 11.7725 17.671699 0.3 $ Driver41
409     C/Z 11.7725 17.671699 0.305 $ Driver41
410     C/Z 11.7725 17.671699 0.35 $ Driver41
411     C/Z 11.7725 17.671699 0.45 $ Driver41
412     C/Z 11.7725 17.671699 0.5 $ Driver41
413     C/Z 0 21.749929 0.3 $ Driver42
414     C/Z 0 21.749929 0.305 $ Driver42
415     C/Z 0 21.749929 0.35 $ Driver42
416     C/Z 0 21.749929 0.45 $ Driver42
417     C/Z 0 21.749929 0.5 $ Driver42

M8      40000 1 1001 1.84 $ ZrH
MT8     H/ZR.05T ZR/H.05T
M5      11023 -0.78 19000 -0.22 $ NaK
M6      26000 1 $ iron
M4      41093 1 $ Nb
M3      1001 1 $ cesium
M2      74000 1 $ Nat W
M9      42000 1 $ Mo
M1      92235 0.95 92238 0.05 8016 2 $ UO2 fuel 95%
M7      4009 1 8016 1 $ BeO
MT7     BE.05T
MODE    N
F7:N    8 17 26 35 44 53 62 71 80 89 98 107 116 125 134 143 152 161 170
       179 188 197 205 210 215 220 225 230 235 240 245 250 255 260 265
       270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345
       350 355 360 365 370 375 380 385 390 395 400 405 410 $ heat
       tally
TOTNU   NO
KCODE   750 1. 5 20
PHYS:N  10.0 0.00001
KSRC    0.15 2R
PRINT   120
CTME    150
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