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# Neutron Generator Driven Subcritical Fast Neutron Source Facility

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## **I. Introduction**

### **○ Objectives**

The purpose of this project is to design and model a facility that can produce fast neutrons inside the new Nuclear Engineering building being planned at the University of Tennessee. This facility would produce fast neutrons by using a D-D neutron generator to power a lead-cooled, subcritical-multiplying core consisting of Uranium fuel rods enriched to 19.75%. One of the main goals of this facility is to remain subcritical while allowing the criticality factor,  $k$ , to get as close to 1 as safely possible. It is estimated that this facility will need to run at a  $k$ -effective value of 0.95 in order to produce 50x source multiplication. Once a sufficient amount of neutrons are generated, they can be utilized for various Nuclear Engineering related experiments. Some of these predicted uses could include cross section measurements, neutron activation measurements, and Gen IV fast neutron reactor calculations. In theory, this facility would primarily serve the faculty and students at the University of Tennessee. However, it would be of great benefit to the scientific community if outside universities, research institutions, and other science organizations were able to conduct fast neutron research at this facility. The main areas of focus for the design of this facility are designing the subcritical multiplier, determining a logistical construction and layout of the facility, designing the utilization sectors, applying control and safety systems, and licensing the entirety of the facility.

### **○ Background information**

Several nations around the globe have fast neutron sources for scientists to conduct fast neutron research. Russia, India, and China each have one source available for use. Having these sources gives them a leading advantage in the development of future fast neutron reactors. The United States, on the other hand, does not have any fast neutron flux facilities. This makes it difficult to solve key problems in the design of fast reactors such as the study of future reactor materials and structural components. Facilities such as HFIR only produce thermal neutrons which are not suitable for these types of studies. The University of Tennessee-Knoxville aims to solve this problem by constructing a fast neutron source that will be made available to researchers from this university and others throughout the United States. This will aid the design and development of United States fast reactors such as the Lead Cooled Fast Reactor (LFR) being designed by Westinghouse.

The LFR poses several important advantages over current GEN II and GEN III reactor designs. One interesting feature is that the LFR uses fertile uranium (U-238) as fuel, which is far more abundant in the Earth's crust than U-235. This helps to establish and maintain energy sustainability in future generations, which is a topic of great importance both domestically and globally. The large amount of heat generated in the LFR also provides several uses for the reactor other than just power. Rather than wasting excess heat by dumping it into a nearby heat sink, the

LFR's excess heat can be used to produce Hydrogen fuel for vehicles and also for providing freshwater through desalination of seawater to coastal areas with a lack of freshwater, such as in a large portion of coastal Africa. A simplified diagram of the LFR is shown below in Figure 1 below [1].

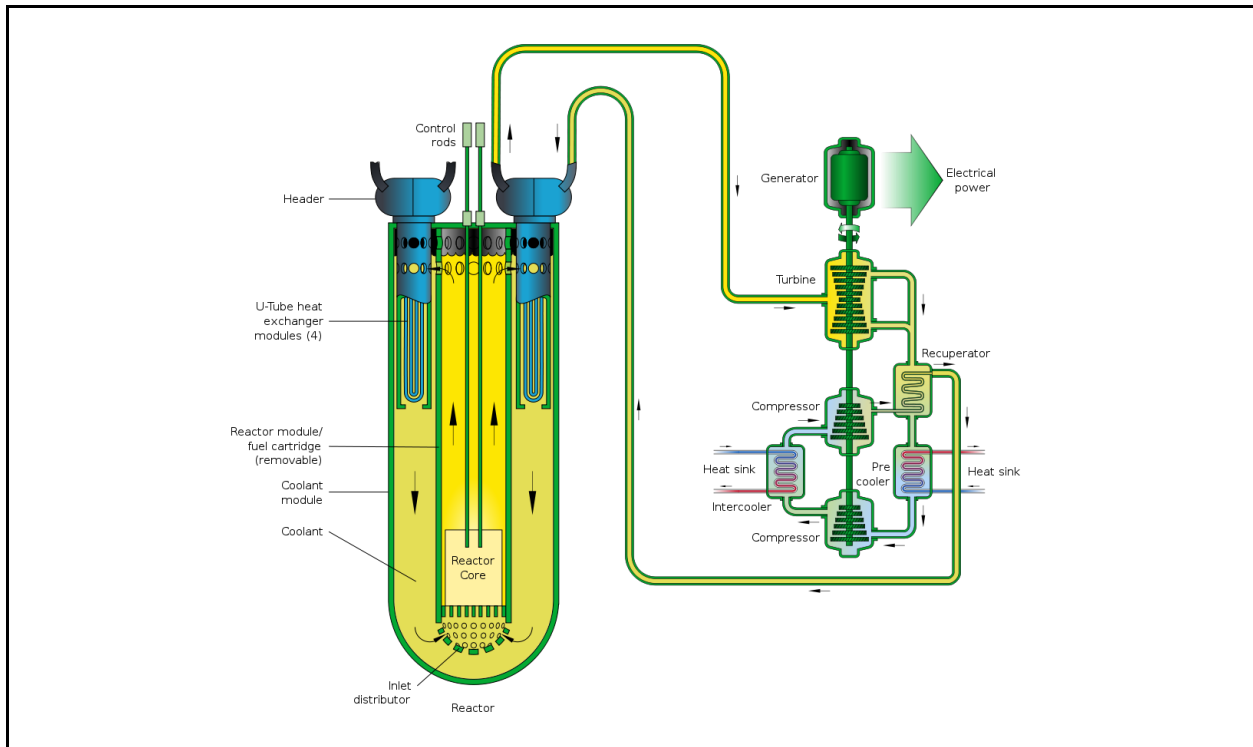


Figure 1: Simplified diagram of the LFR concept [1].

Beyond the potential applications of this fast neutron source in both fast reactor research and nuclear cross section measurement, of which there is a lack of data, the following topics must be resolved prior to fabrication of this assembly:

- Accelerator-driven source strength and placement
- Fast multiplying core design and associated thermal modeling
- Neutron flux measurement both in and outside of assembly core
- Beamline design for experimental setups (cross section measurements primarily)
- Safety systems (shielding effects and materials)

In order to properly understand how these challenges will be tackled, it is first important to understand the science behind them. The first primary component of this fast neutron multiplying assembly is the neutron generator itself. There are many types of neutron sources on the market, including but not limited to: spontaneous fission neutron sources such as Cf-252, alpha sources packed into a low-Z material matrix such as PuBe, and fusion generators. In order to achieve both a stable and monoenergetic source that can be turned on and off, it was decided that

a fusion generator would be the best option. There are two primary types of fusion neutron generators on the market, D-T and D-D generators, which fuse deuterium/tritium and deuterium/deuterium ions, respectively. D-T generators produce monoenergetic neutrons at an energy of 14.1 MeV and D-D generators produces monoenergetic neutrons at an energy of 2.45 MeV. While D-T generators produce a more energetic neutron, which could be beneficial in some cases, tritium is a radioactive gas that is extremely difficult to control. It poses an environmental and health hazard if released to the environment and is also heavily export controlled as it is used in the design of some nuclear weapons. Because of these reasons, it was decided that a D-D generator is the best option for this project.

D-D generators operate by fusing deuterium ions to produce a Helium-3 nucleus and a 2.45 MeV neutron. The way this is done is surprisingly simple. In the most general sense, D-D fusion generators consist of two electrodes, a deuterium gas flow loop, and a high voltage power supply. Figure 2 below shows a simple diagram of this setup more clearly [2]. The high voltage power supply is generally set to a voltage between -40 and -120 kV. The negative voltage is supplied to the cathode in the center, and the anode is set to ground potential. Both the anode and cathode are generally constructed of a thick wire mesh bent into a spherical shape, in order to allow the permeation of deuterium ions. Deuterium gas is pumped into the system by the feeder pumps, which when entering the inside of the spherical anode sheath, are stripped of their electrons, creating deuterium ions. These deuterium ions are then accelerated towards the center cathode and penetrate through. As they penetrate through the cathode back into the electric field region, they are once again accelerated towards the cathode. This creates an oscillation effect. The ions oscillate and build energy up until they collide with other ions in the center of the cathode. When these ions attain enough energy and collide, they can fuse to produce Helium-3 and a 2.45 MeV neutron, which is then emitted outside of the fusion generator.

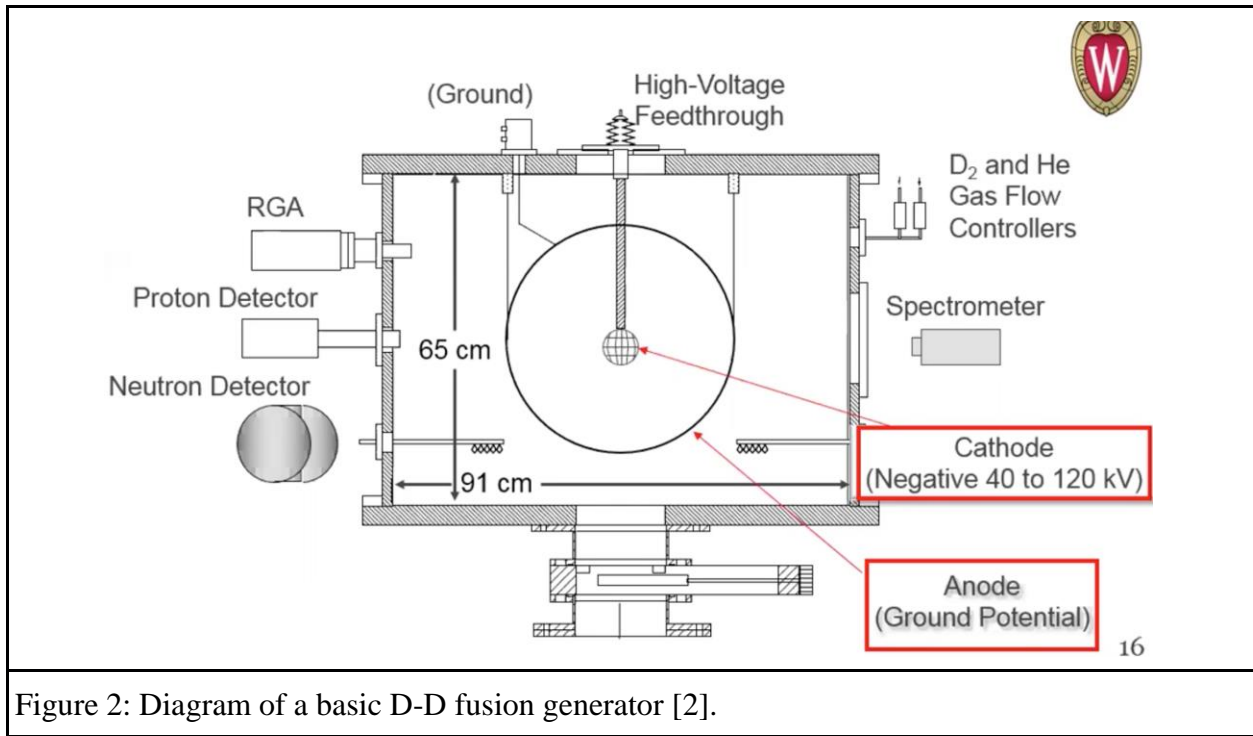


Figure 2: Diagram of a basic D-D fusion generator [2].

Accurate fast neutron flux measurement poses an interesting challenge for this project. Most common types of neutron detectors on the market, such as Helium-3, BF<sub>3</sub>, and fission chambers have very low interaction cross sections with fast neutrons, but have very high interaction cross sections for thermal neutrons. The ability for these detectors to accurately detect and quantify fast neutron flux is further hindered by the low gamma-ray sensitivity of these detectors (besides fission chambers). Both of these problems pose a challenge in reliably quantifying the fast neutron flux in a small flux, but in our case, we will have such a high fast neutron flux (on the order of  $10^{10}$  to  $10^{12}$  cm<sup>-2</sup>), that even if we only detect a thousandth of the neutrons that hit the detector due to the low interaction cross section, we will still get a large enough signal to accurately make the measurement. This solves the low interaction cross section problem, but not necessarily the gamma-ray problem. In our case, we will likely not have a high enough gamma-ray flux to significantly affect the fast neutron flux measurement, however, because funding is not really an issue, we found a solution to this problem. This solution involves the use of two ionization detectors, one Boron-10 lined for detecting both neutrons and gamma-rays, and one that is not Boron-lined for detecting only gamma-rays. The signals from both detectors can then be fed to a subtraction circuit that removes the gamma-ray signal from the neutron signal. Because the neutron flux will be so large, voltage pulse mode is not really the ideal way to measure counts, so Campbelling or current mode can be used. Figure 3 shows an example of a typical boron-lined ionization chamber setup used for reactor instrumentation [3].



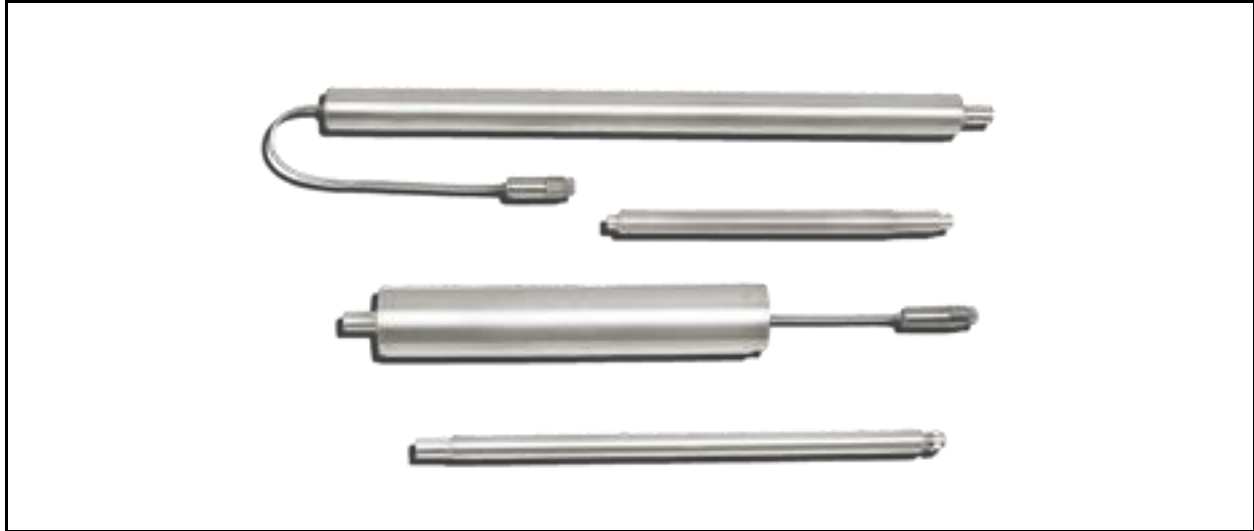


Figure 3: Typical B-10 lined ionization detectors used for reactor instrumentation. This one in particular is produced by a company names Photonis [3].

A much more costly alternative to using B-10 lined ion chambers is to use U238-lined fission chambers to perform the same measurements. As far as sensitivity to fast neutrons goes, both U238 and B10 are nearly identical, with U238 having a fission cross section of about 0.53 barns and B10 having an  $(n,\alpha)$  cross section of about 0.32 barns for 2.5MeV neutrons. Figure 4 shows a comparison of the cross sections for both interactions.

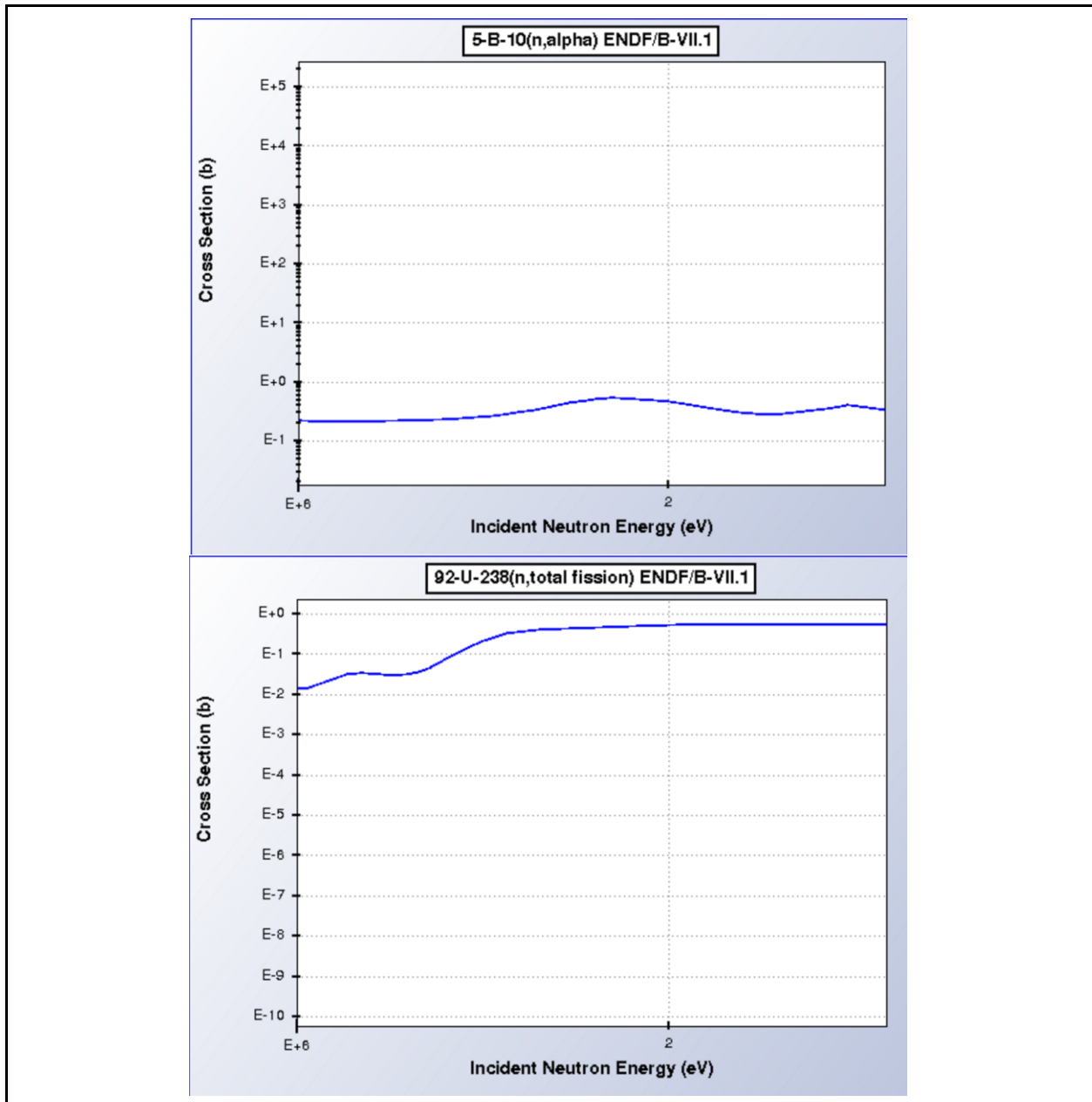


Figure 4:  $(n,\alpha)$  cross sections for B10 (top) and fission cross section for U238. Energy ranges from 1 to 3 MeV for both plots.

While both types of detectors are alike when it comes down to sensitivity, fission chambers have their own advantages and disadvantages. In particular, fission chambers are not sensitive to gamma-rays, so a combined subtracting circuit for gamma-ray discrimination is not required as is needed for B10-lined ion chambers. Having one single detector can make the post-processing circuitry simpler, but it is important to weigh this added simplicity against the disadvantages posed by the use of fission chambers, in particular the fact that they often cost a significant more amount of money to purchase due to having to use highly enriched U238 on the inner surface of the

chamber. Because they contain radioactive material, storage and handling is also more difficult in terms of safety and regulatory practices. Table 1 below lays out the advantages and disadvantages of both proposed detector types. It is the senior design group's opinion that due to the large price difference and the nearly identical cross sections, the B10 lined ionization chambers are probably the better option.

	<b>B10 Lined Ionization Chambers</b>	<b>U238 Fission Chambers</b>
Advantages	<ul style="list-style-type: none"> <li>● Inexpensive</li> <li>● <math>\sigma(\text{fission})=0.32</math> barns</li> <li>● Readily available</li> </ul>	<ul style="list-style-type: none"> <li>● Insensitive to gamma-rays</li> <li>● <math>\sigma(n,\alpha)=0.53</math> barns</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>● Slightly sensitive to gamma-rays</li> </ul>	<ul style="list-style-type: none"> <li>● Very expensive</li> <li>● Difficult storage and handling</li> </ul>

### ○ *Constraints*

The construction of a fast source facility of this size is subject to strenuous constraints. The constraints identified thus far include the safety of unqualified individuals, regulatory constraints, and size constraints. The largest concerns in the sector of keeping unqualified individuals safe include minimizing the dose to surroundings, ensuring the facility cannot go critical, ensuring the impossibility of activating the room, not using tritium considering its high toxicity, and finally, keeping it sub-critical even if the facility were somehow submerged. This limits what kind of neutron generator that can be used, the material in which the core and surrounding attachments are made from, possibly the need to fully waterproof the system, and the amount of neutron flux that can possibly be generated. Safety to the public is the greatest constraint as this facility is set to be on the edge of campus near Neyland Stadium. This raises the safety level needed to be achieved by this reactor significantly. The space in which the facility will be is also a limiting factor, requiring a compact design instead of an expansive system. The facility will, however, be small enough to fit in the room with all appropriate safety and control systems, most likely with a crane above it for construction of the facility as well as manipulation of core configuration. Regulations and requirements from the state also limit the facility. This makes it so that the facility, already required to stay subcritical, can have no chance of going critical from any accident conceivable. Heat generation was also of concern for the facility. However, upon further calculation, passive heat removal by conduction as well as radiation and convection to the surrounding air were found to be suitable for the proposed standard operation of the facility. The final constraint is that the facility needs to be designed so that if needed, the university could take it critical in the future, but initially ensure its sub-criticality.

## ○ *Standards and Licensing*

The current understanding is that the fast neutron facility will not fall under any classifications that require additional licensing as a type of reactor. This is due to the low heat generation of the facility, as well as the fact that it will stay subcritical. However, if the university was considering redesigning the core configuration so that criticality would be achieved, then the licensing demands would be significantly greater. The facility would be classified most likely as a test reactor, and be subject to additional restrictions within 10 CFR 70 as well as most likely Nuclear Regulatory Commission requirements. Industry and University standards for radiation protection will need to be followed thoroughly, so as to limit exposure to students and reduce the risk of catastrophe, especially considering the proximity of the proposed facility to Neyland Stadium.

The facility will need the safety analyses as outlined in 10 CFR 70 in order to be in accordance with a special nuclear material (SNM) license. The SNM license is necessary due to the great quantities of uranium that will be present in the fast neutron facility. These involve certifying the security of the material against incident, such as criticality accidents, fires, explosions, and other accidents. Specifically, some of the directly applicable standards in 10 CFR 70 (Subpart H, section 70.61) involve acute dose. The limits listed are separated into high-consequence and intermediate-consequence events. The high-consequence limits are 1 Sievert for radiation workers and 0.25 Sieverts for the general public. The medium-consequence limits are 0.25 Sieverts for radiation workers and 0.05 Sieverts for the general public. As shown in our MCNP results later in the report, our decisions regarding the shielding material and layout guarantee that these doses should never be achieved under normal operation, and the safety systems involved in the facility should be more than enough to prevent accidents that would lead to acute levels of exposure. Additionally, the thick concrete walls around the room should do quite well in preventing exposure to the general public.

The core is designed with control rods that permanently stay in position as well as rods that can be removed mechanically. Yet, the core cannot go critical and will not exceed the acute dose limits set even if the removable control rods are absent. This section of 10 CFR 70 also talks about toxic chemical release, but the most toxic materials in the facility design are the lead and uranium, both of which will stay isolated within the reactor. The temperatures the reactor will operate within are well inside the melting temperature of the lead, and even if an accident were to occur, aluminum sheathing will be placed around the lead blocks so that if the lead were to melt, the rods would not be able to fall down in molten lead and clump together, which could cause a criticality accident. Additionally, we chose to use carbon steel instead of stainless steel, as stainless has some elements that pose high activation risks. A criticality safety analysis will of course be necessary to verify the design considerations and certify that the facility will be safe in all foreseeable circumstances and not experience any criticality accidents.

The area housing the facility will need to be a secure area, which will be maintained by the University of Tennessee Lock and Key department, likely with physical key access as well as card swipe readers being required to enter the lab area. Access to this area will only be granted to individuals who have taken the appropriate radiation safety courses and are fully aware of the

dangers and responsibilities involved in the maintenance and use of the facility. These trainings will be designed to address standard radiation safety topics, including the topics listed in 10 CFR 19. The costs associated with the inspections and licensing are relatively obscure, and further investigation will be necessary to establish a firm idea of their total expenses. The university will also be responsible for maintaining documentation regarding compliance with these standards, as well as detailed reports of any instances in which these standards and regulations are violated. In the event that an extreme event that prevents access to the radioactive materials occurs, a report must be sent to the NRC within four hours of discovery. Furthermore, a more detailed report must be communicated within 24 hours to the NRC in these events as well as less severe events that are still notable, and listed in 10 CFR 70.50. Within 30 days of these events, a full written report must be delivered to the NRC describing the event, probable causes of it, and the preventative measures taken or planned in response.

*For full details, refer to Appendix A on Licensing, containing 10 CFR 70 in its entirety.*

## **II. Methods**

### **○ Description of Computational Methods**

#### **1. Overview**

In order to carry out the process of designing this facility, certain computational tools are required. A modeling software called SERPENT will be utilized in designing and ensuring the safety of the subcritical multiplying core due to its ability to simulate the specific geometry and materials of the system and how the neutron flux profile will change with minor and major changes to the system. MCNP will be utilized to model the core geometry and safety systems.

#### **2. SERPENT**

SERPENT is a Monte Carlo particle transport code which inherently offers a few computational advantages over other modeling software. The primary use of SERPENT is to model reactor physics for the affirmation of transport models by comparing them with physical and simulated facilities. Models were developed in SERPENT to provide heat calculations, flux profiles, k-effective values, and burnup calculations- which is unique to SERPENT. SERPENT excels at lattice based core design while other modeling software, namely MCNP, excels at particle propagation and is used to model the system as a whole for dose calculations and detector arrangement.

In order to efficiently write the input deck that SERPENT reads, python scripts were developed to automatically generate the input deck based on certain input parameters. These python scripts can be seen for the final design in Appendix B and are broken down into five subscripts: surfaces.py, cells.py, drumdeck.py, materials.py, and writecore.py. The surfaces script reads user inputs for dimensions and parameters, then builds the geometry of the subcritical multiplier core based on those inputs. It is responsible for the building of the lattice of each assembly or cassette (explained in detail later), as well as the overall lattice placement of assemblies. The cells script specifies cell boundaries and definitions as well as which material each cell consists of. The drum deck imports the cross section libraries, defines the neutron

source, specifies plotting parameters, and other parameters. The materials script defines material compositions as well as specifies which cross section libraries to utilize. The write core script compiles the other scripts and generates the SERPENT readable input deck.

### **3. MCNP**

In MCNP, multiple models were produced and compared among the design team. James Ghawaly developed a code to write the complete MCNP input file to mimic the geometry of the core while Daniel Peffley and Zachary Bingham investigated candidate shielding materials and developed a mock-room set up in MCNP. The design consists of a simple room 60 ft. long by 16 ft. wide by 15 ft. tall containing the core with a concrete wall and human phantom right outside of the room. This model is detailed in figure 4.

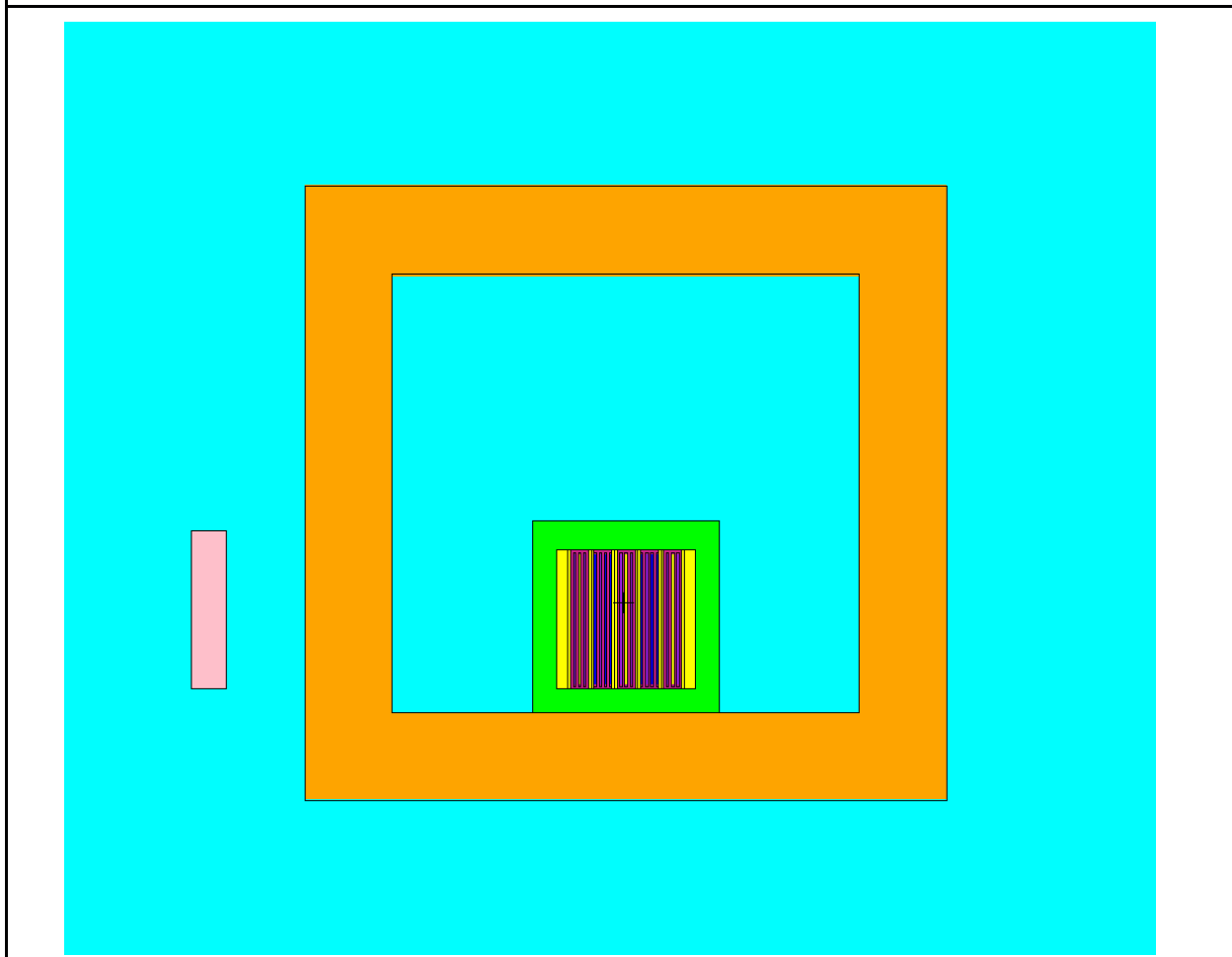
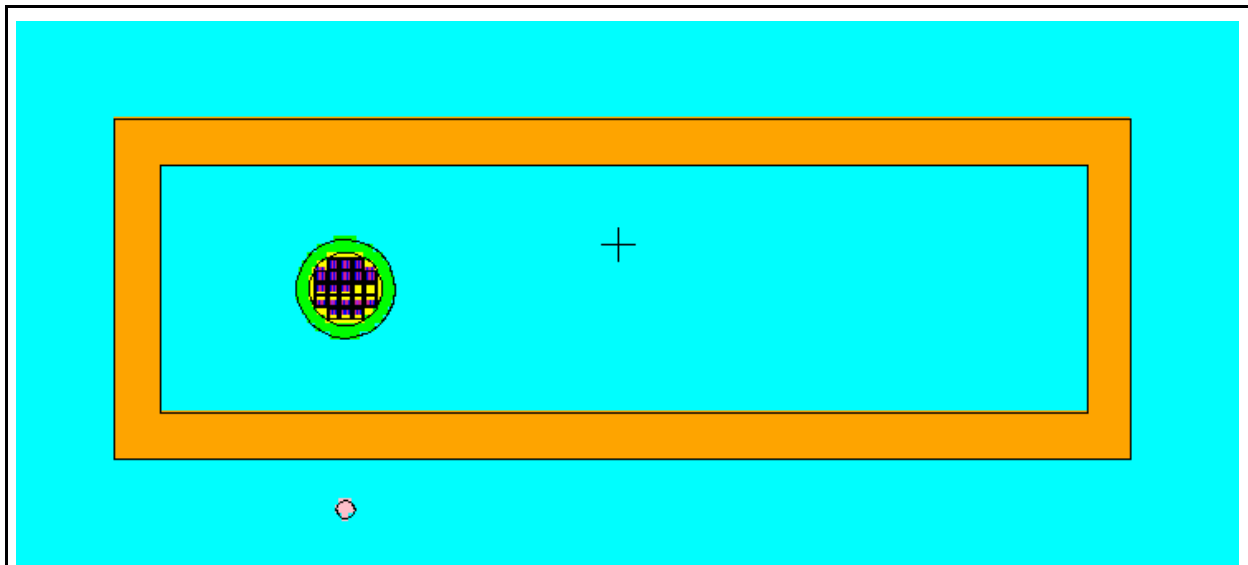


Figure 4: MCNP mock-room set up as viewed by the MCNP interactive plotter. Blue layer is ORNL concrete, pink is air, core and shielding are white. *Top: XY-Plane, Bottom: YZ-Plane*

Due to the difficulty of modeling complex geometry in MCNP6 by hand, a python script was written in Python 2.7.6 that automatically generates the entire MCNP6 input deck. This Python script was designed in such a way that makes it possible to easily and quickly make large changes to the model (such as core height, cladding thickness, etc.) without having to manually change dimensions and inevitably have to debug errors in the input deck. On a decent PC, the Python script takes less than one second to completely generate the input deck. The user must simply then run it in MCNP6 to get the results that they desire. Overall, the following bullet points list the primary capabilities of this script:

- Automatic generation of the cell cards.
- Automatic generation of the surface cards.
- Automatic generation of the data cards.
  - Materials
  - Basic K-effective source card
- Automatic commenting of each surface and cell with information including what type of cell/surface it is and the position of it relative to what cassette it is in.

In order to run this script, the user must provide the following information to the code:

1. Number of cassettes along the side of the core.
2. The fuel cladding dimensions.
3. The height and radius of the core.
4. The radius and length of the fuel rods.
5. The number of rods per cassette along one axis.
6. The cassette enclosure thickness.
7. The reflector thickness.
8. The position of the left-hand corner of the reactor

From this given information, the Python script begins by generating the surface card of the input deck. It does this in the following way (details omitted):

1. For each cassette in the structure
  - a. Calculate the position of the cassette
  - b. If the cassette's edges extend outside of the radius of the reactor:
    - i. Throw it away and start back at step 1.
  - c. Otherwise:
    - i. Generate a RPP macrobody for the cassette.
    - ii. Append that macrobody to the surface array.
    - iii. Continue to step 2.
2. For each structure (fuel/cladding bundle or lead block)
  - a. Calculate the position of the structure.
  - b. If the structure needs to be a fuel rod/cladding bundle:



- i. Generate a RCC fuel rod macrobody.
    - ii. Generate a RPP cladding macrobody.
    - iii. Append both macrobodies to the surface array
  - c. If the structure needs to be a lead block:
    - i. Generate a RPP macrobody in that position.
    - ii. Append that macrobody to the surface array.
3. Generate an RCC smacrobody for the cylindrical core around the cassettes.
4. Generate an RCC macrobody for the reflector.
5. Generate the “universe” SPH macrobody.

Once the surface card has been completely built, the cell card can be constructed. Using the surface card array, the code generates the cells using the following algorithm (details omitted):

1. Iterate over every surface in the surface card array.
2. Determine the surface type based off of the comments generated for the surfaces, which contain the keywords: “FUEL\_ROD”, “CASSETTE”, FUEL\_CLADDING”, etc.
3. Based off of the surface type and knowing the relative position of the current surface number with respect to the surface card numbers that are connected to it, generate the cell.
  - a. Example: If the current surface is a fuel rod with surface number i, it is known that the surface with number i-1 is the fuel cladding surrounding the rod, thus the appropriate cells can be made.
4. Append the cell to the cell array.

Once both the surface and cell cards are generated, the data card is built using the materials needed for the design. In order to write the input deck, the code first iterates over the surface array and writes each surface to a file with a user-given filename. It then iterates over the cell array and writes each cell to the file. Finally, it writes the data card and saves the file to the user-given directory. An example of a section of the input deck is shown below. As can be seen, each surface is automatically commented so that the user knows where each cell/surface belongs. This is useful if the user wants to change a random fuel rod into a control rod or a detector, for example.

```

578 RPP -10.525 10.525 10.525 31.575 0 60.96 $ Cassette: (-10.525 , 10.525) ::: CASSETTE
579 RPP -9.525 -5.715 11.525 15.335 0 60.96 $ Lead Block ::: (0,0) ::: In Cassette: (-10.525 , 10.525) ::: LEAD_BLOCK
580 RPP -9.525 -5.715 15.335 19.145 0 60.96 $ Fuel Cladding ::: (0,1) ::: In Cassette: (-10.525 , 10.525) ::: FUEL_CLADDING
581 RCC -7.62 17.24 1 0 0 58.96 1.27 $ Fuel Rod ::: (0,1) ::: In Cassette: (-10.525 , 10.525) ::: FUEL_ROD
582 RPP -9.525 -5.715 19.145 22.955 0 60.96 $ Lead Block ::: (0,2) ::: In Cassette: (-10.525 , 10.525) ::: LEAD_BLOCK
583 RPP -9.525 -5.715 22.955 26.765 0 60.96 $ Fuel Cladding ::: (0,3) ::: In Cassette: (-10.525 , 10.525) ::: FUEL_CLADDING
584 RCC -7.62 24.86 1 0 0 58.96 1.27 $ Fuel Rod ::: (0,3) ::: In Cassette: (-10.525 , 10.525) ::: FUEL_ROD
585 RPP -9.525 -5.715 26.765 30.575 0 60.96 $ Lead Block ::: (0,4) ::: In Cassette: (-10.525 , 10.525) ::: LEAD_BLOCK
586 RPP -5.715 -1.905 11.525 15.335 0 60.96 $ Fuel Cladding ::: (1,0) ::: In Cassette: (-10.525 , 10.525) ::: FUEL_CLADDING

```

## ○ Gantt Chart

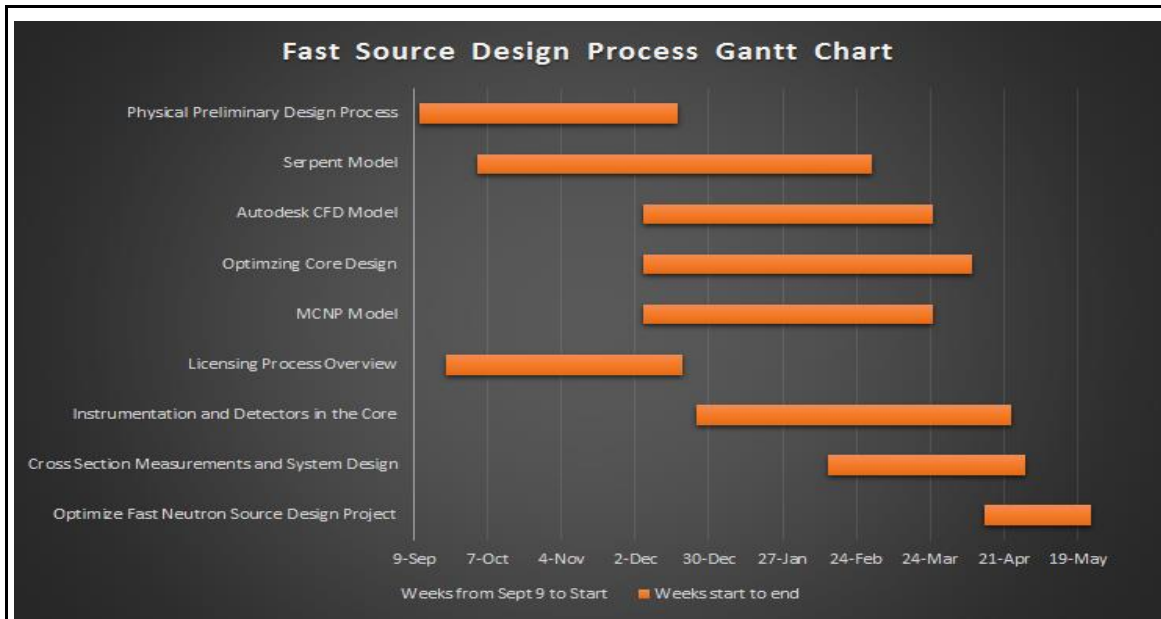


Figure 5. Gantt Chart detailing work process.

## ○ Work Breakdown Structure

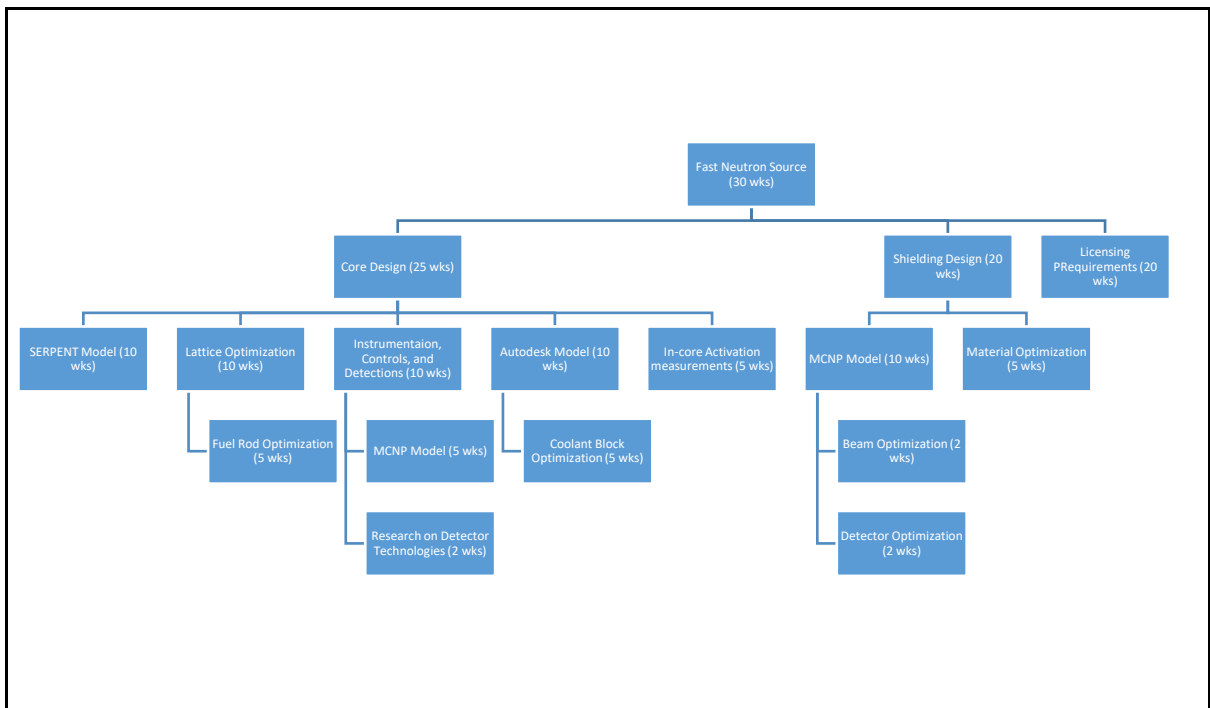


Figure 6. Work breakdown schedule detailing work process.

## ○ *Description of Effort by Team Members*

- Zach Bingham
  - Designed the mock-room in MCNP with materials in place
  - Worked in collaboration with Dr. Pevey and Daniel Peffley to discover the correct materials for shielding
  - Worked in collaboration with Dr. Pevey and Daniel Peffley to optimize the shielding
  - Met with Dr. Hines multiple times about the project
  - Supported preliminary hand calculations
  - Supported computational efforts
  - Performed Heat dissipation calculations alongside Duncan Brocklehurst
- Duncan Brocklehurst
  - Responsible for licensing and standards investigation for the reactor facility
  - Supported preliminary design processes related to the structure and layout of the core facility
  - Performed calculations related to the heat generation within the facility
  - Supported computational efforts
- Will Cureton
  - Lead effort on SERPENT model
  - Applied fuel cassette design to SERPENT model
  - Adjusted various models to attain desired k-effective
  - Ran criticality calculations on the subcritical multiplier core with different accident scenarios.
  - Performed calculations on heat generation within the subcritical multiplying core
- James Ghawaly
  - Wrote a python script to generate the MCNP6 input decks for 3 different core designs
  - Run multiple k-effective tabulations for different core designs and modified accordingly
  - Ran flux measurements on the core in MCNP6.
  - Literary research for detector technology for fast neutrons
  - Research on activation of nuclear materials
  - Poster development and presentation at EURECA
- Colton Oldham
  - Assisted effort on SERPENT model
  - Performed heat generation calculations for the core and materials
  - Literary research for cassette core design

- Preliminary hand calculations
- Preliminary core design options
- Lead effort on AutoDesk models
- Daniel Peffley
  - Communicated with Dr. Pevey to determine optimum shielding for core design
  - Collaborated with Zach Bingham on the MCNP model of the lab space
  - Met with Dr. Hines to discuss room layout and dimensions
  - Aided in Licensing and Regulations considerations

### **III.Results**

#### **○ Physical Design**

The physical design of this facility brings many challenges such as material limitations, neutron streaming, and simplicity of construction. With the large amount of complications that are associated with the development of this facility, the design has gone through many iterations to reach its current state. The separate phases of the core design will be shown below, along with the benefits and drawbacks associated with them.

##### **i) Simple Checkerboard Lattice Core**

This core lattice was the first explored for the fast source neutron facility. This geometry allows for the most simplicity throughout the core, but this comes at a great cost to customization and adaptability. With full length fuel rods, and lead coolant blocks, there are few ways to easily adjust the core to run the large variety of experiments that are desired. This lead to the desire of adjusting the lattice within the core.

##### **ii) Hexagonal Lattice Core**

The hexagonal lattice core was designed to address the issues for a variable pitch between the fuel pins in a solid lead-cooled system. The hexagonal blocks allow minimal void space, while allowing the pins to be adjusted to varying pitches. Figure 7 shows the hexagonal core configuration in more detail. Although this design addresses these problems quite well, it over complicates the structure and system as a whole. Due to this, a different approach to the lattice was needed in order to address the concerns of flexibility for a variety of experiments.

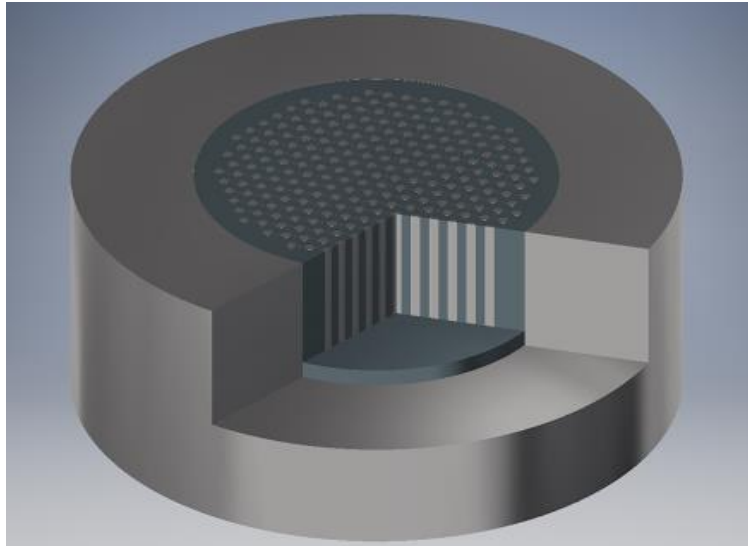


Figure 7: 3D view of the AutoDesk hexagonal lattice core model

### iii) Cassette Core

The cassette design is the current structure that is the best fit for this facility. It combines the simplicity of the checkerboard lattice, while structuring the core into individual cassettes that excel in adaptability and customization. These cassettes allow for many different arrangements to be used in local areas in order to simulate mixed oxide fuels, as well as locations to insert samples and detectors into the core at desired positions. These lattice points are also used to place instrumentation cells. These cells can either be the detectors of interest previously mentioned, or thermocouples for temperature readings. Having many instrumentation sites throughout the core allow for the system to be operated with safety as a top priority. It is also great to allow for easy placement of the generator within the core. This core configuration is shown in figures 8-10.

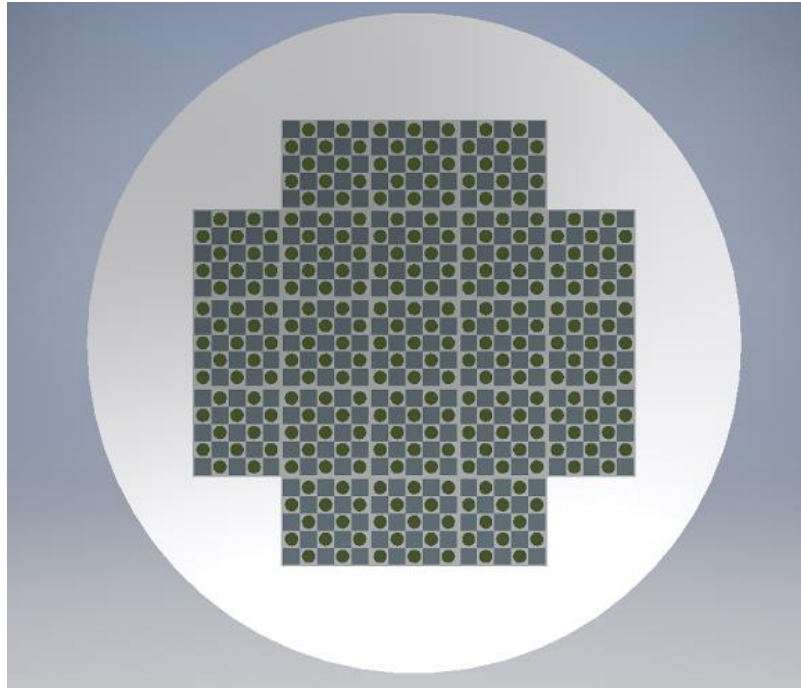


Figure 8: XY Plane slice of the AutoDesk cassette core model

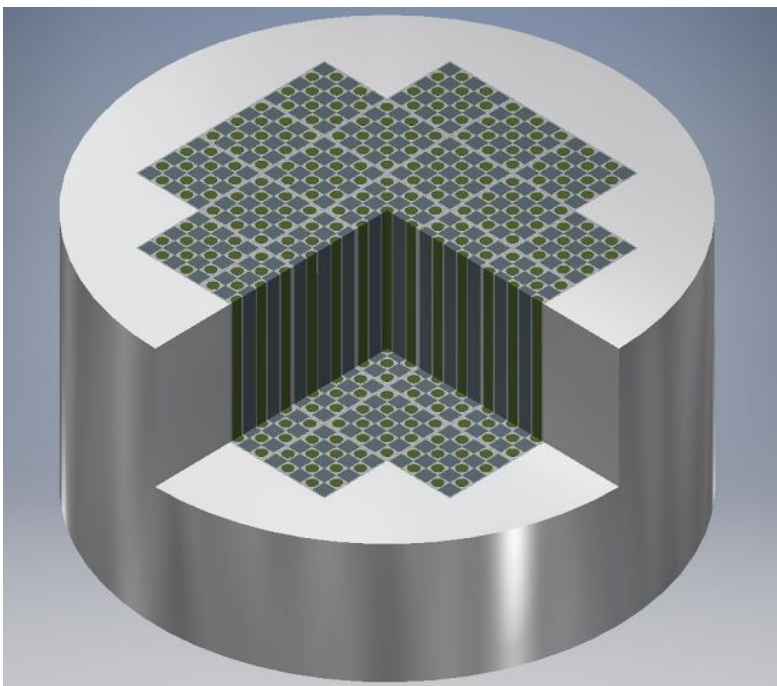


Figure 9: 3D view of the AutoDesk cassette core model

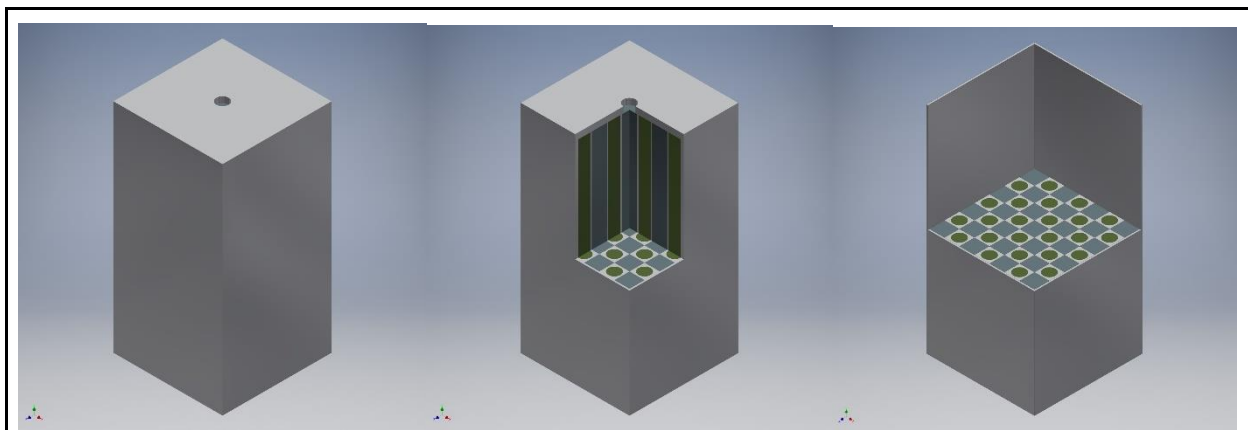


Figure 10: Cutaway view of an individual cassette

The individual cassettes can be seen above. They are designed to each contain a seven by seven matrix that can contain a variety of components depending on the desired experiment or simulation. The default, most critical lattice, is shown below as a checkerboard fuel and lead coolant alternating lattice. These cassettes are then stacked vertically three cassettes tall, with a designated center lattice point, for which mechanized control rods can be placed. The outer shell of the cassette is constructed out of 6061 aluminum alloy. This is the same alloy used in HFIR, and it allows for improved mechanical properties while also minimizing the concern of activation products. This alloy contains around 0.04% chromium which is significantly lower than the 10% or higher used in stainless steels. With this combination, the cassettes frame can be lightweight, structural integrity, and have very minimal activation concerns after experiments are conducted. A lead reflector is placed outside of the cassette arrangement. Utilizing lead for the initial section of the reflector allows the overall size of the reflector to be decreased, as well decreasing the amount of steel needed due to activation products. A steel reflector exists on the perimeter of the lead reflector. Although stainless steels are commonly used to prevent oxidation of the surfaces, carbon steel is proposed for this iteration as it will function very similar, but greatly decrease the amount of heavy metals, particularly chromium, in the alloy. Eliminating this relatively large concentration of chromium vastly improves a post irradiation scenario due to the elimination of potential activation products. The remaining pieces of shielding, polyethylene and additional steel, will then surround the core and enclose the facility such that external dose is minimized to acceptable limits.

### ○ MCNP

MCNP models for 3 different core models include, a hexagonal structure, a checkerboard lattice, and a fuel cassette lattice. These were constructed using a Python script to formulate a MCNP code with surfaces and cells. Calculations were performed using these models to estimate the k-effective value and to find the neutron flux measurements outside of each core design. Figure 11 below shows the X-Y cross section of the core with reflector as viewed from the positive z-axis in the MCNP6 interactive plotter. This core uses Low-Enriched Uranium (LEU) fuel, lead coolant,

an aluminum core rim, and a carbon steel neutron reflector. Fuel pins can easily be changed into control rods or instrumentation ports by changing the material in said fuel pin's cell card. Each cell in the input deck is commented so that finding a particular fuel pin in the core is a simple task.

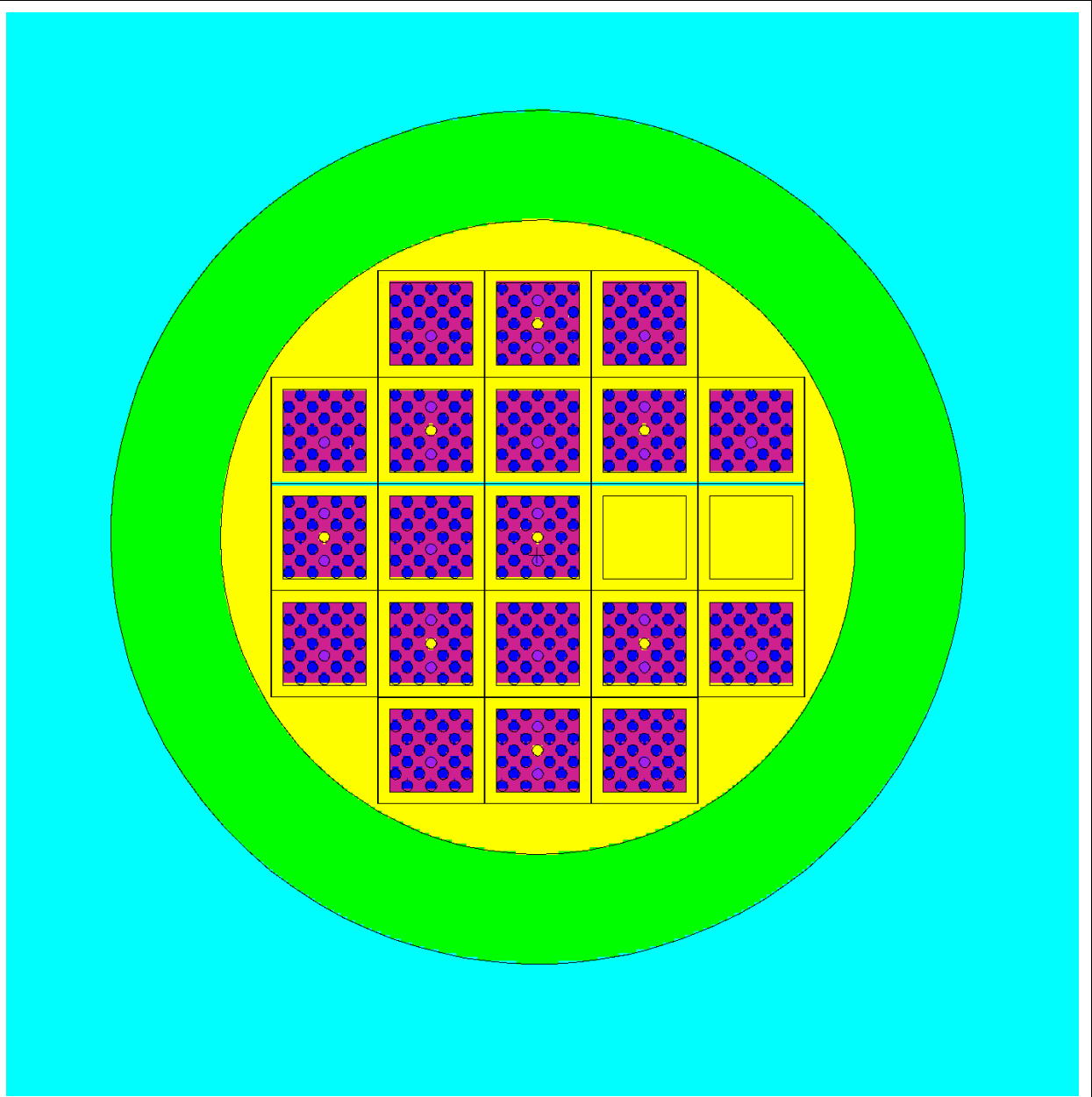


Figure 11: X-Y Cross section of the core as seen from the positive z-axis in the MCNP6 interactive plotter. Dark blue: fuel ; Purple: control rods ; Yellow: aluminum ; Pink: lead ; Green: carbon steel ; Cyan: air



Using the design seen in Figure 11, a k-effective calculation was ran using 500 iterations of 5000 neutrons each, positioned within the neutron generator slot. 10 iterations were skipped in order to produce good statistical results. From this model, the MCNP6 estimate of k-effective is  $0.96921 \pm 0.000301$ , which is well within the desired range and matches well with the SERPENT results for the same core configuration.

It is also important to acquire flux estimates on the surface of the core and reflector. This was done using a F2 tally on these surfaces with a 2.5 MeV point neutron source placed in the neutron generator slot of the reactor. The source strength from the neutron generator used was its average value of  $4.7E9$  neutrons/second. The results of this configuration are shown below in Table 1.

Further, in order to produce an estimate of the dose-rate that a person would receive inside of the room during reactor operation, a human phantom was placed inside of the room, 200cm away from the center of the core. The human phantom is a very simple model, consisting entirely of a 5'5" tall cylinder with a radius of 18.5cm, consisting entirely of tissue-equivalent polyethylene. An F4 cell tally with a dose-rate response function from Appendix H of the MCNP6 manual was applied to the phantom. This tally outputs the result in rem/hr. Further, a +F6 tally was placed within the phantom [6] in order to tally the absorbed energy rate on the phantom. This tally measures absorbed energy in units of MeV/kg. To convert it to a rate, this result must be multiplied by the source strength of the DD-generator as the result is normalized per source particle.  $4.7E10$  is used throughout this section as the DD-generator source strength. For better visualization of this, see Figure 12. The results of the dose-rate calculation are displayed in Table 1.

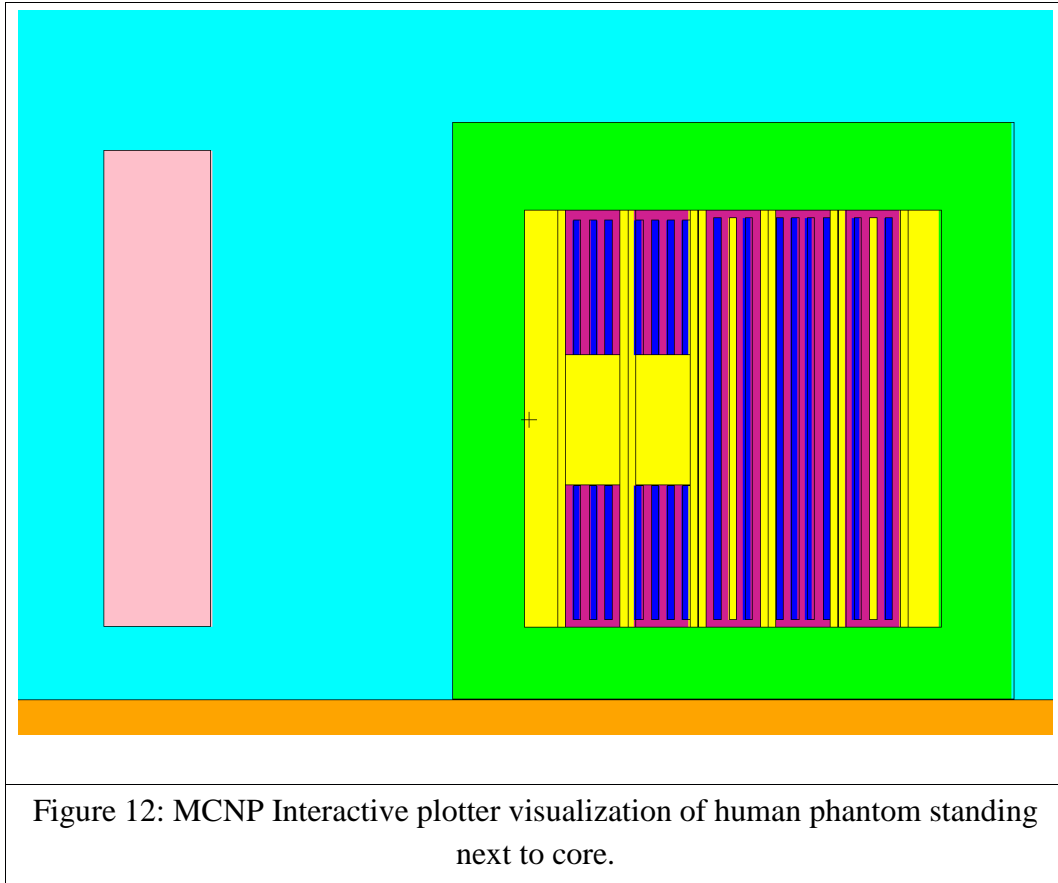


Table 1: MCNP6 Results

Flux on Core Rim (#/sec/cm**2)	3.678E6 ± 6.068E4
Flux on Reflector Rim (#/sec/cm**2)	3.265E5 ± 5.42E3
$K_{eff}$ (dry)	0.96921 ± 0.000301
$K_{eff}$ (flooded, no SCRAM)	1.00040 ± 0.00034
Dose-rate in Phantom w/o Shielding (rem/hr)	0.6217 ± 9.636E-3
Energy Absorption-rate in Phantom (Gy/hr)	1.342E-4 ± 2.376E-6

Clearly, the dose-rate on a human standing next to the reactor while it is running is not acceptable without a significant amount of shielding. Shielding is covered in more detail later on in this report.

### ○ SERPENT

As mentioned before, several models for the subcritical multiplier core were considered. Initially, Dr. Chvala provided a starting point core which consisted of a checkerboard lattice of lead blocks and fuel rods surrounded by a stainless steel reflector. The next design we adopted utilized a hexagonal lattice with modular lead cooling blocks that could be added or removed in

order to adjust rod pitch and therefore the neutron energy spectrum. A rendering of the hexagonal lattice utilizing serpent as well as flux plots, where brighter areas are areas of higher neutron flux can be visualized in figure 13. This design allowed for a k-effective very near the desired value of 0.95 with added instrumentation and control.

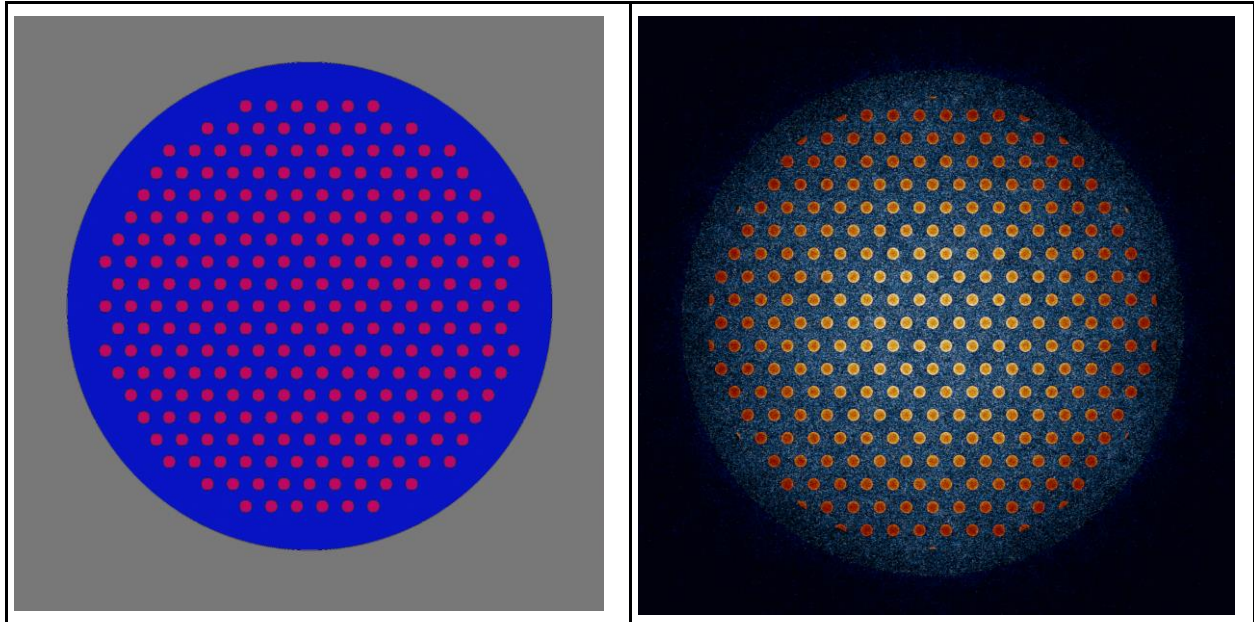


Figure 13: Top views of serpent rendering of hexagonal subcritical multiplier core (left) and flux plot of hexagonal subcritical multiplier core (right). Red circles are 19.75% enriched uranium fuel rods and blue area is solid lead coolant.

The hexagonal lattice design, while ingenious and creative, was deemed too complex for assembly, rearrangement, and tear-down and most likely cost ineffective. In addition, it was realized that in some sort of accident scenario, if excess heat is generated within the core, the lead coolant is subject to melting due to its low melting point. If indeed the lead liquefied, the fuel rods would be prone to fall upon one another, increasing criticality immensely. The hexagonal lattice design's replacement, as mentioned previously, was inspired by a foreign fast neutron source application [7] which utilizes fuel cassettes that's innards can be rearranged and replaced with different materials in order to allow for spectral flexibility. The cassettes can be visualized in Figure 14 and consist of a 5x5 checkerboard pattern of alternating 19.75% enriched uranium fuel rods and solid lead coolant blocks. Each rodlet (either uranium or lead) is completely surrounded by an aluminum enclosure in order to ensure components remain stationary regardless of lead melting. This configuration allowed for a k-effective of 0.99 without instrumentation or control rods, which seems very reasonable.

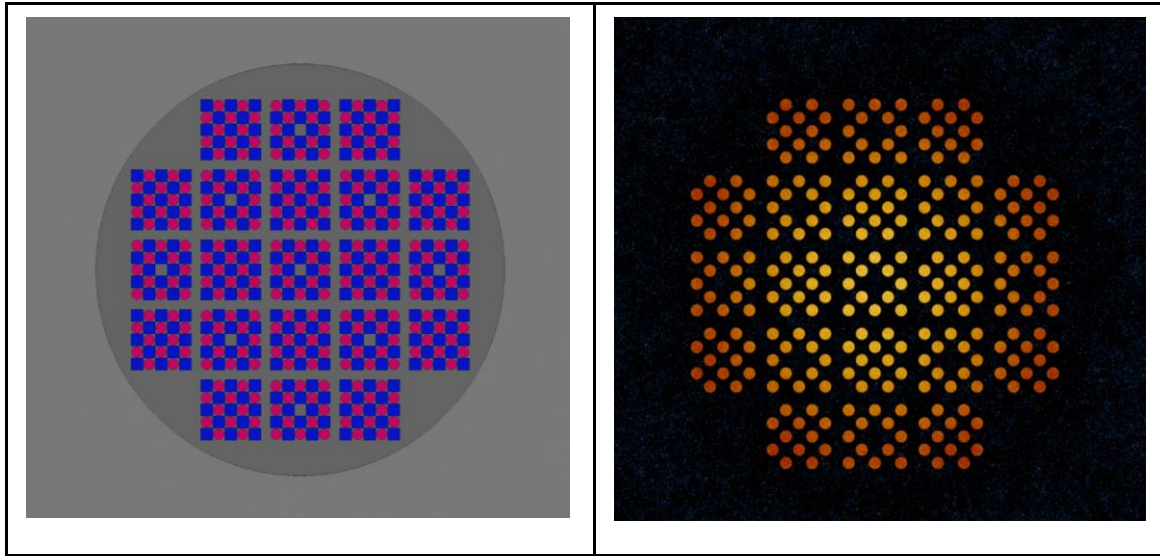


Figure 14: Top views of serpent rendering of the subcritical multiplier core filled with fuel cassettes (left) and flux plot of this subcritical multiplier core (right). Red circles are 19.75% enriched uranium fuel rods and blue squares are solid lead coolant blocks. Dark gray area is aluminum, while outer layer of lighter gray is carbon steel.

In order to improve system flexibility, it was decided to increase the size of the individual cassettes and therefore the entire core. This allows the removal of “normal” cassettes consisting of checker boarded fuel and lead and replacement with test assemblies. Since these test assemblies would contain less or an absence of fuel, surrounding assemblies would need more fuel to maintain the desired criticality and neutron flux within the subcritical multiplying core. These test assemblies could contain a combination of fuel and other materials such as alumina [7] in order to achieve a MOX fuel simulated neutron spectra or an assembly filled with materials for activation studies. Therefore, the 5x5 cassettes were enlarged to 7x7, seen in figure 15, a view of a center cut of the subcritical multiplier core.

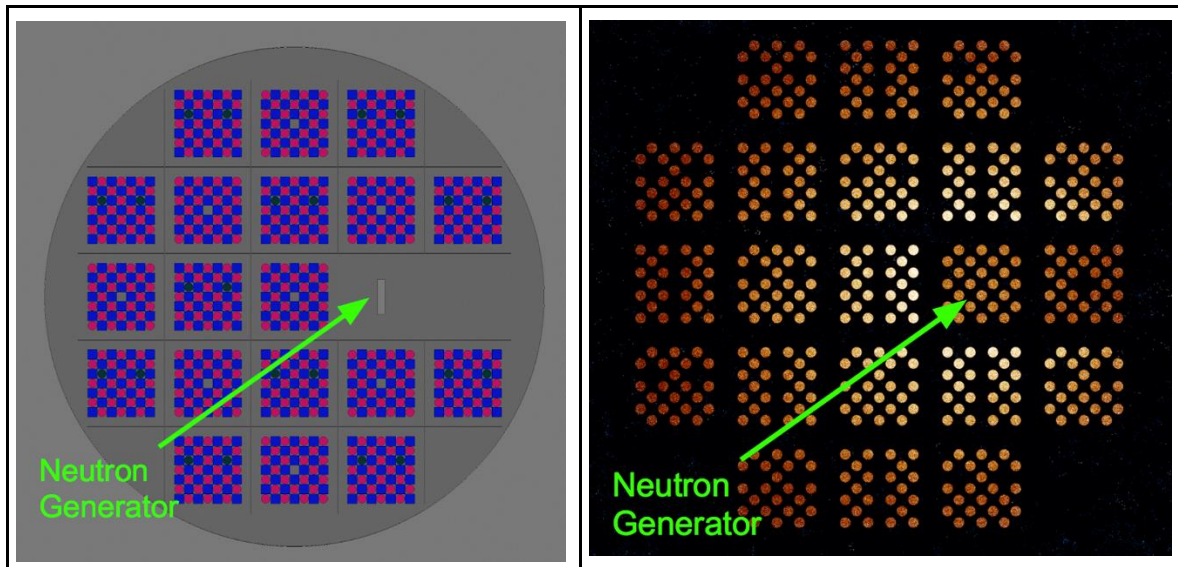


Figure 15: Center cut views of serpent rendering of the subcritical multiplier core filled with fuel cassettes (left) and flux plot of this subcritical multiplier core (right). Red circles are 19.75% enriched uranium fuel rods and blue squares are solid lead coolant blocks, dark green circles are control rods. Dark gray area is aluminum, while outer layer of lighter gray is carbon steel.

This model also incorporated the neutron generator, which specified where all neutrons were emitted and, in turn, affected the flux profile (also included in figure 15). Again, in each flux profile figure, brighter areas correlate to an area of higher neutron flux. Notice in the flux profile how the areas of higher flux are near where all neutrons are emitted from the generator. Assemblies were placed below and above the neutron generator as seen in figure 16, an axial cut view of the subcritical multiplier. Note the darker area of flux around the neutron generator is due to the removal of “normal” assemblies in order to place the neutron generator within the core. In addition, this model accounted for burnable absorbers or control rods. The placement of these control rods for normal operations and shutdown (normal and SCRAM) can be optimized based on the highest areas of flux to determine their greatest worth.



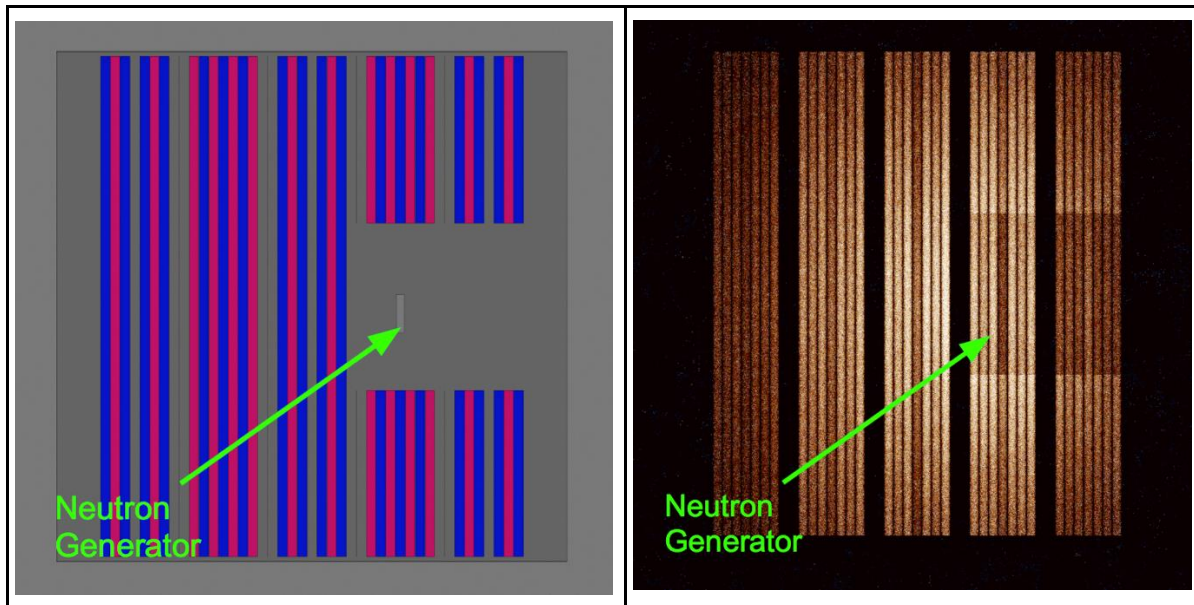


Figure 16: Axial cut views of serpent rendering of the subcritical multiplier core filled with fuel cassettes (left) and flux plot of this subcritical multiplier core (right). Red rectangles are 19.75% enriched uranium fuel rods and blue rectangles are solid lead coolant blocks. Dark gray area is aluminum, while outer layer of lighter gray is carbon steel.

Desired values for criticality can easily be achieved either with the addition of control rods, or with the removal of “normal” assemblies. However, when removing an assembly, it is imperative to fill the space with either a test assembly or an aluminum filler. In order to probe a worst case scenario, a layer of water was placed around the core as well as the widening and filling all air gaps with water. With a preliminary configuration, the criticality under normal conditions is around 0.97 and just 1.01 under flooding conditions without SCRAM rods.

### ○ Shielding

The primary objective of the shielding surrounding the core is to properly reflect neutrons back into the core while minimizing the radiation dose a human would receive inside the facility. Ideally, the shielding would consist of multiple layers, five in total. Typically, materials that have a higher density and higher  $Z$  are used as reflecting material. So, the innermost layer of shielding will most likely either be carbon-steel or lead. The next layer would be a low  $Z$  material that would act as a neutron absorber. However, in the act of slowing down or stopping neutrons, gamma rays are created. So, the outermost layer of shielding would again be a higher  $Z$  material that would prevent the secondary gammas created from escaping into the lab space. The finalized recommended shield layering is: innermost layer of carbon steel, the second layer is borated polyethylene, the third is regular high density polyethylene, the fourth is another layer of borated polyethylene, and the fifth and final layer is of carbon steel.

The materials chosen were taken into great consideration. As mentioned before, the primary reason for the use of carbon steel versus another kind of steel (stainless) is due to the

decreased chromium concentration in carbon-steel. Stainless steel has a small amount of chromium in its composition which can potentially be activated by the neutrons coming out of the core. Using stainless steel could result in a radiation exposure event. In addition to its safety benefits, carbon-steel is more economical versus its more expensive cousin, stainless steel. The second material consideration and design aspect is the layered design of the polyethylene layer of the shield. Consisting of three layers, borated polyethylene on the inside and outside of a layer of regular high density polyethylene. Borated polyethylene is simply comprised of polyethylene doped with B4C. B4C and polyethylene both being low Z materials have a high affinity for neutron slow-down and capture. Borated polyethylene does a very good job at capturing any stray thermal neutrons that make it out of the core. The main reason for the layered design is to attempt to cut down on the cost of the shielding as it will all in all be quite large. Borated polyethylene is expensive and so having two thin layers and one thick layer of polyethylene should cut down on cost.

During the process of choosing potential shielding materials, Dr. Pevey was contacted in request of his expertise in the area. Dr. Pevey had an old shielding optimization code that could give a recommended amount of shielding based on what parameters you wanted to limit (cost, materials, etc). The design team's initial guess was around 2 feet of shielding surrounding the core. After giving Dr. Pevey the calculated flux values, he was able to confirm that 2 feet was the correct order of magnitude for shielding. Initially, it was expected that this optimization code would be able to give exact dimensions for each shielding material but that was not the case. This is a future avenue to look down. As for right now the thicknesses for the layer of polyethylene and the outer layer of carbon steel were chosen in a very conservative manner based on the results of a previous project displayed in the journal article of reference 5. The thicknesses of each layer is stated above in the MCNP room model explanation.

### ○ Heat Calculations

Heat calculations were performed by hand and with Microsoft Excel, assuming 5000 kilograms of 19.75% enriched Uranium. Using nuclear reaction cross sections as shown in equation 1, and assuming two hundred Megaelectronvolts, fifty times multiplication, and ten million neutrons being generated per second, a heat generation of 178 Joules per second was found.

$$1) \quad R = \sigma\phi$$

The value obtained was then used to find temperature change in the lead around the fuel, utilizing equation 2, using the specific heat of lead and assuming 680 kilograms of lead are present in the core.

$$2) \quad dT = \frac{q}{c \cdot m}$$

This resulted in a 7.35 degrees Celsius rise in temperature per hour of operation. This is a relatively conservative estimate due to the high assumed neutron flux and multiplication. There

are also considerations of using aluminum in combination with or potentially instead of the lead, which would decrease the temperature generation, as the specific heat of aluminum is significantly higher than that of lead, allowing it to absorb more energy before increasing in temperature.

Heat dissipation calculations by hand were performed to investigate the rate at which heat would travel through the different materials to be used in the reflector and shield. It has been concluded that the optimal shield and reflector will consist of a reflector made of carbon steel followed by a shield comprised of 4 additional layers. The first layer after the reflector will be borated polyethylene. Following that will be high density polyethylene, another layer of borated polyethylene, and ending with a layer of carbon-steel. Heat dissipation calculations were performed for both carbon steel and the borated polyethylene. The method to which this was completed follows. From previous calculations it was found that the heat generation of the core was 178 Joules per second. Equation 2 provides the means to solve the dissipation through different materials. Using the dimensions that are in the current Serpent model, and high density polyethylene as an estimation of the borated polyethylene density and specific heat. Estimations for the size of the shield were chosen conservatively based on a similar situation in which Californium-252 was used and the dimensions for the shield they used were available. It is assumed that the thickness of the borated-poly/polyethylene layers is conservatively 1 foot in total and the assumed thickness of the outermost carbon steel shielding layer is 0.5 feet thick. To get the total core to shield approximation, a variation of equation 2 was used and is displayed as equation 3. Table 2 displays the results gathered from this analysis.

$$3) \quad \frac{dT}{dt} = \frac{Q}{(\sum_{n=1} m_n c_n)}$$



Table 2: Heat Calculation Data

	Volume [cm <sup>3</sup> ]	Density [g/cm <sup>3</sup> ]	Specific Heat [kJ/(kg *K)]	Mass*Specific Heat [J/K]	dT/dt [K/s] [K/hr]
Carbon Steel Reflector	3.31014E6	7.85	0.49	1.2732E7	1.3980E-5 0.0503
Borated Polyethylene (HDPE Approx.)	7.15396E6	0.93	2.4	1.5968E7	1.1148E-5 0.0401
Carbon Steel Shield Layer	5.17143E6	7.85	0.49	1.9892E7	8.9484E-6 0.0322
Core to Edge of Shield approximation			Sum Total	4.8592E7	3.9244E-6 0.014128

#### IV. Benefit from Classes

Many courses in the nuclear engineering curriculum were of vital importance to the understanding and completion of this design project. The most crucial to this project have been courses on health physics, radiation shielding, reactor theory, numerical methods, thermal science, criticality safety and radiation laboratory courses. Starting from the inside and working out, reactor theory helped aid in the understanding of reactor kinetics and other general nuclear reactor related topics. Some of these include control rods, knowing where the highest concentration of neutron flux would be, and providing students with the knowledge of how to calculate k-effective. The reactor theory course as well as the numerical methods and laboratory courses helped guide the programming necessary to model a feasible reactor design and change it as needed. Laboratory and data analysis classes helped in the understanding of how to work with some of the software, know what detectors are best suited for each situation, and how to interpret the results. The detector knowledge received in each of the laboratory courses provided aided students in knowing the internal reactions of detectors in order to know that fission chamber detectors are capable of producing results under the duress of heavy neutron bombardment. The radiation shielding course helped students to know the building blocks of MCNP and also how to understand tallies and

effectively use and communicate these in a report. Courses in health physics helped to bring to light the different types of radiation and the different interactions it will have with matter. This provided the necessary knowledge to create shielding designs that resulted in the least amount of exposure to nearby people. In the laboratory courses, students were taught that secondary radiation reactions occur from some radiation interactions with matter such as Compton scattering, as well as gamma rays being produced upon neutron absorption. Thermal science helped students to understand the theory behind heat transfer in the facility and gave them the tools necessary to perform the heat transfer and heat dissipation calculations. The numerical methods course greatly assisted in the development and understanding of the algorithms and basic coding used to produce the input decks. Lastly, the criticality safety course brought to light different aspects of the design project that could be potentially dangerous and also potential solutions to those circumstances. The criticality safety class gave an understanding on the possible catastrophes that can happen with negligence and inexperience when working on a design project. So, safety was a very important factor when making decisions in the design process. All-in-all, the curriculum offered by the Nuclear Engineering department successfully prepared the design team for nearly all facets of the design process. Learning the SERPENT code was the only part of the project that required outside instruction that was otherwise not offered in the course curriculum.

## **V. Conclusions**

The final design of the fast neutron multiplying facility lends itself to simple construction and modification of core configurations. The checkerboard lattice fuel cassettes allows simple channels to be opened up for instrumentation and experiments. However, the flux predictions for the facility with the neutron generators allotted seem like they may be lacking in power to perform for out of core experiments. Materials experiments inside the core are still feasible, but external beams may be too weak to produce results in a reasonably timely fashion. Furthermore, the design team has had some concerns, and has been advised about the safety of the facility, especially considering its proximity to Neyland Stadium. This is especially of concern if the facility transitions to a critical facility. A criticality accident so close to an area frequently holding 100,000+ people would be of major consequence. Significant amounts of work will need to be done to guarantee beyond a shadow of a doubt that these types of accidents could not occur under any circumstances whatsoever. Further, regardless of having shielding around the core, a human should under no circumstances ever enter the reactor room during operation. Further studies need to be performed in order to evaluate how long a person must wait before entering the room, given that some level of neutron activation of the materials is inevitable to occur. The design team is doing everything possible to ensure that the facility will safely operate in a subcritical manner, but will need specific professional attention if the facility is to evolve beyond the scope of this project.

## **VI. Future Work**

Although much progress has been made on this project with many goals met, there is much that could be added onto the facility design itself, such as a beam port, a crane to construct the core

as well as operate test/control rods in the core, determination of optimal shielding layer dimensions, automatic control systems, passive safety systems, and various others. Other items to complete include research on the type of crane to be used and looking into the core cassette manipulation system and the rod mechanisms. Lastly, once all of these tasks are completed, the final heat generation/dissipation calculations can be made giving how much heat will be taken away from the core over time.

## VII. References

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- [2] Donovan, Dr. David. "Fast Source Design Webinar: Neutron Generators." NE471 Webinar. University of Tennessee at Knoxville, Pasqua Nuclear Engineering Building, Knoxville. 24 Oct. 2016. PowerPoint Webinar.
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- [6] Los Alamos Scientific Laboratory. Group X-6. (1979). *MCNP: a general Monte Carlo code for neutron and photon transport*. Los Alamos, N.M. : [Springfield, Va.]: Dept. of Energy, Los Alamos Scientific Laboratory.
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## VIII. Appendices

### A. Licensing

#### PART 70—DOMESTIC LICENSING OF SPECIAL NUCLEAR MATERIAL

##### Subpart A--General Provisions



##### § 70.1 Purpose.

(a) Except as provided in paragraphs (c) and (d) of this section, the regulations of this part establish procedures and criteria for the issuance of licenses to receive title to, own, acquire, deliver, receive, possess, use, and transfer special nuclear material; and establish and provide for the terms and conditions upon which the Commission will issue such licenses.

(b) The regulations contained in this part are issued pursuant to the Atomic Energy Act of 1954, as amended (68 Stat. 919) and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242).

(c) The regulations in part 72 of this chapter establish requirements, procedures, and criteria for the issuance of licenses to possess:

(1) Spent fuel, power reactor-related Greater than Class C (GTCC) waste, and other radioactive materials associated with spent fuel storage in an independent spent fuel storage installation (ISFSI), or

(2) Spent fuel, high-level radioactive waste, power reactor-related GTCC waste, and other radioactive materials associated with the storage in a monitored retrievable storage installation (MRS), and the terms and conditions under which the Commission will issue such licenses.

(d) As provided in part 76 of this chapter, the regulations of this part establish procedures and criteria for physical security and material control and accounting for the issuance of a certificate of compliance or the approval of a compliance plan.

(e) As provided in the Atomic Energy Act of 1954, as amended, the regulations in this part establish requirements, procedures, and criteria for the issuance of licenses to uranium enrichment facilities.

[21 FR 764, Feb. 3, 1956, as amended at 32 FR 4056, Mar. 15, 1967; 40 FR 8791, Mar. 3, 1975; 43 FR 6924, Feb. 17, 1978; 45 FR 74712, Nov. 12, 1980; 53 FR 31682, Aug. 19, 1988; 59 FR 48960, Sept. 23, 1994; 62 FR 6669, Feb. 12, 1997; 66 FR 51838, Oct. 11, 2001]

##### § 70.2 Scope.



Except as provided in §§ 70.11 to 70.13, inclusive, the regulations in this part apply to all persons in the United States. This part also gives notice to all persons who knowingly provide to any licensee, applicant, contractor, or subcontractor, components, equipment, materials, or other goods or services, that relate to a licensee's or applicant's activities subject to this part, that they may be individually subject to NRC enforcement action for violation of § 70.10.

[56 FR 40691, Aug. 15, 1991]

##### § 70.3 License requirements.



No person subject to the regulations in this part shall receive title to, own, acquire, deliver, receive, possess, use, or transfer special nuclear material except as authorized in a license issued by the Commission pursuant to these regulations.

[32 FR 2562, Feb. 7, 1967, as amended at 43 FR 6924, Feb. 17, 1978]

#### § 70.4 Definitions.



*Act* means the Atomic Energy Act of 1954 (68 Stat 919), including any amendments thereto;  
*Acute*, as used in this part, means a single radiation dose or chemical exposure event or multiple radiation dose or chemical exposure events occurring within a short time (24 hours or less).  
*Agreement State* as designated in part 150 of this chapter means any State with which the Commission has entered into an effective agreement under subsection 274b. of the Act. Non-agreement State means any other State.

*Alert* means events may occur, are in progress, or have occurred that could lead to a release of radioactive material[s] but that the release is not expected to require a response by an offsite response organization to protect persons offsite.

*Atomic energy* means all forms of energy released in the course of nuclear fission or nuclear transformation;

*Atomic weapon* means any device utilizing atomic energy, exclusive of the means for transporting or propelling the device (where such means is a separable and divisible part of the device), the principal purpose of which is for use as, or for development of, a weapon, a weapon prototype, or a weapon test device;

*Available and reliable to perform their function when needed*, as used in subpart H of this part, means that, based on the analyzed, credible conditions in the integrated safety analysis, items relied on for safety will perform their intended safety function when needed, and management measures will be implemented that ensure compliance with the performance requirements of § 70.61 of this part, considering factors such as necessary maintenance, operating limits, common-cause failures, and the likelihood and consequences of failure or degradation of the items and measures.

*Commencement of construction* means taking any action defined as "construction" or any other activity at the site of a facility subject to the regulations in this part that has a reasonable nexus to:

- (1) Radiological health and safety; or
- (2) Common defense and security.

*Commission* means the Nuclear Regulatory Commission or its duly authorized representatives;

*Common defense and security* means the common defense and security of the United States;

*Configuration management (CM)* means a management measure that provides oversight and control of design information, safety information, and records of modifications (both temporary and permanent) that might impact the ability of items relied on for safety to perform their functions when needed.

*Construction* means the installation of foundations, or in-place assembly, erection, fabrication, or testing for any structure, system, or component of a facility or activity subject to the regulations in this part that are related to radiological safety or security. The term "construction" does not include:

- (1) Changes for temporary use of the land for public recreational purposes;

- (2) Site exploration, including necessary borings to determine foundation conditions or other preconstruction monitoring to establish background information related to the suitability of the site, the environmental impacts of construction or operation, or the protection of environmental values;
- (3) Preparation of the site for construction of the facility, including clearing of the site, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas;
- (4) Erection of fences and other access control measures that are not related to the safe use of, or security of, radiological materials subject to this part;
- (5) Excavation;
- (6) Erection of support buildings (*e.g.*, construction equipment storage sheds, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings) for use in connection with the construction of the facility;
- (7) Building of service facilities (*e.g.*, paved roads, parking lots, railroad spurs, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and transmission lines);
- (8) Procurement or fabrication of components or portions of the proposed facility occurring at other than the final, in-place location at the facility; or
- (9) Taking any other action that has no reasonable nexus to:
  - (i) Radiological health and safety, or
  - (ii) Common defense and security.

*Contiguous sites* means licensee controlled locations, deemed by the Commission to be in close enough proximity to each other, that the special nuclear material must be considered in the aggregate for the purpose of physical protection.

*Corporation* means the United States Enrichment Corporation (USEC), or its successor, a Corporation that is authorized by statute to lease the gaseous diffusion enrichment plants in Paducah, Kentucky, and Piketon, Ohio, from the Department of Energy, or any person authorized to operate one or both of the gaseous diffusion plants, or other facilities, pursuant to a plan for the privatization of USEC that is approved by the President.

*Critical mass of special nuclear material (SNM)*, as used in Subpart H, means special nuclear material in a quantity exceeding 700 grams of contained uranium-235; 520 grams of uranium-233; 450 grams of plutonium; 1500 grams of contained uranium-235, if no uranium enriched to more than 4 percent by weight of uranium-235 is present; 450 grams of any combination thereof; or one-half such quantities if massive moderators or reflectors made of graphite, heavy water, or beryllium may be present.

*Decommission* means to remove a facility or site safely from service and reduce residual radioactivity to a level that permits—

- (1) Release of the property for unrestricted use and termination of the license; or
- (2) Release of the property under restricted conditions and termination of the license.

*Department and Department of Energy* means the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.), to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104(b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section

301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

*Double contingency principle* means that process designs should incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

*Effective dose equivalent* means the sum of the products of the dose equivalent to the body organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. Weighting factors are: 0.25 for gonads, 0.15 for breast, 0.12 for red bone marrow, 0.12 for lungs, 0.03 for thyroid, 0.03 for bone surface, and 0.06 for each of the other five organs receiving the highest dose equivalent.

*Effective kilograms of special nuclear material* means: (1) For plutonium and uranium-233 their weight in kilograms; (2) For uranium with an enrichment in the isotope U-235 of 0.01 (1%) and above, its element weight in kilograms multiplied by the square of its enrichment expressed as a decimal weight fraction; and (3) For uranium with an enrichment in the isotope U-235 below 0.01 (1%), by its element weight in kilograms multiplied by 0.0001.

*Formula quantity* means strategic special nuclear material in any combination in a quantity of 5000 grams or more computed by the formula, grams=(grams contained U-235)+2.5 (grams U-233+grams plutonium). This class of material is sometimes referred to as a Category I quantity of material.

*Government agency* means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

*Hazardous chemicals produced from licensed materials* means substances having licensed material as precursor compound(s) or substances that physically or chemically interact with licensed materials; and that are toxic, explosive, flammable, corrosive, or reactive to the extent that they can endanger life or health if not adequately controlled. These include substances commingled with licensed material, and include substances such as hydrogen fluoride that is produced by the reaction of uranium hexafluoride and water, but do not include substances prior to process addition to licensed material or after process separation from licensed material.

*Integrated safety analysis (ISA)* means a systematic analysis to identify facility and external hazards and their potential for initiating accident sequences, the potential accident sequences, their likelihood and consequences, and the items relied on for safety. As used here, integrated means joint consideration of, and protection from, all relevant hazards, including radiological, nuclear criticality, fire, and chemical. However, with respect to compliance with the regulations of this part, the NRC requirement is limited to consideration of the effects of all relevant hazards on radiological safety, prevention of nuclear criticality accidents, or chemical hazards directly associated with NRC licensed radioactive material. An ISA can be performed process by process, but all processes must be integrated, and process interactions considered.

*Integrated safety analysis summary* means a document or documents submitted with the license application, license amendment application, license renewal application, or pursuant to § 70.62(c)(3)(ii) that provides a synopsis of the results of the integrated safety analysis and contains the information specified in § 70.65(b). The ISA Summary can be submitted as one document for the entire facility, or as multiple documents that cover all portions and processes of the facility.



*Items relied on for safety* mean structures, systems, equipment, components, and activities of personnel that are relied on to prevent potential accidents at a facility that could exceed the performance requirements in § 70.61 or to mitigate their potential consequences. This does not limit the licensee from identifying additional structures, systems, equipment, components, or activities of personnel (i.e., beyond those in the minimum set necessary for compliance with the performance requirements) as items relied on for safety.

*License*, except where otherwise specified, means a license issued pursuant to the regulations in this part;

*Management measures* mean the functions performed by the licensee, generally on a continuing basis, that are applied to items relied on for safety, to ensure the items are available and reliable to perform their functions when needed. Management measures include configuration management, maintenance, training and qualifications, procedures, audits and assessments, incident investigations, records management, and other quality assurance elements.

*Person* means (1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department, except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244), any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing;

*Plutonium processing and fuel fabrication plant* means a plant in which the following operations or activities are conducted: (1) Operations for manufacture of reactor fuel containing plutonium including any of the following: (i) Preparation of fuel material; (ii) formation of fuel material into desired shapes; (iii) application of protective cladding; (iv) recovery of scrap material; and (v) storage associated with such operations; or (2) Research and development activities involving any of the operations described in paragraph (1) of this definition except for research and development activities utilizing unsubstantial amounts of plutonium.

*Principal activities*, as used in this part, means activities authorized by the license which are essential to achieving the purpose(s) for which the license was issued or amended. Storage during which no licensed material is accessed for use or disposal and activities incidental to decontamination or decommissioning are not principal activities.

*Produce*, when used in relation to special nuclear material, means (1) to manufacture, make, produce, or refine special nuclear material; (2) to separate special nuclear material from other substances in which such material may be contained; or (3) to make or to produce new special nuclear material;

*Research and development means* (1) theoretical analysis, exploration, or experimentation; or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes;

*Restricted Data* means all data concerning (1) design, manufacture or utilization of atomic weapons; (2) the production of special nuclear material; or (3) the use of special nuclear material in the production of energy, but shall not include data declassified or removed from the Restricted Data category pursuant to section 142 of the Act;

*Sealed source* means any special nuclear material that is encased in a capsule designed to prevent leakage or escape of the special nuclear material.

*Site Area emergency* means events may occur, are in progress, or have occurred that could lead to a significant release of radioactive material and that could require a response by offsite response organizations to protect persons offsite.

*Source material* means source material as defined in section 11z. of the Act and in the regulations contained in part 40 of this chapter;

*Special nuclear material* means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing but does not include source material;

*Special nuclear material of low strategic significance* means:

(1) Less than an amount of special nuclear material of moderate strategic significance as defined in paragraph (1) of the definition of strategic nuclear material of moderate strategic significance in this section, but more than 15 grams of uranium-235 (contained in uranium enriched to 20 percent or more in U-235 isotope) or 15 grams of uranium-233 or 15 grams of plutonium or the combination of 15 grams when computed by the equation,  $\text{grams} = (\text{grams contained U-235}) + (\text{grams plutonium}) + (\text{grams U-233})$ ; or

(2) Less than 10,000 grams but more than 1,000 grams of uranium-235 (contained in uranium enriched to 10 percent or more but less than 20 percent in the U-235 isotope); or

(3) 10,000 grams or more of uranium-235 (contained in uranium enriched above natural but less than 10 percent in the U-235 isotope).

This class of material is sometimes referred to as a Category III quantity of material.

*Special nuclear material of moderate strategic significance* means:

(1) Less than a formula quantity of strategic special nuclear material but more than 1,000 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope) or more than 500 grams of uranium-233 or plutonium, or in a combined quantity of more than 1,000 grams when computed by the equation,  $\text{grams} = (\text{grams contained U-235}) + 2 (\text{grams U-233} + \text{grams plutonium})$ ; or

(2) 10,000 grams or more of uranium-235 (contained in uranium enriched to 10 percent or more but less than 20 percent in the U-235 isotope).

This class of material is sometimes referred to as a Category II quantity of material.

*Special nuclear material scrap* means the various forms of special nuclear material generated during chemical and mechanical processing, other than recycle material and normal process intermediates, which are unsuitable for use in their present form, but all or part of which will be used after further processing.

*Strategic special nuclear material* means uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium.

*Transient shipment* means a shipment of nuclear material, originating and terminating in foreign countries, on a vessel or aircraft which stops at a United States port.

*Unacceptable performance deficiencies* mean deficiencies in the items relied on for safety or the management measures that need to be corrected to ensure an adequate level of protection as defined in 10 CFR 70.61(b), (c), or (d).

*United States*, when used in a geographical sense, includes Puerto Rico and all territories and possessions of the United States.

*Uranium enrichment facility* means:

(1) Any facility used for separating the isotopes of uranium or enriching uranium in the isotope 235, except laboratory scale facilities designed or used for experimental or analytical purposes only; or

(2) Any equipment or device, or important component part especially designed for such equipment or device, capable of separating the isotopes of uranium or enriching uranium in the isotope 235.

*Worker*, when used in Subpart H of this Part, means an individual who receives an occupational dose as defined in 10 CFR 20.1003.

[21 FR 764, Feb. 3, 1956; 76 FR 56965, Sep. 15, 2011]

Editorial Note: For *Federal Register* citations affecting § 70.4, see the List of CFR

Sections [Affected](#).

## § 70.5 Communications.



(a) Unless otherwise specified or covered under the regional licensing program as provided in paragraph (b) of this section, any communication or report concerning the regulations in this part and any application filed under these regulations may be submitted to the Commission as follows:

(1) By mail addressed to: ATTN: Document Control Desk, Director, Office of Nuclear Material Safety and Safeguards or Director, Division of Security Policy, Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission, Washington, DC 20555–0001.

(2) By hand delivery to the Director, Office of Nuclear Material Safety and Safeguards or Director, Division of Security Policy, Office of Nuclear Security and Incident Response at the NRC's offices at 11555 Rockville Pike, Rockville, Maryland.

(3) Where practicable, by electronic submission, for example, via Electronic Information Exchange, and CD-ROM. Electronic submissions must be made in a manner that enables the NRC to receive, read, authenticate, distribute, and archive the submission, and process and retrieve it a single page at a time. Detailed guidance on making electronic submissions can be obtained by visiting the NRC's Web site at <http://www.nrc.gov/site-help/e-submittals.html>; by e-mail to [MSHD.Resource@nrc.gov](mailto:MSHD.Resource@nrc.gov); or by writing the Office of the Chief Information Officer, U.S. Nuclear Regulatory Commission, Washington, DC 20555–0001. The guidance discusses, among other topics, the formats the NRC can accept, the use of electronic signatures, and the treatment of nonpublic information.

(4) Classified communications shall be transmitted to the NRC Headquarters' classified mailing address as specified in appendix A to part 73 of this chapter or delivered by hand in accordance with paragraph (a)(2) of this section.

(b) The Commission has delegated to the four Regional Administrators licensing authority for selected parts of its decentralized licensing program for nuclear materials as described in paragraph (b)(1) of this section. Any communication, report, or application covered under this licensing program must be submitted to the appropriate Regional Administrator. The Administrators' jurisdictions and mailing addresses are listed in paragraph (b)(2) of this section.

(1) The delegated licensing program includes authority to issue, renew, amend, cancel, modify, suspend, or revoke licenses for nuclear materials issued pursuant to 10 CFR parts 30 through 36, 39, 40, and 70 to all persons for academic, medical, and industrial uses, with the following exceptions:

- (i) Activities in the fuel cycle and special nuclear material in quantities sufficient to constitute a critical mass in any room or area. This exception does not apply to license modifications relating to termination of special nuclear material licenses that authorize possession of larger quantities when the case is referred for action from NRC's Headquarters to the Regional Administrators.
- (ii) Health and safety design review of sealed sources and devices and approval, for licensing purposes, of sealed sources and devices.
- (iii) Processing of source material for extracting of metallic compounds (including Zirconium, Hafnium, Tantalum, Titanium, Niobium, etc.).
- (iv) Distribution of products containing radioactive material under §§ 32.11 through 32.30 and 40.52 of this chapter to persons exempt from licensing requirements.
- (v) New uses or techniques for use of byproduct, source, or special nuclear material.
- (vi) Reviews pursuant to § 70.32(c).
- (vii) Uranium enrichment facilities.

(2) *Submissions.* (i) *Region I.* The regional licensing program involves all Federal facilities in the region and non-Federal licensees in the following Region I non-Agreement States and the District of Columbia: Connecticut, Delaware, and Vermont. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment or renewal of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region I, Nuclear Material Section B, 2100 Renaissance Boulevard, Suite 100, King of Prussia, PA 19406–2713; where email is appropriate it should be addressed to *RidsRgn1MailCenter.Resource@nrc.gov*.

(ii) *Region II.* The regional licensing program involves all Federal facilities in the region and non-Federal licensees in the following Region II non-Agreement States and territories: West Virginia, Puerto Rico, and the Virgin Islands. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment, renewal, or termination request of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region I, Nuclear Material Section B, 475 Allendale Road, King of Prussia, PA 19406–1415; where e-mail is appropriate it should be addressed to *RidsRgn1MailCenter.Resource@nrc.gov*.

(iii) *Region III.* (A) The regional licensing program for mining and milling involves all Federal facilities in the region, and non-Federal licensees in the Region III non-Agreement States of Indiana, Michigan, Missouri and Region III Agreement States of Minnesota, Wisconsin, and Iowa. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment, renewal, or termination request of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region III, Material Licensing Section, 2443 Warrenville Road, Suite 210, Lisle, IL 60532–4352; where e-mail is appropriate it should be addressed to *RidsRgn3MailCenter.Resource@nrc.gov*.

(B) Otherwise, the regional licensing program involves all Federal facilities in the region and non-Federal licensees in the following Region III non-Agreement States: Indiana, Michigan, and Missouri. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment, or renewal of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region III, Material Licensing Section, 2443 Warrenville Road, Suite 210, Lisle, IL 60532 –4352; where e-mail is appropriate it should be addressed to *RidsRgn3MailCenter.Resource@nrc.gov*. Outside of

this jurisdiction, concerning the licensing program involving mining and milling, the Agreement States of Illinois and Ohio should be contacted.

(iv) *Region IV.* (A) The regional licensing program for mining and milling involves all Federal facilities in the region, and non-Federal licensees in the Region IV non-Agreement States and territory of Alaska, Hawaii, Idaho, Montana, South Dakota, Wyoming and Guam and Region IV Agreement States of Oregon, California, Nevada, New Mexico, Louisiana, Mississippi, Arkansas, Oklahoma, Kansas, Nebraska, and North Dakota. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment or renewal of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region IV, Division of Nuclear Materials Safety, 1600 E. Lamar Blvd., Arlington, TX 76011–4511; where email is appropriate, it should be addressed to *RidsRgn4MailCenter.Resource@nrc.gov*.

(B) Otherwise, the regional licensing program involves all Federal facilities in the region and non-Federal licensees in the following Region IV non-Agreement States and territory: Alaska, Hawaii, Idaho, Montana, South Dakota, Wyoming, and Guam. All mailed or hand-delivered inquiries, communications, and applications for a new license or an amendment or renewal of an existing license specified in paragraph (b)(1) of this section must use the following address: U.S. Nuclear Regulatory Commission, Region IV, Division of Nuclear Materials Safety, 1600 E. Lamar Blvd., Arlington, TX 76011–4511; where email is appropriate, it should be addressed to *RidsRgn4MailCenter.Resource@nrc.gov*.

[48 FR 16032, Apr. 14, 1983, as amended at 49 FR 19631, May 9, 1984; 49 FR 47824, Dec. 7, 1984; 50 FR 14694, Apr. 15, 1985; 51 FR 36001, Oct. 8, 1986; 52 FR 38392, Oct. 16, 1987; 52 FR 48093, Dec. 18, 1987; 53 FR 3862, Feb. 10, 1988; 53 FR 4111, Feb. 12, 1988; 53 FR 43421, Oct. 27, 1988; 54 FR 6877, Feb. 15, 1989; 57 FR 18392, Apr. 30, 1992; 58 FR 7737, Feb. 9, 1993; 58 FR 64112, Dec. 6, 1993; 59 FR 17466, Apr. 13, 1994; 60 FR 24552, May 9, 1995; 62 FR 22880, Apr. 28, 1997; 68 FR 58816, Oct. 10, 2003; 70 FR 69421, Nov. 16, 2005; 71 FR 15012, Mar. 27, 2006; 72 FR 33386, Jun. 18, 2007; 74 FR 62683, Dec. 1, 2009; 75 FR 21981, Apr. 27, 2010; 75 FR 73944, Nov. 30, 2010; 76 FR 72086, Nov. 22, 2011; 77 FR 39908, Jul. 6, 2012; 77 FR 43696, Jul. 25, 2012; 78 FR 32341, May 29, 2013; 80 FR 74981, Dec. 1, 2015]

## § 70.6 Interpretations.



TOP

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

## § 70.7 Employee protection.



TOP

(a) Discrimination by a Commission licensee, an applicant for a Commission license, or a contractor or subcontractor of a Commission licensee or applicant against an employee for engaging in certain protected activities is prohibited. Discrimination includes discharge and other actions that relate to compensation, terms, conditions, or privileges of employment. The protected activities are established in section 211 of the Energy Reorganization Act of 1974, as amended, and in general are related to the administration or enforcement of a requirement imposed under the Atomic Energy Act or the Energy Reorganization Act.

(1) The protected activities include but are not limited to:

- (i) Providing the Commission or his or her employer information about alleged violations of either of the statutes named in paragraph (a) introductory text of this section or possible violations of requirements imposed under either of those statutes;
  - (ii) Refusing to engage in any practice made unlawful under either of the statutes named in paragraph (a) introductory text or under these requirements if the employee has identified the alleged illegality to the employer;
  - (iii) Requesting the Commission to institute action against his or her employer for the administration or enforcement of these requirements;
  - (iv) Testifying in any Commission proceeding, or before Congress, or at any Federal or State proceeding regarding any provision (or proposed provision) of either of the statutes named in paragraph (a) introductory text.
  - (v) Assisting or participating in, or is about to assist or participate in, these activities.
- (2) These activities are protected even if no formal proceeding is actually initiated as a result of the employee assistance or participation.
- (3) This section has no application to any employee alleging discrimination prohibited by this section who, acting without direction from his or her employer (or the employer's agent), deliberately causes a violation of any requirement of the Energy Reorganization Act of 1974, as amended, or the Atomic Energy Act of 1954, as amended.
- (b) Any employee who believes that he or she has been discharged or otherwise discriminated against by any person for engaging in protected activities specified in paragraph (a)(1) of this section may seek a remedy for the discharge or discrimination through an administrative proceeding in the Department of Labor. The administrative proceeding must be initiated within 180 days after an alleged violation occurs. The employee may do this by filing a complaint alleging the violation with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor may order reinstatement, back pay, and compensatory damages.
- (c) A violation of paragraphs (a), (e), or (f) of this section by a Commission licensee, an applicant for a Commission license, or a contractor or subcontractor of a Commission licensee or applicant may be grounds for—
- (1) Denial, revocation, or suspension of the license.
  - (2) Imposition of a civil penalty on the licensee, applicant, or a contractor or subcontractor of the licensee or applicant.
  - (3) Other enforcement action.
- (d) Actions taken by an employer, or others, which adversely affect an employee may be predicated upon nondiscriminatory grounds. The prohibition applies when the adverse action occurs because the employee has engaged in protected activities. An employee's engagement in protected activities does not automatically render him or her immune from discharge or discipline for legitimate reasons or from adverse action dictated by nonprohibited considerations.
- (e)(1) Each specific licensee, each applicant for a specific license, and each general licensee subject to part 19 shall prominently post the revision of NRC Form 3, "Notice to Employees," referenced in 10 CFR 19.11(c).
- (2) The posting of NRC Form 3 must be at locations sufficient to permit employees protected by this section to observe a copy on the way to or from their place of work. Premises must be posted not later than 30 days after an application is docketed and remain posted while the application is pending before the Commission, during the term of the license, and for 30 days following license termination.

(3) Copies of NRC Form 3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in appendix D to part 20 of this chapter, via email to *Forms.Resource@nrc.gov*, or by visiting the NRC's online library at <http://www.nrc.gov/reading-rm/doc-collections/forms/>.

(f) No agreement affecting the compensation, terms, conditions, or privileges of employment, including an agreement to settle a complaint filed by an employee with the Department of Labor pursuant to section 211 of the Energy Reorganization Act of 1974, as amended, may contain any provision which would prohibit, restrict, or otherwise discourage an employee from participating in protected activity as defined in paragraph (a)(1) of this section including, but not limited to, providing information to the NRC or to his or her employer on potential violations or other matters within NRC's regulatory responsibilities.

[58 FR 52413, Oct. 8, 1993, as amended at 60 FR 24552, May 9, 1995; 61 FR 6765, Feb. 22, 1996; 68 FR 58817, Oct. 10, 2003; 72 FR 63974, Nov. 14, 2007; 79 FR 66605, Nov. 10, 2014]

### § 70.8 Information collection requirements: OMB approval.



TOP

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act (44 U.S.C. 3501 et seq.). The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. OMB has approved the information collection requirements contained in this part under control number 3150-0009.

(b) The approved information collection requirements contained in this part appear in §§ 70.9, 70.17, 70.19, 70.20a, 70.20b, 70.21, 70.22, 70.24, 70.25, 70.32, 70.33, 70.34, 70.38, 70.39, 70.42, 70.50, 70.51, 70.52, 70.59, 70.61, 70.62, 70.64, 70.65, 70.72, 70.73, 70.74, and Appendix A.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In § 70.21(g), Form N-71 and associated forms are approved under control number 3150-0056.

(2) In § 70.38, NRC form 314 is approved under control number 3150-0028.

(3) In § 70.21(g), DOC/NRC Forms AP-1, AP-A, and associated forms are approved under control number 0694-0135.

[49 FR 19628, May 9, 1984, as amended at 52 FR 19305, May 22, 1987; 56 FR 40769, Aug. 16, 1991; 57 FR 18392, Apr. 30, 1992; 58 FR 39634, July 26, 1993; 62 FR 52189, Oct. 6, 1997; 65 FR 56225, Sept. 18, 2000; 67 FR 78412, Dec. 23, 2002; 73 FR 78606, Dec. 23, 2008]

### § 70.9 Completeness and accuracy of information.



TOP

(a) Information provided to the Commission by an applicant for a license or by a licensee or information required by statute or by the Commission's regulations, orders, or license conditions to be maintained by the applicant or the licensee shall be complete and accurate in all material respects.

(b) Each applicant or licensee shall notify the Commission of information identified by the applicant or licensee as having for the regulated activity a significant implication for public



health and safety or common defense and security. An applicant or licensee violates this paragraph only if the applicant or licensee fails to notify the Commission of information that the applicant or licensee has identified as having a significant implication for public health and safety or common defense and security. Notification shall be provided to the Administrator of the appropriate Regional Office within two working days of identifying the information. This requirement is not applicable to information which is already required to be provided to the Commission by other reporting or updating requirements.

[52 FR 49373, Dec. 31, 1987]

### § 70.10 Deliberate misconduct.



TOP

(a) Any licensee, applicant for a license, employee of a licensee or applicant; or any contractor (including a supplier or consultant), subcontractor, employee of a contractor or subcontractor of any licensee or applicant for a license, who knowingly provides to any licensee, applicant, contractor, or subcontractor, any components, equipment, materials, or other goods or services that relate to a licensee's or applicant's activities in this part, may not:

(1) Engage in deliberate misconduct that causes or would have caused, if not detected, a licensee or applicant to be in violation of any rule, regulation, or order; or any term, condition, or limitation of any license issued by the Commission; or

(2) Deliberately submit to the NRC, a licensee, an applicant, or a licensee's or applicant's contractor or subcontractor, information that the person submitting the information knows to be incomplete or inaccurate in some respect material to the NRC.

(b) A person who violates paragraph (a)(1) or (a)(2) of this section may be subject to enforcement action in accordance with the procedures in 10 CFR part 2, subpart B.

(c) For the purposes of paragraph (a)(1) of this section, deliberate misconduct by a person means an intentional act or omission that the person knows:

(1) Would cause a licensee or applicant to be in violation of any rule, regulation, or order; or any term, condition, or limitation, of any license issued by the Commission; or

(2) Constitutes a violation of a requirement, procedure, instruction, contract, purchase order, or policy of a licensee, applicant, contractor, or subcontractor.

[63 FR 1899, Jan. 13, 1998]

### Subpart B--Exemptions



TOP

§ 70.11 Persons using special nuclear material under certain Department of Energy and Nuclear Regulatory Commission contracts.

Except to the extent that Department facilities or activities of the types subject to licensing pursuant to section 202 of the Energy Reorganization Act of 1974 are involved, any prime contractor of the Department is exempt from the requirements for a license set forth in section 53 of the Act and from the regulations in this part to the extent that such contractor, under his prime contract with the Department receives title to, owns, acquires, delivers, receives, possesses, uses, or transfers special nuclear material for:

(a) The performance of work for the Department at a United States Government-owned or controlled site, including the transportation of special nuclear material to or from such site and the performance of contract services during temporary interruptions of such transportation; (b) research in, or development, manufacture, storage, testing or transportation of, atomic weapons



or components thereof; or (c) the use or operation of nuclear reactors or other nuclear devices in a United States Government-owned vehicle or vessel. In addition to the foregoing exemptions, and subject to the requirement for licensing of Department facilities and activities pursuant to section 202 of the Energy Reorganization Act of 1974, any prime contractor or subcontractor of the Department or the Commission is exempt from the requirements for a license set forth in section 53 of the Act and from the regulations in this part to the extent that such prime contractor or subcontractor receives title to, owns, acquires, delivers, receives, possesses, uses, or transfers special nuclear material under his prime contract or subcontract when the Commission determines that the exemption of the prime contractor or subcontractor is authorized by law; and that, under the terms of the contract or subcontract there is adequate assurance that the work thereunder can be accomplished without undue risk to the public health and safety.

[40 FR 14085, Mar. 28, 1975; 40 FR 16047, Apr. 9, 1975; as amended at 43 FR 6924, Feb. 17, 1978; 65 FR 54950, Sept. 12, 2000]

### § 70.12 Carriers.



Common and contract carriers, freight forwarders, warehousemen, and the U.S. Postal Service are exempt from the regulations in this part to the extent that they transport special nuclear material in the regular course of carriage for another or storage incident thereto. This exemption does not apply to the storage in transit or transport of material by persons covered by the general license issued under § 70.20a and § 70.20b.

[46 FR 12696, Feb. 18, 1981]

### § 70.13 Department of Defense.



The regulations in this part do not apply to the Department of Defense to the extent that the Department receives, possesses and uses special nuclear material in accordance with the direction of the President pursuant to section 91 of the Act.

### § 70.14 Foreign military aircraft.



The regulations in this part do not apply to persons who carry special nuclear material (other than plutonium) in aircraft of the armed forces of foreign nations subject to 49 U.S.C. 40103(d).

[46 FR 12194, Feb. 13, 1981. Redesignated at 65 FR 56225, Sept. 18, 2000; 71 FR 15012, Mar. 27, 2006]

### § 70.17 Specific exemptions.



(a) The Commission may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

(b) [Reserved]

(c) The DOE is exempt from the requirements of the regulations in this part to the extent that its activities are subject to the requirements of part 60 or part 63 of this chapter.

(d) Except as specifically provided in part 61 of this chapter, any licensee is exempt from the requirements of the regulations in this part to the extent that its activities are subject to the requirements of part 61 of this chapter.

[37 FR 5749, Mar. 21, 1972, as amended at 45 FR 65536, Oct. 3, 1980; 46 FR 13987, Feb. 25, 1981; 47 FR 57481, Dec. 27, 1982; Redesignated at 65 FR 56225, Sept. 18, 2000, as amended at 66 FR 55815, Nov. 2, 2001]

## Subpart C--General Licenses



### § 70.18 Types of licenses.

Licenses for special nuclear material are of two types: general and specific. Any general license provided in this part is effective without the filing of applications with the Commission or the issuance of licensing documents to particular persons. Specific licenses are issued to named persons upon applications filed pursuant to the regulations in this part.

[29 FR 5884, May 5, 1964]

### § 70.19 General license for calibration or reference sources.



(a) A general license is hereby issued to those persons listed below to receive title to, own, acquire, deliver, receive, possess, use and transfer in accordance with the provisions of paragraphs (b) and (c) of this section, plutonium in the form of calibration or reference sources:

(1) Any person in a non-agreement State who holds a specific license issued by the Commission or the Atomic Energy Commission which authorizes him to receive, possess, use and transfer byproduct material, source material, or special nuclear material;

(2) Any Government agency as defined in § 70.4 that holds a specific license issued by the Commission that authorizes it to receive, possess, use, or transfer byproduct material, source material, or special nuclear material; and

(3) Any person in an agreement State who holds a specific license issued by the Commission or the Atomic Energy Commission which authorizes him to receive, possess, use and transfer special nuclear material.

(b) The general license in paragraph (a) of this section applies only to calibration or reference sources which have been manufactured or initially transferred in accordance with the specifications contained in a specific license issued pursuant to § 70.39 or in accordance with the specifications contained in a specific license issued by an agreement State which authorizes manufacture of the sources for distribution to persons generally licensed by the agreement State.

(c) The general license in paragraph (a) of this section is subject to the provisions of §§ 70.32, 70.50, 70.55, 70.56, 70.91, 70.81, and 70.82; the provisions of §§ 74.11 and 74.19 of this chapter; and to the provisions of parts 19, 20, and 21 of this chapter. In addition, persons who receive title to own, acquire, deliver, receive, possess, use or transfer one or more calibration or reference sources under this general license:

(1) Shall not possess at any one time, at any one location of storage or use, more than 5 microcuries of plutonium in such sources;

(2) Shall not receive, possess, use or transfer such source unless the source, or the storage container, bears a label which includes the following statement or a substantially similar statement which contains the information called for in the following statement:<sup>1</sup>

The receipt, possession, use and transfer of this source, Model\_\_\_\_\_, Serial No.\_\_\_\_\_, are subject to a general license and the regulations of the United States Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority. Do not remove this label.

**CAUTION—RADIOACTIVE MATERIAL—THIS SOURCE CONTAINS PLUTONIUM. DO NOT TOUCH RADIOACTIVE PORTION OF THIS SOURCE.**

(Name of Manufacturer or Initial Transferor)

- (3) Shall not transfer, abandon, or dispose of such source except by transfer to a person authorized by a license from the Commission or the Atomic Energy Commission or an Agreement State to receive the source.
  - (4) Shall store such source, except when the source is being used, in a closed container adequately designed and constructed to contain plutonium which might otherwise escape during storage.
  - (5) Shall not use such source for any purpose other than the calibration of radiation detectors or the standardization of other sources.
  - (d) The general license in paragraph (a) of this section does not authorize the manufacture, import, or export of calibration or reference sources containing plutonium.
- [29 FR 5884, May 5, 1964, as amended at 32 FR 8124, June 7, 1967; 38 FR 22221, Aug. 17, 1973; 40 FR 8792, Mar. 3, 1975; 42 FR 28896, June 6, 1977; 43 FR 6924, Feb. 17, 1978; 48 FR 32329, July 15, 1983; 56 FR 40769, Aug. 16, 1991; 57 FR 33428, July 29, 1992; 67 FR 78142, Dec. 23, 2002; 72 FR 35144, June 27, 2007]

<sup>1</sup> Sources generally licensed under this section prior to January 19, 1975 may bear labels authorized by the regulations in effect on January 1, 1975.

#### § 70.20 General license to own special nuclear material.



A general license is hereby issued to receive title to and own special nuclear material without regard to quantity. Notwithstanding any other provision of this chapter, a general licensee under this section is not authorized to acquire, deliver, receive, possess, use, transfer, import, or export special nuclear material, except as authorized in a specific license.

[33 FR 9810, July 9, 1968]

#### § 70.20a General license to possess special nuclear material for transport.



(a) A general license is issued to any person to possess formula quantities of strategic special nuclear material of the types and quantities subject to the requirements of §§ 73.20, 73.25, 73.26 and 73.27 of this chapter, and irradiated reactor fuel containing material of the types and quantities subject to the requirements of § 73.37 of this chapter, in the regular course of carriage for another or storage incident. Carriers generally licensed under § 70.20b are exempt from the requirements of this section. Carriers of irradiated reactor fuel for the United States Department of Energy are also exempt from the requirements of this section. The general license is subject to the applicable provisions of §§ 70.7 (a) through (e), 70.32 (a) and (b), and §§ 70.42, 70.52, 70.55, 70.91, 70.81, 70.82 and 10 CFR 74.11.

(b) Notwithstanding any other provision of this chapter, the general license issued under this section does not authorize any person to conduct any activity that would be authorized by a license issued pursuant to parts 30 through 36, 39, 40, 50, 72, 110, or other sections of this part.

(c) Notwithstanding any other provision of this chapter, the duties of a general licensee under this section while in possession of formula quantities of strategic special nuclear material or irradiated reactor fuel in the regular course of carriage for another or storage incident thereto shall be limited to providing for the physical protection of such material against theft or sabotage. Unless otherwise provided by this section, a general license under this section is not subject to the requirements of Parts 19, 20, 70 and 73.

(d) Any person who possesses formula quantities of strategic special nuclear material under this general license:

(1) Shall have submitted and received approval of a transportation security plan. The security plan shall outline the procedures that will be used to meet the requirements of §§ 73.20, 73.25, 73.26, 73.27 and 73.70(g) of this chapter including a plan for the selection, qualification, and training of armed escorts, or the specification and design of a specially designed truck or trailer as appropriate.

(2) Shall assure that the transportation is in accordance with the applicable physical protection requirements of §§ 73.20, 73.25, 73.26, 73.27 and 73.70(g) of this chapter and the applicable approved transportation security plan.

(3) Shall be subject to part 26 and § 73.80 of this chapter.

(e) Any person who possesses irradiated reactor fuel under this general license shall:

(1) Assure or receive certification from the shipper that the transportation is in accordance with the applicable physical protection requirements of § 73.37 of this chapter; and

(2) Comply with the reporting requirements of § 73.71 of this chapter.

[44 FR 26851, May 8, 1979, as amended at 44 FR 68186, Nov. 28, 1979; 46 FR 12696, Feb. 18, 1981; 47 FR 30458, July 14, 1982; 53 FR 31682, Aug. 19, 1988; 58 FR 7737, Feb. 9, 1993; 58 FR 31471, June 3, 1993; 67 FR 78142, Dec. 23, 2002; 72 FR 35144, June 27, 2007]

§ 70.20b General license for carriers of transient shipments of formula quantities of strategic special nuclear material, special nuclear material of moderate strategic significance, special nuclear material of low strategic significance, and irradiated reactor fuel.



(a) A general license is hereby issued to any person to possess transient shipments of the following kinds and quantities of special nuclear material:

(1) A formula quantity of special nuclear material of the types and quantities subject to the requirements of §§ 73.20, 73.25, 73.26, and 73.27 of this chapter.

(2) Special nuclear material of moderate and low strategic significance of the types and quantities subject to the requirements of § 73.67 of this chapter.

(3) Irradiated reactor fuel of the type and quantity subject to the requirements of § 73.37 of this chapter.

(b) Persons generally licensed under this section are exempt from the requirements of parts 19 and 20 of this chapter and the requirements of this part, except §§ 70.32 (a) and (b), 70.52, 70.55, 70.91, 70.81, and 70.82.

(c) Persons generally licensed under this section to possess a transient shipment of special nuclear material of the kind and quantity specified in paragraph (a)(1) of this section shall provide physical protection for that shipment in accordance with or equivalent to §§ 73.20(a), 73.20(b), 73.25, and 73.71(b) of this chapter from the time a shipment enters a United States port until it exits that or another United States port.

(d) Persons generally licensed under this section to possess a transient shipment of special nuclear material of moderate or low strategic significance of the kind and quantity specified in paragraph (a)(2) of this section shall provide physical protection for that shipment in accordance with or equivalent to § 73.67 of this chapter and shall comply with the requirements of § 73.71(b) of this chapter.

(e) Persons generally licensed under this section to possess a transient shipment of irradiated reactor fuel of the kind and quantity specified in paragraph (a)(3) of this section shall provide physical protection for that shipment in accordance with or equivalent to § 73.37 of this chapter and shall comply with the requirements of § 73.71(b) of this chapter.

(f)(1) Persons generally licensed under this section, who plan to carry transient shipments with scheduled stops at United States ports, shall notify in writing the Director, Division of Security Policy, Office of Nuclear Security and Incident Response, using an appropriate method listed in § 70.5(a). Classified notifications shall be sent to the NRC headquarters classified mailing address listed in appendix A to part 73 of this chapter.

(2) A person generally licensed under this section shall assure that:

(i) The notification will be received at least 10 days before transport of the shipment commences at the shipping facility;

(ii) The NRC Headquarters Operations Center shall be notified by telephone at least 2 days before commencement of the shipment at the numbers listed in appendix A to part 73 of this chapter. Classified notifications shall be made by secure telephone.

(iii) The NRC Headquarters Operations Center shall be notified by telephone of schedule changes greater than  $\pm 6$  hours at the numbers listed in appendix A to part 73 of this chapter. Classified notifications shall be made by secure telephone.

(3) Persons who are generally licensed under paragraph (a)(1) of this section must include the information listed in paragraphs (f)(3)(i) through (ix) of this section. Persons who are generally licensed under § 70.20b(a)(2) and § 70.20b(a)(3) must include the information listed in paragraphs (f)(3) (i) through (viii) of this section.

(i) Location of all scheduled stops in United States territory;

(ii) Arrival and departure times for all scheduled stops in United States territory;

(iii) The type of transport vehicle;

(iv) A physical description of the shipment (elements, isotopes, and enrichments);

(v) The number and types of containers;

(vi) The name and telephone number of the carrier's representative at each stopover location in United States territory;

(vii) The estimated time and date that shipment will commence and that each country (other than the United States) along the route is scheduled to be entered;

(viii) For shipments between countries that are not party to the Convention on the Physical Protection of Nuclear Material, provide assurances, as far as is practicable, that this nuclear material will be protected during international transport at levels described in Annex I to that Convention (see appendices E and F of part 73 of this chapter); and

(ix) A physical protection plan for implementing the requirement of § 70.20b(c), which will include the use of armed personnel to protect the shipment during the time the shipment is in a United States port.

(g) Persons generally licensed under this section making unscheduled stops at United States ports, immediately after the decision to make an unscheduled stop, shall:

- (1) Provide to the Director, Division of Security Policy, Office of Nuclear Security and Incident Response, the information required under paragraph (f) of this section.
- (2) In the case of persons generally licensed under paragraph (a)(1) of this section, arrange for local law enforcement authorities or trained and qualified private guards to protect the shipment during the stop.
- (3) In the case of persons generally licensed under paragraph (a)(2) of this section, arrange for the shipment to be protected as required in § 73.67(e) of this chapter.
- (4) In the case of persons generally licensed under paragraph (a)(3) of this section, arrange for the shipment to be protected as required in § 73.37(e) of this chapter.
- (5) Implement these arrangements within a reasonable time after the arrival of the shipment at a United States port to remain in effect until the shipment exits that or another United States port. [52 FR 9652, Mar. 26, 1987, as amended at 60 FR 24552, May 9, 1995; 67 FR 3585, Jan. 25, 2002; 68 FR 58817, Oct. 10, 2003; 72 FR 35144, June 27, 2007; 74 FR 62683, Dec. 1, 2009]

### Subpart D--License Applications



#### § 70.21 Filing.

- (a)(1) A person may apply for a license to possess and use special nuclear material in a plutonium processing or fuel fabrication plant, or for a uranium enrichment facility license, by filing the application with the Director of the NRC's Office of Nuclear Material Safety and Safeguards in accordance with the instructions in § 70.5(a). If the application is on paper or CD-ROM, only one copy need be provided. If the application is to be submitted electronically, see guidance for electronic submissions to the Commission.
- (2) A person may apply for any other license issued under this part, by filing the application in accordance with the instructions in § 70.5(a). If the application is on paper, only one copy need be provided. If the application is to be submitted electronically, see guidance for electronic submissions to the Commission.
- (3) Information contained in previous applications, statements, or reports filed with the Commission may be incorporated by reference if the references are clear and specific.
- (b) An application for license filed pursuant to the regulations in this part will be considered also as an application for licenses authorizing other activities for which licenses are required by the Act, provided the application specifies the additional activities for which licenses are requested and complies with regulations of the Commission as to applications for such licenses.
- (c) Any application which contains Restricted Data shall be prepared in such manner that all Restricted Data are separated from the unclassified information.
- (d) Applications and documents submitted to the Commission in connection with applications may be made available for public inspection in accordance with the provisions of the regulations contained in part 2 of this chapter.
- (e) Each application for a special nuclear material license, other than a license exempted from part 170 of this chapter, shall be accompanied by the fee prescribed in § 170.31 of this chapter. No fee will be required to accompany an application for renewal or amendment of a license, except as provided in § 170.31 of this chapter.
- (f) An application for a license to possess and use special nuclear material for processing and fuel fabrication, scrap recovery or conversion of uranium hexafluoride, or for the conduct of any other activity which the Commission has determined pursuant to subpart A of part 51 of this chapter will significantly affect the quality of the environment shall be filed at least 9 months



prior to commencement of construction of the plant or facility in which the activity will be conducted, and shall be accompanied by an Environmental Report required under subpart A of part 51 of this chapter.

(g)(1) In response to a written request by the Commission, each applicant for a construction authorization or license and each recipient of a construction authorization or a license to possess and use special nuclear material shall submit facility information, as described in § 75.10 of this chapter, on Form N-71 and associated forms and site information on DOC/NRC Form AP-A and associated forms;

(2) As required by the Additional Protocol, applicants and licensees specified in paragraph (a) of this section shall submit location information described in § 75.11 of this chapter on DOC/NRC Form AP-1 and associated forms; and

(3) Shall permit verification thereof by the International Atomic Energy Agency (IAEA) and take other action as necessary to implement the US/IAEA Safeguards Agreement, as described in Part 75 of this chapter.

(h) A license application for a uranium enrichment facility must be accompanied by an Environmental Report required under subpart A of part 51 of this chapter.

[21 FR 764, Feb. 3, 1956, as amended at 23 FR 1122, Feb. 21, 1958; 31 FR 4670, Mar. 19, 1966; 34 FR 19546, Dec. 11, 1969; 36 FR 146, Jan. 6, 1971; 37 FR 5749, Mar. 21, 1972; 49 FR 9406, Mar. 12, 1984; 49 FR 19628 and 19632, May 9, 1984; 49 FR 21699, May 23, 1984; 57 FR 18392, Apr. 30, 1992; 68 FR 58817, Oct. 10, 2003; 73 FR 78606, Dec. 23, 2008]

## § 70.22 Contents of applications.



(a) Each application for a license shall contain the following information:

(1) The full name, address, age (if an individual), and citizenship of the applicant and the names and addresses of three personal references. If the applicant is a corporation or other entity, it shall indicate the State where it was incorporated or organized, the location of the principal office, the names, addresses, and citizenship of its principal officers, and shall include information known to the applicant concerning the control or ownership, if any, exercised over the applicant by any alien, foreign corporation, or foreign government;

(2) The activity for which the special nuclear material is requested, or in which special nuclear material will be produced, the place at which the activity is to be performed and the general plan for carrying out the activity;

(3) The period of time for which the license is requested;

(4) The name, amount, and specifications (including the chemical and physical form and, where applicable, isotopic content) of the special nuclear material the applicant proposes to use or produce;

(5) [Reserved]

(6) The technical qualifications, including training and experience of the applicant and members of his staff to engage in the proposed activities in accordance with the regulations in this chapter;

(7) A description of equipment and facilities which will be used by the applicant to protect health and minimize danger to life or property (such as handling devices, working areas, shields, measuring and monitoring instruments, devices for the disposal of radioactive effluents and wastes, storage facilities, criticality accident alarm systems, etc.);

(8) Proposed procedures to protect health and minimize danger to life or property (such as procedures to avoid accidental criticality, procedures for personnel monitoring and waste disposal, post-criticality accident emergency procedures, etc.).

Note: Where the nature of the proposed activities is such as to require consideration of the applicant's financial qualifications to engage in the proposed activities in accordance with the regulations in this chapter, the Commission may request the applicant to submit information with respect to his financial qualifications.

(9) As provided by § 70.25, certain applications for specific licenses filed under this part must contain a proposed decommissioning funding plan or a certification of financial assurance for decommissioning. In the case of renewal applications submitted on or before July 27, 1990, this submittal may follow the renewal application but must be submitted on or before July 27, 1990.

(b) Each application for a license to possess special nuclear material, to possess equipment capable of enriching uranium, to operate an uranium enrichment facility, to possess and use at any one time and location special nuclear material in a quantity exceeding one effective kilogram, except for applications for use as sealed sources and for those uses involved in the operation of a nuclear reactor licensed pursuant to part 50 of this chapter and those involved in a waste disposal operation, must contain a full description of the applicant's program for control and accounting of such special nuclear material or enrichment equipment that will be in the applicant's possession under license to show how compliance with the requirements of §§ 74.31, 74.33, 74.41, or 74.51 of this chapter, as applicable, will be accomplished.

(c) [Reserved]

(d) The Commission may at any time after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Commission to determine whether the application should be granted or denied or whether a license should be modified or revoked. All applications and statements shall be signed by the applicant or licensee or a corporate officer thereof.

(e) Each application and statement shall contain complete and accurate disclosure as to all matters and things required to be disclosed.

(f) Each application for a license to possess and use special nuclear material in a plutonium processing and fuel fabrication plant shall contain, in addition to the other information required by this section, a description of the plantsite, a description and safety assessment of the design bases of the principal structure, systems, and components of the plant, including provisions for protection against natural phenomena, and a description of the quality assurance program to be applied to the design, fabrication, construction, testing and operation of the structures, systems, and components of the plant.<sup>2</sup>

(g)(1) Each application for a license that would authorize the transport or delivery to a carrier for transport of special nuclear material in an amount specified in § 73.1(b)(2) of this chapter must include (i) a description of the plan for physical protection of special nuclear material in transit in accordance with §§ 73.20, 73.25, 73.26, 73.27, and 73.67(a), (e), and (g) for 10 kg or more of special nuclear material of low strategic significance, and § 73.70(g) of this chapter including, as appropriate, a plan for the selection, qualification, and training of armed escorts, or the specification and design of a specially designed truck or trailer, and (ii) a licensee safeguards contingency plan or response procedures, as appropriate, for dealing with threats, thefts, and radiological sabotage relating to the special nuclear material in transit.

(2) Each application for such a license involving formula quantities of strategic special nuclear material must include the first four categories of information contained in the applicant's



safeguards contingency plan. (The first four categories of information, as set forth in appendix C to part 73 of this chapter, are Background, Generic Planning Base, Licensee Planning Base, and Responsibility Matrix. The fifth category of information, Procedures, does not have to be submitted for approval.)

(3) The licensee shall retain this description of the plan for physical protection of special nuclear material in transit and the safeguards contingency plan or safeguards response procedures and each change to the plan or procedures as a record for a period of three years following the date on which the licensee last possessed the appropriate type and quantity of special nuclear material requiring this record under each license.

(h)(1) Each application for a license to possess or use, at any site or contiguous sites subject to licensee control, a formula quantity of strategic special nuclear material, as defined in § 70.4, other than a license for possession or use of this material in the operation of a nuclear reactor licensed pursuant to part 50 of this chapter, must include a physical security plan. The plan must describe how the applicant will meet the applicable requirements of part 73 of this chapter in the conduct of the activity to be licensed, including the identification and description of jobs as required by 10 CFR 11.11(a). The plan must list tests, inspections, audits, and other means to be used to demonstrate compliance with the requirements of 10 CFR parts 11 and 73, if applicable.

(2) The licensee shall retain a copy of this physical security plan and each change to the plan as a record for a period of three years following the date on which the licensee last possessed the appropriate type and quantity of special nuclear material requiring this record under each license.

(i)(1) Each application to possess enriched uranium or plutonium for which a criticality accident alarm system is required, uranium hexafluoride in excess of 50 kilograms in a single container or 1000 kilograms total, or in excess of 2 curies of plutonium in unsealed form or on foils or plated sources, must contain either:

(i) An evaluation showing that the maximum dose to a member of the public offsite due to a release of radioactive materials would not exceed 1 rem effective dose equivalent or an intake of 2 milligrams of soluble uranium, or

(ii) An emergency plan for responding to the radiological hazards of an accidental release of special nuclear material and to any associated chemical hazards directly incident thereto.

(2) One or more of the following factors may be used to support an evaluation submitted under paragraph (i)(1)(i) of this section:

(i) The radioactive material is physically separated so that only a portion could be involved in an accident;

(ii) All or part of the radioactive material is not subject to release during an accident or to criticality because of the way it is stored or packaged;

(iii) In the case of fires or explosions, the release fraction would be lower than 0.001 due to the chemical or physical form of the material;

(iv) The solubility of the material released would reduce the dose received;

(v) The facility design or engineered safety features in the facility would cause the release fraction to be lower than 0.001;

(vi) Operating restrictions or procedures would prevent a release large enough to cause a member of the public offsite to receive a dose exceeding 1 rem effective dose equivalent; or

(vii) Other factors appropriate for the specific facility.

(3) Emergency plans submitted under paragraph (i)(1)(ii) of this section must include the following information:

(i) *Facility description.* A brief description of the licensee's facility and area near the site.

- (ii) *Types of accidents.* An identification of each type of radioactive materials accident for which protective actions may be needed.
- (iii) *Classification of accidents.* A classification system for classifying accidents as alerts or site area emergencies.
- (iv) *Detection of accidents.* Identification of the means of detecting each type of accident in a timely manner.
- (v) *Mitigation of consequences.* A brief description of the means and equipment for mitigating the consequences of each type of accident, including those provided to protect workers onsite, and a description of the program for maintaining the equipment.
- (vi) *Assessment of releases.* A brief description of the methods and equipment to assess releases of radioactive materials.
- (vii) *Responsibilities.* A brief description of the responsibilities of licensee personnel should an accident occur, including identification of personnel responsible for promptly notifying offsite response organizations and the NRC; also responsibilities for developing, maintaining, and updating the plan.
- (viii) *Notification and coordination.* A commitment to and a brief description of the means to promptly notify offsite response organizations and request offsite assistance, including medical assistance for the treatment of contaminated injured onsite workers when appropriate. A control point must be established. The notification and coordination must be planned so that unavailability of some personnel, parts of the facility, and some equipment will not prevent the notification and coordination. The licensee shall also commit to notify the NRC operations center immediately after notification of the appropriate offsite response organizations and not later than one hour after the licensee declares an emergency.<sup>1</sup>
- (ix) *Information to be communicated.* A brief description of the types of information on facility status, radioactive releases, and recommended protective actions, if necessary, to be given to offsite response organizations and to the NRC.
- (x) *Training.* A brief description of the frequency, performance objectives and plans for the training that the licensee will provide workers on how to respond to an emergency including any special instructions and orientation tours the licensee would offer to fire, police, medical and other emergency personnel. The training shall familiarize personnel with site-specific emergency procedures. Also, the training shall thoroughly prepare site personnel for their responsibilities in the event of accident scenarios postulated as most probable for the specific site, including the use of team training for such scenarios.
- (xi) *Safe shutdown.* A brief description of the means of restoring the facility to a safe condition after an accident.
- (xii) *Exercises.* Provisions for conducting quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies. Quarterly communications checks with offsite response organizations must include the check and update of all necessary telephone numbers. The licensee shall invite offsite response organizations to participate in the biennial exercises. Participation of offsite response organizations in biennial exercises although recommended is not required. Exercises must use accident scenarios postulated as most probable for the specific site and the scenarios shall not be known to most exercise participants. The licensee shall critique each exercise using individuals not having direct implementation responsibility for the plan. Critiques of exercises must evaluate the appropriateness of the plan, emergency procedures, facilities, equipment, training of personnel, and overall effectiveness of the response. Deficiencies found by the critiques must be corrected.

(xiii) Hazardous chemicals. A certification that the applicant has met its responsibilities under the Emergency Planning and Community Right-to-Know Act of 1986, Title III, Pub. L. 99-499, if applicable to the applicant's activities at the proposed place of use of the special nuclear material.

(4) The licensee shall allow the offsite response organizations expected to respond in case of an accident 60 days to comment on the licensee's emergency plan before submitting it to NRC. The licensee shall provide any comments received within the 60 days to the NRC with the emergency plan.

(j)(1) Each application for a license to possess or use at any site or contiguous sites subject to control by the licensee uranium-235 (contained in uranium enriched to 20 percent or more in the uranium-235 isotope), uranium-233, or plutonium alone or in any combination in a quantity of 5,000 grams or more computed by the formula,  $\text{grams} = (\text{grams contained U - 235}) + 2.5 (\text{grams U-233} + \text{grams plutonium})$  other than a license for possession or use of this material in the operation of a nuclear reactor licensed pursuant to part 50 of this chapter, must include a licensee safeguards contingency plan for dealing with threats, thefts, and radiological sabotage, as defined in part 73 of this chapter, relating to nuclear facilities licensed under part 50 of this chapter or to the possession of special nuclear material licensed under this part.

(2) Each application for such a license must include the first four categories of information contained in the applicant's safeguards contingency plan. (The first four categories of information, as set forth in appendix C to part 73 of this chapter, are Background, Generic Planning Base, Licensee Planning Base, and Responsibility Matrix.) The fifth category of information, Procedures, does not have to be submitted for approval.

(3) The licensee shall retain a copy of this safeguards contingency plan as a record until the Commission terminates each license obtained by this application or any application for renewal of a license and retain each change to the plan as a record for three years after the date of the change.

(k) Each application for a license to possess or use at any site or contiguous sites subject to licensee control, special nuclear material of moderate strategic significance or 10 kg or more of special nuclear material of low strategic significance as defined under § 70.4, other than a license for possession or use of this material in the operation of a nuclear power reactor licensed pursuant to part 50 of this chapter, must include a physical security plan that demonstrates how the applicant plans to meet the requirements of paragraphs (d), (e), (f), and (g) of § 73.67 of this chapter, as appropriate. The licensee shall retain a copy of this physical security plan as a record for the period during which the licensee possesses the appropriate type and quantity of special nuclear material under each license, and if any portion of the plan is superseded, retain that superseded portion of the plan for 3 years after the effective date of the change.

(l) Each applicant for a license shall protect Safeguards Information against unauthorized disclosure in accordance with the requirements in § 73.21 and the requirements of § 73.22, or 73.23 of this chapter, as applicable, and shall protect classified information in accordance with the requirements of parts 25 and 95 of this chapter, as applicable.

(m) Each application for a license to possess equipment capable of enriching uranium or operate an enrichment facility, and produce, possess, or use more than one effective kilogram of special nuclear material at any site or contiguous sites subject to control by the applicant, must contain a full description of the applicant's security program to protect against theft, and to protect against unauthorized viewing of classified enrichment equipment, and unauthorized disclosure of classified matter in accordance with the requirements of 10 CFR parts 25 and 95.

(n) A license application that involves the use of special nuclear material in a uranium enrichment facility must include the applicant's provisions for liability insurance.

[21 FR 764, Feb. 3, 1956; 73 FR 63572, Oct. 24, 2008]

Editorial Note: For Federal Register citations affecting § 70.22, see the List of CFR Sections [Affected](#).

<sup>1</sup> These reporting requirements do not supercede or release licensees of complying with the requirements under the Emergency Planning and Community Right-to-Know Act of 1986, Title III, Pub. L. 99-499 or other state or federal reporting requirements.

<sup>2</sup> The description of the quality assurance program should include a discussion of how the criteria in appendix B of part 50 of this chapter will be met.

### § 70.23 Requirements for the approval of applications.



(a) An application for a license will be approved if the Commission determines that:

- (1) The special nuclear material is to be used for the conduct of research or development activities of a type specified in section 31 of the Act,<sup>1</sup> in activities licensed by the Commission under section 103 or 104 of the Act, or for such other uses as the Commission determines to be appropriate to carry out the purposes of the Act;
- (2) The applicant is qualified by reason of training and experience to use the material for the purpose requested in accordance with the regulations in this chapter;
- (3) The applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property;
- (4) The applicant's proposed procedures to protect health and to minimize danger to life or property are adequate;
- (5) Where the nature of the proposed activities is such as to require consideration by the Commission, that the applicant appears to be financially qualified to engage in the proposed activities in accordance with the regulations in this part;
- (6) Where the applicant is required to submit a summary description of the fundamental material controls provided in his procedures for the control of and accounting for special nuclear material pursuant to § 70.22 (b), the applicant's proposed controls are adequate;
- (7) Where the proposed activity is processing and fuel fabrication, scrap recovery, conversion of uranium hexafluoride, uranium enrichment facility construction and operation, or any other activity which the NRC determines will significantly affect the quality of the environment, the Director of Nuclear Material Safety and Safeguards or his/her designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to subpart A of part 51 of this chapter, has concluded, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to this conclusion is grounds for denial to possess and use special nuclear material in the plant or facility. Commencement of construction as defined in section 70.4 may include non-construction activities if the activity has a reasonable nexus to radiological safety and security.
- (8) Where the proposed activity is the operation of a plutonium processing and fuel fabrication plant, construction of the principal structures, systems, and components approved pursuant to paragraph (b) of this section has been completed in accordance with the application;

(9) Where the applicant is required to submit a plan for physical protection of special nuclear material in transit pursuant to § 70.22(g), of this chapter, the applicant's plan is adequate;

(10) Where the applicant is required to submit a physical security plan pursuant to § 70.22(h), the applicant's proposed plan is adequate;

(11) Where the proposed activity is processing and fuel fabrication, scrap recovery, conversion of uranium hexafluoride, or involves the use of special nuclear material in a uranium enrichment facility, the applicant's proposed emergency plan is adequate.

(12) Where the proposed activity is use of special nuclear material in a uranium enrichment facility, the applicable provisions of part 140 of this chapter have been satisfied.

(b) The Commission will approve construction of the principal structures, systems, and components of a plutonium processing and fuel fabrication plant on the basis of information filed pursuant to § 70.22(f) when the Commission has determined that the design bases of the principal structures, systems, and components, and the quality assurance program provide reasonable assurance of protection against natural phenomena and the consequences of potential accidents.<sup>3</sup> Failure to obtain Commission approval prior to beginning of such construction may be grounds for denial of a license to possess and use special nuclear material in a plutonium processing and fuel fabrication plant.

[36 FR 17574, Sept. 2, 1971, as amended at 37 FR 5749, Mar. 21, 1972; 38 FR 30534, 30538, Nov. 6, 1973; 39 FR 26286, July 18, 1974; 42 FR 17126, Mar. 31, 1977; 43 FR 6924, Feb. 17, 1978; 49 FR 9406, Mar. 12, 1984; 54 FR 14064, Apr. 7, 1989; 57 FR 18392, Apr. 30, 1992; 67 FR 78142, Dec. 23, 2002; 76 FR 56966, Sep. 15, 2011]

<sup>1</sup> The types of research and development activities specified in section 31 are those relating to:

(1) Nuclear processes;

(2) The theory and production of atomic energy, including processes, materials, and devices related to such production;

(3) Utilization of special nuclear material and radioactive material for medical, biological, agricultural, health or military purposes;

(4) Utilization of special nuclear material, atomic energy, and radioactive material and processes entailed in the utilization or production of atomic energy or such material for all other purposes, including industrial use, the generation of usable energy, and the demonstration of the practical value of utilization or production facilities for industrial or commercial purposes; and

(5) The protection of health and the promotion of safety during research and production activities.

<sup>3</sup> The criteria in appendix B of part 50 of this chapter will be used by the Commission in determining the adequacy of the quality assurance program.

### § 70.23a Hearing required for uranium enrichment facility.



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The Commission will hold a hearing under 10 CFR part 2, subparts A, C, G, and I, on each application for issuance of a license for construction and operation of a uranium enrichment facility. The Commission will publish public notice of the hearing in the Federal Register at least thirty (30) days before the hearing.

[57 FR 18392, Apr. 30, 1992; 69 FR 2280, Jan. 14, 2004]

### § 70.24 Criticality accident requirements.



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(a) Each licensee authorized to possess special nuclear material in a quantity exceeding 700 grams of contained uranium-235, 520 grams of uranium-233, 450 grams of plutonium, 1,500 grams of contained uranium-235 if no uranium enriched to more than 4 percent by weight of uranium-235 is present, 450 grams of any combination thereof, or one-half such quantities if massive moderators or reflectors made of graphite, heavy water or beryllium may be present, shall maintain in each area in which such licensed special nuclear material is handled, used, or stored, a monitoring system meeting the requirements of either paragraph (a)(1) or (a)(2), as appropriate, and using gamma- or neutron-sensitive radiation detectors which will energize clearly audible alarm signals if accidental criticality occurs. This section is not intended to require underwater monitoring when special nuclear material is handled or stored beneath water shielding or to require monitoring systems when special nuclear material is being transported when packaged in accordance with the requirements of part 71 of this chapter.

(1) The monitoring system shall be capable of detecting a criticality that produces an absorbed dose in soft tissue of 20 rads of combined neutron and gamma radiation at an unshielded distance of 2 meters from the reacting material within one minute. Coverage of all areas shall be provided by two detectors.

(2) Persons licensed prior to December 6, 1974, to possess special nuclear material subject to this section may maintain a monitoring system capable of detecting a criticality which generates radiation levels of 300 rems per hour one foot from the source of the radiation. The monitoring devices in the system shall have a preset alarm point of not less than 5 millirems per hour (in order to avoid false alarms) nor more than 20 millirems per hour. In no event may any such device be farther than 120 feet from the special nuclear material being handled, used, or stored; lesser distances may be necessary to meet the requirements of this paragraph (a)(2) on account of intervening shielding or other pertinent factors.

(3) The licensee shall maintain emergency procedures for each area in which this licensed special nuclear material is handled, used, or stored to ensure that all personnel withdraw to an area of safety upon the sounding of the alarm. These procedures must include the conduct of drills to familiarize personnel with the evacuation plan, and designation of responsible individuals for determining the cause of the alarm, and placement of radiation survey instruments in accessible locations for use in such an emergency. The licensee shall retain a copy of current procedures for each area as a record for as long as licensed special nuclear material is handled, used, or stored in the area. The licensee shall retain any superseded portion of the procedures for three years after the portion is superseded.

(b) Each licensee authorized to possess special nuclear material in quantities in excess of those specified in paragraph (a) shall:

(1) Provide the means for identifying quickly which individuals have received doses of 10 rads or more.

(2) Maintain facilities and supplies at the site for decontamination of personnel, arrangements for the services of a physician and other medical personnel qualified to handle radiation emergencies, arrangements for transportation of injured or contaminated individuals to treatment facilities, and arrangements for treatment of individuals at treatment facilities outside the site boundary.

(c) Holders of licenses for construction or operation of a nuclear reactor issued pursuant to part 50 of this chapter, except critical assembly reactors, are exempt for the requirements of paragraph (b) of this section with respect to special nuclear material used or to be used in the reactor.

(d)(1) The requirements in paragraphs (a) through (c) of this section do not apply to a holder of a construction permit or operating license for a nuclear power reactor issued under part 50 of this chapter or a combined license issued under part 52 of this chapter, if the holder complies with the requirements of paragraph (b) of 10 CFR 50.68.

(2) An exemption from § 70.24 held by a licensee who thereafter elects to comply with requirements of paragraph (b) of 10 CFR 50.68 does not exempt that licensee from complying with any of the requirements in § 50.68, but shall be ineffective so long as the licensee elects to comply with § 50.68.

[39 FR 39021, Nov. 5, 1974, as amended at 41 FR 31522, July 29, 1976; 53 FR 19252, May 27, 1988; 62 FR 63828, Dec. 3, 1997; 63 FR 63130, Nov. 12, 1998]

### § 70.25 Financial assurance and recordkeeping for decommissioning.



(a) Each applicant for a specific license of the types described in paragraphs (a)(1) and (2) of this section shall submit a decommissioning funding plan as described in paragraph (e) of this section.

(1) A specific license for a uranium enrichment facility;

(2) A specific license authorizing the possession and use of unsealed special nuclear material in quantities exceeding  $10^5$  times the applicable quantities set forth in appendix B to part 30. A decommissioning funding plan must also be submitted when a combination of isotopes is involved if  $R$  divided by 105 is greater than 1 (unity rule), where  $R$  is the sum of the ratios of the quantity of each isotope to the applicable value in appendix B to part 30.

(b) Each applicant for a specific license authorizing possession and use of unsealed special nuclear material in quantities specified in paragraph (d) of this section shall either—

(1) Submit a decommissioning funding plan as described in paragraph (e) of this section; or

(2) Submit a certification that financial assurance for decommissioning has been provided in the amount prescribed by paragraph (d) of this section using one of the methods described in paragraph (f) of this section. For an applicant, this certification may state that the appropriate assurance will be obtained after the application has been approved and the license issued but before the receipt of licensed material. If the applicant defers execution of the financial instrument until after the license has been issued, a signed original of the financial instrument obtained to satisfy the requirements of paragraph (f) of this section must be submitted to NRC before receipt of licensed material. If the applicant does not defer execution of the financial instrument, the applicant shall submit to NRC, as part of the certification, a signed original of the financial instrument obtained to satisfy the requirements of paragraph (f) of this section.

(c)(1) Each holder of a specific license issued on or after July 27, 1990, which is of a type described in paragraph (a) or (b) of this section, shall provide financial assurance for decommissioning in accordance with the criteria set forth in this section.

(2) Each holder of a specific license issued before July 27, 1990, and of a type described in paragraph (a) of this section shall submit a decommissioning funding plan as described in paragraph (e) of this section or a certification of financial assurance for decommissioning in an amount at least equal to \$1,125,000 in accordance with the criteria set forth in this section. If the licensee submits the certification of financial assurance rather than a decommissioning funding plan, the licensee shall include a decommissioning funding plan in any application for license renewal.



(3) Each holder of a specific license issued before July 27, 1990, and of a type described in paragraph (b) of this section shall submit, on or before July 27, 1990, a decommissioning funding plan, described in paragraph (e) of this section, or a certification of financial assurance for decommissioning in accordance with the criteria set forth in this section.

(4) Any licensee who has submitted an application before July 27, 1990, for renewal of license in accordance with § 70.33 shall provide financial assurance for decommissioning in accordance with paragraphs (a) and (b) of this section. This assurance must be submitted when this rule becomes effective November 24, 1995.

(5) If, in surveys made under 10 CFR 20.1501(a), residual radioactivity in the facility and environment, including the subsurface, is detected at levels that would, if left uncorrected, prevent the site from meeting the 10 CFR 20.1402 criteria for unrestricted use, the licensee must submit a decommissioning funding plan within one year of when the survey is completed

(d) Table of required amounts of financial assurance for decommissioning by quantity of material. Licensees required to submit the \$1,125,000 amount must do so by December 2, 2004. Licensees required to submit the \$225,000 amount must do so by June 2, 2005. Licensees having possession limits exceeding the upper bounds of this table must base financial assurance on a decommissioning funding plan.

\$225,000

greater than $10^4$ but less than or equal to $10^5$ times the applicable quantities of appendix B to part 30. (For a combination of isotopes, if R, as defined in § 70.25(a), divided by $10^4$ is greater than 1 but R divided by $10^5$ is less than or equal to 1.)	\$1,125,000
greater than $10^3$ but less than or equal to $10^4$ times the applicable quantities of appendix B to part 30. (For a combination of isotopes, if R, as defined in § 70.25(a), divided by $10^3$ is greater than 1 but R divided by $10^4$ is less than or equal to 1.)	

(e)(1) Each decommissioning funding plan must be submitted for review and approval and must contain—

- (i) A detailed cost estimate for decommissioning, in an amount reflecting:
  - (A) The cost of an independent contractor to perform all decommissioning activities;
  - (B) The cost of meeting the 10 CFR 20.1402 criteria for unrestricted use, provided that, if the applicant or licensee can demonstrate its ability to meet the provisions of 10 CFR 20.1403, the cost estimate may be based on meeting the 10 CFR 20.1403 criteria;
  - (C) The volume of onsite subsurface material containing residual radioactivity that will require remediation; and
  - (D) An adequate contingency factor.
- (ii) Identification of and justification for using the key assumptions contained in the DCE;
- (iii) A description of the method of assuring funds for decommissioning from paragraph (f) of this section, including means for adjusting cost estimates and associated funding levels periodically over the life of the facility;
- (iv) A certification by the licensee that financial assurance for decommissioning has been provided in the amount of the cost estimate for decommissioning; and



(v) A signed original, or, if permitted, a copy, of the financial instrument obtained to satisfy the requirements of paragraph (f) of this section (unless a previously submitted and accepted financial instrument continues to cover the cost estimate for decommissioning).

(2) At the time of license renewal and at intervals not to exceed 3 years, the decommissioning funding plan must be resubmitted with adjustments as necessary to account for changes in costs and the extent of contamination. If the amount of financial assurance will be adjusted downward, this can not be done until the updated decommissioning funding plan is approved. The decommissioning funding plan must update the information submitted with the original or prior approved plan, and must specifically consider the effect of the following events on decommissioning costs:

(i) Spills of radioactive material producing additional residual radioactivity in onsite subsurface material;

(ii) Waste inventory increasing above the amount previously estimated;

(iii) Waste disposal costs increasing above the amount previously estimated;

(iv) Facility modifications;

(v) Changes in authorized possession limits;

(vi) Actual remediation costs that exceed the previous cost estimate;

(vii) Onsite disposal; and

(viii) Use of a settling pond.

(f) The financial instrument must include the licensee's name, license number, and docket number; and the name, address, and other contact information of the issuer, and, if a trust is used, the trustee. When any of the foregoing information changes, the licensee must, within 30 days, submit financial instruments reflecting such changes. Financial assurance for decommissioning must be provided by one or more of the following methods:

(1) *Prepayment.* Prepayment is the deposit before the start of operation into an account segregated from licensee assets and outside the licensee's administrative control of cash or liquid assets such that the amount of funds would be sufficient to pay decommissioning costs. Prepayment must be made into a trust account, and the trustee and the trust must be acceptable to the Commission.

(2) *A surety method, insurance, or other guarantee method.* These methods guarantee that decommissioning costs will be paid. A surety method may be in the form of a surety bond, or letter of credit. A parent company guarantee of funds for decommissioning costs based on a financial test may be used if the guarantee and test are as contained in appendix A to part 30 of this chapter. For commercial corporations that issue bonds, a guarantee of funds by the applicant or licensee for decommissioning costs based on a financial test may be used if the guarantee and test are as contained in appendix C to part 30 of this chapter. For nonprofit entities, such as colleges, universities, and nonprofit hospitals, a guarantee of funds by the applicant or licensee may be used if the guarantee and test are as contained in appendix E to part 30 of this chapter. Except for an external sinking fund, a parent company guarantee or a guarantee by the applicant or licensee may not be used in combination with any other financial methods used to satisfy the requirements of this section. A guarantee by the applicant or licensee may not be used in any situation where the applicant or licensee has a parent company holding majority control of the voting stock of the company. Any surety method or insurance used to provide financial assurance for decommissioning must contain the following conditions:

(i) The surety method or insurance must be open-ended or, if written for a specified term, such as five years, must be renewed automatically unless 90 days or more prior to the renewal date, the

issurer notifies the Commission, the beneficiary, and the licensee of its intention not to renew. The surety method or insurance must also provide that the full face amount be paid to the beneficiary automatically prior to the expiration without proof of forfeiture if the licensee fails to provide a replacement acceptable to the Commission within 30 days after receipt of notification of cancellation.

(ii) The surety method or insurance must be payable to a trust established for decommissioning costs. The trustee and trust must be acceptable to the Commission. An acceptable trustee includes an appropriate State or Federal government agency or an entity which has the authority to act as a trustee and whose trust operations are regulated and examined by a Federal or State agency.

(iii) The surety method or insurance must remain in effect until the Commission has terminated the license.

(3) *An external sinking fund in which deposits are made at least annually, coupled with a surety method, insurance, or other guarantee method, the value of which may decrease by the amount being accumulated in the sinking fund.* An external sinking fund is a fund established and maintained by setting aside funds periodically in an account segregated from licensee assets and outside the licensee's administrative control in which the total amount of funds would be sufficient to pay decommissioning costs at the time termination of operation is expected. An external sinking fund must be in the form of a trust. If the other guarantee method is used, no surety or insurance may be combined with the external sinking fund. The surety, insurance, or other guarantee provisions must be as stated in paragraph (f)(2) of this section.

(4) In the case of Federal, State, or local government licensees, a statement of intent containing a cost estimate for decommissioning or an amount based on the Table in paragraph (d) of this section, and indicating that funds for decommissioning will be obtained when necessary.

(5) When a governmental entity is assuming custody and ownership of a site, an arrangement that is deemed acceptable by such governmental entity.

(g) Each person licensed under this part shall keep records of information important to the decommissioning of a facility in an identified location until the site is released for unrestricted use. If records important to the decommissioning of a facility are kept for other purposes, reference to these records and their locations may be used. Information the Commission considers important to decommissioning consists of—

(1) Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site. These records may be limited to instances when contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete. These records must include any known information on identification of involved nuclides, quantities, forms, and concentrations.

(2) As-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored and of locations of possible inaccessible contamination such as buried pipes which may be subject to contamination. If required drawings are referenced, each relevant document need not be indexed individually. If drawings are not available, the licensee shall substitute appropriate records of available information concerning these areas and locations.

(3) Except for areas containing only sealed sources (provided the sources have not leaked or no contamination remains after cleanup of any leak), a list contained in a single document and updated every 2 years, of the following:

- (i) All areas designated and formerly designated as restricted areas as defined under 10 CFR 20.1003 (For requirements prior to January 1, 1994, see 10 CFR 20.3 as contained in the CFR edition revised as of January 1, 1993.);
  - (ii) All areas outside of restricted areas that require documentation under § 70.25(g)(1);
  - (iii) All areas outside of restricted areas where current and previous wastes have been buried as documented under 10 CFR 20.2108; and
  - (iv) All areas outside of restricted areas that contain material such that, if the license expired, the licensee would be required to either decontaminate the area to meet the criteria for decommissioning in 10 CFR part 20, subpart E, or apply for approval for disposal under 10 CFR 20.2002.
- (4) Records of the cost estimate performed for the decommissioning funding plan or of the amount certified for decommissioning, and records of the funding method used for assuring funds if either a funding plan or certification is used.
- (h) In providing financial assurance under this section, each licensee must use the financial assurance funds only for decommissioning activities and each licensee must monitor the balance of funds held to account for market variations. The licensee must replenish the funds, and report such actions to the NRC, as follows:
- (1) If, at the end of a calendar quarter, the fund balance is below the amount necessary to cover the cost of decommissioning, but is not below 75 percent of the cost, the licensee must increase the balance to cover the cost, and must do so within 30 days after the end of the calendar quarter.
  - (2) If, at any time, the fund balance falls below 75 percent of the amount necessary to cover the cost of decommissioning, the licensee must increase the balance to cover the cost, and must do so within 30 days of the occurrence.
  - (3) Within 30 days of taking the actions required by paragraph (h)(1) or (h)(2) of this section, the licensee must provide a written report of such actions to the Director, Office of Nuclear Material Safety and Safeguards, and state the new balance of the fund.
- [53 FR 24053, Jun. 27, 1988, as amended at 56 FR 23474, May 21, 1991; 57 FR 18393, Apr. 30, 1992; 58 FR 39634, Jul. 26, 1993; 58 FR 67662, Dec. 22, 1993; 58 FR 68731, Dec. 29, 1993; 59 FR 1618, Jan. 12, 1994; 60 FR 38239, Jul. 26, 1995; 61 FR 24675, May 16, 1996; 62 FR 39091, Jul. 21, 1997; 63 FR 29544, Jun. 1, 1998; 68 FR 57337, Oct. 3, 2003; 76 FR 35572, Jun. 17, 2011; 78 FR 34250, Jun. 7, 2013; 78 FR 75450, Dec. 12, 2013; 79 FR 75740, Dec. 19, 2014]

## Subpart E--Licenses



### § 70.31 Issuance of licenses.

- (a) Upon a determination that an application meets the requirements of the act and of the regulations of the Commission, the Commission will issue a license in such form and containing such conditions and limitations as it deems appropriate or necessary to effectuate the purposes of the act.
- (b) [Reserved]
- (c) Each license issued to a person for use of special nuclear material in activities in which special nuclear material will be produced shall (subject to the provisions of § 70.41(b)) be deemed to authorize such person to receive title to, own, acquire, receive, possess, use, and transfer the special nuclear material produced in the course of such authorized activities.

(d) No license will be issued by the Commission to any person within the United States if the Commission finds that the issuance of such license would be inimical to the common defense and security or would constitute an unreasonable risk to the health and safety of the public.

(e) No license to construct and operate a uranium enrichment facility may be issued until a hearing pursuant to 10 CFR part 2, subparts G and I, is completed and decision issued on the application.

[21 FR 764, Feb. 3, 1956, as amended at 32 FR 2563, Feb. 7, 1967; 32 FR 4056, Mar. 15, 1967; 43 FR 6925, Feb. 17, 1978; 57 FR 18393, Apr. 30, 1992]

### § 70.32 Conditions of licenses.



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(a) Each license shall contain and be subject to the following conditions:

(1) [Reserved]

(2) No right to the special nuclear material shall be conferred by the license except as defined by the license;

(3) Neither the license nor any right under the license shall be assigned or otherwise transferred in violation of the provisions of the Act;

(4) All special nuclear material shall be subject to the right of recapture or control reserved by section 108 and to all other provisions of the Act;

(5) No special nuclear material may be used in any utilization or production facility except in accordance with the provisions of the Act;

(6) The licensee shall not use the special nuclear material to construct an atomic weapon or any component of an atomic weapon;

(7) Except to the extent that the indemnification and limitation of liability provisions of part 140 of this chapter apply, the licensee will hold the United States and the Department harmless from any damages resulting from the use or possession of special nuclear material leased from the Department by the licensee;

(8) The license shall be subject to and the licensee shall observe, all applicable rules, regulations and orders of the Commission.

(9)(i) Each licensee shall notify the appropriate NRC Regional Administrator, in writing, immediately following the filing of a voluntary or involuntary petition for bankruptcy under any Chapter of Title 11 (Bankruptcy) of the United States Code by or against:

(A) The licensee;

(B) An entity (as that term is defined in 11 U.S.C. 101(14)) controlling the licensee or listing the license or licensee as property of the estate; or

(C) An affiliate (as that term is defined in 11 U.S.C. 101(a)) of the licensee.

(ii) This notification must indicate:

(A) The bankruptcy court in which the petition for bankruptcy was filed; and

(B) The date of the filing of the petition.

(b) The Commission may incorporate in any license such additional conditions and requirements with respect to the licensee's ownership, receipt, possession, use, and transfer of special nuclear material as it deems appropriate or necessary in order to:

(1) Promote the common defense and security;

(2) Protect health or to minimize danger to life or property;

(3) Protect restricted data;

(4) Guard against the loss or diversion of special nuclear material;

(5) Require such reports and the keeping of such records, and to provide for such inspections, of activities under the license as may be necessary or appropriate to effectuate the purposes of the act and regulations thereunder.

(c)(1) Each license authorizing the possession and use at any one time and location of uranium source material at an uranium enrichment facility or special nuclear material in a quantity exceeding one effective kilogram, except for use as sealed sources and those uses involved in the operation of a nuclear reactor licensed pursuant to part 50 of this chapter and those involved in a waste disposal operation, shall contain and be subject to a condition requiring the licensee to maintain and follow:

(i) The program for control and accounting of uranium source material at an uranium enrichment facility and special nuclear material at all applicable facilities as implemented pursuant to § 70.22(b), or §§ 74.31(b), 74.33(b), 74.41(b), or 74.51(c) of this chapter, as appropriate;

(ii) The measurement control program for uranium source material at an uranium enrichment facility and for special nuclear material at all applicable facilities as implemented pursuant to §§ 74.31(b), 74.33(b), 74.45(c), or 74.59(e) of this chapter, as appropriate; and

(iii) Other material control procedures as the Commission determines to be essential for the safeguarding of uranium source material at an uranium enrichment facility or of special nuclear material and providing that the licensee shall make no change that would decrease the effectiveness of the material control and accounting program implemented pursuant to § 70.22(b), or §§ 74.31(b), 74.33(b), 74.41(b), or 74.51(c) of this chapter, and the measurement control program implemented pursuant to §§ 74.31(b), 74.33(b), 74.41(b), or 74.59(e) of this chapter without the prior approval of the Commission. A licensee desiring to make changes that would decrease the effectiveness of its material control and accounting program or its measurement control program shall submit an application for amendment to its license pursuant to § 70.34.

(2) The licensee shall maintain records of changes to the material control and accounting program made without prior Commission approval for a period of 5 years from the date of the change. Licensees located in all four Regions as indicated in appendix A of part 73 of this chapter shall furnish to the Director, Division of Security Policy, Office of Nuclear Security and Incident Response, using an appropriate method listed in § 70.5(a), a report containing a description of each change within:

(i) Two months of the change if it pertains to uranium-233, uranium-235 contained in uranium enriched 20 percent or more in the uranium-235 isotope, or plutonium, except plutonium containing 80 percent or more by weight of the isotope Pu-238, and

(ii) Six months of the change if it pertains to uranium enriched less than 20 percent in the uranium-235 isotope, or plutonium containing 80 percent or more by weight of the isotope Pu-238.

(d) The licensee shall make no change which would decrease the effectiveness of the plan for physical protection of special nuclear material in transit prepared pursuant to § 70.22(g) or § 73.20(c) of this chapter without the prior approval of the Commission. A licensee desiring to make such changes shall submit an application for a change in the technical specifications incorporated in his or her license, if any, or for an amendment to the license pursuant to § 50.90 or § 70.34 of this chapter, as appropriate. The licensee may make changes to the plan for physical protection of special nuclear material without prior Commission approval if these changes do not decrease the effectiveness of the plan. The licensee shall retain a copy of the plan as a record for the period during which the licensee possesses a formula quantity of special

nuclear material requiring this record under each license and each change to the plan for three years from the effective date of the change. Within two months after each change, a report containing a description of the change must be furnished to the Director of the NRC's Office of Nuclear Material Safety and Safeguards, using an appropriate method listed in § 70.5(a); and a copy must be sent to the appropriate NRC Regional Office shown in appendix A to part 73 of this chapter.

(e) The licensee shall make no change which would decrease the effectiveness of a security plan prepared pursuant to §§ 70.22(h), 70.22(k), or 73.20(c) without the prior approval of the Commission. A licensee desiring to make such a change shall submit an application for an amendment to its license pursuant to § 70.34. The licensee shall maintain records of changes to the plan made without prior Commission approval, for three years from the effective date of the change, and shall, within two months after the change is made, furnish a report containing a description of each change to the Director, Division of Security Policy, Office of Nuclear Security and Incident Response; the report may be sent using an appropriate method listed in § 70.5(a), and a copy of the report must be sent to the appropriate NRC Regional Office shown in appendix A to part 73 of this chapter.

(f) [Reserved]

(g) The licensee shall prepare and maintain safeguards contingency plan procedures in accordance with appendix C to part 73 of this chapter for bringing about the actions and decisions contained in the Responsibility Matrix of its safeguards contingency plan. The licensee shall retain the current safeguards contingency plan procedures as a record for the entire period during which the licensee possesses the appropriate type and quantity of special nuclear material under each license for which the procedures were developed and, if any portion of the plan is superseded, retain that superseded portion for 3 years after the effective date of the change. The licensee shall not make a change that would decrease the safeguards effectiveness of the first four categories of information (i.e., Background, Generic Planning Base, Licensee Planning Base, and Responsibility Matrix) contained in any licensee safeguards contingency plan prepared pursuant to §§ 70.22(g), 70.22(j), 72.184, 73.20(c), 73.26(e)(1), 73.46(h)(1), or 73.50(g)(1) of this chapter without the prior approval of the NRC. A licensee desiring to make such a change shall submit an application for an amendment to its license pursuant to § 70.34. The licensee may make changes to the licensee safeguards contingency plan without prior NRC approval if the changes do not decrease the safeguards effectiveness of the plan. The licensee shall maintain each change to the plan made without prior approval as a record during the period for which possession of a formula quantity of special nuclear material is authorized under a license and retain the superseded portion for 3 years after the effective date of the change, and shall, within 60 days after the change is made, furnish a report containing a description of each change to the Director of Nuclear Material Safety and Safeguards; the report may be sent using an appropriate method listed in § 70.5(a), and a copy of the report must be sent to the Regional Administrator of the appropriate NRC Regional Office as specified in appendix A to part 73 of this chapter.

(h) [Reserved]

(i) Licensees required to submit emergency plans in accordance with § 70.22(i) shall follow the emergency plan approved by the Commission. The licensee may change the approved plan without Commission approval if the changes do not decrease the effectiveness of the plan. Within six months after each change is made, the licensee shall, using an appropriate method listed in § 70.5(a), furnish the Director, Division of Security Policy, Office of Nuclear Security and Incident Response, a copy of each change, with copies to the appropriate NRC Regional

Office specified in appendix D to part 20 of this chapter and to affected offsite response organizations. Proposed changes that decrease the effectiveness of the approved emergency plan may not be implemented without prior application to and prior approval by the Commission.

(j) Each licensee who possesses special nuclear material, or who transports, or delivers to a carrier for transport, a formula quantity of strategic special nuclear material, special nuclear material of moderate strategic significance, or special nuclear material of low strategic significance, or more than 100 grams of irradiated reactor fuel shall ensure that Safeguards Information is protected against unauthorized disclosure in accordance with the requirements in § 73.21 and the requirements of § 73.22 or § 73.23 of this chapter, as applicable, and shall protect classified information in accordance with the requirements of parts 25 and 95 of this chapter, as applicable.

(k) No person may commence operation of a uranium enrichment facility until the Commission verifies through inspection that the facility has been constructed in accordance with the requirements of the license. The Commission shall publish notice of the inspection results in the Federal Register.

[21 FR 764, Feb. 3, 1956; 73 FR 63572, Oct. 24, 2008; 74 FR 62683, Dec. 1, 2009]

Editorial Note: For Federal Register citations affecting § 70.32, see the List of CFR Sections [Affected](#), which appears in the Finding Aids section of the printed volume and on GPO Access.

### § 70.33 Applications for renewal of licenses.



TOP

Applications for renewal of a license should be filed in accordance with §§ 70.21 and 70.22. Information contained in previous applications, statements or reports filed with the Commission under the license may be incorporated by reference, provided that such references are clear and specific.

[21 FR 764, Feb. 3, 1956, as amended at 59 FR 36037, July 15, 1994; 61 FR 1115, Jan. 16, 1996; 75 FR 73944, Nov. 30, 2010]

### § 70.34 Amendment of licenses.



TOP

Applications for amendment of a license shall be filed in accordance with § 70.21(a) and shall specify the respects in which the licensee desires his license to be amended and the grounds for such amendment.

### § 70.35 Commission action on applications to renew or amend.



TOP

In considering an application by a licensee to renew or amend his license, the Commission will apply the criteria set forth in § 70.23.

### § 70.36 Inalienability of licenses.



TOP

(a) No license granted under the regulations in this part and no right to possess or utilize special nuclear material granted by any license issued pursuant to the regulations in this part shall be transferred, assigned or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of any license to any person unless the Commission shall

after securing full information, find that the transfer is in accordance with the provisions of the Act, and shall give its consent in writing.

(b) An application for transfer of license must include:

- (1) The identity, technical and financial qualifications of the proposed transferee; and
- (2) Financial assurance for decommissioning information required by § 70.25.

[21 FR 764, Feb. 3, 1956, as amended at 35 FR 11461, July 17, 1970; 76 FR 35573, Jun. 17, 2011]

### § 70.37 Disclaimer of warranties.



TOP

Neither the Government nor the Commission makes any warranty or other representation that special nuclear material (a) will not result in injury or damage when used for purposes approved by the Commission, (b) will accomplish the results for which it is requested and approved by the Commission, or (c) is safe for any other use.

### § 70.38 Expiration and termination of licenses and decommissioning of sites and separate buildings or outdoor areas.



TOP

(a) Each specific license expires at the end of the day on the expiration date stated in the license unless the licensee has filed an application for renewal under § 70.33 not less than 30 days before the expiration date stated in the existing license. If an application for renewal has been filed at least 30 days before the expiration date stated in the existing license, the existing license expires at the end of the day on which the Commission makes a final determination to deny the renewal application or, if the determination states an expiration date, the expiration date stated in the determination.

(b) Each specific license revoked by the Commission expires at the end of the day on the date of the Commission's final determination to revoke the license, or on the expiration date stated in the determination, or as otherwise provided by Commission Order.

(c) Each specific license continues in effect, beyond the expiration date if necessary, with respect to possession of special nuclear material until the Commission notifies the licensee in writing that the license is terminated. During this time, the licensee shall—

- (1) Limit actions involving special nuclear material to those related to decommissioning; and
- (2) Continue to control entry to restricted areas until they are suitable for release in accordance with NRC requirements.

(d) Within 60 days of the occurrence of any of the following, consistent with the administrative directions in § 70.5, each licensee shall provide notification to the NRC in writing and either begin decommissioning its site, or any separate building or outdoor area that contains residual radioactivity, so that the building or outdoor area is suitable for release in accordance with NRC requirements, or submit within 12 months of notification a decommissioning plan, if required by paragraph (g)(1) of this section, and begin decommissioning upon approval of that plan if—

- (1) The license has expired pursuant to paragraph (a) or (b) of this section; or
- (2) The licensee has decided to permanently cease principal activities, as defined in this part, at the entire site or in any separate building or outdoor area; or
- (3) No principal activities under the license have been conducted for a period of 24 months; or



(4) No principal activities have been conducted for a period of 24 months in any separate building or outdoor area that contains residual radioactivity such that the building or outdoor area is unsuitable for release in accordance with NRC requirements.

(e) Coincident with the notification required by paragraph (d) of this section, the licensee shall maintain in effect all decommissioning financial assurances established by the licensee pursuant to § 70.25 in conjunction with a license issuance or renewal or as required by this section. The amount of the financial assurance must be increased, or may be decreased, as appropriate, to cover the detailed cost estimate for decommissioning established pursuant to paragraph (g)(4)(v) of this section.

(1) Any licensee who has not provided financial assurance to cover the detailed cost estimate submitted with the decommissioning plan shall do so when this rule becomes effective November 24, 1995.

(2) Following approval of the decommissioning plan, a licensee may reduce the amount of the financial assurance as decommissioning proceeds and radiological contamination is reduced at the site with the approval of the Commission.

(f) The Commission may grant a request to delay or postpone initiation of the decommissioning process if the Commission determines that this relief is not detrimental to the public health and safety and is otherwise in the public interest. The request must be submitted no later than 30 days before notification pursuant to paragraph (d) of this section. The schedule for decommissioning set forth in paragraph (d) of this section may not commence until the Commission has made a determination on the request.

(g)(1) A decommissioning plan must be submitted if required by license condition or if the procedures and activities necessary to carry out decommissioning of the site or separate building or outdoor area have not been previously approved by the Commission and these procedures could increase potential health and safety impacts to workers or to the public, such as in any of the following cases:

(i) Procedures would involve techniques not applied routinely during cleanup or maintenance operations;

(ii) Workers would be entering areas not normally occupied where surface contamination and radiation levels are significantly higher than routinely encountered during operation;

(iii) Procedures could result in significantly greater airborne concentrations of radioactive materials than are present during operation; or

(iv) Procedures could result in significantly greater releases of radioactive material to the environment than those associated with operation.

(2) The Commission may approve an alternate schedule for submittal of a decommissioning plan required pursuant to paragraph (d) of this section if the Commission determines that the alternative schedule is necessary to the effective conduct of decommissioning operations and presents no undue risk from radiation to the public health and safety and is otherwise in the public interest.

(3) The procedures listed in paragraph (g)(1) of this section may not be carried out prior to approval of the decommissioning plan.

(4) The proposed decommissioning plan for the site or separate building or outdoor area must include:

(i) A description of the conditions of the site or separate building or outdoor area sufficient to evaluate the acceptability of the plan;

(ii) A description of planned decommissioning activities;

(iii) A description of methods used to ensure protection of workers and the environment against radiation hazards during decommissioning;

(iv) A description of the planned final radiation survey; and

(v) An updated detailed cost estimate for decommissioning, comparison of that estimate with present funds set aside for decommissioning, and a plan for assuring the availability of adequate funds for completion of decommissioning.

(vi) A description of the physical security plan and material control and accounting plan provisions in place during decommissioning.

(vii) For decommissioning plans calling for completion of decommissioning later than 24 months after plan approval, a justification for the delay based on the criteria in paragraph (i) of this section.

(5) The proposed decommissioning plan will be approved by the Commission if the information therein demonstrates that the decommissioning will be completed as soon as practical and that the health and safety of workers and the public will be adequately protected.

(h)(1) Except as provided in paragraph (i) of this section, licensees shall complete decommissioning of the site or separate building or outdoor area as soon as practicable but no later than 24 months following the initiation of decommissioning.

(2) Except as provided in paragraph (i) of this section, when decommissioning involves the entire site, the licensee shall request license termination as soon as practicable but no later than 24 months following the initiation of decommissioning.

(i) The Commission may approve a request for an alternate schedule for completion of decommissioning of the site or separate building or outdoor area, and license termination if appropriate, if the Commission determines that the alternative is warranted by consideration of the following:

(1) Whether it is technically feasible to complete decommissioning within the allotted 24-month period;

(2) Whether sufficient waste disposal capacity is available to allow completion of decommissioning within the allotted 24-month period;

(3) Whether a significant volume reduction in wastes requiring disposal will be achieved by allowing short-lived radionuclides to decay;

(4) Whether a significant reduction in radiation exposure to workers can be achieved by allowing short-lived radionuclides to decay; and

(5) Other site-specific factors which the Commission may consider appropriate on a case-by-case basis, such as regulatory requirements of other government agencies, lawsuits, groundwater treatment activities, monitored natural groundwater restoration, actions that could result in more environmental harm than deferred cleanup, and other factors beyond the control of the licensee.

(j) As the final step in decommissioning, the licensee shall—

(1) Certify the disposition of all licensed material, including accumulated wastes, by submitting a completed NRC Form 314 or equivalent information; and

(2) Conduct a radiation survey of the premises where the licensed activities were carried out and submit a report of the results of this survey, unless the licensee demonstrates in some other manner that the premises are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E. The licensee shall, as appropriate—

(i) Report levels of gamma radiation in units of millisieverts (microroentgen) per hour at one meter from surfaces, and report levels of radioactivity, including alpha and beta, in units of megabecquerels (disintegrations per minute or microcuries) per 100 square centimeters

removable and fixed for surfaces, megabecquerels (microcuries) per milliliter for water, and becquerels (picocuries) per gram for solids such as soils or concrete; and

(ii) Specify the survey instrument(s) used and certify that each instrument is properly calibrated and tested.

(k) Specific licenses, including expired licenses, will be terminated by written notice to the licensee when the Commission determines that:

(1) Special nuclear material has been properly disposed;

(2) Reasonable effort has been made to eliminate residual radioactive contamination, if present; and

(3)(i) A radiation survey has been performed which demonstrates that the premises are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E; or

(ii) Other information submitted by the licensee is sufficient to demonstrate that the premises are suitable for release in accordance with the criteria for decommissioning in 10 CFR part 20, subpart E.

(4) Records required by § 70.51(b)(6) have been received.

[59 FR 36037, July 15, 1994, as amended at 60 FR 38240, July 26, 1995; 61 FR 1115, Jan. 16, 1996; 61 FR 24675, May 16, 1996; 61 FR 29637, 29638, June 12, 1996; 62 FR 39091, July 21, 1997; 66 FR 24049, May 11, 2001; 73 FR 42675; Jul. 23, 2008; 81 FR 86910, Dec. 2, 2016]

#### § 70.39 Specific licenses for the manufacture or initial transfer of calibration or reference sources.



TOP

(a) An application for a specific license to manufacture or initially transfer calibration or reference sources containing plutonium, for distribution to persons generally licensed under § 70.19, will be approved if:

(1) The applicant satisfies the general requirements of § 70.23.

(2) The applicant submits sufficient information regarding each type of calibration or reference source pertinent to evaluation of the potential radiation exposure, including:

(i) Chemical and physical form and maximum quantity of plutonium in the source;

(ii) Details of construction and design;

(iii) Details of the method of incorporation and binding of the plutonium in the source;

(iv) Procedures for and results of prototype testing of sources, which are designed to contain more than 0.005 microcurie of plutonium, to demonstrate that the plutonium contained in each source will not be released or be removed from the source under normal conditions of use;

(v) Details of quality control procedures to be followed in manufacture of the source;

(vi) Description of labeling to be affixed to the source or the storage container for the source;

(vii) Any additional information, including experimental studies and tests, required by the Commission to facilitate a determination of the safety of the source.

(3) Each source will contain no more than 5 microcuries of plutonium.

(4) The Commission determines, with respect to any type of source containing more than 0.005 microcurie of plutonium, that:

(i) The method of incorporation and binding of the plutonium in the source is such that the plutonium will not be released or be removed from the source under normal conditions of use and handling of the source; and

(ii) The source has been subjected to and has satisfactorily passed the prototype tests prescribed by paragraph (a)(5) of this section.

(5) For any type of source which is designed to contain more than 0.005 microcurie of plutonium, the applicant has conducted prototype tests, in the order listed, on each of five prototypes of such source, which contains more than 0.005 microcurie of plutonium, as follows:

(i) *Initial measurement.* The quantity of radioactive material deposited on the source shall be measured by direct counting of the source.

(ii) *Dry wipe test.* The entire radioactive surface of the source shall be wiped with filter paper with the application of moderate finger pressure. Removal of radioactive material from the source shall be determined by measuring the radioactivity on the filter paper or by direct measurement of the radioactivity on the source following the dry wipe.

(iii) *Wet wipe test.* The entire radioactive surface of the source shall be wiped with filter paper, moistened with water, with the application of moderate finger pressure. Removal of radioactive material from the source shall be determined by measuring the radioactivity on the filter paper after it has dried or by direct measurement of the radioactivity on the source following the wet wipe.

(iv) *Water soak test.* The source shall be immersed in water at room temperature for a period of 24 consecutive hours. The source shall then be removed from the water. Removal of radioactive material from the source shall be determined by direct measurement of the radioactivity on the source after it has dried or by measuring the radioactivity in the residue obtained by evaporation of the water in which the source was immersed.

(v) *Dry wipe test.* On completion of the preceding tests in paragraphs (a)(5)(i) through (iv) of this section, the dry wipe test described in paragraph (a)(5)(ii) of this section shall be repeated.

(vi) *Observations.* Removal of more than 0.005 microcurie of radioactivity in any test prescribed by this paragraph shall be cause for rejection of the source design. Results of prototype tests submitted to the Commission shall be given in terms of radioactivity in microcuries and percent of removal from the total amount of radioactive material deposited on the source.

(b) Each person licensed under this section shall affix to each source, or storage container for the source, a label which shall contain sufficient information relative to safe use and storage of the source and shall include the following statement or a substantially similar statement which contains the information called for in the following statement.<sup>1</sup>

The receipt, possession, use and transfer of this source, Model-- --- , Serial No.-----, are subject to a general license and the regulations of the United States Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority. Do not remove this label.

**CAUTION—RADIOACTIVE MATERIAL—THIS SOURCE CONTAINS  
PLUTONIUM. DO NOT TOUCH RADIOACTIVE PORTION OF THIS SOURCE.**

(Name of Manufacturer or Initial Transferor)

(c) Each person licensed under this section shall perform a dry wipe test upon each source containing more than 0.1 microcurie of plutonium prior to transferring the source to a general licensee under § 70.19. This test shall be performed by wiping the entire radioactive surface of the source with a filter paper with the application of moderate finger pressure. The radioactivity on the paper shall be measured by using radiation detection instrumentation capable of detecting 0.005 microcurie of plutonium. If any such test discloses more than 0.005 microcurie of radioactive material, the source shall be deemed to be leaking or losing plutonium and shall not be transferred to a general licensee under § 70.19.

[29 FR 5884, May 5, 1964, as amended at 32 FR 2563, Feb. 7, 1967; 38 FR 1272, Jan. 11, 1973; 40 FR 8792, Mar. 3, 1975; 42 FR 43966, Sept. 1, 1977; 43 FR 6925, Feb. 17, 1978]

1. Sources generally licensed under this section prior to January 19, 1975 may bear labels authorized by the regulations in effect on January 1, 1975.

#### § 70.40 Ineligibility of certain applicants.



A license may not be issued to the Corporation if the Commission determines that:

(a) The Corporation is owned, controlled, or dominated by an alien, a foreign corporation, or a foreign government; or

(b) The issuance of such a license would be inimical to--

(1) The common defense and security of the United States; or

(2) The maintenance of a reliable and economical domestic source of enrichment services.

[62 FR 6669, Feb. 12, 1997]

#### Subpart F--Acquisition, Use, and Transfer of Special Nuclear Material, Creditors' Rights



§ 70.41 Authorized use of special nuclear material.

(a) Each licensee shall confine his possession and use of special nuclear material to the locations and purposes authorized in his license. Except as otherwise provided in the license, each license issued pursuant to the regulations in this part shall carry with it the right to receive title to, own, acquire, receive, possess and use special nuclear material. Preparation for shipment and transport of special nuclear material shall be in accordance with the provisions of part 71 of this chapter.

(b) The possession, use and transfer of any special nuclear material produced by a licensee, in connection with or as a result of use of special nuclear material received under his license, shall be subject to the provisions of the license and the regulations in this part.

[21 FR 764, Feb. 3, 1956, as amended at 38 FR 33970, Dec. 10, 1973; 43 FR 6925, Feb. 17, 1978]

#### § 70.42 Transfer of special nuclear material.



(a) No licensee shall transfer special nuclear material except as authorized pursuant to this section.

(b) Except as otherwise provided in his license and subject to the provisions of paragraphs (c) and (d) of this section, any licensee may transfer special nuclear material:

(1) To the Department;

(2) To the agency in any Agreement State which regulates radioactive materials pursuant to an agreement with the Commission or the Atomic Energy Commission under section 274 of the Act, if the quantity transferred is not sufficient to form a critical mass;

(3) To any person exempt from the licensing requirements of the Act and regulations in this part, to the extent permitted under such exemption;

(4) To any person in an Agreement State, subject to the jurisdiction of that State, who has been exempted from the licensing requirements and regulations of that State, to the extent permitted under such exemption;

- (5) To any person authorized to receive such special nuclear material under terms of a specific license or a general license or their equivalents issued by the Commission or an Agreement State;
- (6) To any person abroad pursuant to an export license issued under part 110 of this chapter; or
- (7) As otherwise authorized by the Commission in writing.
- (c) Before transferring special nuclear material to a specific licensee of the Commission or an Agreement State or to a general licensee who is required to register with the Commission or with an Agreement State prior to receipt of the special nuclear material, the licensee transferring the material shall verify that the transferee's license authorizes receipt of the type, form, and quantity of special nuclear material to be transferred.
- (d) The following methods for the verification required by paragraph (c) of this section are acceptable:
- (1) The transferor may have in his or her possession, and read, a current copy of the transferee's specific license or registration certificate. The transferor shall retain a copy of each license or certificate for three years from the date that it was obtained.
- (2) The transferor may have in its possession a written certification by the transferee that the transferee is authorized by license or registration certificate to receive the type, form, and quantity of special nuclear material to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date. The transferor shall retain the written certification as a record for three years from the date of receipt of the certification;
- (3) For emergency shipments the transferor may accept oral certification by the transferee that he or she is authorized by license or registration certification to receive the type, form, and quantity of special nuclear material to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date, provided that the oral certification is confirmed in writing within ten days. The transferor shall retain the written confirmation of the oral certification for three years from the date of receipt of the confirmation;
- (4) The transferor may obtain other sources of information compiled by a reporting service from official records of the Commission or the licensing agency of an Agreement State as to the identity of licensees and the scope and expiration dates of licenses and registrations. The transferor shall retain the compilation of information as a record for three years from the date that it was obtained; or
- (5) When none of the methods of verification described in paragraphs (d) (1) to (4) of this section are readily available or when a transferor desires to verify that information received by one of these methods is correct or up-to-date, the transferor may obtain and record confirmation from the Commission or the licensing agency of an Agreement State that the transferee is licensed to receive the special nuclear material. The transferor shall retain the record of confirmation for three years from the date the record is made.

[38 FR 33970, Dec. 10, 1973, as amended at 40 FR 8792, Mar. 3, 1975; 43 FR 6925, Feb. 21, 1978; 53 FR 19253, May 27, 1988]

#### § 70.44 Creditor regulations.



- (a) Pursuant to section 184 of the Act, the Commission consents, without individual application, to the creation of any mortgage, pledge, or other lien upon any special nuclear material, not owned by the United States, which is subject to licensing: Provided:

(1) That the rights of any creditor so secured may be exercised only in compliance with and subject to the same requirements and restrictions as would apply to the licensee pursuant to the provisions of the license, the Atomic Energy Act of 1954, as amended, and regulations issued by the Commission pursuant to said Act; and

(2) That no creditor so secured may take possession of the special nuclear material pursuant to the provisions of this section prior to either the issuance of a license by the Commission authorizing such possession or the transfer of a license pursuant to § 70.36.

(b) Nothing contained in this section shall be deemed to affect the means of acquiring, or the priority of, any tax lien or other lien provided by law.

(c) As used in this section, creditor includes, without implied limitation, the trustee under any mortgage, pledge, or lien on special nuclear material made to secure any creditor, any trustee or receiver of the special nuclear material appointed by a court of competent jurisdiction in any action brought for the benefit of any creditor secured by such mortgage, pledge, or lien, any purchaser of such special nuclear material at the sale thereof upon foreclosure of such mortgage, pledge, or lien or upon exercise of any power of sale contained therein, or any assignee of any such purchaser.

[32 FR 2563, Feb. 7, 1967, as amended at 35 FR 11461, July 17, 1970]

### Subpart G—Special Nuclear Material Control Records, Reports, and Inspections



TOP

#### § 70.50 Reporting requirements.

(a) *Immediate report.* Each licensee shall notify the NRC as soon as possible but not later than 4 hours after the discovery of an event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of licensed material that could exceed regulatory limits (events may include fires, explosions, toxic gas releases, etc.).

(b) *Twenty-four hour report.* Each licensee shall notify the NRC within 24 hours after the discovery of any of the following events involving licensed material:

(1) An unplanned contamination event that:

(i) Requires access to the contaminated area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;

(ii) Involves a quantity of material greater than five times the lowest annual limit on intake specified in Appendix B of §§ 20.1001-20.2401 of 10 CFR part 20 for the material; and

(iii) Has access to the area restricted for a reason other than to allow isotopes with a half-life of less than 24 hours to decay prior to decontamination.

(2) An event in which equipment is disabled or fails to function as designed when:

(i) The equipment is required by regulation or licensee condition to prevent releases exceeding regulatory limits, to prevent exposures to radiation and radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident;

(ii) The equipment is required to be available and operable when it is disabled or fails to function; and

(iii) No redundant equipment is available and operable to perform the required safety function.

(3) An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.

(4) An unplanned fire or explosion damaging any licensed material or any device, container, or equipment containing licensed material when:



- (i) The quantity of material involved is greater than five times the lowest annual limit on intake specified in appendix B of §§ 20.1001-20.2401 of 10 CFR part 20 for the material; and
- (ii) The damage affects the integrity of the licensed material or its container.
- (c) *Preparation and submission of reports.* Reports made by licensees in response to the requirements of this section must be made as follows:
  - (1) Licensees shall make reports required by paragraphs (a) and (b) of this section, and by § 70.74 and Appendix A of this part, if applicable, by telephone to the NRC Operations Center.<sup>1</sup> To the extent that the information is available at the time of notification, the information provided in these reports must include:
    - (i) Caller's name, position title, and call-back telephone number;
    - (ii) Date, time, and exact location of the event;
    - (iii) Description of the event, including:
      - (A) Radiological or chemical hazards involved, including isotopes, quantities, and chemical and physical form of any material released;
      - (B) Actual or potential health and safety consequences to the workers, the public, and the environment, including relevant chemical and radiation data for actual personnel exposures to radiation or radioactive materials or hazardous chemicals produced from licensed materials (e.g., level of radiation exposure, concentration of chemicals, and duration of exposure);
      - (C) The sequence of occurrences leading to the event, including degradation or failure of structures, systems, equipment, components, and activities of personnel relied on to prevent potential accidents or mitigate their consequences; and
      - (D) Whether the remaining structures, systems, equipment, components, and activities of personnel relied on to prevent potential accidents or mitigate their consequences are available and reliable to perform their function;
    - (iv) External conditions affecting the event;
    - (v) Additional actions taken by the licensee in response to the event;
    - (vi) Status of the event (e.g., whether the event is on-going or was terminated);
    - (vii) Current and planned site status, including any declared emergency class;
    - (viii) Notifications, related to the event, that were made or are planned to any local, State, or other Federal agencies;
    - (ix) Status of any press releases, related to the event, that were made or are planned.
  - (2) *Written report.* Each licensee that makes a report required by paragraph (a) or (b) of this section shall submit a written follow-up report within 30 days of the initial report. Written reports prepared pursuant to other regulations may be submitted to fulfill this requirement if the report contains all the necessary information, and the appropriate distribution is made. These written reports must be sent to the NRC's Document Control Desk, using an appropriate method listed in § 70.5(a), with a copy to the appropriate NRC regional office listed in appendix D to part 20 of this chapter. The reports must include the following:
    - (i) Complete applicable information required by § 70.50(c)(1);
    - (ii) The probable cause of the event, including all factors that contributed to the event and the manufacturer and model number (if applicable) of any equipment that failed or malfunctioned;
    - (iii) Corrective actions taken or planned to prevent occurrence of similar or identical events in the future and the results of any evaluations or assessments; and
    - (iv) For licensees subject to Subpart H of this part, whether the event was identified and evaluated in the Integrated Safety Analysis.



(d) The provisions of § 70.50 do not apply to licensees subject to § 50.72. They do apply to those Part 50 licensees possessing material licensed under Part 70 that are not subject to the notification requirements in § 50.72.

<sup>1</sup> The commercial telephone number for the NRC Operations Center is (301) 816-5100. [56 FR 40769, Aug. 16, 1991; 56 FR 64980, Dec. 13, 1991, as amended at 59 FR 14087, Mar. 25, 1994; 65 FR 56226, Sept. 18, 2000; 68 FR 58817, Oct. 10, 2003; 79 FR 57725, Sept. 26, 2014]

### § 70.51 Records requirements.



TOP

(a) Before license termination, licensees shall forward the following records to the appropriate NRC Regional Office:

(1) Records of disposal of licensed material made under 10 CFR 20.2002 (including burials authorized before January 28, 1981<sup>1</sup>), 20.2003, 20.2004, 20.2005;

(2) Records required by 10 CFR 20.2103(b)(4); and

(3) Records required by § 70.25(g).

(b) If licensed activities are transferred or assigned in accordance with § 70.32(a)(3), the licensee shall transfer the following records to the new licensee and the new licensee will be responsible for maintaining these records until the license is terminated:

(1) Records of disposal of licensed material made under 10 CFR 20.2002 (including burials authorized before January 28, 1981<sup>1</sup>), 20.2003, 20.2004, 20.2005;

(2) Records required by 10 CFR 20.2103(b)(4); and

(3) Records required by § 70.25(g).

(c)(1) Records which must be maintained pursuant to this part may be the original or a reproduced copy, or microform if the reproduced copy or microform is duly authenticated by authorized personnel, and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications, must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

(2) If there is a conflict between the Commission's regulations in this part, license condition, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for these records shall apply unless the Commission, under § 70.17 has granted a specific exemption from the record retention requirements specified in the regulations in this part.

[38 FR 30544, Nov. 6, 1973, as amended at 38 FR 32784, Nov. 28, 1973; 41 FR 18303, May 3, 1976; 43 FR 6925, Feb. 17, 1978; 50 FR 7579, Feb. 25, 1985; 52 FR 10038, Mar. 30, 1987; 53 FR 19253, May 27, 1988; 56 FR 55998, Oct. 31, 1991; 61 FR 24675, May 16, 1996; 67 FR 78142, Dec. 23, 2002; 72 FR 35144, June 27, 2007]

<sup>1</sup>A previous § 20.304 permitted burial of small quantities of licensed materials in soil before January 28, 1981, without specific Commission authorization. See § 20.304 contained in the 10 CFR, parts 0 to 199, edition revised as of January 1, 1981.

### § 70.52 Reports of accidental criticality.



TOP

(a) Each licensee shall notify the NRC Operations Center<sup>1</sup> within one hour after discovery of any case of accidental criticality.

(b) This notification must be made to the NRC Operations Center via the Emergency Notification System if the licensee is party to that system. If the Emergency Notification System is inoperative or unavailable, the licensee shall make the required notification via commercial telephonic service or other dedicated telephonic system or any other method that will ensure that a report is received by the NRC Operations Center within one hour.

[52 FR 21657, June 9, 1987, as amended at 59 FR 14087, Mar. 25, 1994; 67 FR 78143, Dec. 23, 2002]

<sup>1</sup>Commercial telephone number of the NRC Operations Center is (301) 816-5100.

### § 70.55 Inspections.



(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect special nuclear material and the premises and facilities wherein special nuclear material is used, produced, or stored.

(b) Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by the licensee pertaining to his receipt, possession, use, acquisition, import, export, or transfer of special nuclear material.

(c)(1) In the case of fuel cycle facilities where nuclear reactor fuel is fabricated or processed each licensee shall upon request by the Director, Office of Nuclear Material Safety and Safeguards or the appropriate NRC Regional Administrator, provide rent-free office space for the exclusive use of Commission inspection personnel. Heat, air conditioning, light, electrical outlets and janitorial services shall be furnished by each licensee. The office shall be convenient to and have full access to the facility and, shall provide the inspector both visual and acoustic privacy.

(2) For a site with a single fuel facility licensed pursuant to part 70, the space provided shall be adequate to accommodate a full-time inspector, a part-time secretary and transient NRC personnel and will be generally commensurate with other office facilities at the site. A space of 250 square feet either within the site's office complex or in an office trailer or other on site space is suggested as a guide. For sites containing multiple fuel facilities, additional space may be requested to accommodate additional full-time inspector(s). The office space that is provided shall be subject to the approval of the Director, Office of Nuclear Material Safety and Safeguards or the appropriate NRC Regional Administrator. All furniture, supplies and communication equipment will be furnished by the Commission.

(3) The licensee shall afford any NRC resident inspector assigned to that site or other NRC inspectors identified by the Director, Office of Nuclear Material Safety and Safeguards, as likely to inspect the facility, immediate unfettered access, equivalent to access provided regular plant employees, following proper identification and compliance with applicable access control measures for security, radiological protection, and personal safety.

[21 FR 764, Feb. 3, 1956. Redesignated at 25 FR 1607, Feb. 25, 1960, and 25 FR 12730, Dec. 13, 1960, and amended at 32 FR 2563, Feb. 7, 1967; 44 FR 47919, Aug. 16, 1979; 52 FR 31612, Aug. 21, 1987; 54 FR 6877, Feb. 15, 1989; 55 FR 5979, Feb. 21, 1990]

### § 70.56 Tests.



Each licensee shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part, including tests of (a) special nuclear material, (b) facilities wherein special nuclear material is utilized, produced or stored, (c) radiation detection and monitoring instruments, and (d) other equipment and devices used in connection with the production, utilization or storage of special nuclear material.

[21 FR 764, Feb. 3, 1956. Redesignated at 25 FR 1607, Feb. 25, 1960, and 25 FR 12730, Dec. 13, 1960]

#### § 70.59 Effluent monitoring reporting requirements.



TOP

Within 60 days after January 1 and July 1 of each year, and using an appropriate method listed in § 70.5(a), each licensee authorized to possess and use special nuclear material for processing and fuel fabrication, scrap recovery, conversion of uranium hexafluoride, or in a uranium enrichment facility shall submit a report addressed: ATTN: Document Control Desk, Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, with a copy to the appropriate NRC Regional Office shown in appendix D to part 20 of this chapter. The report must specify the quantity of each of the principal radionuclides released to unrestricted areas in liquid and gaseous effluents during the previous six months of operation, and such other information as the Commission may require to estimate maximum potential annual radiation doses to the public resulting from effluent releases. If quantities of radioactive materials released during the reporting periods are significantly above the licensee's design objectives previously reviewed as part of the licensing action, the report must cover this specifically. On the basis of these reports and any additional information the Commission may obtain from the licensee or others, the Commission may from time to time require the licensee to take such action as the Commission deems appropriate.

[40 FR 53230, Nov. 17, 1975, as amended at 41 FR 21627, May 27, 1976; 42 FR 25721, May 19, 1977; 52 FR 31612, Aug. 21, 1987; 57 FR 18393, Apr. 30, 1992; 68 FR 58817, Oct. 10, 2003]

#### Subpart H--Additional Requirements for Certain Licensees Authorized To Possess a Critical Mass of Special Nuclear Material



TOP

Source: 65 FR 56226, Sept. 18, 2000, unless otherwise noted.

#### § 70.60 Applicability.

The regulations in § 70.61 through § 70.76 apply, in addition to other applicable Commission regulations, to each applicant or licensee that is or plans to be authorized to possess greater than a critical mass of special nuclear material, and engaged in enriched uranium processing, fabrication of uranium fuel or fuel assemblies, uranium enrichment, enriched uranium hexafluoride conversion, plutonium processing, fabrication of mixed-oxide fuel or fuel assemblies, scrap recovery of special nuclear material, or any other activity that the Commission determines could significantly affect public health and safety. The regulations in § 70.61 through § 70.76 do not apply to decommissioning activities performed pursuant to other applicable Commission regulations including § 70.25 and § 70.38 of this part. Also, the regulations in § 70.61 through § 70.76 do not apply to activities that are certified by the Commission pursuant to part 76 of this chapter or licensed by the Commission pursuant to other parts of this chapter.

Unless specifically addressed in § 70.61 through § 70.76, implementation by current licensees of the Subpart H requirements shall be completed no later than the time of the ISA Summary submittal required in § 70.62(c)(3)(ii).

### § 70.61 Performance requirements.



- TOP
- (a) Each applicant or licensee shall evaluate, in the integrated safety analysis performed in accordance with § 70.62, its compliance with the performance requirements in paragraphs (b), (c), and (d) of this section.
- (b) The risk of each credible high-consequence event must be limited. Engineered controls, administrative controls, or both, shall be applied to the extent needed to reduce the likelihood of occurrence of the event so that, upon implementation of such controls, the event is highly unlikely or its consequences are less severe than those in paragraphs (b)(1)-(4) of this section. High consequence events are those internally or externally initiated events that result in:
- (1) An acute worker dose of 1 Sv (100 rem) or greater total effective dose equivalent;
  - (2) An acute dose of 0.25 Sv (25 rem) or greater total effective dose equivalent to any individual located outside the controlled area identified pursuant to paragraph (f) of this section;
  - (3) An intake of 30 mg or greater of uranium in soluble form by any individual located outside the controlled area identified pursuant to paragraph (f) of this section; or
  - (4) An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that:
    - (i) Could endanger the life of a worker, or
    - (ii) Could lead to irreversible or other serious, long-lasting health effects to any individual located outside the controlled area identified pursuant to paragraph (f) of this section. If an applicant possesses or plans to possess quantities of material capable of such chemical exposures, then the applicant shall propose appropriate quantitative standards for these health effects, as part of the information submitted pursuant to § 70.65 of this subpart.
- (c) The risk of each credible intermediate-consequence event must be limited. Engineered controls, administrative controls, or both shall be applied to the extent needed so that, upon implementation of such controls, the event is unlikely or its consequences are less than those in paragraphs (c)(1)-(4) of this section. Intermediate consequence events are those internally or externally initiated events that are not high consequence events, that result in:
- (1) An acute worker dose of 0.25 Sv (25 rem) or greater total effective dose equivalent;
  - (2) An acute dose of 0.05 Sv (5 rem) or greater total effective dose equivalent to any individual located outside the controlled area identified pursuant to paragraph (f) of this section;
  - (3) A 24-hour averaged release of radioactive material outside the restricted area in concentrations exceeding 5000 times the values in Table 2 of Appendix B to Part 20; or
  - (4) An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that:
    - (i) Could lead to irreversible or other serious, long-lasting health effects to a worker, or
    - (ii) Could cause mild transient health effects to any individual located outside the controlled area as specified in paragraph (f) of this section. If an applicant possesses or plans to possess quantities of material capable of such chemical exposures, then the applicant shall propose appropriate quantitative standards for these health effects, as part of the information submitted pursuant to § 70.65 of this subpart.

(d) In addition to complying with paragraphs (b) and (c) of this section, the risk of nuclear criticality accidents must be limited by assuring that under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety. Preventive controls and measures must be the primary means of protection against nuclear criticality accidents.

(e) Each engineered or administrative control or control system necessary to comply with paragraphs (b), (c), or (d) of this section shall be designated as an item relied on for safety. The safety program, established and maintained pursuant to § 70.62 of this subpart, shall ensure that each item relied on for safety will be available and reliable to perform its intended function when needed and in the context of the performance requirements of this section.

(f) Each licensee must establish a controlled area, as defined in § 20.1003. In addition, the licensee must retain the authority to exclude or remove personnel and property from the area. For the purpose of complying with the performance requirements of this section, individuals who are not workers, as defined in § 70.4, may be permitted to perform ongoing activities (e.g., at a facility not related to the licensed activities) in the controlled area, if the licensee:

(1) Demonstrates and documents, in the integrated safety analysis, that the risk for those individuals at the location of their activities does not exceed the performance requirements of paragraphs (b)(2), (b)(3), (b)(4)(ii), (c)(2), and (c)(4)(ii) of this section; or

(2) Provides training that satisfies 10 CFR 19.12(a)(1)-(5) to these individuals and ensures that they are aware of the risks associated with accidents involving the licensed activities as determined by the integrated safety analysis, and conspicuously posts and maintains notices stating where the information in 10 CFR 19.11(a) may be examined by these individuals. Under these conditions, the performance requirements for workers specified in paragraphs (b) and (c) of this section may be applied to these individuals.

#### § 70.62 Safety program and integrated safety analysis.



TOP

(a) **Safety program.** (1) Each licensee or applicant shall establish and maintain a safety program that demonstrates compliance with the performance requirements of § 70.61. The safety program may be graded such that management measures applied are graded commensurate with the reduction of the risk attributable to that item. Three elements of this safety program; namely, process safety information, integrated safety analysis, and management measures, are described in paragraphs (b) through (d) of this section.

(2) Each licensee or applicant shall establish and maintain records that demonstrate compliance with the requirements of paragraphs (b) through (d) of this section.

(3) Each licensee or applicant shall maintain records of failures readily retrievable and available for NRC inspection, documenting each discovery that an item relied on for safety or management measure has failed to perform its function upon demand or has degraded such that the performance requirements of § 70.61 are not satisfied. These records must identify the item relied on for safety or management measure that has failed and the safety function affected, the date of discovery, date (or estimated date) of the failure, duration (or estimated duration) of the time that the item was unable to perform its function, any other affected items relied on for safety or management measures and their safety function, affected processes, cause of the failure, whether the failure was in the context of the performance requirements or upon demand or both, and any corrective or compensatory action that was taken. A failure must be recorded at the time

of discovery and the record of that failure updated promptly upon the conclusion of each failure investigation of an item relied on for safety or management measure.

(b) *Process safety information.* Each licensee or applicant shall maintain process safety information to enable the performance and maintenance of an integrated safety analysis. This process safety information must include information pertaining to the hazards of the materials used or produced in the process, information pertaining to the technology of the process, and information pertaining to the equipment in the process.

(c) *Integrated safety analysis.* (1) Each licensee or applicant shall conduct and maintain an integrated safety analysis, that is of appropriate detail for the complexity of the process, that identifies:

(i) Radiological hazards related to possessing or processing licensed material at its facility;

(ii) Chemical hazards of licensed material and hazardous chemicals produced from licensed material;

(iii) Facility hazards that could affect the safety of licensed materials and thus present an increased radiological risk;

(iv) Potential accident sequences caused by process deviations or other events internal to the facility and credible external events, including natural phenomena;

(v) The consequence and the likelihood of occurrence of each potential accident sequence identified pursuant to paragraph (c)(1)(iv) of this section, and the methods used to determine the consequences and likelihoods; and

(vi) Each item relied on for safety identified pursuant to § 70.61(e) of this subpart, the characteristics of its preventive, mitigative, or other safety function, and the assumptions and conditions under which the item is relied upon to support compliance with the performance requirements of § 70.61.

(2) *Integrated safety analysis team qualifications.* To assure the adequacy of the integrated safety analysis, the analysis must be performed by a team with expertise in engineering and process operations. The team shall include at least one person who has experience and knowledge specific to each process being evaluated, and persons who have experience in nuclear criticality safety, radiation safety, fire safety, and chemical process safety. One member of the team must be knowledgeable in the specific integrated safety analysis methodology being used.

(3) *Requirements for existing licensees.* Individuals holding an NRC license on September 18, 2000 shall, with regard to existing licensed activities:

(i) By April 18, 2001, submit for NRC approval, a plan that describes the integrated safety analysis approach that will be used, the processes that will be analyzed, and the schedule for completing the analysis of each process.

(ii) By October 18, 2004, or in accordance with the approved plan submitted under § 70.62(c)(3)(i), complete an integrated safety analysis, correct all unacceptable performance deficiencies, and submit, for NRC approval, an integrated safety analysis summary, including a description of the management measures, in accordance with § 70.65. The Commission may approve a request for an alternative schedule for completing the correction of unacceptable performance deficiencies if the Commission determines that the alternative is warranted by consideration of the following:

(A) Adequate compensatory measures have been established;

(B) Whether it is technically feasible to complete the correction of the unacceptable performance deficiency within the allotted 4-year period;



(C) Other site-specific factors which the Commission may consider appropriate on a case-by-case basis and that are beyond the control of the licensee.

(iii) Pending the correction of unacceptable performance deficiencies identified during the conduct of the integrated safety analysis, the licensee shall implement appropriate compensatory measures to ensure adequate protection.

(d) *Management measures.* Each applicant or licensee shall establish management measures to ensure compliance with the performance requirements of § 70.61. The measures applied to a particular engineered or administrative control or control system may be graded commensurate with the reduction of the risk attributable to that control or control system. The management measures shall ensure that engineered and administrative controls and control systems that are identified as items relied on for safety pursuant to § 70.61(e) of this subpart are designed, implemented, and maintained, as necessary, to ensure they are available and reliable to perform their function when needed, to comply with the performance requirements of § 70.61 of this subpart.

#### § 70.64 Requirements for new facilities or new processes at existing facilities.



(a) *Baseline design criteria.* Each prospective applicant or licensee shall address the following baseline design criteria in the design of new facilities. Each existing licensee shall address the following baseline design criteria in the design of new processes at existing facilities that require a license amendment under § 70.72. The baseline design criteria must be applied to the design of new facilities and new processes, but do not require retrofits to existing facilities or existing processes (e.g., those housing or adjacent to the new process); however, all facilities and processes must comply with the performance requirements in § 70.61. Licensees shall maintain the application of these criteria unless the analysis performed pursuant to § 70.62(c) demonstrates that a given item is not relied on for safety or does not require adherence to the specified criteria.

(1) Quality standards and records. The design must be developed and implemented in accordance with management measures, to provide adequate assurance that items relied on for safety will be available and reliable to perform their function when needed. Appropriate records of these items must be maintained by or under the control of the licensee throughout the life of the facility.

(2) Natural phenomena hazards. The design must provide for adequate protection against natural phenomena with consideration of the most severe documented historical events for the site.

(3) Fire protection. The design must provide for adequate protection against fires and explosions.

(4) Environmental and dynamic effects. The design must provide for adequate protection from environmental conditions and dynamic effects associated with normal operations, maintenance, testing, and postulated accidents that could lead to loss of safety functions.

(5) Chemical protection. The design must provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.

(6) Emergency capability. The design must provide for emergency capability to maintain control of:

(i) Licensed material and hazardous chemicals produced from licensed material;

(ii) Evacuation of on-site personnel; and

(iii) Onsite emergency facilities and services that facilitate the use of available offsite services.

(7) Utility services. The design must provide for continued operation of essential utility services.

- (8) Inspection, testing, and maintenance. The design of items relied on for safety must provide for adequate inspection, testing, and maintenance, to ensure their availability and reliability to perform their function when needed.
- (9) Criticality control. The design must provide for criticality control including adherence to the double contingency principle.
- (10) Instrumentation and controls. The design must provide for inclusion of instrumentation and control systems to monitor and control the behavior of items relied on for safety.
- (b) Facility and system design and facility layout must be based on defense-in-depth practices.<sup>1</sup> The design must incorporate, to the extent practicable:
- (1) Preference for the selection of engineered controls over administrative controls to increase overall system reliability; and
  - (2) Features that enhance safety by reducing challenges to items relied on for safety.

<sup>1</sup> As used in § 70.64, Requirements for new facilities or new processes at existing facilities, defense-in-depth practices means a design philosophy, applied from the outset and through completion of the design, that is based on providing successive levels of protection such that health and safety will not be wholly dependent upon any single element of the design, construction, maintenance, or operation of the facility. The net effect of incorporating defense-in-depth practices is a conservatively designed facility and system that will exhibit greater tolerance to failures and external challenges. The risk insights obtained through performance of the integrated safety analysis can be then used to supplement the final design by focusing attention on the prevention and mitigation of the higher-risk potential accidents.

#### § 70.65 Additional content of applications.



- TOP
- (a) In addition to the contents required by § 70.22, each application must include a description of the applicant's safety program established under § 70.62.
- (b) The integrated safety analysis summary must be submitted with the license or renewal application (and amendment application as necessary), but shall not be incorporated in the license. However, changes to the integrated safety analysis summary shall meet the conditions of § 70.72. The integrated safety analysis summary must contain:
- (1) A general description of the site with emphasis on those factors that could affect safety (i.e., meteorology, seismology);
  - (2) A general description of the facility with emphasis on those areas that could affect safety, including an identification of the controlled area boundaries;
  - (3) A description of each process (defined as a single reasonably simple integrated unit operation within an overall production line) analyzed in the integrated safety analysis in sufficient detail to understand the theory of operation; and, for each process, the hazards that were identified in the integrated safety analysis pursuant to § 70.62(c)(1)(i)-(iii) and a general description of the types of accident sequences;
  - (4) Information that demonstrates the licensee's compliance with the performance requirements of § 70.61, including a description of the management measures; the requirements for criticality monitoring and alarms in § 70.24; and, if applicable, the requirements of § 70.64;
  - (5) A description of the team, qualifications, and the methods used to perform the integrated safety analysis;



- (6) A list briefly describing each item relied on for safety which is identified pursuant to § 70.61(e) in sufficient detail to understand their functions in relation to the performance requirements of § 70.61;
- (7) A description of the proposed quantitative standards used to assess the consequences to an individual from acute chemical exposure to licensed material or chemicals produced from licensed materials which are on-site, or expected to be on-site as described in § 70.61(b)(4) and (c)(4);
- (8) A descriptive list that identifies all items relied on for safety that are the sole item preventing or mitigating an accident sequence that exceeds the performance requirements of § 70.61; and
- (9) A description of the definitions of unlikely, highly unlikely, and credible as used in the evaluations in the integrated safety analysis.

#### § 70.66 Additional requirements for approval of license application.



- (a) An application for a license from an applicant subject to subpart H will be approved if the Commission determines that the applicant has complied with the requirements of § 70.21, 70.22, 70.23, and 70.60 through 70.65.
- (b) Submittals by existing licensees in accordance with § 70.62(c)(3)(i) will be approved if the Commission determines that:
  - (1) The integrated safety analysis approach is in accordance with the requirements of § 70.61, 70.62(c)(1), and 70.62(c)(2); and
  - (2) The schedule is in compliance with § 70.62(c)(3)(ii).
- (c) Submittals by existing licensees in accordance with § 70.62(c)(3)(ii) will be approved if the Commission determines that:
  - (1) The requirements of § 70.65(b) are satisfied; and
  - (2) The performance requirements in § 70.61 (b), (c) and (d) are satisfied, based on the information in the ISA Summary, together with other information submitted to NRC or available to NRC at the licensee's site.

#### § 70.72 Facility changes and change process.



- (a) The licensee shall establish a configuration management system to evaluate, implement, and track each change to the site, structures, processes, systems, equipment, components, computer programs, and activities of personnel. This system must be documented in written procedures and must assure that the following are addressed prior to implementing any change:
  - (1) The technical basis for the change;
  - (2) Impact of the change on safety and health or control of licensed material;
  - (3) Modifications to existing operating procedures including any necessary training or retraining before operation;
  - (4) Authorization requirements for the change;
  - (5) For temporary changes, the approved duration (e.g., expiration date) of the change; and
  - (6) The impacts or modifications to the integrated safety analysis, integrated safety analysis summary, or other safety program information, developed in accordance with § 70.62.
- (b) Any change to site, structures, processes, systems, equipment, components, computer programs, and activities of personnel must be evaluated by the licensee as specified in paragraph (a) of this section, before the change is implemented. The evaluation of the change must

determine, before the change is implemented, if an amendment to the license is required to be submitted in accordance with § 70.34.

(c) The licensee may make changes to the site, structures, processes, systems, equipment, components, computer programs, and activities of personnel, without prior Commission approval, if the change:

(1) Does not:

(i) Create new types of accident sequences that, unless mitigated or prevented, would exceed the performance requirements of § 70.61 and that have not previously been described in the integrated safety analysis summary; or

(ii) Use new processes, technologies, or control systems for which the licensee has no prior experience;

(2) Does not remove, without at least an equivalent replacement of the safety function, an item relied on for safety that is listed in the integrated safety analysis summary and is necessary for compliance with the performance requirements of § 70.61;

(3) Does not alter any item relied on for safety, listed in the integrated safety analysis summary, that is the sole item preventing or mitigating an accident sequence that exceeds the performance requirements of § 70.61; and

(4) Is not otherwise prohibited by this section, license condition, or order.

(d)(1) For changes that require pre-approval under § 70.72, the licensee shall submit an amendment request to the NRC in accordance with § 70.34 and § 70.65 of this chapter.

(2) For changes that do not require pre-approval under § 70.72, the licensee shall submit to NRC annually, within 30 days after the end of the calendar year during which the changes occurred, a brief summary of all changes to the records required by § 70.62(a)(2) of this subpart.

(3) For all changes that affect the integrated safety analysis summary, the licensee shall submit to NRC annually, within 30 days after the end of the calendar year during which the changes occurred, revised integrated safety analysis summary pages.

(e) If a change covered by § 70.72 is made, the affected on-site documentation must be updated promptly.

(f) The licensee shall maintain records of changes to its facility carried out under this section.

These records must include a written evaluation that provides the bases for the determination that the changes do not require prior Commission approval under paragraph (c) or (d) of this section.

These records must be maintained until termination of the license.

[71 FR 56344, Sep. 27, 2006]

### § 70.73 Renewal of licenses.



TOP

Applications for renewal of a license must be filed in accordance with §§ 2.109, 70.21, 70.22, 70.33, 70.38, and 70.65 of this chapter. Information contained in previous applications, statements, or reports filed with the Commission under the license may be incorporated by reference, provided that these references are clear and specific.

### § 70.74 Additional reporting requirements.



TOP

(a) Reports to NRC Operations Center. (1) Each licensee shall report to the NRC Operations Center the events described in Appendix A to Part 70.

(2) Reports must be made by a knowledgeable licensee representative and by any method that will ensure compliance with the required time period for reporting.

(3) The information provided must include a description of the event and other related information as described in § 70.50(c)(1).

(4) Follow-up information to the reports must be provided until all information required to be reported in § 70.50(c)(1) of this subpart is complete.

(5) Each licensee shall provide reasonable assurance that reliable communication with the NRC Operations Center is available during each event.

(b) *Written reports.* Each licensee that makes a report required by paragraph (a)(1) of this section shall submit a written follow-up report within 60 days of the initial report. The written report must be sent to the NRC's Document Control Desk, using an appropriate method listed in § 70.5(a), with a copy to the appropriate NRC regional office listed in appendix D to part 20 of this chapter. The reports must include the information as described in § 70.50(c)(2)(i) through (iv).

[79 FR 57725, Sept. 26, 2014]

### § 70.76 Backfitting.



TOP

(a) For each licensee, this provision shall apply to Subpart H requirements as soon as the NRC approves that licensee's ISA Summary pursuant to § 70.66. For requirements other than Subpart H, this provision applies regardless of the status of the approval of a licensee's ISA Summary.

(1) Backfitting is defined as the modification of, or addition to, systems, structures, or components of a facility; or to the procedures or organization required to operate a facility; any of which may result from a new or amended provision in the Commission rules or the imposition of a regulatory staff position interpreting the Commission rules that is either new or different from a previous NRC staff position.

(2) Except as provided in paragraph (a)(4) of this section, the Commission shall require a systematic and documented analysis pursuant to paragraph (b) of this section for backfits which it seeks to impose.

(3) Except as provided in paragraph (a)(4) of this section, the Commission shall require the backfitting of a facility only when it determines, based on the analysis described in paragraph (b) of this section, that there is a substantial increase in the overall protection of the public health and safety or the common defense and security to be derived from the backfit and that the direct and indirect costs of implementation for that facility are justified in view of this increased protection.

(4) The provisions of paragraphs (a)(2) and (a)(3) of this section are inapplicable and, therefore, backfit analysis is not required and the standards in paragraph (a)(3) of this section do not apply where the Commission finds and declares, with appropriately documented evaluation for its finding, any of the following:

(i) That a modification is necessary to bring a facility into compliance with Subpart H of this part;

(ii) That a modification is necessary to bring a facility into compliance with a license or the rules or orders of the Commission, or into conformance with written commitments by the licensee;

(iii) That regulatory action is necessary to ensure that the facility provides adequate protection to the health and safety of the public and is in accord with the common defense and security; or

(iv) That the regulatory action involves defining or redefining what level of protection to the public health and safety or common defense and security should be regarded as adequate.

(5) The Commission shall always require the backfitting of a facility if it determines that the regulatory action is necessary to ensure that the facility provides adequate protection to the health and safety of the public and is in accord with the common defense and security.

(6) The documented evaluation required by paragraph (a)(4) of this section must include a statement of the objectives of and reasons for the modification and the basis for invoking the exception. If immediate effective regulatory action is required, then the documented evaluation may follow, rather than precede, the regulatory action.

(7) If there are two or more ways to achieve compliance with a license or the rules or orders of the Commission, or with written license commitments, or there are two or more ways to reach an adequate level of protection, then ordinarily the licensee is free to choose the way that best suits its purposes. However, should it be necessary or appropriate for the Commission to prescribe a specific way to comply with its requirements or to achieve adequate protection, then cost may be a factor in selecting the way, provided that the objective of compliance or adequate protection is met.

(b) In reaching the determination required by paragraph (a)(3) of this section, the Commission will consider how the backfit should be scheduled in light of other ongoing regulatory activities at the facility and, in addition, will consider information available concerning any of the following factors as may be appropriate and any other information relevant and material to the proposed backfit:

(1) Statement of the specific objectives that the proposed backfit is designed to achieve;

(2) General description of the activity that would be required by the licensee in order to complete the backfit;

(3) Potential change in the risk to the public from the accidental release of radioactive material and hazardous chemicals produced from licensed material;

(4) Potential impact on radiological exposure or exposure to hazardous chemicals produced from licensed material of facility employees;

(5) Installation and continuing costs associated with the backfit, including the cost of facility downtime;

(6) The potential safety impact of changes in facility or operational complexity, including the relationship to proposed and existing regulatory requirements;

(7) The estimated resource burden on the NRC associated with the proposed backfit and the availability of such resources;

(8) The potential impact of differences in facility type, design, or age on the relevancy and practicality of the proposed backfit; and

(9) Whether the proposed backfit is interim or final and, if interim, the justification for imposing the proposed backfit on an interim basis.

(c) No license will be withheld during the pendency of backfit analyses required by the Commission's rules.

(d) The Executive Director for Operations shall be responsible for implementation of this section, and all analyses required by this section shall be approved by the Executive Director for Operations or his or her designee.

## Subpart I--Modification and Revocation of Licenses

#### § 70.81 Modification and revocation of licenses.

(a) The terms and conditions of all licenses shall be subject to amendment, revision, or modification by reason of amendments to the Atomic Energy Act of 1954, or by reason of rules, regulations or orders issued in accordance with the Act or any amendments thereto;

(b) Any license may be revoked, suspended or modified for any material false statements in the application or any statement of fact required under section 182 of the Act or because of conditions revealed by such application or statement of fact or any report, record, or inspection or other means which would warrant the Commission to refuse to grant a license on an original application, or for failure to construct or operate a facility in accordance with the terms of the construction permit or license, the technical specifications in the application, or for violation of, or failure to observe any of the terms and conditions of the Act, or of any regulation of the Commission.

(c) Upon revocation, suspension or modification of a license, the Commission may immediately retake possession of all special nuclear material held by the licensee. In cases found by the Commission to be of extreme importance to the national defense or security, or to the health and safety of the public, the Commission may recapture any special nuclear material held by the licensee prior to any of the procedures provided under section 551-558 of title 5 of the United States Code.

(d) Except in cases of willfulness or those in which the public health, interest or safety requires otherwise, no license shall be modified, suspended or revoked unless, prior to the institution of proceedings therefor, facts or conduct which may warrant such action shall have been called to the attention of the licensee in writing and the licensee shall have been accorded opportunity to demonstrate or achieve compliance with all lawful requirements.

[21 FR 764, Feb. 3, 1956, as amended at 35 FR 11461, July 17, 1970. Redesignated at 65 FR 56226, Sept. 18, 2000]

#### § 70.82 Suspension and operation in war or national emergency.



TOP

Whenever Congress declares that a state of war or national emergency exists, the Commission, if it finds it necessary to the common defense and security may,

(a) Suspend any license it has issued.

(b) Order the recapture of special nuclear material.

(c) Order the operation of any licensed facility.

(d) Order entry into any plant or facility in order to recapture special nuclear material or to operate the facility. Just compensation shall be paid for any damages caused by recapture of special nuclear material or by operation of any facility, pursuant to this section.

[21 FR 764, Feb. 3, 1956, as amended at 32 FR 4056, Mar. 15, 1967; 35 FR 11461, July 17, 1970. Redesignated at 65 FR 56226, Sept. 18, 2000]

#### Subpart J--Enforcement



TOP

#### § 70.91 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of--

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or

- (3) A regulation or order issued pursuant to those Acts.
- (b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:
- (1) For violations of--
- (i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;
- (ii) Section 206 of the Energy Reorganization Act;
- (iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;
- (iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.
- (2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.
- [57 FR 55077, Nov. 24, 1992. Redesignated at 65 FR 56226, Sept. 18, 2000]

### § 70.92 Criminal penalties.



- (a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in part 70 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.
- (b) The regulations in part 70 that are not issued under sections 161b, 161i, or 161o, for the purposes of section 223 are as follows: § 70.1, 70.2, 70.4, 70.5, 70.6, 70.8, 70.11, 70.12, 70.13, 70.14, 70.17, 70.18, 70.23, 70.31, 70.33, 70.34, 70.35, 70.37, 70.66, 70.73, 70.76, 70.81, 70.82, 70.63, 70.91, and 70.92.
- [57 FR 55077, Nov. 24, 1992. Redesignated and amended at 65 FR 56226, Sept. 18, 2000]

### Appendix A to Part 70—Reportable Safety Events



Licenses must comply with reporting requirements in this appendix. As required by 10 CFR 70.74, licensees subject to the requirements in subpart H of part 70, shall report:

- (a) One hour reports. Events to be reported to the NRC Operations Center within 1 hour of discovery, supplemented with the information in 10 CFR 70.50(c)(1) as it becomes available, followed by a written report within 60 days:
- (1) An inadvertent nuclear criticality.
- (2) An acute intake by an individual of 30 mg or greater of uranium in a soluble form.
- (3) An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that exceeds the quantitative standards established to satisfy the requirements in § 70.61(b)(4).
- (4) An event or condition such that no items relied on for safety, as documented in the Integrated Safety Analysis summary, remain available and reliable, in an accident sequence evaluated in the Integrated Safety Analysis, to perform their function:
- (i) In the context of the performance requirements in § 70.61(b) and § 70.61(c), or
- (ii) Prevent a nuclear criticality accident (i.e., loss of all controls in a particular sequence).

(b) Twenty-four hour reports. Events to be reported to the NRC Operations Center within 24 hours of discovery, supplemented with the information in 10 CFR 70.50(c)(1) as it becomes available, followed by a written report within 60 days:

(1) Any event or condition that results in the facility being in a state that was not analyzed, was improperly analyzed, or is different from that analyzed in the Integrated Safety Analysis, and which results in failure to meet the performance requirements of § 70.61.

(2) Loss or degradation of items relied on for safety that results in failure to meet the performance requirement of § 70.61.

(3) An acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed materials that exceeds the quantitative standards that satisfy the requirements of § 70.61(c)(4).

(4) Any natural phenomenon or other external event, including fires internal and external to the facility, that has affected or may have affected the intended safety function or availability or reliability of one or more items relied on for safety.

(c) Concurrent Reports. Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made, shall be reported to the NRC Operations Center concurrent to the news release or other notification.

[65 FR 56231, Sept. 18, 2000; 75 FR 73944, Nov. 30, 2010; 79 FR 57725, Sept. 26, 2014]

## **B. SERPENT Related Codes**



## Drumdeck.py

```
#!/usr/bin/env python3
#
# Generate Serpent deck for 7x7 Cassette filled Serpent deck
# Ondrej Chvala, ochvala@utk.edu
# Will Cureton, wcureton@vols.utk.edu
# 2017-04-18

import materials
import cells
import surfaces

def write_deck(N=21, r=1.25, refl=50, Nports=3, rport=2.5):
    '''Function to write the FastDrum Serpent input deck.
    Inputs:
        N:      size of the N x N checkerboard lattice
        r:      radius of the fuel in the fuel pin [cm]
        refl:   reflector thickness [cm]
        Nports: number of beam ports [0,1,2,3]
        rport:  radius of a port [cm]
    Outputs:
        output: String containing the FastDrum deck'''

    # Header
    output = '''set title "Fast Flux Research Reactor, N {N}, rfuel
{r}, reflector thickness {refl}, {Nports} beamports radius {rport}
cm."
'''

    # Surfaces
    output += surfaces.write_surfaces(N, r, refl, Nports, rport)

    # Cells
    output += cells.write_cells(Nports)

    # Materials
    output += materials.write_materials()

    # Data cards
    data_cards = '''
%_____data cards_____

% Power [W]
set power 100
set cpd 2

% Boundary condition
set bc 1

% Subcritical mode with external source
set nps 25000 200
src 1 sc 6 se 2'''

```

## Materials.py

```
#!/usr/bin/env python3
#
# Generate materials for FastDrum Serpent deck
# Ondrej Chvala, ochvala@utk.edu
# Will Cureton, wcureton@vols.utk.edu
# 2017-04-18

def write_materials(lib = '03c'):
    '''Function to write material cards for Serpent input deck.
    Inputs:
        lib:    String containing the neutron cross section library
               to use (e.g., {lib}).
    Outputs:
        mats:   String containing the material cards'''

    mats = '''
%_____material definitions_____

mat fuel -19.10 tmp 300.0 rgb 190 10 100    % Fuel is 20% LEU metal
92235.03c  -19.75          % U-235
92238.03c  -80.25          % U-238

mat lead -11.34 tmp 300.0 rgb 10 20 195
82204.03c  -0.014          % Pb-204
82206.03c  -0.241          % Pb-206
82207.03c  -0.221          % Pb-207
82208.03c  -0.524          % Pb-208

mat air -0.001205 tmp 300 rgb 200 200 200    % Dry air, sea level
6000.03c  -0.000124
7014.03c  -0.755268
8016.03c  -0.231781
18040.03c -0.012827

mat water -0.998207 tmp 300 moder lwtr 1001 rgb 100 100 250 % De-
aerated water at 1 atm.
1001.03c  -0.111894
8016.03c  -0.888106

mat contr -2.52 tmp 300 rgb 0 50 50
5011.03c  -0.391305
5010.03c  -0.391305
6012.03c  -0.21739

mat alum -2.6989 tmp 300 rgb 100 100 100
13027.03c -1

therm lwtr lwe7.00t

mat salt -4.326 tmp 300 rgb 50 240 50 % FNaK with natural uranium
```

## Surfaces.py

```
#!/usr/bin/env python3
#
# Generate surfaces, pins, and lattice for 7x7 Cassette Filled Serpent
deck
# Ondrej Chvala, ochvala@utk.edu
# Will Cureton, wcureton@vols.utk.edu
# 2017-04-18

import math

def write_surfaces(N=11, r=1.25, refl=25, Nports=3, rport=5.0):
    '''Function to write material cards for Serpent input deck.
    Inputs:
        N:      size of the N x N checkerboard lattice
        r:      radius of the fuel in the fuel pin [cm]
        refl:   reflector thickness [cm]
        Nports: number of beam ports [0,1,2,3]
        rport:  radius of a port [cm]
    Outputs:
        surfaces: String containing the surface cards'''

    rclad = r + 0.1          # Cladding outer radius
    pitch = 2.0 * rclad + 0.01 # Lattice pitch
    asemb = 9 * pitch + 0.05
    l10 = 65                # Radius of the cylinder bounding the lattice
    l20 = l10 + 0.5 * pitch # Radius of the cylinder
    bounding the lead block
    l21 = l20 + 0.1         # Radius of the air gap cylinder
    l22 = l21 + refl        # Radius of the steel reflector
    cylinder
    fuel_rod_weight = 19.1 * math.pi * r*r * l10 # Uranium mass in
    each rod [g]

    surfaces = '''
%_____pins_____

pin 1  % fuel pin
fuel  {r}
alum {rclad}
alum

pin 29 % control rod
contr {r}
alum

pin 7  % air gap
air

pin 8  % aluminum siding
alum
```

## Cells.py

```
#!/usr/bin/env python3
#
# Generate cells for 7x7 Cassette Filled Serpent deck
# Ondrej Chvala, ochvala@utk.edu
# Will Cureton, wcureton@vols.utk.edu
# 2017-04-18

def write_cells(Nports=3):
    '''Function to write cell cards for the Serpent input deck.
    Inputs:
        Nports: number of beam ports [0,1,2,3]

    Outputs:
        cells:      String containing cell cards'''

    my_portholes = ''          # Text string that will contain
    porthole cell numbers
    for iport in range(31,31+Nports):
        my_portholes += ' {:d}'.format(iport)

    cells = '''
%_____cell definitions_____
%cell   1   0   fill   50 -23
cell    2   0   alum   10 -20
cell    3   0   air    20 -21
cell    4   0   ssteel  21 -22 {my_portholes}
cell    5   2   alum   -23
cell    6   6   ssteel -80
cell    8   6   alum   80
cell    7   0   fill   99 -10
'''

    for iport in range(31,31+Nports):
        cells += 'cell   {0:d}   0   air 21 -22 -{0:d}
\n'.format(iport)

    cells += '''cell   99   0   outside   22
'''
    cells = cells.format(**locals())
    return cells

if __name__ == '__main__':
    print("This module writes cells for FastDrum Serpent deck.")
    input("Press Ctrl+C to quit, or enter else to test it. ")
    print(write_cells())
```

## Writecore.py

```
#!/usr/bin/env python3
#
# Write the 7x7 Cassette filled Serpent deck
# Ondrej Chvala, ochvala@utk.edu
# Will Cureton, wcureton@vols.utk.edu
# 2017-04-18

import drumdeck
import os

import argparse

# Serpent deck file name
filename = "ffrr.inp"
dirname = "./"

# Command line argument
parser = argparse.ArgumentParser(description='Writes Serpent2 input
deck for the Fast Drum Reactor, mk2.')
parser.add_argument('--latsize', metavar='N', type=int, nargs='?',
default=29,
                    help='lattice size, default = 29') #,
required=False)
parser.add_argument('--fuelradius', metavar='r', type=float,
nargs='?', default=1.17,
                    help='fuel rod radius [cm], default = 1.17 cm')
parser.add_argument('--reflector', metavar='refl', type=float,
nargs='?', default=50,
                    help='fuel rod radius [cm], default = 50 cm')
parser.add_argument('--ports', metavar='Nports', type=int, nargs='?',
default=0,
                    help='number of beam ports [0-3], default = 0',
choices=[0, 1, 2, 3])
parser.add_argument('--rport', metavar='rport', type=float, nargs='?',
default=2.0,
                    help='beam port radius [cm], default = 2.0 cm')

# Parse command line arguments
args = vars(parser.parse_args())
N = args['latsize']
r_fuel = args['fuelradius']
d_refl = args['reflector']
N_ports = args['ports']
r_port = args['rport']

if N_ports<0 or N_ports>3:
    quit("Number of ports has to be 0, 1, 2, or 3")

# Make the deck
s2_deck = drumdeck.write_deck(N, r_fuel, d_refl, N_ports, r_port)
```

**Other variants of SERPENT core design scripts can be found by visiting:**

<https://github.com/ondrejch/FSM>

## C. MCNP Related Codes

CassetteMod.py: This is for generating the MCNP input deck.

```
''' @ author: James Ghawaly Jr.
    @ license: This code cannot be used, modified, or reproduced in any way without acknowledging its author.
    @ version: 2.9
'''
import os
import numpy
class CassetteMod():
    def __init__(self, side, cladSide, coreHeight, rodRadius, rodHeight, radiusLimiter, rods_along_cassette,
                 cassette_enclosure_thickness, reflector_thickness, x0, y0, z0, airgap):
        # generics
        self.surfaceNumber = 0
        self.cellNumber = 0
        self.materNumber = 0
        self.center = [0, 0, 0]
        # core info
        self.s = side
        self.s_c = rods_along_cassette
        self.cladSide = cladSide
        self.coreHeight = coreHeight
        self.rodRadius = rodRadius
        self.rodHeight = rodHeight
        self.radiusLimiter = radiusLimiter
        self.cet = cassette_enclosure_thickness
        self.x0 = x0
        self.y0 = y0
        self.z0 = z0
        self.cassetteLength = rods_along_cassette * cladSide + cassette_enclosure_thickness * 2 + airgap*2;
        self.reflector_thickness = reflector_thickness
        self.airgap = airgap
        # for plotting pins
        self.xPoints = []
        self.yPoints = []
        self.points = []
        # for plotting cladding
        self.xPoints1 = []
        self.yPoints1 = []
        self.points1 = []
        # for plotting lead
        self.xPoints2 = []
        self.yPoints2 = []
        self.points2 = []
        # for writing the MCNP input deck
        self.surfaceCard = []
        self.cellCard = []
        self.dataCard = []
        self.cassetteSurfaceNumbers = [] # cassette lead part
        self.cassetteCladNumbers = [] # cassette clad part
        self.airGapNumbers = [] # air gap surfaces
        self.dataCard = ""
c DATA CARD
c -----MATERIALS-----
M1 82204 -0.014 & $ Pb-204 LEAD
82206 -0.241 & $ Pb-206
82207 -0.221 & $ Pb-207
82208 -0.524 $ Pb-208
```

```

c
c M1 82000 0.55 13027 0.45          $ Pb with Al
c
M2 92235 .1975 92238 0.8025        $ 19.75% enriched Uranium fuel
c
M3 13027 1                          $ Aluminum
c
M4 6012 0.022831 26000 0.977170    $ Carbon Steel
c
M5 6000 -0.000124 &                $ Air
    7014 -0.755268 &
    8016 -0.231781 &
    18040 -0.012827
c
M6 1001 -0.006488 &                $ ORNL Concrete
    8016 -0.518069 &
    11023 -0.016577 &
    13027 -0.035137 &
    14000 -0.349085 &
    19000 -0.015324 &
    20000 -0.045057 &
    26000 -0.014411
c
M7 1001 -0.006488 &                $ Tissue Equivalent: Polyethylene Terephthalate (Mylar)
    8016 -0.518069 &
    11023 -0.016577 &
    13027 -0.035137 &
    14000 -0.349085 &
    19000 -0.015324 &
    20000 -0.045057 &
    26000 -0.014411
c
M8 5011 -0.391305 &                $ B4C Control Rods
    5010 -0.391305 &
    6012 -0.21739
c
M9 1001 -0.111894 &                $ Water
    8016 -0.888106
c
KSRC 48 0 75 $ KSRC 48 0 75
KCODE 5000 1 10 500
*****
def genCasetteCore(self):
    for cassette_along_x in range(self.s): # Go along the x
        c_y = self.casetteLength * cassette_along_x + self.y0
        for cassette_along_y in range(self.s): # Go along the y
            c_x = self.casetteLength * cassette_along_y + self.x0
            center = [c_x + self.casetteLength / 2, c_y + self.casetteLength / 2]
            # if the current position is outside of the radius limiting boundary, then skip
            if (numpy.sqrt(numpy.power(center[0]-2*self.airgap, 2.0) + numpy.power(center[1]-2*self.airgap,2.0)) + self.casetteLength / 2.0 *
numpy.sqrt(2.0) >= self.radiusLimiter):
                pass
            else:
                if ((casette_along_y + casette_along_x) % 2 == 0):
                    multiplier = 2
                else:
                    multiplier = 1
            # generate the lead inside the cassette
            self.cube([c_x+self.cet+self.airgap, c_y+self.cet+self.airgap, self.z0], self.cladSide * self.s_c,
                    self.cladSide * self.s_c, self.coreHeight, "casette_lead",

```

```

    "$ Casette: (" + str(c_x) + " , " + str(c_y) + ") ::: CASSETTE_LEAD")
# generate the aluminum cassette enclosure
self.cube([c_x+self.airgap, c_y+self.airgap, self.z0], self.cladSide * self.s_c + 2 * self.cet,
self.cladSide * self.s_c + 2 * self.cet, self.coreHeight, "cassette_clad",
    "$ Casette: (" + str(c_x) + " , " + str(c_y) + ") ::: CASSETTE_CLAD")
# generate the air gap outside of the cassette enclosure
self.cube([c_x, c_y, self.z0], self.cladSide * self.s_c + 2 * self.cet + 2 * self.airgap,
self.cladSide * self.s_c + 2 * self.cet + 2 * self.airgap, self.coreHeight, "air_gap",
    "$ Casette: (" + str(c_x) + " , " + str(c_y) + ") ::: AIRGAP")
# go through every lattice in the cassette along the x direction
for lattice_x in range(self.s_c):
    # go through every lattice in the cassette along the y direction
    for lattice_y in range(self.s_c):
        # generate the x position of the lattice
        x_position = c_x + self.cet + self.airgap + lattice_x * self.cladSide
        # generate the y position of the lattice
        y_position = c_y + self.cet + self.airgap + lattice_y * self.cladSide
        # generate the z position of the lattice
        z_position = self.z0
        if (multiplier == 2):
            if (lattice_x % 2 == 0):
                if (lattice_y % 2 == 0):
                    # generate the fuel rod
                    self.cylinder([x_position + self.cladSide / 2, y_position + self.cladSide / 2,
z_position + self.cet], self.rodRadius, self.rodHeight,
                        "$ Fuel Rod ::: (" + str(lattice_x) + " , " + str(
lattice_y) + ") ::: In Casette: (" + str(c_x) + " , " + str(
c_y) + ") ::: FUEL_ROD")
                else:
                    if (lattice_y % 2 != 0):
                        # generate the fuel rod
                        self.cylinder([x_position + self.cladSide / 2, y_position + self.cladSide / 2,
z_position + self.cet], self.rodRadius, self.rodHeight,
                            "$ Fuel Rod ::: (" + str(lattice_x) + " , " + str(
lattice_y) + ") ::: In Casette: (" + str(c_x) + " , " + str(
c_y) + ") ::: FUEL_ROD")
                    else:
                        if (lattice_x % 2 == 0): # change this for even/odd
                            if (lattice_y % 2 != 0):
                                # generate the fuel rod
                                self.cylinder([x_position + self.cladSide / 2, y_position + self.cladSide / 2,
z_position + self.cet], self.rodRadius, self.rodHeight,
                                    "$ Fuel Rod ::: (" + str(lattice_x) + " , " + str(
lattice_y) + ") ::: In Casette: (" + str(c_x) + " , " + str(
c_y) + ") ::: FUEL_ROD")
                            else:
                                if (lattice_y % 2 == 0):
                                    # generate the fuel rod
                                    self.cylinder([x_position + self.cladSide / 2, y_position + self.cladSide / 2,
z_position + self.cet], self.rodRadius, self.rodHeight,
                                        "$ Fuel Rod ::: (" + str(lattice_x) + " , " + str(
lattice_y) + ") ::: In Casette: (" + str(c_x) + " , " + str(
c_y) + ") ::: FUEL_ROD")

# generate the core
self.cylinder([self.x0 + self.cassetteLength * self.s / 2, self.y0 + self.cassetteLength * self.s / 2, self.z0],
self.radiusLimiter, self.coreHeight,
    "$ Core ::: This is the cylindrical enclosure around the core ::: CORE")
# generate the reflector
self.cylinder([self.x0 + self.cassetteLength * self.s / 2, self.y0 + self.cassetteLength * self.s / 2,
self.z0 - self.reflector_thickness], self.radiusLimiter + self.reflector_thickness,

```



```

        self.coreHeight + 2 * self.reflector_thickness,
        "    $ Reflector ::: This is the reflector around the core ::: REFLECTOR")
# generate the universe
self.sphere([self.x0 + self.cassetteLength * self.s / 2, self.y0 + self.cassetteLength * self.s / 2, self.z0],
            self.radiusLimiter * 3, "    $ UNIVERSE")
# generate the cells
self.generateCells()
def cylinder(self, position, radius, height, comment):
    self.surfaceNumber += 1
    # self.xPoints.append(position[0])
    # self.yPoints.append(position[1])
    self.points.append([position[0], position[1]])
    #   x y z   h1 h2 h3 R
    self.surfaceCard.append(str("%s RCC %g %g %g   %s %s %s   %s %s") % (
        self.surfaceNumber, position[0], position[1], position[2], 0, 0, height, radius, comment))
    # print(self.surfaceCard[-1])
def cube(self, position, xD, yD, zD, type, comment):
    self.surfaceNumber += 1
    xMin = position[0]
    xMax = position[0] + xD
    yMin = position[1]
    yMax = position[1] + yD
    zMin = position[2]
    zMax = position[2] + zD
    if type == "clad":
        self.points1.append([position[0], position[1]])
    elif type == "lead_block":
        self.points2.append([position[0], position[1]])
    elif type == "cassette_lead":
        self.cassetteSurfaceNumbers.append(self.surfaceNumber)
    elif type == "cassette_clad":
        self.cassetteCladNumbers.append(self.surfaceNumber)
    elif type == "air_gap":
        self.airGapNumbers.append(self.surfaceNumber)
    self.surfaceCard.append(str("%s RPP %g %g   %g %g   %g %g %s") % (
        self.surfaceNumber, xMin, xMax, yMin, yMax, zMin, zMax, comment))
    # print(self.surfaceCard[-1])
def sphere(self, position, radius, comment):
    self.surfaceCard.append(
        str("%s SPH %g %g %g   %g %s") % (999, position[0], position[1], position[2], radius, comment))
    # print(self.surfaceCard[-1])
# for making a single cell
def cell(self, inSurfaceNum, outSurfaceNum):
    self.cellNumber += 1
    try:
        inSurfaceNum = -1 * inSurfaceNum
    except Exception:
        pass
    self.cellCard.append(str("%s %s %s imp:n=%s") % (self.cellNumber, inSurfaceNum, outSurfaceNum, 1))
# for making all of the cells
def generateCells(self):
    numSurfs = len(self.surfaceCard) - 1
    # go through every surface
    for surface in self.surfaceCard:
        surface = surface.split()
        i = int(surface[0])
        # print(surface)
        # check what type of surface this is
        type = surface[-1]
        if type == "CASSETTE_LEAD":

```

```

current_cassette = i
try:
    self.cellCard.append("%s %s %s %s %s %s %s" % (i, 1, "-11.34", str(-(i)), self.cellUnion(i +
3,self.cassetteSurfaceNumbers[self.cassetteSurfaceNumbers.index(i) + 1] - 1,[i], len(
    str(i - 1) + "-999imp:n=1") + 1), "imp:n=1", "    $ Inside CASSETTE LEAD: " + str(current_cassette)))
except IndexError:
    self.cellCard.append("%s %s %s %s %s %s %s" % (i, 1, "-11.34", str(-(i)),self.cellUnion(i + 3, self.surfaceNumber - 2,
[i],len(str(i - 1) + "-999imp:n=1") + 1),
        "imp:n=1", "    $ Inside CASSETTE LEAD: " + str(current_cassette)))
elif type == "CASSETTE_CLAD":
    self.cellCard.append("%s %s %s %s %s %s %s" % (i, 3, "-2.70", str(-(i)), str(i-1), "imp:n=1",
        "    $ Inside Cassette Cladding at " + surface[
        13] + " inside of cassette: " + str(
        current_cassette)))
elif type == "AIRGAP":
    self.cellCard.append("%s %s %s %s %s %s %s" % (i, 5, "-0.001205", str(-(i)), str(i - 1), "imp:n=1",
        "    $ Inside Cassette Air Gap at " + surface[
        13] + " inside of cassette: " + str(
        current_cassette)))
elif type == "FUEL_ROD":
    p1 = surface[13].strip("(").strip(")").split(",")
    # this is for control rod placement
    if(p1[0]=="3" and p1[1]=="1"):
        self.cellCard.append("%s %s %s %s %s %s %s" % (i, 8, "-2.48", str(-(i)), "", "imp:n=1",
            "    $ Inside CONTROL ROD at " + surface[
            13] + " inside of cassette: " + str(
            current_cassette)))
    elif(p1[0]=="3" and p1[1]=="2"):
        self.cellCard.append("%s %s %s %s %s %s %s" % (i, 8, "-2.48", str(-(i)), "", "imp:n=1",
            "    $ Inside CONTROL ROD at " + surface[
            13] + " inside of cassette: " + str(
            current_cassette)))
    else:
        self.cellCard.append("%s %s %s %s %s %s %s" % (i, 2, "-19.1", str(-(i)), "", "imp:n=1",
            "    $ Inside FUEL ROD at " + surface[
            13] + " inside of cassette: " + str(
            current_cassette)))
elif type == "CORE":
    self.cellCard.append("%s %s %s %s %s %s %s" % (i, 1, "-11.34", str(-(i)),
        self.cellUnionList(self.airGapNumbers,
            len(str(i - 1) + "-999imp:n=1") + 1),
            "imp:n=1",
            "    $ Inside of core, outside of cassettes "))
elif type == "REFLECTOR":
    self.cellCard.append("%s %s %s %s %s %s %s" % (
    i, 4, "-7.82", str(-(i)), str(i - 1), "imp:n=1", "    $ Inside of reflector, outside of core "))
    reflector_surface = i
elif type == "UNIVERSE":
    pass
else:
    print("WARNING: UNRECOGNIZED SURFACE TYPE!!!")
# make the universe cell (inside)
self.cellCard.append("%s %s %s %s %s %s %s" % (
998, 0, "", "-" + str(i), str(reflector_surface), "imp:n=1    $ Inside Universe, Outside of Reflector"))
# make the universe cell (outside)
self.cellCard.append("%s %s %s %s %s %s %s" % (999, 0, "", "", str(i), "imp:n=0    $ Outside of Universe"))
# generate a union string for a cell
def cellUnion(self, min, max, skip, size):
    i = min
    result = "("

```

```

counter = size
while i < max:
    counter += len(str(i)) + 1
    if i in skip:
        pass
    elif i == min:
        result += str(i) + " "
    else:
        result += str(i) + " "
    if counter > 70:
        result += "& \n"
        counter = 0
    i += 1
if max in skip:
    result += ")"
else:
    result += str(max) + ")"
if i < 2:
    result = ""
return result
def cellUnionList(self, unions, size):
    result = "("
    counter = size
    for num in unions:
        counter += len(str(num)) + 1
        result += str(num) + " "
    if counter > 70:
        result += "& \n"
        counter = 0
    result += ")"
    return result
def getPoints(self):
    return self.points, self.points1, self.points2
def writeInputDeck(self, filename, title):
    with open(os.getcwd() + "/inputs/" + filename, 'w') as f2w:
        f2w.write(title + "\n")
        f2w.write("c CELL CARD\n")
        for cells in self.cellCard:
            f2w.write(cells + "\n")
        f2w.write("\nc SURFACE CARD\n")
        for surface in self.surfaceCard:
            f2w.write(surface + "\n")
        posK = str(self.coreHeight / 2)
        f2w.write(self.dataCard + "\n")

```

CassetteTest.py: Example of running the CassetteMod.py class.

```

import CassetteMod
import matplotlib.pyplot as plt
import matplotlib.patches as patches
side = 5

```

```

rods_along_cassette = 7
airgap = 0.05
fuelCladding = 0.1
rodRadius = 1.25
rclad = rodRadius + 0.1
cladSideLength = rodRadius*2 + 2*fuelCladding
pitch = 2*rclad+0.01
assemb = 9*pitch+airgap
cassette_enclosure_thickness = assemb - 8*pitch - airgap*2
reflector_thickness = 30.48
radius_limiter = 71 + pitch*0.5
coreHeight=2*radius_limiter
rodHeight =coreHeight-2*cassette_enclosure_thickness
cassette_length = rods_along_cassette*cladSideLength+cassette_enclosure_thickness*2
position = [-1*side*cassette_length/2,-1*side*cassette_length/2,0]
core1 = CassetteMod.CassetteMod(side,cladSideLength,coreHeight,rodRadius,rodHeight,radius_limiter,
rods_along_cassette,cassette_enclosure_thickness, reflector_thickness, position[0], position[1], position[2],airgap)
core1.genCassetteCore()
core1.writeInputDeck("testCassette7ROD.i","James Ghawaly Checkerboard Core Test")
p0,p1,p2 = core1.getPoints()
ax = plt.gca()
circle1 = plt.Circle(xy=p0[-1],radius=radius_limiter,color="green",fill=False)
ax.add_artist(circle1)
x=1
for pair in p0: # pins
    ax.add_patch(plt.Circle(pair,radius=rodRadius,facecolor="red"))
x=2
#circle = plt.Circle((0, 0), radius_limiter, color='b', fill=False)
#ax.add_artist(circle)
ax.set_xlim([-100,100])
ax.set_ylim([-100,100])
plt.show()

```

### Cassette7x7.i: Example MCNP6 input deck for cassette core design with 7x7 lattices.

```

James Ghawaly Cassette Core Test
c CELL CARD
1 1 -11.34 -1 (4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 &
26 27) imp:n=1 $ Inside CASSETTE LEAD: 1
2 3 -2.70 -2 1 imp:n=1 $ Inside Cassette Cladding at ::: inside of cassette: 1
3 5 -0.001205 -3 2 imp:n=1 $ Inside Cassette Air Gap at ::: inside of cassette: 1
4 2 -19.1 -4 imp:n=1 $ Inside FUEL ROD at (0,1) inside of cassette: 1
5 2 -19.1 -5 imp:n=1 $ Inside FUEL ROD at (0,3) inside of cassette: 1
6 2 -19.1 -6 imp:n=1 $ Inside FUEL ROD at (0,5) inside of cassette: 1
7 2 -19.1 -7 imp:n=1 $ Inside FUEL ROD at (1,0) inside of cassette: 1
8 2 -19.1 -8 imp:n=1 $ Inside FUEL ROD at (1,2) inside of cassette: 1
9 2 -19.1 -9 imp:n=1 $ Inside FUEL ROD at (1,4) inside of cassette: 1
10 2 -19.1 -10 imp:n=1 $ Inside FUEL ROD at (1,6) inside of cassette: 1
11 2 -19.1 -11 imp:n=1 $ Inside FUEL ROD at (2,1) inside of cassette: 1
12 2 -19.1 -12 imp:n=1 $ Inside FUEL ROD at (2,3) inside of cassette: 1
13 2 -19.1 -13 imp:n=1 $ Inside FUEL ROD at (2,5) inside of cassette: 1
14 2 -19.1 -14 imp:n=1 $ Inside FUEL ROD at (3,0) inside of cassette: 1
15 8 -2.48 -15 imp:n=1 $ Inside CONTROL ROD at (3,2) inside of cassette: 1
16 2 -19.1 -16 imp:n=1 $ Inside FUEL ROD at (3,4) inside of cassette: 1
17 2 -19.1 -17 imp:n=1 $ Inside FUEL ROD at (3,6) inside of cassette: 1
18 2 -19.1 -18 imp:n=1 $ Inside FUEL ROD at (4,1) inside of cassette: 1
19 2 -19.1 -19 imp:n=1 $ Inside FUEL ROD at (4,3) inside of cassette: 1

```

20 2 -19.1 -20 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 1  
 21 2 -19.1 -21 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 1  
 22 2 -19.1 -22 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 1  
 23 2 -19.1 -23 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 1  
 24 2 -19.1 -24 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 1  
 25 2 -19.1 -25 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 1  
 26 2 -19.1 -26 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 1  
 27 2 -19.1 -27 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 1  
 28 1 -11.34 -28 (31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 &  
 50 51 52 53 54 55) imp:n=1 \$ Inside CASSETTE LEAD: 28  
 29 3 -2.70 -29 28 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 28  
 30 5 -0.001205 -30 29 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 28  
 31 2 -19.1 -31 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 28  
 32 2 -19.1 -32 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 28  
 33 2 -19.1 -33 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 28  
 34 2 -19.1 -34 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 28  
 35 2 -19.1 -35 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 28  
 36 2 -19.1 -36 imp:n=1 \$ Inside FUEL ROD at (1,3) inside of cassette: 28  
 37 2 -19.1 -37 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 28  
 38 2 -19.1 -38 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 28  
 39 2 -19.1 -39 imp:n=1 \$ Inside FUEL ROD at (2,2) inside of cassette: 28  
 40 2 -19.1 -40 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 28  
 41 2 -19.1 -41 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 28  
 42 8 -2.48 -42 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 28  
 43 3 -2.70 -43 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 28  
 44 8 -2.48 -44 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 28  
 45 2 -19.1 -45 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 28  
 46 2 -19.1 -46 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 28  
 47 2 -19.1 -47 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 28  
 48 2 -19.1 -48 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 28  
 49 2 -19.1 -49 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 28  
 50 2 -19.1 -50 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 28  
 51 2 -19.1 -51 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 28  
 52 2 -19.1 -52 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 28  
 53 2 -19.1 -53 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 28  
 54 2 -19.1 -54 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 28  
 55 2 -19.1 -55 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 28  
 56 1 -11.34 -56 (59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 &  
 78 79 80 81 82) imp:n=1 \$ Inside CASSETTE LEAD: 56  
 57 3 -2.70 -57 56 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 56  
 58 5 -0.001205 -58 57 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 56  
 59 2 -19.1 -59 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 56  
 60 2 -19.1 -60 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 56  
 61 2 -19.1 -61 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 56  
 62 2 -19.1 -62 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 56  
 63 2 -19.1 -63 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 56  
 64 2 -19.1 -64 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 56  
 65 2 -19.1 -65 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 56  
 66 2 -19.1 -66 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 56  
 67 2 -19.1 -67 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 56  
 68 2 -19.1 -68 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 56  
 69 2 -19.1 -69 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 56  
 70 8 -2.48 -70 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 56  
 71 2 -19.1 -71 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 56  
 72 2 -19.1 -72 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 56  
 73 2 -19.1 -73 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 56  
 74 2 -19.1 -74 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 56  
 75 2 -19.1 -75 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 56  
 76 2 -19.1 -76 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 56  
 77 2 -19.1 -77 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 56

78 2 -19.1 -78 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 56  
79 2 -19.1 -79 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 56  
80 2 -19.1 -80 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 56  
81 2 -19.1 -81 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 56  
82 2 -19.1 -82 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 56  
83 1 -11.34 -83 (86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 &  
104 105 106 107 108 109) imp:n=1 \$ Inside CASSETTE LEAD: 83  
84 3 -2.70 -84 83 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 83  
85 5 -0.001205 -85 84 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 83  
86 2 -19.1 -86 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 83  
87 2 -19.1 -87 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 83  
88 2 -19.1 -88 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 83  
89 2 -19.1 -89 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 83  
90 2 -19.1 -90 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 83  
91 2 -19.1 -91 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 83  
92 2 -19.1 -92 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 83  
93 2 -19.1 -93 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 83  
94 2 -19.1 -94 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 83  
95 2 -19.1 -95 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 83  
96 2 -19.1 -96 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 83  
97 8 -2.48 -97 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 83  
98 2 -19.1 -98 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 83  
99 2 -19.1 -99 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 83  
100 2 -19.1 -100 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 83  
101 2 -19.1 -101 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 83  
102 2 -19.1 -102 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 83  
103 2 -19.1 -103 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 83  
104 2 -19.1 -104 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 83  
105 2 -19.1 -105 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 83  
106 2 -19.1 -106 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 83  
107 2 -19.1 -107 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 83  
108 2 -19.1 -108 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 83  
109 2 -19.1 -109 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 83  
110 1 -11.34 -110 (113 114 115 116 117 118 119 120 121 122 123 124 125 126 &  
127 128 129 130 131 132 133 134 135 136 137) imp:n=1 \$ Inside CASSETTE LEAD: 110  
111 3 -2.70 -111 110 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 110  
112 5 -0.001205 -112 111 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 110  
113 2 -19.1 -113 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 110  
114 2 -19.1 -114 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 110  
115 2 -19.1 -115 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 110  
116 2 -19.1 -116 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 110  
117 2 -19.1 -117 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 110  
118 2 -19.1 -118 imp:n=1 \$ Inside FUEL ROD at (1,3) inside of cassette: 110  
119 2 -19.1 -119 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 110  
120 2 -19.1 -120 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 110  
121 2 -19.1 -121 imp:n=1 \$ Inside FUEL ROD at (2,2) inside of cassette: 110  
122 2 -19.1 -122 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 110  
123 2 -19.1 -123 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 110  
124 8 -2.48 -124 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 110  
125 3 -2.70 -125 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 110  
126 8 -2.48 -126 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 110  
127 2 -19.1 -127 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 110  
128 2 -19.1 -128 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 110  
129 2 -19.1 -129 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 110  
130 2 -19.1 -130 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 110  
131 2 -19.1 -131 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 110  
132 2 -19.1 -132 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 110  
133 2 -19.1 -133 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 110  
134 2 -19.1 -134 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 110  
135 2 -19.1 -135 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 110

136 2 -19.1 -136 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 110  
137 2 -19.1 -137 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 110  
138 1 -11.34 -138 (141 142 143 144 145 146 147 148 149 150 151 152 153 154 &  
155 156 157 158 159 160 161 162 163 164) imp:n=1 \$ Inside CASSETTE LEAD: 138  
139 3 -2.70 -139 138 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 138  
140 5 -0.001205 -140 139 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 138  
141 2 -19.1 -141 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 138  
142 2 -19.1 -142 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 138  
143 2 -19.1 -143 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 138  
144 2 -19.1 -144 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 138  
145 2 -19.1 -145 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 138  
146 2 -19.1 -146 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 138  
147 2 -19.1 -147 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 138  
148 2 -19.1 -148 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 138  
149 2 -19.1 -149 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 138  
150 2 -19.1 -150 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 138  
151 2 -19.1 -151 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 138  
152 8 -2.48 -152 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 138  
153 2 -19.1 -153 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 138  
154 2 -19.1 -154 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 138  
155 2 -19.1 -155 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 138  
156 2 -19.1 -156 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 138  
157 2 -19.1 -157 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 138  
158 2 -19.1 -158 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 138  
159 2 -19.1 -159 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 138  
160 2 -19.1 -160 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 138  
161 2 -19.1 -161 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 138  
162 2 -19.1 -162 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 138  
163 2 -19.1 -163 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 138  
164 2 -19.1 -164 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 138  
165 1 -11.34 -165 (168 169 170 171 172 173 174 175 176 177 178 179 180 181 &  
182 183 184 185 186 187 188 189 190 191 192) imp:n=1 \$ Inside CASSETTE LEAD: 165  
166 3 -2.70 -166 165 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 165  
167 5 -0.001205 -167 166 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 165  
168 2 -19.1 -168 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 165  
169 2 -19.1 -169 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 165  
170 2 -19.1 -170 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 165  
171 2 -19.1 -171 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 165  
172 2 -19.1 -172 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 165  
173 2 -19.1 -173 imp:n=1 \$ Inside FUEL ROD at (1,3) inside of cassette: 165  
174 2 -19.1 -174 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 165  
175 2 -19.1 -175 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 165  
176 2 -19.1 -176 imp:n=1 \$ Inside FUEL ROD at (2,2) inside of cassette: 165  
177 2 -19.1 -177 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 165  
178 2 -19.1 -178 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 165  
179 8 -2.48 -179 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 165  
180 3 -2.70 -180 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 165  
181 8 -2.48 -181 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 165  
182 2 -19.1 -182 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 165  
183 2 -19.1 -183 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 165  
184 2 -19.1 -184 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 165  
185 2 -19.1 -185 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 165  
186 2 -19.1 -186 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 165  
187 2 -19.1 -187 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 165  
188 2 -19.1 -188 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 165  
189 2 -19.1 -189 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 165  
190 2 -19.1 -190 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 165  
191 2 -19.1 -191 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 165  
192 2 -19.1 -192 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 165  
193 1 -11.34 -193 (196 197 198 199 200 201 202 203 204 205 206 207 208 209 &

210 211 212 213 214 215 216 217 218 219) imp:n=1      \$ Inside CASSETTE LEAD: 193  
 194 3 -2.70 -194 193 imp:n=1      \$ Inside Cassette Cladding at ::: inside of cassette: 193  
 195 5 -0.001205 -195 194 imp:n=1      \$ Inside Cassette Air Gap at ::: inside of cassette: 193  
 196 2 -19.1 -196 imp:n=1      \$ Inside FUEL ROD at (0,1) inside of cassette: 193  
 197 2 -19.1 -197 imp:n=1      \$ Inside FUEL ROD at (0,3) inside of cassette: 193  
 198 2 -19.1 -198 imp:n=1      \$ Inside FUEL ROD at (0,5) inside of cassette: 193  
 199 2 -19.1 -199 imp:n=1      \$ Inside FUEL ROD at (1,0) inside of cassette: 193  
 200 2 -19.1 -200 imp:n=1      \$ Inside FUEL ROD at (1,2) inside of cassette: 193  
 201 2 -19.1 -201 imp:n=1      \$ Inside FUEL ROD at (1,4) inside of cassette: 193  
 202 2 -19.1 -202 imp:n=1      \$ Inside FUEL ROD at (1,6) inside of cassette: 193  
 203 2 -19.1 -203 imp:n=1      \$ Inside FUEL ROD at (2,1) inside of cassette: 193  
 204 2 -19.1 -204 imp:n=1      \$ Inside FUEL ROD at (2,3) inside of cassette: 193  
 205 2 -19.1 -205 imp:n=1      \$ Inside FUEL ROD at (2,5) inside of cassette: 193  
 206 2 -19.1 -206 imp:n=1      \$ Inside FUEL ROD at (3,0) inside of cassette: 193  
 207 8 -2.48 -207 imp:n=1      \$ Inside CONTROL ROD at (3,2) inside of cassette: 193  
 208 2 -19.1 -208 imp:n=1      \$ Inside FUEL ROD at (3,4) inside of cassette: 193  
 209 2 -19.1 -209 imp:n=1      \$ Inside FUEL ROD at (3,6) inside of cassette: 193  
 210 2 -19.1 -210 imp:n=1      \$ Inside FUEL ROD at (4,1) inside of cassette: 193  
 211 2 -19.1 -211 imp:n=1      \$ Inside FUEL ROD at (4,3) inside of cassette: 193  
 212 2 -19.1 -212 imp:n=1      \$ Inside FUEL ROD at (4,5) inside of cassette: 193  
 213 2 -19.1 -213 imp:n=1      \$ Inside FUEL ROD at (5,0) inside of cassette: 193  
 214 2 -19.1 -214 imp:n=1      \$ Inside FUEL ROD at (5,2) inside of cassette: 193  
 215 2 -19.1 -215 imp:n=1      \$ Inside FUEL ROD at (5,4) inside of cassette: 193  
 216 2 -19.1 -216 imp:n=1      \$ Inside FUEL ROD at (5,6) inside of cassette: 193  
 217 2 -19.1 -217 imp:n=1      \$ Inside FUEL ROD at (6,1) inside of cassette: 193  
 218 2 -19.1 -218 imp:n=1      \$ Inside FUEL ROD at (6,3) inside of cassette: 193  
 219 2 -19.1 -219 imp:n=1      \$ Inside FUEL ROD at (6,5) inside of cassette: 193  
 220 1 -11.34 -220 (223 224 225 226 227 228 229 230 231 232 233 234 235 236 &  
 237 238 239 240 241 242 243 244 245 246 247) imp:n=1      \$ Inside CASSETTE LEAD: 220  
 221 3 -2.70 -221 220 imp:n=1      \$ Inside Cassette Cladding at ::: inside of cassette: 220  
 222 5 -0.001205 -222 221 imp:n=1      \$ Inside Cassette Air Gap at ::: inside of cassette: 220  
 223 2 -19.1 -223 imp:n=1      \$ Inside FUEL ROD at (0,0) inside of cassette: 220  
 224 2 -19.1 -224 imp:n=1      \$ Inside FUEL ROD at (0,2) inside of cassette: 220  
 225 2 -19.1 -225 imp:n=1      \$ Inside FUEL ROD at (0,4) inside of cassette: 220  
 226 2 -19.1 -226 imp:n=1      \$ Inside FUEL ROD at (0,6) inside of cassette: 220  
 227 2 -19.1 -227 imp:n=1      \$ Inside FUEL ROD at (1,1) inside of cassette: 220  
 228 2 -19.1 -228 imp:n=1      \$ Inside FUEL ROD at (1,3) inside of cassette: 220  
 229 2 -19.1 -229 imp:n=1      \$ Inside FUEL ROD at (1,5) inside of cassette: 220  
 230 2 -19.1 -230 imp:n=1      \$ Inside FUEL ROD at (2,0) inside of cassette: 220  
 231 2 -19.1 -231 imp:n=1      \$ Inside FUEL ROD at (2,2) inside of cassette: 220  
 232 2 -19.1 -232 imp:n=1      \$ Inside FUEL ROD at (2,4) inside of cassette: 220  
 233 2 -19.1 -233 imp:n=1      \$ Inside FUEL ROD at (2,6) inside of cassette: 220  
 234 8 -2.48 -234 imp:n=1      \$ Inside CONTROL ROD at (3,1) inside of cassette: 220  
 235 3 -2.70 -235 imp:n=1      \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 220  
 236 8 -2.48 -236 imp:n=1      \$ Inside CONTROL ROD at (3,5) inside of cassette: 220  
 237 2 -19.1 -237 imp:n=1      \$ Inside FUEL ROD at (4,0) inside of cassette: 220  
 238 2 -19.1 -238 imp:n=1      \$ Inside FUEL ROD at (4,2) inside of cassette: 220  
 239 2 -19.1 -239 imp:n=1      \$ Inside FUEL ROD at (4,4) inside of cassette: 220  
 240 2 -19.1 -240 imp:n=1      \$ Inside FUEL ROD at (4,6) inside of cassette: 220  
 241 2 -19.1 -241 imp:n=1      \$ Inside FUEL ROD at (5,1) inside of cassette: 220  
 242 2 -19.1 -242 imp:n=1      \$ Inside FUEL ROD at (5,3) inside of cassette: 220  
 243 2 -19.1 -243 imp:n=1      \$ Inside FUEL ROD at (5,5) inside of cassette: 220  
 244 2 -19.1 -244 imp:n=1      \$ Inside FUEL ROD at (6,0) inside of cassette: 220  
 245 2 -19.1 -245 imp:n=1      \$ Inside FUEL ROD at (6,2) inside of cassette: 220  
 246 2 -19.1 -246 imp:n=1      \$ Inside FUEL ROD at (6,4) inside of cassette: 220  
 247 2 -19.1 -247 imp:n=1      \$ Inside FUEL ROD at (6,6) inside of cassette: 220  
 248 1 -11.34 -248 (251 252 253 254 255 256 257 258 259 260 261 262 263 264 &  
 265 266 267 268 269 270 271 272 273 274) imp:n=1      \$ Inside CASSETTE LEAD: 248  
 249 3 -2.70 -249 248 imp:n=1      \$ Inside Cassette Cladding at ::: inside of cassette: 248  
 250 5 -0.001205 -250 249 imp:n=1      \$ Inside Cassette Air Gap at ::: inside of cassette: 248



251 2 -19.1 -251 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 248  
 252 2 -19.1 -252 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 248  
 253 2 -19.1 -253 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 248  
 254 2 -19.1 -254 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 248  
 255 2 -19.1 -255 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 248  
 256 2 -19.1 -256 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 248  
 257 2 -19.1 -257 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 248  
 258 2 -19.1 -258 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 248  
 259 2 -19.1 -259 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 248  
 260 2 -19.1 -260 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 248  
 261 2 -19.1 -261 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 248  
 262 8 -2.48 -262 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 248  
 263 2 -19.1 -263 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 248  
 264 2 -19.1 -264 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 248  
 265 2 -19.1 -265 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 248  
 266 2 -19.1 -266 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 248  
 267 2 -19.1 -267 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 248  
 268 2 -19.1 -268 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 248  
 269 2 -19.1 -269 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 248  
 270 2 -19.1 -270 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 248  
 271 2 -19.1 -271 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 248  
 272 2 -19.1 -272 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 248  
 273 2 -19.1 -273 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 248  
 274 2 -19.1 -274 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 248  
 275 1 -11.34 -275 (278 279 280 281 282 283 284 285 286 287 288 289 290 291 &  
 292 293 294 295 296 297 298 299 300 301 302) imp:n=1 \$ Inside CASSETTE LEAD: 275  
 276 3 -2.70 -276 275 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 275  
 277 5 -0.001205 -277 276 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 275  
 278 2 -19.1 -278 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 275  
 279 2 -19.1 -279 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 275  
 280 2 -19.1 -280 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 275  
 281 2 -19.1 -281 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 275  
 282 2 -19.1 -282 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 275  
 283 2 -19.1 -283 imp:n=1 \$ Inside FUEL ROD at (1,3) inside of cassette: 275  
 284 2 -19.1 -284 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 275  
 285 2 -19.1 -285 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 275  
 286 2 -19.1 -286 imp:n=1 \$ Inside FUEL ROD at (2,2) inside of cassette: 275  
 287 2 -19.1 -287 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 275  
 288 2 -19.1 -288 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 275  
 289 8 -2.48 -289 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 275  
 290 3 -2.70 -290 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 275  
 291 8 -2.48 -291 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 275  
 292 2 -19.1 -292 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 275  
 293 2 -19.1 -293 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 275  
 294 2 -19.1 -294 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 275  
 295 2 -19.1 -295 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 275  
 296 2 -19.1 -296 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 275  
 297 2 -19.1 -297 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 275  
 298 2 -19.1 -298 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 275  
 299 2 -19.1 -299 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 275  
 300 2 -19.1 -300 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 275  
 301 2 -19.1 -301 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 275  
 302 2 -19.1 -302 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 275  
 303 1 -11.34 -303 (306 307 308 309 310 311 312 313 314 315 316 317 318 319 &  
 320 321 322 323 324 325 326 327 328 329 806 807 808 809 810 811 812 813 814 &  
 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 902) imp:n=1 \$ Inside CASSETTE LEAD: 303  
 304 3 -2.70 -304 303 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 303  
 305 5 -0.001205 -305 304 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 303  
 306 2 -19.1 -306 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 303  
 307 2 -19.1 -307 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 303

308 2 -19.1 -308 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 303  
 309 2 -19.1 -309 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 303  
 310 2 -19.1 -310 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 303  
 311 2 -19.1 -311 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 303  
 312 2 -19.1 -312 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 303  
 313 2 -19.1 -313 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 303  
 314 2 -19.1 -314 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 303  
 315 2 -19.1 -315 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 303  
 316 2 -19.1 -316 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 303  
 317 8 -2.48 -317 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 303  
 318 2 -19.1 -318 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 303  
 319 2 -19.1 -319 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 303  
 320 2 -19.1 -320 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 303  
 321 2 -19.1 -321 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 303  
 322 2 -19.1 -322 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 303  
 323 2 -19.1 -323 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 303  
 324 2 -19.1 -324 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 303  
 325 2 -19.1 -325 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 303  
 326 2 -19.1 -326 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 303  
 327 2 -19.1 -327 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 303  
 328 2 -19.1 -328 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 303  
 329 2 -19.1 -329 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 303  
 c  
 806 2 -19.1 -806 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 303  
 807 2 -19.1 -807 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 303  
 808 2 -19.1 -808 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 303  
 809 2 -19.1 -809 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 303  
 810 2 -19.1 -810 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 303  
 811 2 -19.1 -811 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 303  
 812 2 -19.1 -812 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 303  
 813 2 -19.1 -813 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 303  
 814 2 -19.1 -814 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 303  
 815 2 -19.1 -815 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 303  
 816 2 -19.1 -816 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 303  
 817 8 -2.48 -817 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 303  
 818 2 -19.1 -818 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 303  
 819 2 -19.1 -819 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 303  
 820 2 -19.1 -820 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 303  
 821 2 -19.1 -821 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 303  
 822 2 -19.1 -822 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 303  
 823 2 -19.1 -823 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 303  
 824 2 -19.1 -824 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 303  
 825 2 -19.1 -825 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 303  
 826 2 -19.1 -826 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 303  
 827 2 -19.1 -827 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 303  
 828 2 -19.1 -828 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 303  
 829 2 -19.1 -829 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 303  
 c  
 902 3 -2.70 -902 imp:n=1 \$ inside aluminum source block  
 c  
 330 1 -11.34 -330 (333 334 335 336 337 338 339 340 341 342 343 344 345 346 &  
 347 348 349 350 351 352 353 354 355 356 357 833 834 835 836 837 838 839 840 &  
 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 903) imp:n=1 \$ Inside CASSETTE LEAD: 330  
 331 3 -2.70 -331 330 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 330  
 332 5 -0.001205 -332 331 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 330  
 333 2 -19.1 -333 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 330  
 334 2 -19.1 -334 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 330  
 335 2 -19.1 -335 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 330  
 336 2 -19.1 -336 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 330  
 337 2 -19.1 -337 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 330

338 2 -19.1 -338 imp:n=1	\$ Inside FUEL ROD at (1,3) inside of cassette: 330
339 2 -19.1 -339 imp:n=1	\$ Inside FUEL ROD at (1,5) inside of cassette: 330
340 2 -19.1 -340 imp:n=1	\$ Inside FUEL ROD at (2,0) inside of cassette: 330
341 2 -19.1 -341 imp:n=1	\$ Inside FUEL ROD at (2,2) inside of cassette: 330
342 2 -19.1 -342 imp:n=1	\$ Inside FUEL ROD at (2,4) inside of cassette: 330
343 2 -19.1 -343 imp:n=1	\$ Inside FUEL ROD at (2,6) inside of cassette: 330
344 8 -2.48 -344 imp:n=1	\$ Inside CONTROL ROD at (3,1) inside of cassette: 330
345 2 -19.1 -345 imp:n=1	\$ Inside FUEL ROD at (3,3) inside of cassette: 330
346 8 -2.48 -346 imp:n=1	\$ Inside CONTROL ROD at (3,5) inside of cassette: 330
347 2 -19.1 -347 imp:n=1	\$ Inside FUEL ROD at (4,0) inside of cassette: 330
348 2 -19.1 -348 imp:n=1	\$ Inside FUEL ROD at (4,2) inside of cassette: 330
349 2 -19.1 -349 imp:n=1	\$ Inside FUEL ROD at (4,4) inside of cassette: 330
350 2 -19.1 -350 imp:n=1	\$ Inside FUEL ROD at (4,6) inside of cassette: 330
351 2 -19.1 -351 imp:n=1	\$ Inside FUEL ROD at (5,1) inside of cassette: 330
352 2 -19.1 -352 imp:n=1	\$ Inside FUEL ROD at (5,3) inside of cassette: 330
353 2 -19.1 -353 imp:n=1	\$ Inside FUEL ROD at (5,5) inside of cassette: 330
354 2 -19.1 -354 imp:n=1	\$ Inside FUEL ROD at (6,0) inside of cassette: 330
355 2 -19.1 -355 imp:n=1	\$ Inside FUEL ROD at (6,2) inside of cassette: 330
356 2 -19.1 -356 imp:n=1	\$ Inside FUEL ROD at (6,4) inside of cassette: 330
357 2 -19.1 -357 imp:n=1	\$ Inside FUEL ROD at (6,6) inside of cassette: 330
c	
833 2 -19.1 -833 imp:n=1	\$ Inside FUEL ROD at (0,0) inside of cassette: 330
834 2 -19.1 -834 imp:n=1	\$ Inside FUEL ROD at (0,2) inside of cassette: 330
835 2 -19.1 -835 imp:n=1	\$ Inside FUEL ROD at (0,4) inside of cassette: 330
836 2 -19.1 -836 imp:n=1	\$ Inside FUEL ROD at (0,6) inside of cassette: 330
837 2 -19.1 -837 imp:n=1	\$ Inside FUEL ROD at (1,1) inside of cassette: 330
838 2 -19.1 -838 imp:n=1	\$ Inside FUEL ROD at (1,3) inside of cassette: 330
839 2 -19.1 -839 imp:n=1	\$ Inside FUEL ROD at (1,5) inside of cassette: 330
840 2 -19.1 -840 imp:n=1	\$ Inside FUEL ROD at (2,0) inside of cassette: 330
841 2 -19.1 -841 imp:n=1	\$ Inside FUEL ROD at (2,2) inside of cassette: 330
842 2 -19.1 -842 imp:n=1	\$ Inside FUEL ROD at (2,4) inside of cassette: 330
843 2 -19.1 -843 imp:n=1	\$ Inside FUEL ROD at (2,6) inside of cassette: 330
844 8 -2.48 -844 imp:n=1	\$ Inside CONTROL ROD at (3,1) inside of cassette: 330
845 2 -19.1 -845 imp:n=1	\$ Inside FUEL ROD at (3,3) inside of cassette: 330
846 8 -2.48 -846 imp:n=1	\$ Inside CONTROL ROD at (3,5) inside of cassette: 330
847 2 -19.1 -847 imp:n=1	\$ Inside FUEL ROD at (4,0) inside of cassette: 330
848 2 -19.1 -848 imp:n=1	\$ Inside FUEL ROD at (4,2) inside of cassette: 330
849 2 -19.1 -849 imp:n=1	\$ Inside FUEL ROD at (4,4) inside of cassette: 330
850 2 -19.1 -850 imp:n=1	\$ Inside FUEL ROD at (4,6) inside of cassette: 330
851 2 -19.1 -851 imp:n=1	\$ Inside FUEL ROD at (5,1) inside of cassette: 330
852 2 -19.1 -852 imp:n=1	\$ Inside FUEL ROD at (5,3) inside of cassette: 330
853 2 -19.1 -853 imp:n=1	\$ Inside FUEL ROD at (5,5) inside of cassette: 330
854 2 -19.1 -854 imp:n=1	\$ Inside FUEL ROD at (6,0) inside of cassette: 330
855 2 -19.1 -855 imp:n=1	\$ Inside FUEL ROD at (6,2) inside of cassette: 330
856 2 -19.1 -856 imp:n=1	\$ Inside FUEL ROD at (6,4) inside of cassette: 330
857 2 -19.1 -857 imp:n=1	\$ Inside FUEL ROD at (6,6) inside of cassette: 330
c	
903 3 -2.70 -903 imp:n=1	\$ inside aluminum source block
c	
358 1 -11.34 -358 (361 362 363 364 365 366 367 368 369 370 371 372 373 374 & 375 376 377 378 379 380 381 382 383 384) imp:n=1	\$ Inside CASSETTE LEAD: 358
359 3 -2.70 -359 358 imp:n=1	\$ Inside Cassette Cladding at ::: inside of cassette: 358
360 5 -0.001205 -360 359 imp:n=1	\$ Inside Cassette Air Gap at ::: inside of cassette: 358
361 2 -19.1 -361 imp:n=1	\$ Inside FUEL ROD at (0,1) inside of cassette: 358
362 2 -19.1 -362 imp:n=1	\$ Inside FUEL ROD at (0,3) inside of cassette: 358
363 2 -19.1 -363 imp:n=1	\$ Inside FUEL ROD at (0,5) inside of cassette: 358
364 2 -19.1 -364 imp:n=1	\$ Inside FUEL ROD at (1,0) inside of cassette: 358
365 2 -19.1 -365 imp:n=1	\$ Inside FUEL ROD at (1,2) inside of cassette: 358
366 2 -19.1 -366 imp:n=1	\$ Inside FUEL ROD at (1,4) inside of cassette: 358
367 2 -19.1 -367 imp:n=1	\$ Inside FUEL ROD at (1,6) inside of cassette: 358

368 2 -19.1 -368 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 358  
369 2 -19.1 -369 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 358  
370 2 -19.1 -370 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 358  
371 2 -19.1 -371 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 358  
372 8 -2.48 -372 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 358  
373 2 -19.1 -373 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 358  
374 2 -19.1 -374 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 358  
375 2 -19.1 -375 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 358  
376 2 -19.1 -376 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 358  
377 2 -19.1 -377 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 358  
378 2 -19.1 -378 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 358  
379 2 -19.1 -379 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 358  
380 2 -19.1 -380 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 358  
381 2 -19.1 -381 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 358  
382 2 -19.1 -382 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 358  
383 2 -19.1 -383 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 358  
384 2 -19.1 -384 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 358  
385 1 -11.34 -385 (388 389 390 391 392 393 394 395 396 397 398 399 400 401 &  
402 403 404 405 406 407 408 409 410 411 412) imp:n=1 \$ Inside CASSETTE LEAD: 385  
386 3 -2.70 -386 385 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 385  
387 5 -0.001205 -387 386 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 385  
388 2 -19.1 -388 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 385  
389 2 -19.1 -389 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 385  
390 2 -19.1 -390 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 385  
391 2 -19.1 -391 imp:n=1 \$ Inside FUEL ROD at (0,6) inside of cassette: 385  
392 2 -19.1 -392 imp:n=1 \$ Inside FUEL ROD at (1,1) inside of cassette: 385  
393 2 -19.1 -393 imp:n=1 \$ Inside FUEL ROD at (1,3) inside of cassette: 385  
394 2 -19.1 -394 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 385  
395 2 -19.1 -395 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 385  
396 2 -19.1 -396 imp:n=1 \$ Inside FUEL ROD at (2,2) inside of cassette: 385  
397 2 -19.1 -397 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 385  
398 2 -19.1 -398 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 385  
399 8 -2.48 -399 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 385  
400 3 -2.70 -400 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 385  
401 8 -2.48 -401 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 385  
402 2 -19.1 -402 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 385  
403 2 -19.1 -403 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 385  
404 2 -19.1 -404 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 385  
405 2 -19.1 -405 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 385  
406 2 -19.1 -406 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 385  
407 2 -19.1 -407 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 385  
408 2 -19.1 -408 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 385  
409 2 -19.1 -409 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 385  
410 2 -19.1 -410 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 385  
411 2 -19.1 -411 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 385  
412 2 -19.1 -412 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 385  
413 1 -11.34 -413 (416 417 418 419 420 421 422 423 424 425 426 427 428 429 &  
430 431 432 433 434 435 436 437 438 439) imp:n=1 \$ Inside CASSETTE LEAD: 413  
414 3 -2.70 -414 413 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 413  
415 5 -0.001205 -415 414 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 413  
416 2 -19.1 -416 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 413  
417 2 -19.1 -417 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 413  
418 2 -19.1 -418 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 413  
419 2 -19.1 -419 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 413  
420 2 -19.1 -420 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 413  
421 2 -19.1 -421 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 413  
422 2 -19.1 -422 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 413  
423 2 -19.1 -423 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 413  
424 2 -19.1 -424 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 413  
425 2 -19.1 -425 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 413

426 2 -19.1 -426 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 413  
 427 8 -2.48 -427 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 413  
 428 2 -19.1 -428 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 413  
 429 2 -19.1 -429 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 413  
 430 2 -19.1 -430 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 413  
 431 2 -19.1 -431 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 413  
 432 2 -19.1 -432 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 413  
 433 2 -19.1 -433 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 413  
 434 2 -19.1 -434 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 413  
 435 2 -19.1 -435 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 413  
 436 2 -19.1 -436 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 413  
 437 2 -19.1 -437 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 413  
 438 2 -19.1 -438 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 413  
 439 2 -19.1 -439 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 413  
 440 1 -11.34 -440 (443 444 445 446 447 448 449 450 451 452 453 454 455 456 &  
 457 458 459 460 461 462 463 464 465 466 467) imp:n=1 \$ Inside CASSETTE LEAD: 440  
 441 3 -2.70 -441 440 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 440  
 442 5 -0.001205 -442 441 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 440  
 443 2 -19.1 -443 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 440  
 444 2 -19.1 -444 imp:n=1 \$ Inside FUEL ROD at (0,2) inside of cassette: 440  
 445 2 -19.1 -445 imp:n=1 \$ Inside FUEL ROD at (0,4) inside of cassette: 440  
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 449 2 -19.1 -449 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 440  
 450 2 -19.1 -450 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 440  
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 452 2 -19.1 -452 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 440  
 453 2 -19.1 -453 imp:n=1 \$ Inside FUEL ROD at (2,6) inside of cassette: 440  
 454 8 -2.48 -454 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 440  
 455 3 -2.70 -455 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 440  
 456 8 -2.48 -456 imp:n=1 \$ Inside CONTORL ROD at (3,5) inside of cassette: 440  
 457 2 -19.1 -457 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 440  
 458 2 -19.1 -458 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 440  
 459 2 -19.1 -459 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 440  
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 467 2 -19.1 -467 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 440  
 468 1 -11.34 -468 (471 472 473 474 475 476 477 478 479 480 481 482 483 484 &  
 485 486 487 488 489 490 491 492 493 494) imp:n=1 \$ Inside CASSETTE LEAD: 468  
 469 3 -2.70 -469 468 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 468  
 470 5 -0.001205 -470 469 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 468  
 471 2 -19.1 -471 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 468  
 472 2 -19.1 -472 imp:n=1 \$ Inside FUEL ROD at (0,3) inside of cassette: 468  
 473 2 -19.1 -473 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 468  
 474 2 -19.1 -474 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 468  
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 476 2 -19.1 -476 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 468  
 477 2 -19.1 -477 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 468  
 478 2 -19.1 -478 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 468  
 479 2 -19.1 -479 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 468  
 480 2 -19.1 -480 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 468  
 481 2 -19.1 -481 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 468  
 482 8 -2.48 -482 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 468  
 483 2 -19.1 -483 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 468

484 2 -19.1 -484 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 468  
 485 2 -19.1 -485 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 468  
 486 2 -19.1 -486 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 468  
 487 2 -19.1 -487 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 468  
 488 2 -19.1 -488 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 468  
 489 2 -19.1 -489 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 468  
 490 2 -19.1 -490 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 468  
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 493 2 -19.1 -493 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 468  
 494 2 -19.1 -494 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 468  
 495 1 -11.34 -495 (498 499 500 501 502 503 504 505 506 507 508 509 510 511 &  
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 496 3 -2.70 -496 495 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 495  
 497 5 -0.001205 -497 496 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 495  
 498 2 -19.1 -498 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 495  
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 508 2 -19.1 -508 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 495  
 509 8 -2.48 -509 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 495  
 510 2 -19.1 -510 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 495  
 511 2 -19.1 -511 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 495  
 512 2 -19.1 -512 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 495  
 513 2 -19.1 -513 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 495  
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 521 2 -19.1 -521 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 495  
 522 1 -11.34 -522 (525 526 527 528 529 530 531 532 533 534 535 536 537 538 &  
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 523 3 -2.70 -523 522 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 522  
 524 5 -0.001205 -524 523 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 522  
 525 2 -19.1 -525 imp:n=1 \$ Inside FUEL ROD at (0,0) inside of cassette: 522  
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 531 2 -19.1 -531 imp:n=1 \$ Inside FUEL ROD at (1,5) inside of cassette: 522  
 532 2 -19.1 -532 imp:n=1 \$ Inside FUEL ROD at (2,0) inside of cassette: 522  
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 534 2 -19.1 -534 imp:n=1 \$ Inside FUEL ROD at (2,4) inside of cassette: 522  
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 536 8 -2.48 -536 imp:n=1 \$ Inside CONTROL ROD at (3,1) inside of cassette: 522  
 537 3 -2.70 -537 imp:n=1 \$ Inside INSTRUMENT ROD at (3,3) inside of cassette: 522  
 538 8 -2.48 -538 imp:n=1 \$ Inside CONTROL ROD at (3,5) inside of cassette: 522  
 539 2 -19.1 -539 imp:n=1 \$ Inside FUEL ROD at (4,0) inside of cassette: 522  
 540 2 -19.1 -540 imp:n=1 \$ Inside FUEL ROD at (4,2) inside of cassette: 522  
 541 2 -19.1 -541 imp:n=1 \$ Inside FUEL ROD at (4,4) inside of cassette: 522

542 2 -19.1 -542 imp:n=1 \$ Inside FUEL ROD at (4,6) inside of cassette: 522  
 543 2 -19.1 -543 imp:n=1 \$ Inside FUEL ROD at (5,1) inside of cassette: 522  
 544 2 -19.1 -544 imp:n=1 \$ Inside FUEL ROD at (5,3) inside of cassette: 522  
 545 2 -19.1 -545 imp:n=1 \$ Inside FUEL ROD at (5,5) inside of cassette: 522  
 546 2 -19.1 -546 imp:n=1 \$ Inside FUEL ROD at (6,0) inside of cassette: 522  
 547 2 -19.1 -547 imp:n=1 \$ Inside FUEL ROD at (6,2) inside of cassette: 522  
 548 2 -19.1 -548 imp:n=1 \$ Inside FUEL ROD at (6,4) inside of cassette: 522  
 549 2 -19.1 -549 imp:n=1 \$ Inside FUEL ROD at (6,6) inside of cassette: 522  
 550 1 -11.34 -550 (553 554 555 556 557 558 559 560 561 562 563 564 565 566 &  
 567 568 569 570 571 572 573 574 575 576) imp:n=1 \$ Inside CASSETTE LEAD: 550  
 551 3 -2.70 -551 550 imp:n=1 \$ Inside Cassette Cladding at ::: inside of cassette: 550  
 552 5 -0.001205 -552 551 imp:n=1 \$ Inside Cassette Air Gap at ::: inside of cassette: 550  
 553 2 -19.1 -553 imp:n=1 \$ Inside FUEL ROD at (0,1) inside of cassette: 550  
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 555 2 -19.1 -555 imp:n=1 \$ Inside FUEL ROD at (0,5) inside of cassette: 550  
 556 2 -19.1 -556 imp:n=1 \$ Inside FUEL ROD at (1,0) inside of cassette: 550  
 557 2 -19.1 -557 imp:n=1 \$ Inside FUEL ROD at (1,2) inside of cassette: 550  
 558 2 -19.1 -558 imp:n=1 \$ Inside FUEL ROD at (1,4) inside of cassette: 550  
 559 2 -19.1 -559 imp:n=1 \$ Inside FUEL ROD at (1,6) inside of cassette: 550  
 560 2 -19.1 -560 imp:n=1 \$ Inside FUEL ROD at (2,1) inside of cassette: 550  
 561 2 -19.1 -561 imp:n=1 \$ Inside FUEL ROD at (2,3) inside of cassette: 550  
 562 2 -19.1 -562 imp:n=1 \$ Inside FUEL ROD at (2,5) inside of cassette: 550  
 563 2 -19.1 -563 imp:n=1 \$ Inside FUEL ROD at (3,0) inside of cassette: 550  
 564 8 -2.48 -564 imp:n=1 \$ Inside CONTROL ROD at (3,2) inside of cassette: 550  
 565 2 -19.1 -565 imp:n=1 \$ Inside FUEL ROD at (3,4) inside of cassette: 550  
 566 2 -19.1 -566 imp:n=1 \$ Inside FUEL ROD at (3,6) inside of cassette: 550  
 567 2 -19.1 -567 imp:n=1 \$ Inside FUEL ROD at (4,1) inside of cassette: 550  
 568 2 -19.1 -568 imp:n=1 \$ Inside FUEL ROD at (4,3) inside of cassette: 550  
 569 2 -19.1 -569 imp:n=1 \$ Inside FUEL ROD at (4,5) inside of cassette: 550  
 570 2 -19.1 -570 imp:n=1 \$ Inside FUEL ROD at (5,0) inside of cassette: 550  
 571 2 -19.1 -571 imp:n=1 \$ Inside FUEL ROD at (5,2) inside of cassette: 550  
 572 2 -19.1 -572 imp:n=1 \$ Inside FUEL ROD at (5,4) inside of cassette: 550  
 573 2 -19.1 -573 imp:n=1 \$ Inside FUEL ROD at (5,6) inside of cassette: 550  
 574 2 -19.1 -574 imp:n=1 \$ Inside FUEL ROD at (6,1) inside of cassette: 550  
 575 2 -19.1 -575 imp:n=1 \$ Inside FUEL ROD at (6,3) inside of cassette: 550  
 576 2 -19.1 -576 imp:n=1 \$ Inside FUEL ROD at (6,5) inside of cassette: 550  
 577 3 -2.70 -577 (3 30 58 85 112 140 167 195 222 250 277 305 332 360 387 415 &  
 442 470 497 524 552 ) imp:n=1 \$ Inside of core, outside of cassettes  
 578 4 -7.82 -578 577 imp:n=1 \$ Inside of reflector, outside of core  
 995 5 -0.001205 -970 578 972 imp:n=1 \$ Inside air room, Outside of Reflector and Human  
 996 6 -2.220 -971 970 imp:n=1 \$ Inside concrete walls, outside of air room  
 997 7 -1.127 -972 imp:n=1 \$ Inside of human  
 998 5 -0.001205 -999 971 imp:n=1 \$ Inside universe, outside of concrete walls  
 999 0 999 imp:n=0 \$ Outside of Universe

c SURFACE CARD

1 RPP -33.52 -14.62 -57.84 -38.94 0 144.71 \$ Cassette: (-36.23 , -60.55) ::: CASSETTE\_LEAD  
 2 RPP -36.18 -11.96 -60.5 -36.28 0 144.71 \$ Cassette: (-36.23 , -60.55) ::: CASSETTE\_CLAD  
 3 RPP -36.23 -11.91 -60.55 -36.23 0 144.71 \$ Cassette: (-36.23 , -60.55) ::: AIRGAP  
 4 RCC -32.17 -53.79 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (0,1) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 5 RCC -32.17 -48.39 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (0,3) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 6 RCC -32.17 -42.99 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (0,5) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 7 RCC -29.47 -56.49 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,0) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 8 RCC -29.47 -51.09 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,2) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 9 RCC -29.47 -45.69 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,4) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 10 RCC -29.47 -40.29 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,6) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 11 RCC -26.77 -53.79 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,1) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 12 RCC -26.77 -48.39 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,3) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 13 RCC -26.77 -42.99 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,5) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD  
 14 RCC -24.07 -56.49 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (3,0) ::: In Cassette: (-36.23 , -60.55) ::: FUEL\_ROD

15	RCC	-24.07	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,2) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
16	RCC	-24.07	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,4) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
17	RCC	-24.07	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,6) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
18	RCC	-21.37	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,1) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
19	RCC	-21.37	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,3) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
20	RCC	-21.37	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,5) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
21	RCC	-18.67	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,0) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
22	RCC	-18.67	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,2) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
23	RCC	-18.67	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,4) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
24	RCC	-18.67	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,6) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
25	RCC	-15.97	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,1) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
26	RCC	-15.97	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,3) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
27	RCC	-15.97	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,5) ::: In Cassette: (-36.23 , -60.55) ::: FUEL_ROD
28	RPP	-9.2	9.7	-57.84	-38.94	0	144.71	\$	Cassette: (-11.91 , -60.55) ::: CASSETTE_LEAD
29	RPP	-11.86	12.36	-60.5	-36.28	0	144.71	\$	Cassette: (-11.91 , -60.55) ::: CASSETTE_CLAD
30	RPP	-11.91	12.41	-60.55	-36.23	0	144.71	\$	Cassette: (-11.91 , -60.55) ::: AIRGAP
31	RCC	-7.85	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,0) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
32	RCC	-7.85	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,2) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
33	RCC	-7.85	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,4) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
34	RCC	-7.85	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,6) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
35	RCC	-5.15	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,1) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
36	RCC	-5.15	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,3) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
37	RCC	-5.15	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,5) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
38	RCC	-2.45	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,0) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
39	RCC	-2.45	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,2) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
40	RCC	-2.45	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,4) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
41	RCC	-2.45	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,6) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
42	RCC	0.25	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,1) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
43	RCC	0.25	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,3) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
44	RCC	0.25	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,5) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
45	RCC	2.95	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,0) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
46	RCC	2.95	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,2) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
47	RCC	2.95	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,4) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
48	RCC	2.95	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,6) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
49	RCC	5.65	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,1) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
50	RCC	5.65	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,3) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
51	RCC	5.65	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,5) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
52	RCC	8.35	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,0) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
53	RCC	8.35	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,2) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
54	RCC	8.35	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,4) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
55	RCC	8.35	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,6) ::: In Cassette: (-11.91 , -60.55) ::: FUEL_ROD
56	RPP	15.12	34.02	-57.84	-38.94	0	144.71	\$	Cassette: (12.41 , -60.55) ::: CASSETTE_LEAD
57	RPP	12.46	36.68	-60.5	-36.28	0	144.71	\$	Cassette: (12.41 , -60.55) ::: CASSETTE_CLAD
58	RPP	12.41	36.73	-60.55	-36.23	0	144.71	\$	Cassette: (12.41 , -60.55) ::: AIRGAP
59	RCC	16.47	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,1) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
60	RCC	16.47	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,3) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
61	RCC	16.47	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,5) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
62	RCC	19.17	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,0) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
63	RCC	19.17	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,2) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
64	RCC	19.17	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,4) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
65	RCC	19.17	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,6) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
66	RCC	21.87	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,1) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
67	RCC	21.87	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,3) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
68	RCC	21.87	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,5) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
69	RCC	24.57	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,0) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
70	RCC	24.57	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,2) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
71	RCC	24.57	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,4) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
72	RCC	24.57	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,6) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
73	RCC	27.27	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,1) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD
74	RCC	27.27	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,3) ::: In Cassette: (12.41 , -60.55) ::: FUEL_ROD



75	RCC	27.27	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,5) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
76	RCC	29.97	-56.49	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,0) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
77	RCC	29.97	-51.09	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,2) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
78	RCC	29.97	-45.69	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,4) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
79	RCC	29.97	-40.29	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,6) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
80	RCC	32.67	-53.79	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,1) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
81	RCC	32.67	-48.39	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,3) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
82	RCC	32.67	-42.99	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,5) :: In Cassette: (12.41 , -60.55) :: FUEL_ROD
83	RPP	-57.84	-38.94	-33.52	-14.62	0	144.71	\$	Cassette: (-60.55 , -36.23) :: CASSETTE_LEAD
84	RPP	-60.5	-36.28	-36.18	-11.96	0	144.71	\$	Cassette: (-60.55 , -36.23) :: CASSETTE_CLAD
85	RPP	-60.55	-36.23	-36.23	-11.91	0	144.71	\$	Cassette: (-60.55 , -36.23) :: AIRGAP
86	RCC	-56.49	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,1) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
87	RCC	-56.49	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,3) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
88	RCC	-56.49	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,5) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
89	RCC	-53.79	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,0) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
90	RCC	-53.79	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,2) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
91	RCC	-53.79	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,4) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
92	RCC	-53.79	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,6) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
93	RCC	-51.09	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,1) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
94	RCC	-51.09	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,3) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
95	RCC	-51.09	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,5) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
96	RCC	-48.39	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,0) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
97	RCC	-48.39	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,2) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
98	RCC	-48.39	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,4) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
99	RCC	-48.39	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,6) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
100	RCC	-45.69	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,1) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
101	RCC	-45.69	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,3) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
102	RCC	-45.69	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,5) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
103	RCC	-42.99	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,0) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
104	RCC	-42.99	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,2) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
105	RCC	-42.99	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,4) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
106	RCC	-42.99	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,6) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
107	RCC	-40.29	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,1) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
108	RCC	-40.29	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,3) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
109	RCC	-40.29	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,5) :: In Cassette: (-60.55 , -36.23) :: FUEL_ROD
110	RPP	-33.52	-14.62	-33.52	-14.62	0	144.71	\$	Cassette: (-36.23 , -36.23) :: CASSETTE_LEAD
111	RPP	-36.18	-11.96	-36.18	-11.96	0	144.71	\$	Cassette: (-36.23 , -36.23) :: CASSETTE_CLAD
112	RPP	-36.23	-11.91	-36.23	-11.91	0	144.71	\$	Cassette: (-36.23 , -36.23) :: AIRGAP
113	RCC	-32.17	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,0) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
114	RCC	-32.17	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,2) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
115	RCC	-32.17	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,4) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
116	RCC	-32.17	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (0,6) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
117	RCC	-29.47	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,1) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
118	RCC	-29.47	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,3) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
119	RCC	-29.47	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (1,5) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
120	RCC	-26.77	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,0) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
121	RCC	-26.77	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,2) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
122	RCC	-26.77	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,4) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
123	RCC	-26.77	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (2,6) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
124	RCC	-24.07	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,1) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
125	RCC	-24.07	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,3) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
126	RCC	-24.07	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (3,5) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
127	RCC	-21.37	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,0) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
128	RCC	-21.37	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,2) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
129	RCC	-21.37	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,4) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
130	RCC	-21.37	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (4,6) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
131	RCC	-18.67	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,1) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
132	RCC	-18.67	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,3) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
133	RCC	-18.67	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (5,5) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD
134	RCC	-15.97	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod :: (6,0) :: In Cassette: (-36.23 , -36.23) :: FUEL_ROD

135	RCC	-15.97	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,2)	:::	In Cassette:	(-36.23 , -36.23)	:::	FUEL_ROD
136	RCC	-15.97	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,4)	:::	In Cassette:	(-36.23 , -36.23)	:::	FUEL_ROD
137	RCC	-15.97	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,6)	:::	In Cassette:	(-36.23 , -36.23)	:::	FUEL_ROD
138	RPP	-9.2	9.7	-33.52	-14.62	0	144.71	\$	Cassette:	(-11.91 , -36.23)	:::	CASSETTE_LEAD				
139	RPP	-11.86	12.36	-36.18	-11.96	0	144.71	\$	Cassette:	(-11.91 , -36.23)	:::	CASSETTE_CLAD				
140	RPP	-11.91	12.41	-36.23	-11.91	0	144.71	\$	Cassette:	(-11.91 , -36.23)	:::	AIRGAP				
141	RCC	-7.85	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,1)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
142	RCC	-7.85	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,3)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
143	RCC	-7.85	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,5)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
144	RCC	-5.15	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,0)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
145	RCC	-5.15	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,2)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
146	RCC	-5.15	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,4)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
147	RCC	-5.15	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,6)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
148	RCC	-2.45	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,1)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
149	RCC	-2.45	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,3)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
150	RCC	-2.45	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,5)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
151	RCC	0.25	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,0)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
152	RCC	0.25	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,2)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
153	RCC	0.25	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,4)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
154	RCC	0.25	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,6)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
155	RCC	2.95	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,1)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
156	RCC	2.95	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,3)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
157	RCC	2.95	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,5)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
158	RCC	5.65	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,0)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
159	RCC	5.65	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,2)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
160	RCC	5.65	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,4)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
161	RCC	5.65	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,6)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
162	RCC	8.35	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,1)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
163	RCC	8.35	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,3)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
164	RCC	8.35	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,5)	:::	In Cassette:	(-11.91 , -36.23)	:::	FUEL_ROD
165	RPP	15.12	34.02	-33.52	-14.62	0	144.71	\$	Cassette:	(12.41 , -36.23)	:::	CASSETTE_LEAD				
166	RPP	12.46	36.68	-36.18	-11.96	0	144.71	\$	Cassette:	(12.41 , -36.23)	:::	CASSETTE_CLAD				
167	RPP	12.41	36.73	-36.23	-11.91	0	144.71	\$	Cassette:	(12.41 , -36.23)	:::	AIRGAP				
168	RCC	16.47	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,0)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
169	RCC	16.47	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,2)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
170	RCC	16.47	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,4)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
171	RCC	16.47	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(0,6)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
172	RCC	19.17	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,1)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
173	RCC	19.17	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,3)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
174	RCC	19.17	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(1,5)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
175	RCC	21.87	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,0)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
176	RCC	21.87	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,2)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
177	RCC	21.87	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,4)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
178	RCC	21.87	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(2,6)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
179	RCC	24.57	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,1)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
180	RCC	24.57	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,3)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
181	RCC	24.57	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(3,5)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
182	RCC	27.27	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,0)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
183	RCC	27.27	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,2)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
184	RCC	27.27	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,4)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
185	RCC	27.27	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(4,6)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
186	RCC	29.97	-29.47	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,1)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
187	RCC	29.97	-24.07	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,3)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
188	RCC	29.97	-18.67	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(5,5)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
189	RCC	32.67	-32.17	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,0)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
190	RCC	32.67	-26.77	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,2)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
191	RCC	32.67	-21.37	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,4)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
192	RCC	32.67	-15.97	2.66	0 0	139.39	1.25	\$	Fuel Rod	:::	(6,6)	:::	In Cassette:	(12.41 , -36.23)	:::	FUEL_ROD
193	RPP	39.44	58.34	-33.52	-14.62	0	144.71	\$	Cassette:	(36.73 , -36.23)	:::	CASSETTE_LEAD				
194	RPP	36.78	61	-36.18	-11.96	0	144.71	\$	Cassette:	(36.73 , -36.23)	:::	CASSETTE_CLAD				

195	RPP	36.73	61.05	-36.23	-11.91	0	144.71	\$	Cassette: (36.73 , -36.23) ::: AIRGAP
196	RCC	40.79	-29.47	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,1) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
197	RCC	40.79	-24.07	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,3) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
198	RCC	40.79	-18.67	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,5) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
199	RCC	43.49	-32.17	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,0) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
200	RCC	43.49	-26.77	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,2) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
201	RCC	43.49	-21.37	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,4) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
202	RCC	43.49	-15.97	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,6) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
203	RCC	46.19	-29.47	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,1) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
204	RCC	46.19	-24.07	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,3) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
205	RCC	46.19	-18.67	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,5) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
206	RCC	48.89	-32.17	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,0) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
207	RCC	48.89	-26.77	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,2) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
208	RCC	48.89	-21.37	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,4) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
209	RCC	48.89	-15.97	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,6) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
210	RCC	51.59	-29.47	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,1) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
211	RCC	51.59	-24.07	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,3) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
212	RCC	51.59	-18.67	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,5) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
213	RCC	54.29	-32.17	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,0) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
214	RCC	54.29	-26.77	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,2) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
215	RCC	54.29	-21.37	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,4) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
216	RCC	54.29	-15.97	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,6) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
217	RCC	56.99	-29.47	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,1) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
218	RCC	56.99	-24.07	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,3) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
219	RCC	56.99	-18.67	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,5) ::: In Cassette: (36.73 , -36.23) ::: FUEL_ROD
220	RPP	-57.84	-38.94	-9.2	9.7	0	144.71	\$	Cassette: (-60.55 , -11.91) ::: CASSETTE_LEAD
221	RPP	-60.5	-36.28	-11.86	12.36	0	144.71	\$	Cassette: (-60.55 , -11.91) ::: CASSETTE_CLAD
222	RPP	-60.55	-36.23	-11.91	12.41	0	144.71	\$	Cassette: (-60.55 , -11.91) ::: AIRGAP
223	RCC	-56.49	-7.85	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,0) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
224	RCC	-56.49	-2.45	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,2) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
225	RCC	-56.49	2.95	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,4) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
226	RCC	-56.49	8.35	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,6) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
227	RCC	-53.79	-5.15	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,1) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
228	RCC	-53.79	0.25	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,3) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
229	RCC	-53.79	5.65	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,5) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
230	RCC	-51.09	-7.85	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,0) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
231	RCC	-51.09	-2.45	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,2) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
232	RCC	-51.09	2.95	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,4) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
233	RCC	-51.09	8.35	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,6) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
234	RCC	-48.39	-5.15	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,1) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
235	RCC	-48.39	0.25	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,3) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
236	RCC	-48.39	5.65	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,5) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
237	RCC	-45.69	-7.85	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,0) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
238	RCC	-45.69	-2.45	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,2) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
239	RCC	-45.69	2.95	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,4) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
240	RCC	-45.69	8.35	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,6) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
241	RCC	-42.99	-5.15	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,1) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
242	RCC	-42.99	0.25	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,3) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
243	RCC	-42.99	5.65	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,5) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
244	RCC	-40.29	-7.85	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,0) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
245	RCC	-40.29	-2.45	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,2) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
246	RCC	-40.29	2.95	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,4) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
247	RCC	-40.29	8.35	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,6) ::: In Cassette: (-60.55 , -11.91) ::: FUEL_ROD
248	RPP	-33.52	-14.62	-9.2	9.7	0	144.71	\$	Cassette: (-36.23 , -11.91) ::: CASSETTE_LEAD
249	RPP	-36.18	-11.96	-11.86	12.36	0	144.71	\$	Cassette: (-36.23 , -11.91) ::: CASSETTE_CLAD
250	RPP	-36.23	-11.91	-11.91	12.41	0	144.71	\$	Cassette: (-36.23 , -11.91) ::: AIRGAP
251	RCC	-32.17	-5.15	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,1) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
252	RCC	-32.17	0.25	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,3) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
253	RCC	-32.17	5.65	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,5) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
254	RCC	-29.47	-7.85	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,0) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD

255	RCC	-29.47	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,2) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
256	RCC	-29.47	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,4) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
257	RCC	-29.47	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,6) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
258	RCC	-26.77	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,1) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
259	RCC	-26.77	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,3) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
260	RCC	-26.77	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,5) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
261	RCC	-24.07	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,0) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
262	RCC	-24.07	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,2) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
263	RCC	-24.07	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,4) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
264	RCC	-24.07	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,6) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
265	RCC	-21.37	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,1) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
266	RCC	-21.37	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,3) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
267	RCC	-21.37	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,5) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
268	RCC	-18.67	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,0) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
269	RCC	-18.67	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,2) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
270	RCC	-18.67	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,4) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
271	RCC	-18.67	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,6) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
272	RCC	-15.97	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,1) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
273	RCC	-15.97	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,3) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
274	RCC	-15.97	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,5) ::: In Cassette: (-36.23 , -11.91) ::: FUEL_ROD
275	RPP	-9.2	9.7	-9.2	9.7	0 144.71	\$	Cassette: (-11.91 , -11.91) ::: CASSETTE_LEAD	
276	RPP	-11.86	12.36	-11.86	12.36	0 144.71	\$	Cassette: (-11.91 , -11.91) ::: CASSETTE_CLAD	
277	RPP	-11.91	12.41	-11.91	12.41	0 144.71	\$	Cassette: (-11.91 , -11.91) ::: AIRGAP	
278	RCC	-7.85	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,0) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
279	RCC	-7.85	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,2) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
280	RCC	-7.85	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,4) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
281	RCC	-7.85	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,6) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
282	RCC	-5.15	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,1) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
283	RCC	-5.15	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,3) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
284	RCC	-5.15	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,5) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
285	RCC	-2.45	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,0) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
286	RCC	-2.45	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,2) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
287	RCC	-2.45	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,4) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
288	RCC	-2.45	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,6) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
289	RCC	0.25	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,1) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
290	RCC	0.25	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,3) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
291	RCC	0.25	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,5) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
292	RCC	2.95	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,0) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
293	RCC	2.95	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,2) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
294	RCC	2.95	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,4) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
295	RCC	2.95	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,6) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
296	RCC	5.65	-5.15	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,1) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
297	RCC	5.65	0.25	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,3) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
298	RCC	5.65	5.65	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,5) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
299	RCC	8.35	-7.85	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,0) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
300	RCC	8.35	-2.45	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,2) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
301	RCC	8.35	2.95	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,4) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
302	RCC	8.35	8.35	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,6) ::: In Cassette: (-11.91 , -11.91) ::: FUEL_ROD
303	RPP	15.12	34.02	-9.2	9.7	0 144.71	\$	Cassette: (12.41 , -11.91) ::: CASSETTE_LEAD	
304	RPP	12.46	36.68	-11.86	12.36	0 144.71	\$	Cassette: (12.41 , -11.91) ::: CASSETTE_CLAD 12	
305	RPP	12.41	36.73	-11.91	12.41	0 144.71	\$	Cassette: (12.41 , -11.91) ::: AIRGAP	
306	RCC	16.47	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (0,1) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
307	RCC	16.47	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (0,3) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
308	RCC	16.47	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (0,5) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
309	RCC	19.17	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (1,0) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
310	RCC	19.17	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (1,2) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
311	RCC	19.17	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (1,4) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
312	RCC	19.17	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (1,6) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
313	RCC	21.87	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (2,1) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD
314	RCC	21.87	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (2,3) ::: In Cassette: (12.41 , -11.91) ::: FUEL_ROD

315	RCC	21.87	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (2,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
316	RCC	24.57	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,0) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
317	RCC	24.57	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,2) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
318	RCC	24.57	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,4) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD should be 93 for 2/3
319	RCC	24.57	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,6) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
320	RCC	27.27	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (4,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
321	RCC	27.27	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (4,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
322	RCC	27.27	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (4,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
323	RCC	29.97	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (5,0) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
324	RCC	29.97	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (5,2) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
325	RCC	29.97	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (5,4) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
326	RCC	29.97	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (5,6) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
327	RCC	32.67	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (6,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
328	RCC	32.67	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (6,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
329	RCC	32.67	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (6,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
c									
806	RCC	16.47	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (0,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
807	RCC	16.47	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (0,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
808	RCC	16.47	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (0,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
809	RCC	19.17	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (1,0) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
810	RCC	19.17	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (1,2) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
811	RCC	19.17	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (1,4) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
812	RCC	19.17	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (1,6) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
813	RCC	21.87	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (2,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
814	RCC	21.87	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (2,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
815	RCC	21.87	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (2,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
816	RCC	24.57	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (3,0) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
817	RCC	24.57	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (3,2) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
818	RCC	24.57	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (3,4) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
819	RCC	24.57	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (3,6) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
820	RCC	27.27	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (4,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
821	RCC	27.27	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (4,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
822	RCC	27.27	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (4,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
823	RCC	29.97	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (5,0) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
824	RCC	29.97	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (5,2) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
825	RCC	29.97	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (5,4) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
826	RCC	29.97	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (5,6) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
827	RCC	32.67	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (6,1) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
828	RCC	32.67	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (6,3) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
829	RCC	32.67	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod :: (6,5) :: In Cassette: (12.41 , -11.91) :: FUEL_ROD
c									
902	RPP	15.12	34.02	-9.2	9.7	49.26	94.5	\$	Aluminum Source Block
c									
330	RPP	39.44	58.34	-9.2	9.7	0	144.71	\$	Cassette: (36.73 , -11.91) :: CASSETTE_LEAD 13
331	RPP	36.78	61	-11.86	12.36	0	144.71	\$	Cassette: (36.73 , -11.91) :: CASSETTE_CLAD
332	RPP	36.73	61.05	-11.91	12.41	0	144.71	\$	Cassette: (36.73 , -11.91) :: AIRGAP
333	RCC	40.79	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (0,0) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
334	RCC	40.79	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (0,2) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
335	RCC	40.79	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (0,4) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
336	RCC	40.79	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (0,6) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
337	RCC	43.49	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (1,1) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
338	RCC	43.49	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (1,3) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
339	RCC	43.49	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (1,5) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
340	RCC	46.19	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (2,0) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
341	RCC	46.19	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (2,2) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
342	RCC	46.19	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (2,4) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
343	RCC	46.19	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (2,6) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
344	RCC	48.89	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,1) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD
345	RCC	48.89	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod :: (3,3) :: In Cassette: (36.73 , -11.91) :: FUEL_ROD

346	RCC	48.89	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (3,5) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
347	RCC	51.59	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (4,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
348	RCC	51.59	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (4,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
349	RCC	51.59	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (4,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
350	RCC	51.59	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (4,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
351	RCC	54.29	-5.15	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (5,1) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
352	RCC	54.29	0.25	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (5,3) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
353	RCC	54.29	5.65	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (5,5) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
354	RCC	56.99	-7.85	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (6,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
355	RCC	56.99	-2.45	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (6,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
356	RCC	56.99	2.95	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (6,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
357	RCC	56.99	8.35	2.66	0 0	46.5	1.25	\$	Fuel Rod ::: (6,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
c									
833	RCC	40.79	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (0,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
834	RCC	40.79	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (0,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
835	RCC	40.79	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (0,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
836	RCC	40.79	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (0,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
837	RCC	43.49	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (1,1) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
838	RCC	43.49	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (1,3) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
839	RCC	43.49	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (1,5) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
840	RCC	46.19	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (2,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
841	RCC	46.19	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (2,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
842	RCC	46.19	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (2,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
843	RCC	46.19	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (2,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
844	RCC	48.89	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (3,1) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
845	RCC	48.89	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (3,3) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
846	RCC	48.89	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (3,5) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
847	RCC	51.59	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (4,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
848	RCC	51.59	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (4,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
849	RCC	51.59	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (4,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
850	RCC	51.59	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (4,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
851	RCC	54.29	-5.15	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (5,1) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
852	RCC	54.29	0.25	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (5,3) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
853	RCC	54.29	5.65	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (5,5) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
854	RCC	56.99	-7.85	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (6,0) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
855	RCC	56.99	-2.45	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (6,2) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
856	RCC	56.99	2.95	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (6,4) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
857	RCC	56.99	8.35	94.6	0 0	46.5	1.25	\$	Fuel Rod ::: (6,6) ::: In Cassette: (36.73 , -11.91) ::: FUEL_ROD
c									
903	RPP	39.44	58.34	-9.2	9.7	49.26	94.5	\$	Aluminum Source Block
c									
358	RPP	-57.84	-38.94	15.12	34.02	0	144.71	\$	Cassette: (-60.55 , 12.41) ::: CASSETTE_LEAD
359	RPP	-60.5	-36.28	12.46	36.68	0	144.71	\$	Cassette: (-60.55 , 12.41) ::: CASSETTE_CLAD
360	RPP	-60.55	-36.23	12.41	36.73	0	144.71	\$	Cassette: (-60.55 , 12.41) ::: AIRGAP
361	RCC	-56.49	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,1) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
362	RCC	-56.49	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,3) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
363	RCC	-56.49	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,5) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
364	RCC	-53.79	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,0) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
365	RCC	-53.79	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,2) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
366	RCC	-53.79	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,4) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
367	RCC	-53.79	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,6) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
368	RCC	-51.09	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,1) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
369	RCC	-51.09	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,3) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
370	RCC	-51.09	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,5) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
371	RCC	-48.39	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,0) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
372	RCC	-48.39	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,2) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
373	RCC	-48.39	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,4) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
374	RCC	-48.39	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,6) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
375	RCC	-45.69	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,1) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
376	RCC	-45.69	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,3) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD

377	RCC	-45.69	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,5) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
378	RCC	-42.99	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,0) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
379	RCC	-42.99	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,2) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
380	RCC	-42.99	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,4) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
381	RCC	-42.99	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,6) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
382	RCC	-40.29	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,1) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
383	RCC	-40.29	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,3) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
384	RCC	-40.29	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,5) ::: In Cassette: (-60.55 , 12.41) ::: FUEL_ROD
385	RPP	-33.52	-14.62	15.12	34.02	0	144.71	\$	Cassette: (-36.23 , 12.41) ::: CASSETTE_LEAD
386	RPP	-36.18	-11.96	12.46	36.68	0	144.71	\$	Cassette: (-36.23 , 12.41) ::: CASSETTE_CLAD
387	RPP	-36.23	-11.91	12.41	36.73	0	144.71	\$	Cassette: (-36.23 , 12.41) ::: AIRGAP
388	RCC	-32.17	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,0) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
389	RCC	-32.17	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,2) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
390	RCC	-32.17	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,4) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
391	RCC	-32.17	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,6) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
392	RCC	-29.47	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,1) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
393	RCC	-29.47	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,3) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
394	RCC	-29.47	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,5) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
395	RCC	-26.77	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,0) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
396	RCC	-26.77	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,2) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
397	RCC	-26.77	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,4) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
398	RCC	-26.77	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,6) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
399	RCC	-24.07	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,1) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
400	RCC	-24.07	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,3) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
401	RCC	-24.07	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,5) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
402	RCC	-21.37	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,0) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
403	RCC	-21.37	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,2) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
404	RCC	-21.37	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,4) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
405	RCC	-21.37	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,6) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
406	RCC	-18.67	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,1) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
407	RCC	-18.67	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,3) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
408	RCC	-18.67	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,5) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
409	RCC	-15.97	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,0) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
410	RCC	-15.97	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,2) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
411	RCC	-15.97	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,4) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
412	RCC	-15.97	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (6,6) ::: In Cassette: (-36.23 , 12.41) ::: FUEL_ROD
413	RPP	-9.2	9.7	15.12	34.02	0	144.71	\$	Cassette: (-11.91 , 12.41) ::: CASSETTE_LEAD
414	RPP	-11.86	12.36	12.46	36.68	0	144.71	\$	Cassette: (-11.91 , 12.41) ::: CASSETTE_CLAD
415	RPP	-11.91	12.41	12.41	36.73	0	144.71	\$	Cassette: (-11.91 , 12.41) ::: AIRGAP
416	RCC	-7.85	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,1) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
417	RCC	-7.85	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,3) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
418	RCC	-7.85	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (0,5) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
419	RCC	-5.15	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,0) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
420	RCC	-5.15	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,2) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
421	RCC	-5.15	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,4) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
422	RCC	-5.15	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (1,6) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
423	RCC	-2.45	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,1) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
424	RCC	-2.45	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,3) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
425	RCC	-2.45	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (2,5) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
426	RCC	0.25	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,0) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
427	RCC	0.25	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,2) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
428	RCC	0.25	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,4) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
429	RCC	0.25	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (3,6) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
430	RCC	2.95	19.17	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,1) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
431	RCC	2.95	24.57	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,3) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
432	RCC	2.95	29.97	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (4,5) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
433	RCC	5.65	16.47	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,0) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
434	RCC	5.65	21.87	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,2) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
435	RCC	5.65	27.27	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,4) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD
436	RCC	5.65	32.67	2.66	0 0	139.39	1.25	\$	Fuel Rod ::: (5,6) ::: In Cassette: (-11.91 , 12.41) ::: FUEL_ROD

437	RCC	8.35	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,1)	:::	In Cassette:	(-11.91 , 12.41)	:::	FUEL_ROD
438	RCC	8.35	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,3)	:::	In Cassette:	(-11.91 , 12.41)	:::	FUEL_ROD
439	RCC	8.35	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,5)	:::	In Cassette:	(-11.91 , 12.41)	:::	FUEL_ROD
440	RPP	15.12	34.02		15.12	34.02	0	144.71	\$	Cassette:	(12.41 , 12.41)	:::	CASSETTE_LEAD				
441	RPP	12.46	36.68		12.46	36.68	0	144.71	\$	Cassette:	(12.41 , 12.41)	:::	CASSETTE_CLAD				
442	RPP	12.41	36.73		12.41	36.73	0	144.71	\$	Cassette:	(12.41 , 12.41)	:::	AIRGAP				
443	RCC	16.47	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,0)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
444	RCC	16.47	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,2)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
445	RCC	16.47	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,4)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
446	RCC	16.47	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,6)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
447	RCC	19.17	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,1)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
448	RCC	19.17	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,3)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
449	RCC	19.17	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,5)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
450	RCC	21.87	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,0)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
451	RCC	21.87	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,2)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
452	RCC	21.87	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,4)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
453	RCC	21.87	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,6)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
454	RCC	24.57	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,1)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
455	RCC	24.57	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,3)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
456	RCC	24.57	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,5)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
457	RCC	27.27	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,0)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
458	RCC	27.27	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,2)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
459	RCC	27.27	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,4)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
460	RCC	27.27	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,6)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
461	RCC	29.97	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,1)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
462	RCC	29.97	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,3)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
463	RCC	29.97	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,5)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
464	RCC	32.67	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,0)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
465	RCC	32.67	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,2)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
466	RCC	32.67	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,4)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
467	RCC	32.67	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,6)	:::	In Cassette:	(12.41 , 12.41)	:::	FUEL_ROD
468	RPP	39.44	58.34		15.12	34.02	0	144.71	\$	Cassette:	(36.73 , 12.41)	:::	CASSETTE_LEAD				
469	RPP	36.78	61		12.46	36.68	0	144.71	\$	Cassette:	(36.73 , 12.41)	:::	CASSETTE_CLAD				
470	RPP	36.73	61.05		12.41	36.73	0	144.71	\$	Cassette:	(36.73 , 12.41)	:::	AIRGAP				
471	RCC	40.79	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,1)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
472	RCC	40.79	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,3)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
473	RCC	40.79	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(0,5)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
474	RCC	43.49	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,0)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
475	RCC	43.49	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,2)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
476	RCC	43.49	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,4)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
477	RCC	43.49	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(1,6)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
478	RCC	46.19	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,1)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
479	RCC	46.19	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,3)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
480	RCC	46.19	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(2,5)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
481	RCC	48.89	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,0)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
482	RCC	48.89	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,2)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
483	RCC	48.89	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,4)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
484	RCC	48.89	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(3,6)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
485	RCC	51.59	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,1)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
486	RCC	51.59	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,3)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
487	RCC	51.59	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(4,5)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
488	RCC	54.29	16.47	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,0)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
489	RCC	54.29	21.87	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,2)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
490	RCC	54.29	27.27	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,4)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
491	RCC	54.29	32.67	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(5,6)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
492	RCC	56.99	19.17	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,1)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
493	RCC	56.99	24.57	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,3)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
494	RCC	56.99	29.97	2.66	0	0	139.39	1.25	\$	Fuel Rod	:::	(6,5)	:::	In Cassette:	(36.73 , 12.41)	:::	FUEL_ROD
495	RPP	-33.52	-14.62		39.44	58.34	0	144.71	\$	Cassette:	(-36.23 , 36.73)	:::	CASSETTE_LEAD				
496	RPP	-36.18	-11.96		36.78	61	0	144.71	\$	Cassette:	(-36.23 , 36.73)	:::	CASSETTE_CLAD				



497	RPP	-36.23	-11.91	36.73	61.05	0	144.71	\$	Cassette: (-36.23 , 36.73) ::: AIRGAP
498	RCC	-32.17	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,1) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
499	RCC	-32.17	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,3) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
500	RCC	-32.17	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,5) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
501	RCC	-29.47	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,0) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
502	RCC	-29.47	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,2) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
503	RCC	-29.47	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,4) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
504	RCC	-29.47	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,6) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
505	RCC	-26.77	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,1) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
506	RCC	-26.77	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,3) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
507	RCC	-26.77	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,5) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
508	RCC	-24.07	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,0) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
509	RCC	-24.07	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,2) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
510	RCC	-24.07	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,4) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
511	RCC	-24.07	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,6) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
512	RCC	-21.37	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,1) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
513	RCC	-21.37	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,3) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
514	RCC	-21.37	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,5) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
515	RCC	-18.67	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,0) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
516	RCC	-18.67	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,2) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
517	RCC	-18.67	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,4) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
518	RCC	-18.67	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,6) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
519	RCC	-15.97	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,1) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
520	RCC	-15.97	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,3) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
521	RCC	-15.97	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,5) ::: In Cassette: (-36.23 , 36.73) ::: FUEL_ROD
522	RPP	-9.2	9.7	39.44	58.34	0	144.71	\$	Cassette: (-11.91 , 36.73) ::: CASSETTE_LEAD
523	RPP	-11.86	12.36	36.78	61	0	144.71	\$	Cassette: (-11.91 , 36.73) ::: CASSETTE_CLAD
524	RPP	-11.91	12.41	36.73	61.05	0	144.71	\$	Cassette: (-11.91 , 36.73) ::: AIRGAP
525	RCC	-7.85	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,0) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
526	RCC	-7.85	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,2) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
527	RCC	-7.85	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,4) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
528	RCC	-7.85	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,6) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
529	RCC	-5.15	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,1) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
530	RCC	-5.15	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,3) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
531	RCC	-5.15	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,5) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
532	RCC	-2.45	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,0) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
533	RCC	-2.45	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,2) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
534	RCC	-2.45	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,4) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
535	RCC	-2.45	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (2,6) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
536	RCC	0.25	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,1) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
537	RCC	0.25	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,3) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
538	RCC	0.25	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (3,5) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
539	RCC	2.95	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,0) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
540	RCC	2.95	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,2) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
541	RCC	2.95	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,4) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
542	RCC	2.95	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (4,6) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
543	RCC	5.65	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,1) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
544	RCC	5.65	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,3) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
545	RCC	5.65	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (5,5) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
546	RCC	8.35	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,0) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
547	RCC	8.35	46.19	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,2) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
548	RCC	8.35	51.59	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,4) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
549	RCC	8.35	56.99	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (6,6) ::: In Cassette: (-11.91 , 36.73) ::: FUEL_ROD
550	RPP	15.12	34.02	39.44	58.34	0	144.71	\$	Cassette: (12.41 , 36.73) ::: CASSETTE_LEAD
551	RPP	12.46	36.68	36.78	61	0	144.71	\$	Cassette: (12.41 , 36.73) ::: CASSETTE_CLAD
552	RPP	12.41	36.73	36.73	61.05	0	144.71	\$	Cassette: (12.41 , 36.73) ::: AIRGAP
553	RCC	16.47	43.49	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,1) ::: In Cassette: (12.41 , 36.73) ::: FUEL_ROD
554	RCC	16.47	48.89	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,3) ::: In Cassette: (12.41 , 36.73) ::: FUEL_ROD
555	RCC	16.47	54.29	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (0,5) ::: In Cassette: (12.41 , 36.73) ::: FUEL_ROD
556	RCC	19.17	40.79	2.66	0	0	139.39	1.25	\$ Fuel Rod ::: (1,0) ::: In Cassette: (12.41 , 36.73) ::: FUEL_ROD

557 RCC 19.17 46.19 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,2) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
558 RCC 19.17 51.59 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,4) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
559 RCC 19.17 56.99 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (1,6) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
560 RCC 21.87 43.49 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,1) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
561 RCC 21.87 48.89 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,3) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
562 RCC 21.87 54.29 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (2,5) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
563 RCC 24.57 40.79 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (3,0) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
564 RCC 24.57 46.19 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (3,2) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
565 RCC 24.57 51.59 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (3,4) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
566 RCC 24.57 56.99 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (3,6) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
567 RCC 27.27 43.49 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (4,1) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
568 RCC 27.27 48.89 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (4,3) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
569 RCC 27.27 54.29 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (4,5) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
570 RCC 29.97 40.79 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (5,0) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
571 RCC 29.97 46.19 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (5,2) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
572 RCC 29.97 51.59 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (5,4) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
573 RCC 29.97 56.99 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (5,6) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
574 RCC 32.67 43.49 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (6,1) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
575 RCC 32.67 48.89 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (6,3) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD  
576 RCC 32.67 54.29 2.66 0 0 139.39 1.25 \$ Fuel Rod ::: (6,5) ::: In Cassette: (12.41 , 36.73) ::: FUEL\_ROD

c  
577 RCC 0.25 0.25 0 0 0 144.71 72.355 \$ Core ::: This is the cylindrical enclosure around the core ::: CORE 97.355  
578 RCC 0.25 0.25 -25 0 0 200.12 97.355 \$ Reflector ::: This is the reflector around the core ::: REFLECTOR

c  
c 700 RPP 0 1828.8 0 487.68 0 457.2  
970 RPP -365.76 1463.29 -243.84 243.84 -25.1 432.1 \$ room  
971 RPP -426.72 1524.25 -304.8 304.8 -86.06 493.06 \$ concrete walls  
972 RCC 200 -0 0.25 0 0 165.1 18.5 \$ human inside of room

c  
999 SPH 0.25 0.25 0 10000 \$ UNIVERSE

c DATA CARD

c -----MATERIALS-----

M1 82204 -0.014 & \$ Pb-204 LEAD  
82206 -0.241 & \$ Pb-206  
82207 -0.221 & \$ Pb-207  
82208 -0.524 \$ Pb-208

c  
c M1 82000 0.55 13027 0.45 \$ Pb with Al

c  
M2 92235 .1975 92238 0.8025 \$ 19.75% enriched Uranium fuel

c  
M3 13027 1 \$ Aluminum

c  
M4 6012 0.022831 26000 0.977170 \$ Carbon Steel

c  
M5 6000 -0.000124 & \$ Air  
7014 -0.755268 &  
8016 -0.231781 &  
18040 -0.012827

c  
M6 1001 -0.006488 & \$ ORNL Concrete  
8016 -0.518069 &  
11023 -0.016577 &  
13027 -0.035137 &  
14000 -0.349085 &  
19000 -0.015324 &  
20000 -0.045057 &  
26000 -0.014411

c

```

M7 1001 -0.006488 &      $ Tissue Equivalent: Polyethylene Terephthalate (Mylar)
  8016 -0.518069 &
  11023 -0.016577 &
  13027 -0.035137 &
  14000 -0.349085 &
  19000 -0.015324 &
  20000 -0.045057 &
  26000 -0.014411
c
M8 5011 -0.391305 &      $ B4C Control Rods
  5010 -0.391305 &
  6012 -0.21739
c
M9 1001 -0.111894 &      $ Water
  8016 -0.888106
c
mode n
SDEF PAR=1 ERG=2.5 POS=48 0 75
c +F6 997      $ Energy Deposition Tally (MeV/g/s.p. ----> Gy/s.p.) in Phantom
c DXT:n 0 -435.28 82.5  18 $ DXTRAN Sphere in human to sample this region more
F4:n 997      $ Cell Tally in phantom with a dose response function applied (rem/hr/source strength)
c F12:n 578.1      $ Surface Tally on reflector rim
c F22:n 578.3      $ Surface Tally on reflector bottom?
c F32:n 578.3      $ Surface Tally on reflector top?
c F42:n 577.1      $ Surface Tally on core rim
DE4 .01 .03 .05 .07 .1 .15 .2 .25 .3 .35 .4 .45 .5 .55 .6 .65 .7
   .8 1 1.4 1.8 2.2 2.6 2.8 3.25 3.75 4.25 4.75 5 5.25 5.75
   6.25 6.75 7.5 9. 11. 13. 15.
DF4 3.96e-6 5.82e-6 2.90e-7 2.58e-7 2.83e-7 3.79e-7 5.01e-7
   6.31e-7 7.59e-7 8.78e-7 9.85e-7 1.08e-6 1.17e-6 1.27e-6
   1.36e-7 1.44e-6 1.52e-6 1.68e-6 1.98e-6 2.51e-6 2.99e-6
   3.42e-6 3.82e-6 4.01e-6 4.41e-6 4.83e-6 5.23e-6 5.60e-6
   5.80e-6 6.01e-6 6.37e-6 6.74e-6 7.11e-6 7.66e-6 8.77e-6
   1.03e-5 1.18e-5 1.33e-5
nps 100000
c KSRC 48 0 75 $ KSRC 48 0 75
c KCODE 5000 1 10 500

```

**For more MCNP6 codes pertaining to this project, visit:**

<https://github.com/ondrejch/FSM/tree/master/MCNP>