

**FAST CRITICAL EXPERIMENTS IN
PLATE AND PIN GEOMETRY FORM.
THE ZEBRA CADENZA CORES,
ASSEMBLIES 22, 23, 24 AND 25.**

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This document is based on the information given in the NEACRP documents specifying the Pin-Plate Benchmark and the series of Zebra Technical Notes for Assemblies in the ZEBRA 22 series of experiments (denoted by ZTN22-1, etc). Reference is also made to a number of publications on other ZEBRA experimental programmes. Most of these documents are available on cd from the OECD-NEA.

I also wish to thank the Government of Japan for their budget to the OECD which has provided me with contracts during the course of this work of compilation and evaluation of this reactor physics benchmark.

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The main difference is the explicit representation of the superlattice grid plates in the detailed models. Also the adjustments made to the k-effective values to be used with the simplified models have been reevaluated. The opportunity has also been taken of including k-effective values calculated using the more recent nuclear data libraries JEFF-3.1 and JENDL-3.3, calculated using MCNP5. MCNP models are included in Appendices. Reactivity perturbation measurements have been calculated to verify the consistency of different measurements.

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**FAST CRITICAL EXPERIMENTS IN PLATE AND PIN GEOMETRY FORM.
THE ZEBRA CADENZA CORES: ASSEMBLIES 22, 23, 24 AND 25.**

IDENTIFICATION NUMBER:

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KEY WORDS:

fast critical experiments, LMFR, GCFR, ZEBRA, CADENZA Programme, pin and plate geometry lattices, mixed uranium-plutonium dioxide, uranium dioxide plus plutonium metal, sodium cooled, steel structure, sodium voiding, spectral indices, reactivity perturbations, MONK models, MCNP models.

SUMMARY

The ZEBRA CADENZA Experiments consisted of a series of four simple geometry cores, two of which, Zebra 22 and 24, used plate geometry components and two, Zebra 23 and 25, pin geometry components. One plate geometry core, Zebra 22, and one pin geometry core, Zebra 23, contained sodium and the other two were the corresponding cores voided of sodium. Measurements were made to enable the relationships between the four cores to be analysed in more detail.

The cores were surrounded by natural uranium blankets and steel reflectors.

The plate geometry cores contained plutonium metal plates and natural uranium oxide plates whereas the pin geometry cores used mixed uranium-plutonium oxide pins.

The uranium in core and blanket regions was natural. The average plutonium enrichment in the core, $[Pu/(U+Pu)]$, was ~24%. The fissile content of the plutonium, $[(Pu239+Pu241)/Total Pu]$ was ~80%

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The main difference is the explicit representation of the superlattice grid plates in the detailed models. Also the adjustments made to the k-effective values to be used with the simplified models have been reevaluated. The opportunity has also been taken of including k-effective values calculated using the more recent nuclear data libraries JEFF-3.1 and JENDL-3.3, calculated using MCNP5. MCNP models are included in Appendices. Reactivity perturbation measurements have been calculated to verify the consistency of different measurements.

1 DETAILED DESCRIPTION

1.0 Overview

ZEBRA (the Zero Energy Breeder Reactor Assembly) was located at the Winfrith Atomic Energy Establishment, AEEW, of the United Kingdom Atomic Energy Authority, UKAEA, and operated from 1962 to 1982. It was used to validate fast reactor neutronics methods and nuclear data. The CADENZA programme (1980-1982) was the final one carried out in ZEBRA and involved studies on assemblies built using components in both plate geometry and pin geometry form.

The team who carried out the measurements and analyses in the Cadenza programme included the following:

B L H Burbidge, B Franklin, M Grimstone, G Ingram, S E Johnson, A D Knipe, J Marshall, Miss A M Osmond, Miss P A Smart, Miss M P Smith, P M J Stone, and J M Stevenson. The information on the measurements, and the associated analyses carried out by the Zebra team, contained in the present document, have been taken from the series of Zebra Technical Notes, and in particular those in the series ZTN22. Grateful thanks are expressed to these authors. In several cases parts of the text in these documents have been reproduced here unaltered. The experiments were also formulated in the 1980s as an NEACRP benchmark, the Pin-Plate Benchmark, and the associated documents have also been used as sources. Especial thanks are expressed to Gerry Ingram and Mike Stevenson whose work was key to these experiments being carried out and successfully analysed, and subsequently to them being adopted as benchmarks by the NEACRP.

The ZEBRA Zero Power Critical Facility

The ZEBRA facility was housed in a cylindrical steel containment building, as shown in Figure 1.1. The reactor could accommodate cores, blankets and shielding assemblies with a wide range of compositions and sizes up to a 3 m cube. A top view is shown in Figure 1.2 and a vertical drawing in Figure 1.3. The component materials were stacked in thin-walled steel sheaths to form the elements, nominally 5x5 cm square and 3 m long, as shown in Figure 1.4. In the Cadenza cores most elements were in the form of double elements. These were of two types, the "standard" double elements, as shown in Figure 1.6, and the "instrumented" double elements. These latter were designed to hold instruments to measure temperature and Pu239 fission rates. The elements were located in a steel bedplate. Lateral support for groups of 5x5 elements was provided at their tops and at two intermediate positions by thin steel lattice plates (the super-lattice grid plates). The materials in the elements were in either plate form or consisted of mini-calandria containing a 4x4 array of pins.

Assemblies consisted of core regions surrounded by blanket regions outside which were regions of steel shielding material. The blanket and shield regions were chosen to be of sufficient thickness to ensure that the core neutronics was not influenced by the materials beyond the shield regions.

Figure 1.3 shows the dimensions of the reactor regions (in feet and inches). The top of the upper super-lattice grid plate is 3 m (~9ft 10in) above the top of the bedplate and the elements, which are 3 m long and slot into the bedplate, reach up to near the top of the upper super-lattice grid plate (being below this by the height of the location spigot at the bottom of the element). The tops of the elements and the upper super-lattice grid plates (surrounding the groups of 5x5 elements) can be seen in Figure 1.2.

The core sections of the elements are located between the lower two super-lattice grids, these being 100.4 cm apart and having a height of 30.4 cm and thickness of 0.25 cm.

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When the reactor is in operation the shield doors above the assembly are closed. The underside of the doors is over 1.5 m above the top of the elements, the space between being occupied by the control rod mechanisms. Concrete radial shielding surrounds the assembly structure, providing a square space about 3.5 m x 3.5 m within. The vertical steel structure which supports the bedplate and superlattice grid plates is in the four corners of this square space. The concrete radial biological shield includes places for the temporary storage of elements and there is a corridor within it with access to the assembly from the side, as can be seen in Figure 1.1.

The reactor was controlled by means of nine control rods, using two different types of control rod mechanism. Four rods, the shut-off rods, were actuated by cable-type mechanisms located above the reactor (see Figure 1.2). The remaining five rods were actuated by screw-type mechanisms located in the pit below the reactor bed-plate. These five rods comprised two safety-rods, two coarse regulating rods and a fine regulating rod. When the reactor was at power, the safety rods and shut-off rods were fully raised, while the regulating rods were used to balance the power level. The location of the control rods on the bed-plate, and their "fully raised" positions were variable. All the rods operated in guide tubes with the same external dimensions as normal elements. Control rods normally contained a similar plate arrangement to ordinary core elements and when in the raised position the core sections of the rods were aligned with the core sections of neighbouring elements and had similar neutronics characteristics to the core elements.

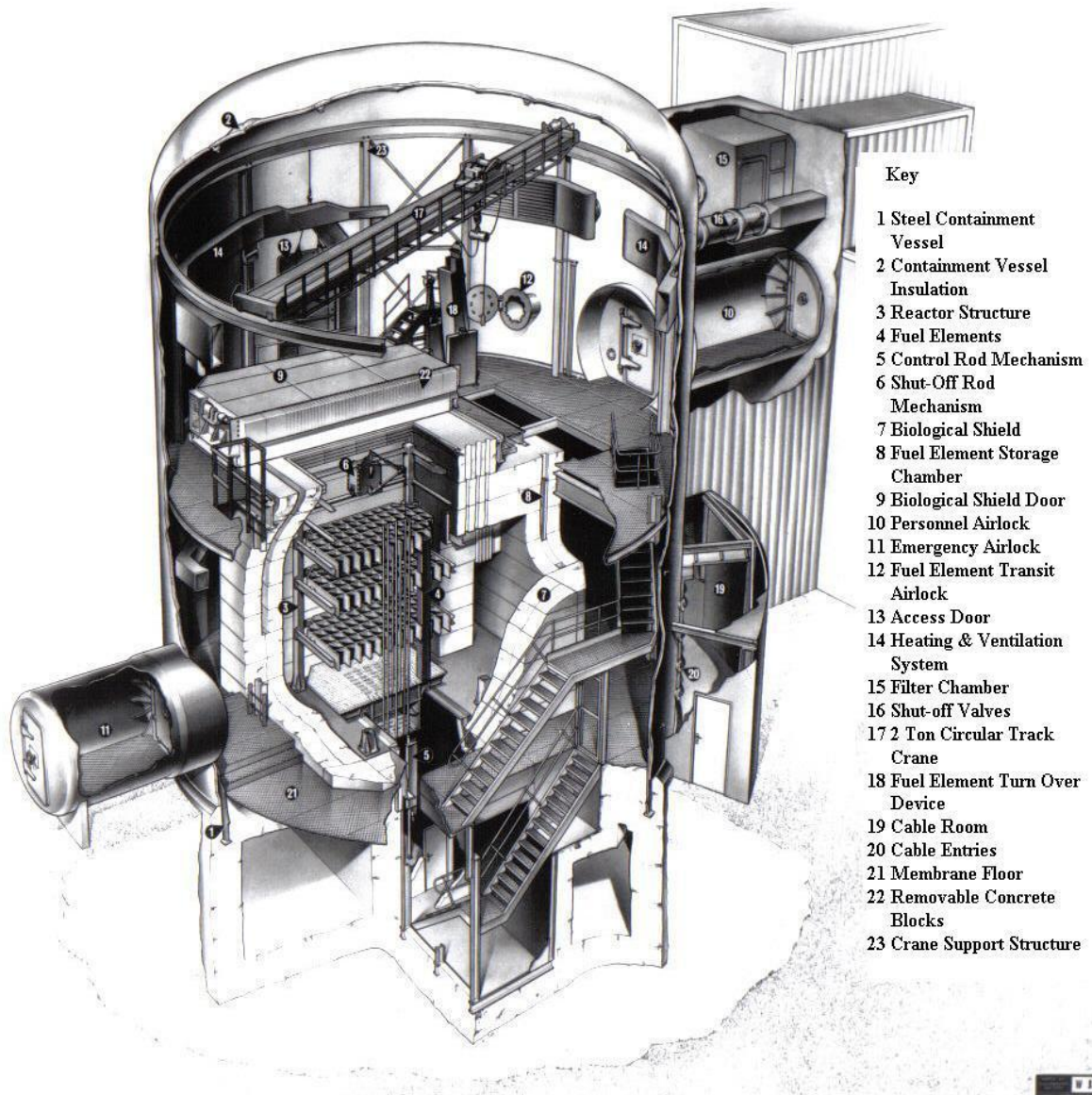
Reactivity changes were measured in terms of the balancing changes in the insertion of regulating control rods and are expressed in terms of "standard centimetres" of movement of the reference regulating rod. A "standard cm." is the worth per cm. of insertion at the point of maximum change in reactivity with insertion. The "std. cm." is then calibrated by inverse kinetics measurements, analysed using the reference set of delayed neutron data, to give reactivities on an absolute scale.

The multi-chamber scanning system measured the Pu239 fission rate at points throughout the core, the fission chambers occupying the places of plate components within core cells.

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Figure 1.1 A Perspective View of the ZEBRA Critical Assembly Facility.

The cut-away reveals the central axial section of the facility.



(With thanks to Bernard Franklin and Atsushi Zukeran, for providing these illustrations of ZEBRA)

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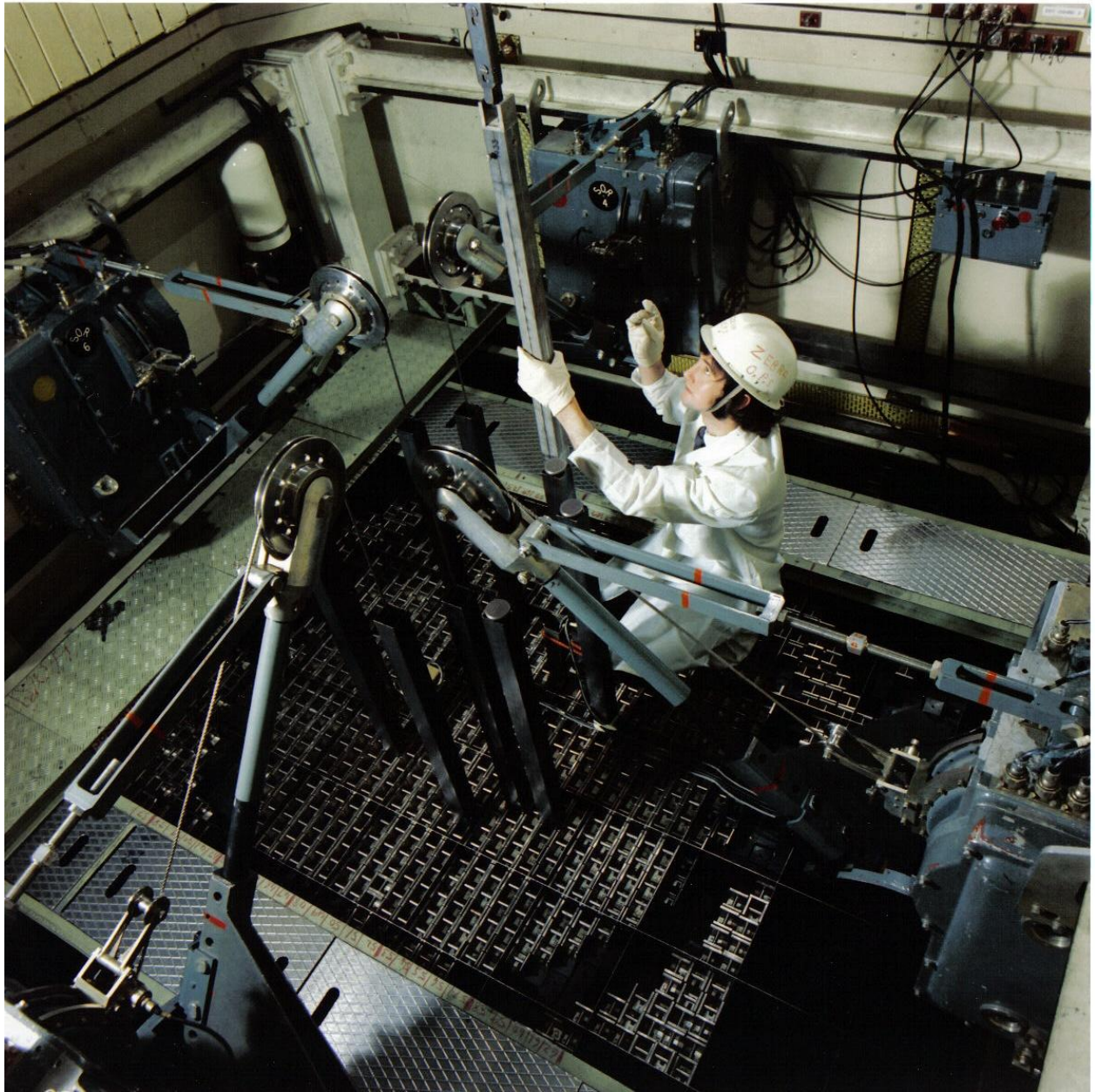


Figure 1.2 View of an Element being Loaded into a ZEBRA Assembly.

The figure shows the tops of the elements and the upper super-lattice grid (within which are the groups of 5x5 elements), with one element being loaded into the assembly. The cable mechanisms of the 4 control rods which are operated from above the assembly can also be seen.

11'-6"
 9'-10"
 3'-7 1/2"
 BIOLOGICAL SHIELDING
 MAINTENANCE BOX
 SHUT OFF ROD MECHANISM
 10.57" SQ.
 12"
 9'-10 1/4"
 7'-6 1/4"
 3'-2 3/4"
 BIOLOGICAL SHIELDING
 13'-0"
 7'-0"
 5 CONTROL ROD MECHANISM MAINTENANCE BOXES. (ELECTRICAL) MOUNTED ON SHIELDING WALL.
 HYDRAULIC DAMPER
 DAMPER SUPPORT PLATE
 SCREW OPERATED MECHANISM (SAFETY RODS) (COARSE REGULATING RODS) (FINE REGULATING ROD)
 BROACH UNIT
 CONTROL GEAR SUPPORT PLATE
 BEDPLATE
 SUPPORTING STRUCTURE
 LATTICE PLATES
 FUEL ELEMENTS
 GUIDE TUBE
 CONTROL ROD
 FUEL PLATES
 UNDERSIDE OF SHIELD DOORS

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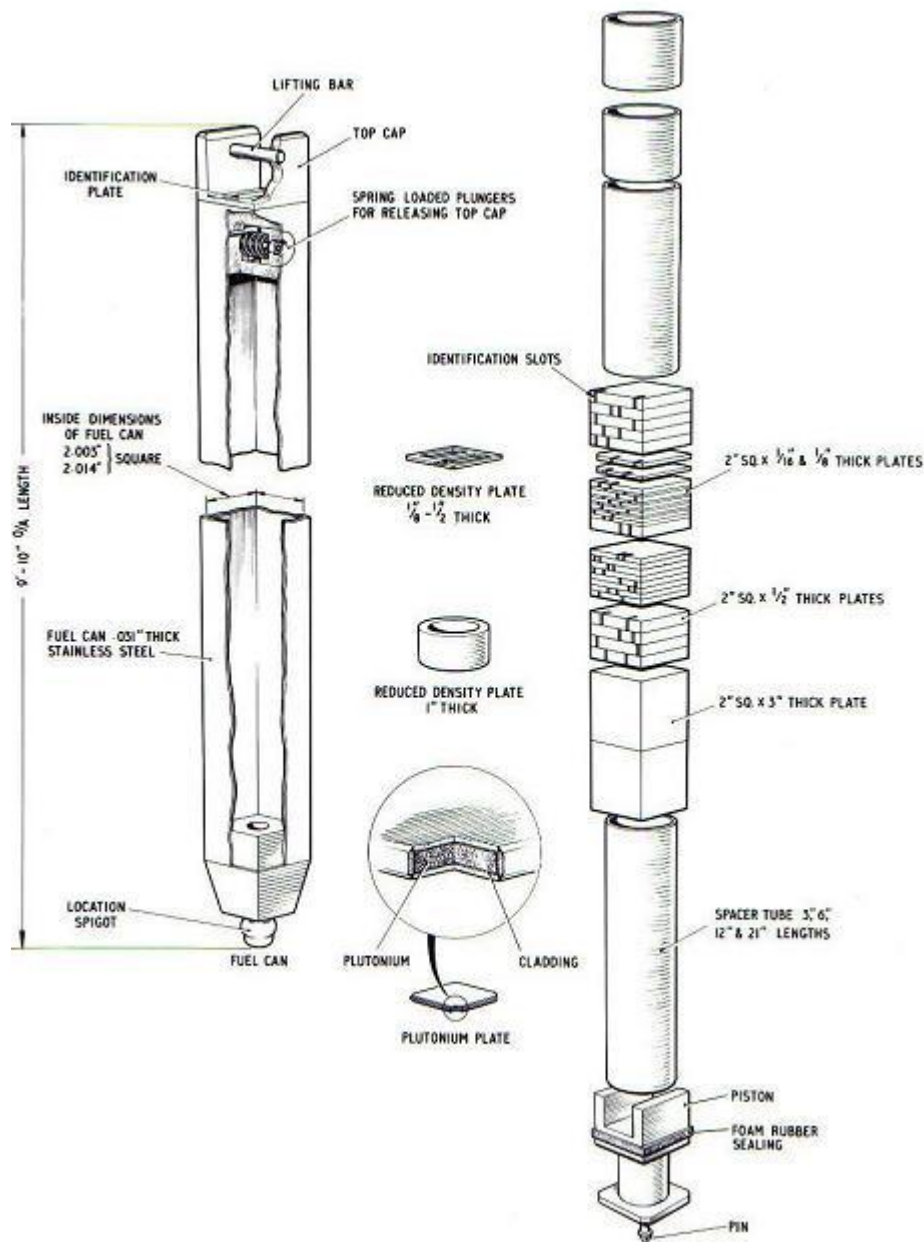


Figure 1.4 Diagram of a Fuel Element Containing Materials in Plate Form

(dimensions in feet and inches).

(There were some differences from this in the bottom and top regions of the double element.

Aluminium components were included at the top and bottom in addition to the mild steel spacer tubes.)

The CADENZA Programme

Most of the assemblies studied in ZEBRA were built using materials in plate geometry form, and this is also the case for most other fast critical assembly facilities. Measurements made in the ZEBRA BIZET programme, with some regions containing fuel in pin geometry form, had shown an inconsistency between the reactivity worths calculated for the two types of geometry using the then current UK fast reactor neutronics methods (see BTN-106). The CADENZA series of simple geometry assemblies was built to explore this difference and to provide a basis for validating the methods used to calculate the two types of cell geometry, plate and pin. The series also provides data suitable for validating the methods and nuclear data used to calculate plutonium/uranium fuelled, sodium cooled and gas cooled fast reactors.

Four assemblies were built, numbered 22 to 25. All cores were surrounded by natural uranium axial and radial blankets, and steel reflectors, thus providing a simple environment for the cores. Assembly 22 had fuel in plate geometry form and included sodium. In Assembly 23 most of the core contained materials in pin geometry form and included sodium. Assembly 24 differed from Assembly 22 in that the sodium plates were replaced by “dummy plates” having the same size and containing the same amount of steel but no sodium. Similarly, Assembly 25 differed from Assembly 23 in that sodium was absent, the sodium regions of the Assembly 23 elements being voided.

The core regions of Assemblies 22 and 24 were essentially uniform. However, Assemblies 23 and 25 had outer rings of plate geometry elements and used mini-calandria containing groups of 4x4 pins having different plutonium enrichments in different regions of the core. Each mini-calandria contained either mixed oxide pins having an enrichment of $\text{Pu}/(\text{U}+\text{Pu}) = 24\%$ or two types of mixed oxide pin having an average plutonium enrichment, for the array of 4x4 pins, of 24%.

The effective multiplication values, k_{eff} , of the four related cores provide a test of the consistency of the methods used to treat cells in plate and pin geometry form although account must be taken of the different oxygen content. This is a consequence of the plutonium in the plate geometry cores being in metal form and that in the pin geometry cores in oxide form (the uranium being in oxide form in both geometries). Thus the oxygen content is about 24% lower in the plate geometry core. There is also a difference in composition due to the gallium stabiliser and the copper cladding used for the plutonium metal plate, and there are other differences in the constituents.

In addition to the four cores the pin and plate elements were replaced in stages and intermediate k_{eff} values determined. Two of these intermediate cores have also been specified here as critical assemblies, the k_{eff} values in these cases having been determined by measuring the changes in reactivity relative to the pin geometry assemblies, 23 and 25. Extrapolated all pin cores were also specified in the original studies.

The assemblies were used to define Benchmarks for an International Comparison of Calculations, sponsored by the OECD/NEA Committee on Reactor Physics, the NEACRP, in 1982 (see NEACRP-A-445). The results of the intercomparison are described in NEACRP-L-300, written in August 1987. The reactivity effects of heterogeneity were separated into two components, the effect excluding streaming and the streaming effect. The effect excluding streaming was calculated to be about +1.8% dk for the plate cell and about +0.4% dk for the pin cells, although the calculated values varied depending on the method and data set used, with a range of about 0.4% dk and 0.2% dk respectively. The streaming effects of the heterogeneity calculated for the two geometries were similar, being about -0.2% dk for the whole core. However, again the values calculated by the different participants covered a wide range. At the time of this analysis the UK methods were overestimating the reactivity of the pin geometry Assembly 23 relative to the plate geometry Assembly 22. The measured value of the reactivity change resulting from replacing the plate geometry elements by pin geometry elements was a reduction of about 0.9% dk. This was compensated by the addition of extra core elements at the

edge of the core to restore criticality. However, using a one dimensional plate cell model the calculated reactivity difference between the two critical assemblies was about 0.9% dk, implying that the effect of replacing the plate elements by pin elements was being calculated as close to zero instead of a reduction of 0.9% dk. When a three dimensional model was used the discrepancy was reduced to about 0.5% dk (the uncertainty on the difference between the measured k_{eff} values being $\pm 0.13\%$ dk 1 s.d.). Using current nuclear data libraries and Monte Carlo codes to calculate detailed models of the assemblies the relative discrepancies between the plate and pin geometry cores are in the range 0.25% dk to 0.4% dk, depending on the nuclear data set used.

At ANL the ZPPR-12 assemblies were built to study the problem of treating heterogeneity in plate versus pin geometry (NEACRP-A-688 and NEACRP-A-723) and are highly relevant to investigations of this effect. The ANL Monte Carlo calculations made for these ZPPR plate and pin geometry cores were consistent for the two geometries (within the uncertainty of $\pm 0.18\%$ dk). However, the ANL Monte Carlo calculations made for the CADENZA cores were discrepant, with a difference of $0.52 \pm 0.19\%$ dk. There is consistency between the results for the ZEBRA and ZPPR pin cell assemblies, suggesting that there was a problem in the analysis made for the ZEBRA plate geometry assembly, or arising from the differences of composition.

The reactivity effects of these differences in composition were calculated. The difference in oxygen content gives a calculated difference of 0.3% dk and the copper cladding on the plutonium plate gives a difference of about 0.15% dk and so the errors in these calculated effects would need to be substantial to explain the discrepancy. There is also the effect of the gallium in the plate geometry cores to be taken into account.

These Zebra measurements also provide a test of the accuracy of predicting the reactivity effect of voiding sodium. Sodium voiding reactivity worth measurements were also made in regions of the cores.

Plutonium enrichment experiments were performed to provide a check of the reactivity scale based on kinetics measurements (interpreted using delayed neutron data). The cell geometry of groups of elements was altered to provide further checks on the methods used to calculate cell heterogeneity and the reactivity changes and reaction rate distributions through the cells were measured. Various material worth measurements were also performed. Central reaction rate ratios and Pu-239 fission rate distributions across the core were also measured.

The CADENZA Programme was the final one carried out in the ZEBRA facility.

Suitability of the measurements as benchmarks

The measurements are summarised in Table 1.1. Not all of these are currently being recommended as benchmarks although descriptions are included and the necessary supplementary references listed so that they can be analysed. The reactivity coefficients were only measured to provide corrections for temperature and Pu241 decay and are not benchmarks.

Concerning the suitability as benchmarks there are two questions to be considered:

- (i) are the data complete and have the uncertainties been assessed
- (ii) do the measurements provide useful information

The data are considered to be complete, and are recommended as benchmarks, for:

the criticality measurements of the four cores and the differences between the criticality of the different cores (including the pin cores with central plate zones), six cores in all;

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- the spectral index measurements;
- the reactivity perturbation measurements (for element interchange, sodium voiding and flooding, and the substitution of different materials);
- the Pu239 fission chamber scans in Core 22 and 24.

However, there is a question over the usefulness of the fission ratio measurements made using fission chambers (except for the fission ratios Pu240/Pu239 and Pu241/Pu239 for which the accuracy requirements are not so high). The measurements made using foils within plates can be accurately modelled but there could be a problem modelling the chambers in the measurement position. Also, some of the small sample reactivity worth measurements might not have sufficient accuracy to be useful (such as the measurements made for Al and Al₂O₃ designed to give information on the reactivity worth of oxygen). Some of the reaction rate scan measurements through cells might not have enough accuracy to give useful information, because the variations through a cell are so small for some reactions, and these measurements have not been evaluated in the present document.

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Table 1.1 Summary of Assemblies and Measurements

	Basic Assemblies				Variants	
	Core 22	Core 23	Core 24	Core 25	Core 23 + inner plate zone	Core 25 + inner plate zones
Geometry	Plate	Pin (outer ring plate)	Plate	Pin (outer ring plate)	Pin/plate	Pin/plate
Materials	Pu/UO ₂ , Na, SS.	U-PuO ₂ , Na, SS.	Pu/UO ₂ , Void, SS.	U-PuO ₂ , Void, SS.	Includes Na	Voided of Na
<u>Measurements</u>						
Criticality	keff	keff	keff	keff		
keff difference		k difference	k difference	k difference	k difference	k difference
Spectral index	F25/F49, F28/F25, C28/F49, F40/F49, F41/F49					
Element interchange reactivity perturbations	Pin versus plate	Plate versus pin	Pin versus plate	Plate versus pin		
Sodium voiding and flooding	2/3 axial regions. 9 elements	2/3 axial regions. 9 elements	2/3 axial regions. 9 elements	2/3 axial regions. 9 elements		
Small sample perturbations	Plate interchange PuO ₂ , Al, Al ₂ O ₃ , C, SS, Cu	Pin interchange PuO ₂ , Al, Al ₂ O ₃ , C, SS, Cu	Plate interchange PuO ₂ , Al, Al ₂ O ₃ , C, SS, Cu, Na	Pin interchange PuO ₂ , Al, Al ₂ O ₃ , C, SS, Cu		
Cell heterogeneity	Change of thickness of Pu plates					
Reactivity coefficients	Temperature Pu241 decay					
Pu239 multichamber and foil scans	F49 and Foil activation	F49 chamber	F49 chamber	F49 chamber	F49 chamber	F49 chamber
Detailed reaction rate scans in cells	F49, F28, C28, F40, Rh103(n,n') In115(n,n')					

1.1 Description of the Critical Configurations.

1.1.1 Overview of Experiment

Four critical assemblies were built in the Cadenza programme, two in plate geometry (Assemblies 22 and 24) and two in pin geometry (Assemblies 23 and 25). There were also intermediate cores, with plate zones at the centres of pin geometry cores. The measurements of primary interest are the reactivities of the reference cores and the differences in reactivity between the different reference cores.

The critical configurations have been evaluated and are considered acceptable for use as benchmarks.

1.1.2A Description of Experimental Configurations.

The plate geometry Assemblies 22 and 24 are described first, followed by the pin geometry Assemblies 23 and 25.

All the assemblies consist of arrays of square section elements held vertically and located on a bedplate. The contents of the elements are built up from components grouped to form the basic cells. There is a central region of core elements surrounded radially by a region of radial blanket elements, containing natural uranium, around which are steel shield (or reflector) elements. The core elements have a central region of core cells above and below which are the axial blanket regions and shield regions. The same control rods were used in all cores. These use plate geometry components and include sodium.

The plan view of the Assembly 22 is shown in Figure 1.7A. Element positions are indicated by their X and Y coordinates, the central position being $(X,Y) = (50,45)$. The outer radial boundary of the blanket is the same in all the CADENZA Assemblies, although the core radial boundary varies. The thickness of the axial blanket is the same in all the assemblies although there are small variations in the core height. The axial and radial steel reflector regions are the same in all of the CADENZA Assemblies.

Elements are grouped in arrays of 5x5 separated by a small gap of 0.2665 cm by the three mild steel superlattice grids. The top superlattice grid plate is above the region of the assembly modelled. The two intermediate superlattice grids are above and below the core section, in the axial blanket/shielding areas. Nominally these two grids extend between 50.2 cm and 80.6 cm above and below the mid plane, each being 30.4 cm high and are 0.25 cm thick. (The horizontally smeared density of the grids is quoted as being 0.154 g/cm^3 .) The distance between the centres of elements within a group of 5x5 is 5.3721 cm and the overall average spacing is 5.4254 cm (the distance between the centres of two superlattices divided by 5). (Please note that this latter spacing has usually been assumed in the ZEBRA calculational models to be found in the ZEBRA documentation.) The dimensions of the element sheath, are inside width 5.102 cm, outside width 5.2544 cm. The nominal width assumed for all the square plate components situated within an element sheath is 5.067 cm.

Dimensions and compositions of components were given in documents presented to the OECD/NEA Committee on Reactor Physics in the 1980s (describing the Pin-Plate Benchmark) and these formed the basis for the data adopted in the present document. Additional data have been obtained from the Zebra PLATEDATA Database. Sometimes slightly different values are given in different sources.

Description of the Plate Geometry Cores, Assemblies 22 and 24.

There are 24 core cells in the core region of a Core 22 element, arranged one above the other. They are composed of plutonium metal plates, natural uranium oxide plates, sodium plates and (in the central 22 cells) a steel plate. Core 22 was built in two versions, 22A and 22B which differed only in the axial orientation of the core region cells. The cells do not have axial symmetry and in the first version of the core, 22A, all of the core cells had the same axial orientation. It was found that the fission rate scans showed an axial asymmetry and so alternate cells were inverted to give axial symmetry. This is version 22B (Figure 1.5). The difference in reactivity between the two versions was found to be negligibly small compared with the uncertainties, $(-1 \pm 4) \times 10^{-5}$ dk.

The plate cells of Assembly 24, the “sodium voided” core, differ from those of Assembly 22 in that the sodium plates have been replaced by “sodium dummy” plates. These steel plates are of three different designs (denoted by X, Y and Z), X and Y being rings of steel and Z having a honeycomb form.

The core elements were not all identical. There were small differences between the plutonium metal plates used in the central region and in the outer region of the cores and in the special elements. The element loading of the core of Assembly 22 is shown in Figure 1.8A.

To summarise the naming convention, in Core 22 the types of core element were:

C22+01C which used the Mark VIII plutonium plate, PUVIII8.

C22+01D which used the Mark IX plutonium plate, PUIX8.

The Mark X plutonium plate, PUX8, was used in the instrumented elements containing resistance-bulbs (denoted by RE), thermocouples (denoted by TE) and chambers of the multi-chamber scanning system (denoted by ME, which contain 5 chambers, NE (the central element) containing 9 chambers and these are paired in these multi-chamber double elements with the HE element arrays). Elements A, B and Z were used in special experiments and these contained the plutonium plates PuIV4, PuVII8 and PuII8 respectively. The reactivity effects of the differences between the plutonium plates are very small and were measured so that corrections could be made for the differences.

The elements in the core of Assembly 24 (Figure 1.8B) have names of the form C24+20CX, where X denotes the sodium dummy plate (X, Y or Z). In addition there were the elements containing the plutonium metal plates of the types used in the corresponding Core 22 elements, C24+20BX, and DX and the instrumented elements RX, TX, MX, NX, and HX (containing the cores of type E).

An automatic loading machine was used to load the plates into an element. This required the edge of the plates which have the identification slots to be on the same side. Thus all of the plates in an element have the same orientation (see Figure 1.4). Figure 1.4 shows a piston at the lower end of the column of materials. This is not present in a double element this being replaced by aluminium components.

(Note the final number, N, in the name of a plate component corresponds to the nominal thickness, or height, in inches, or alternatively to the thickness in the form 1/N inches).

The core region cells

The standard plate cells of Assembly 22 are illustrated in Table 1.2 and Figure 1.5. They contain one plutonium metal plate, two UO₂ plates, three sodium plates and one 40% stainless steel plate (a plate with sections cut out of it). There are a total of 24 cells in the core, 22 standard cells and two cells with the 40% stainless steel plate removed. These two cells are at the top and bottom of the core. This steel plate was omitted to make the height of the core match the pin cell core height more closely. The standard cell is Cell 1. Cell 11 is the inverse of Cell 1 and was combined with it in version 22B of the Assembly to make the core axially symmetrical.

Table 1.2 Standard Plate Geometry Cells

	Cell 1	Cell 11
(Top)	Na	Na
	UO ₂	UO ₂
	Na	40% Steel
	Pu	Pu
	40% Steel	Na
	UO ₂	UO ₂
(Bottom)	Na	Na

Notes: Na is a NASTDL4 plate
UO₂ is a U023R4 plate
Pu is a PUVIII8 plate
40% Steel is a STSTF8 plate.

Thus the central 22 cells in Core 22B can be considered as 11 double cells symmetric about the mid plane of the double cell, formed by inverting Cell 1 to form Cell 11 and placing Cell 11 above Cell 1 (the combined cell being called Cell 13). The end cells, Cell 2 and Cell 12 are formed by omitting the 40% Steel plate from Cell 1 and Cell 11 respectively. The pattern of cells in the core of Assembly 22B, going from the top downwards, is

(2, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 11, 1, 12)
or
(2, 13, 13, 13, 13, 13, 13, 13, 13, 13, 13, 13, 12).

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The arrangement of Cell 1 and Cell 11 forming 11 symmetric double-length cells in Core 22B is shown in Figure 1.5. The end cells, Cell 2 and Cell 12, are also shown.

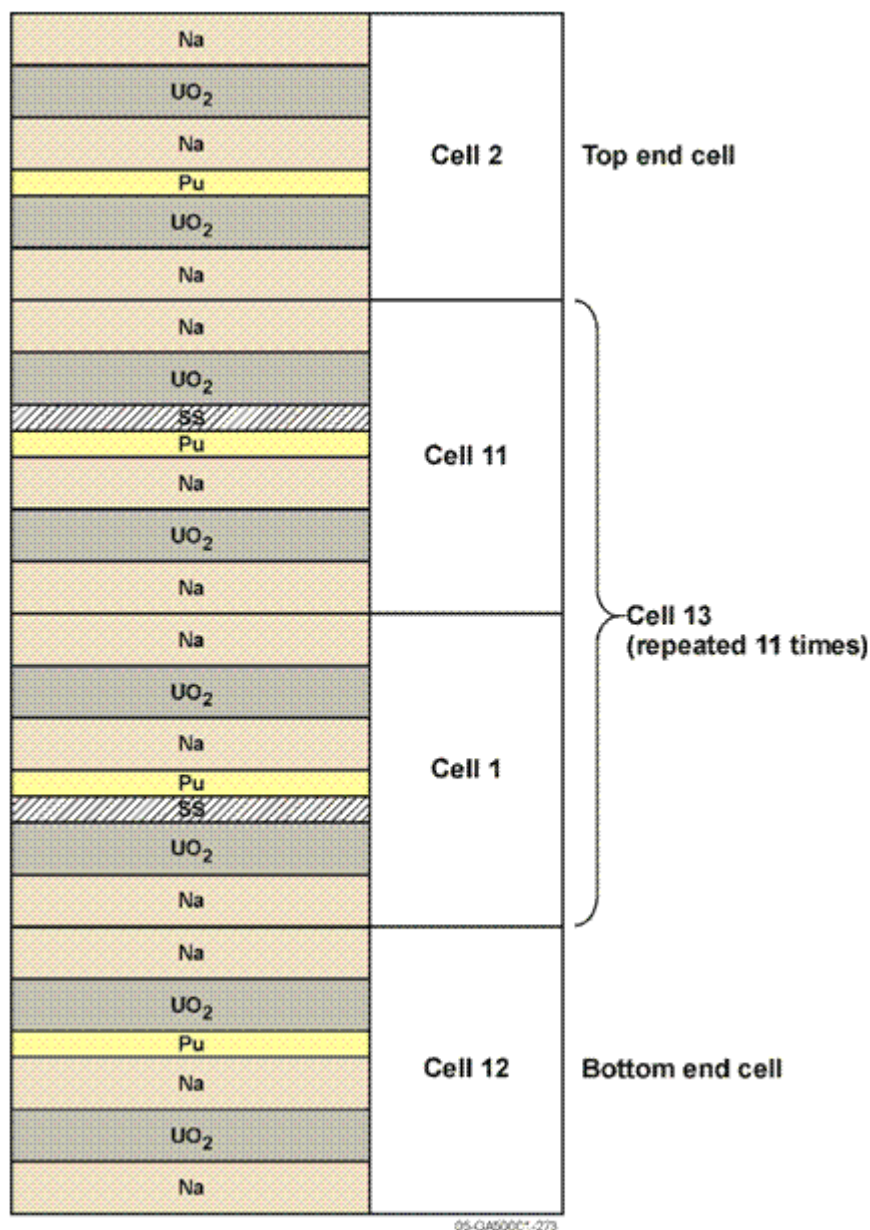


Figure 1.5 Core Cells of Assembly 22B.

The plutonium metal plates have welded copper and steel cans (see Figures 1.9, 1.10, and 1.11), the UO₂ plates have brazed steel cans (Figures 1.12 and 1.13) and the sodium plates have welded steel cans (Figure 1.14).

The objective of the programme of measurements was to provide data for validating calculational methods and nuclear data, with an emphasis on the treatment of cell heterogeneity in whole core criticality calculations. Measurements were made to enable simplifications to be adopted in calculation, in particular measurements of the differences between elements containing the different plutonium plates.

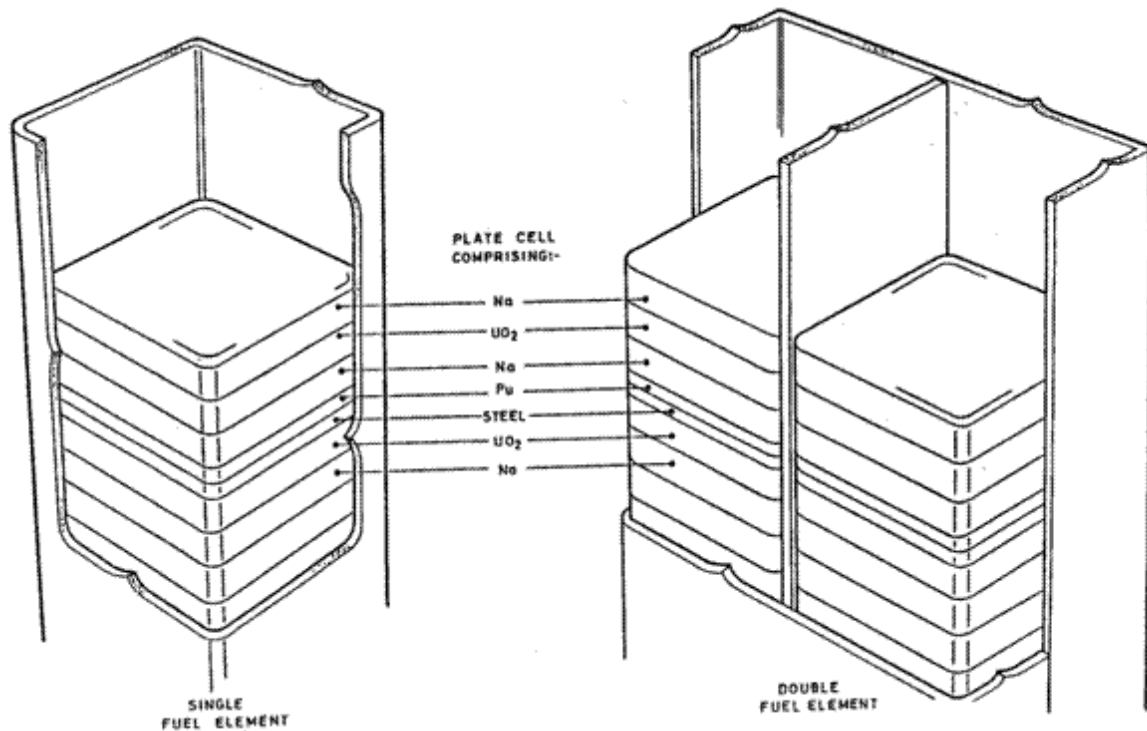


Figure 1.6 Plate Arrangement in the Single and Double Elements.

Most elements were in the form of double elements, some of these being instrumented double elements.

The wall between the two columns of plates in the double element, as it is shown here, applies to the "standard" double element. In the instrumented double elements there is a V-shaped spacer which serves to keep the two columns apart and allow space for the cabling.

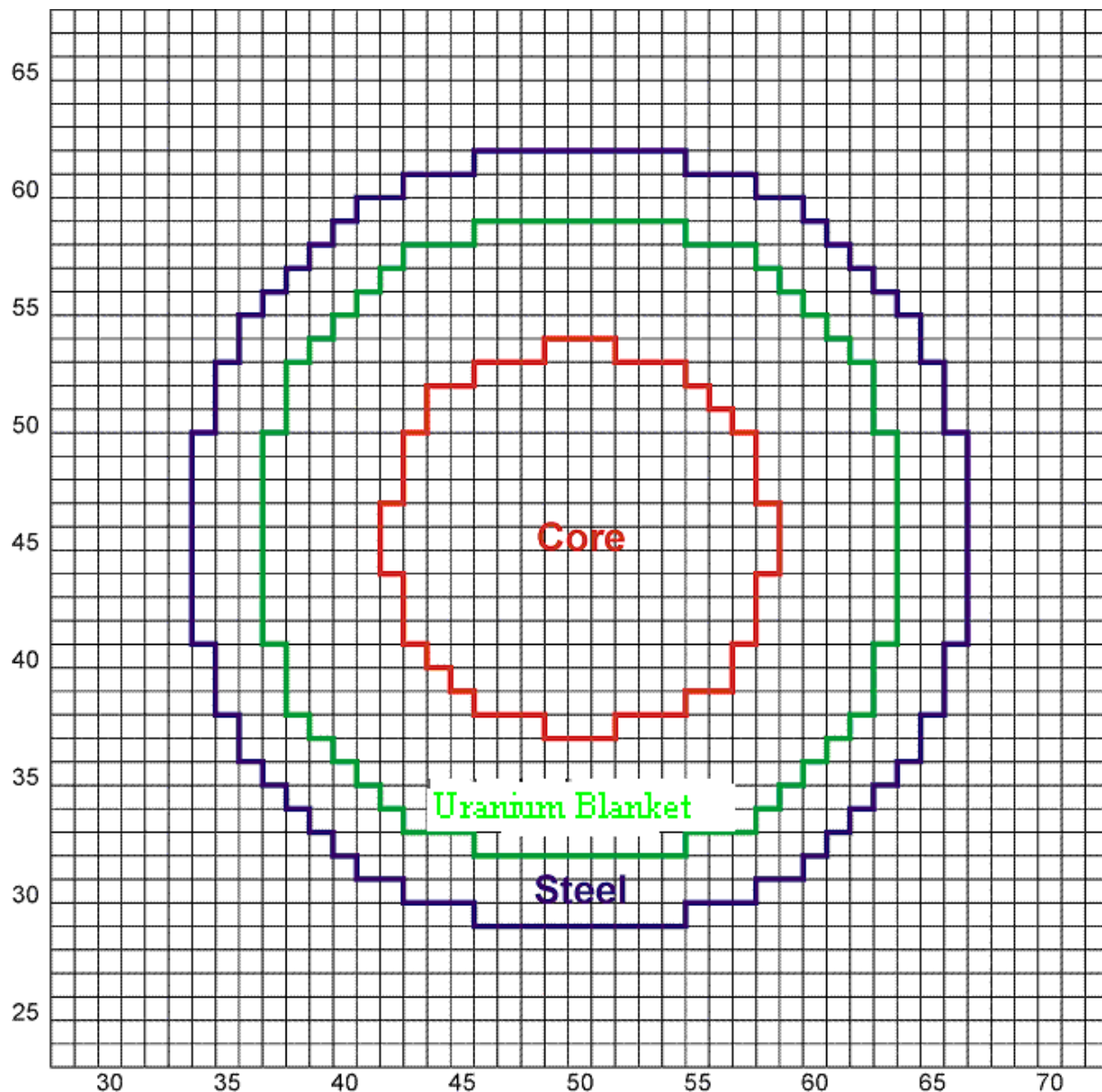


Figure 1.7A Plan of Assembly 22.

In Assembly 22 there are 215 core elements, 386 uranium blanket elements and 276 steel shielding elements.

(The equivalent radii corresponding to these areas are 8.273 p, 13.831 p and 16.708 p where p is the lattice pitch. For the average overall lattice pitch of 5.4254 cm these radii are 44.884 cm, 75.039 cm and 90.648 cm.)

In Assembly 23 there are 226 core elements, equivalent radius, 46.018 cm (375 blanket elements).
In Assembly 24 there are 231 core elements, equivalent radius, 46.523 cm (370 blanket elements).
In Assembly 25 there are 243 core elements, equivalent radius, 47.716 cm (358 blanket elements).

Outside the radial shield the lattice positions are empty in the remainder of the 3m x 3m area, apart from the super-lattice grid plates (see Figure 1.3).

Instrumented elements

Included in the core are a number of instrumented elements. These are the double elements containing resistance bulbs for measuring temperature (elements of the type E containing these are denoted by RE) those containing thermocouples (denoted by TE) and those containing the Pu239 fission chambers of the multichamber scanning system (denoted by HE, ME and NE) with the elements ME and NE containing the fission chambers and HE being the associated element in the double element.

Corrections for the reactivity differences are made to replace these elements by standard elements in the calculational models. These corrections are based on measurements made in the cores.

C22+01RE has 3 resistance bulbs centred on Pu plates and located at 30.48 cm and 1.78 cm above the core centre plane and 27.94 cm below the core centre plane. The bulbs are between the plate stacks and against one stack.

C22+01TE has a thermocouple inserted between the stacks and brazed to a special dividing strip, near the core centre plane.

In the pin geometry assemblies:

C22+03RA and C22+03RC are resistance bulb elements, similar to C22+01RE but are in pin cell elements. The 3 bulbs are located vertically at the side of the calandria and approximately 30.48 cm above and below the core centre plane and on the centre plane.

All special elements contain the v-shaped dividing strip between the two component stacks to protect the connecting leads.

The Pu239 fission chambers in the plate geometry elements (denoted as plate component MFC38, thickness 0.95 cm) each replace either a sodium plate plus a 40% steel plate (nominal thickness 0.616 cm + 0.317 cm = 0.933 cm) or two sodium plates (2 x 0.616 cm nominal thickness), in which case a stainless steel plate, STST8V, (0.3175 cm thick, weight 16.96 g, essentially the same weight as the steel of a sodium plate) is placed next to the chamber (2 x 0.616 - 0.3175 = 0.9145 cm).

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For Assembly 22B the pattern of the standard and multi-chamber cells is shown in Figure 1.7B:

	Cell 13 (standard core cell)	Cell 14	Cell 15
(Top)	Na	Na	Na
	UO2	UO2	UO2
	40% Steel	40% Steel	Pu
	Pu	Pu	Na
	Na	Na	UO2
	UO2	UO2	Na
	Na	STST8V	MFC38
	Na	MFC38	UO2
	UO2	UO2	Na
	Na	Na	Pu
	Pu	Pu	40% Steel
	40% Steel	40% Steel	UO2
	UO2	UO2	Na
(Bottom)	Na	Na	

Figure 1.7B Positions of the Pu239 Fission Chambers in Core Cells of Assembly 22B which Replace Cell 13.

Element ME replaces the normal core element cell pattern (see ZTN22-11):

(2, 13, 13, 13, 13, 13, 13, 13, 13, 13, 13, 12).

by

(2, **14**, 13, 11, **15**, 1, 13, **14**, 13, 11, **15**, 1, 13, **14**, 12).

That is, it contains 5 Pu239 chambers and has 8 fewer sodium plates, and 2 fewer 40% steel plates, but an additional 3 steel plates STST8V.

At the centre of the core is one element NE which has the cell pattern:

(2, **14**, 11, **15**, **15**, 1, **14**, **14**, **14**, 11, **15**, **15**, 1, **14**, 12)

This contains 9 Pu239 fission chambers and has 14 fewer sodium plates 4 fewer 40% steel plates but an additional 5 STST8V plates.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53									1D	1D	1D								
52						1D	1D	1D	1D	1D	1ME	1HE	1D	1D					
51				1C	1RE	1D	1D	1D	1HE	1C	1RE	1D	1D	1D	1RE				
50				1D	1RE	4	1C	1D	1ME	1C	1RE	1D	1C	2	1RE	1D			
49			1D	1D	1ME	1C	1C	1C	1C	1C	1HE	1C	1C	1C	1ME	1D	1D		
48			1D	9	1HE	1C	1CD	1C	1C	1C	1ME	1C	1CD	1C	1HE	1D	1D		
47			1D	1CD	1RE	1TE	1C	1RE	1C	1C	1C	1C	1C	1TE	1RE	1CD	1D		
46		1D	1D	6	1RE	1TE	1C	1RE	1ME	1HE	1C	1C	1C	1TE	1RE	8	1D	1D	
45		1D	1D	1ME	1HE	1ME	1C	1ME	1CD	1NE	1HE	1ME	1C	1ME	1HE	1ME	1D	1D	
44		1D	1D	7	1C	1HE	1C	1HE	1CD	1HE	1ME	1HE	1C	1HE	1C	5	1D	1D	
43			1D	1CD	1C	1TE	1TE	1C	1C	1CD	1RE	1RE	1TE	1TE	1C	1CD	1D		
42			1D	1D	1HE	1C	1CD	1C	1ME	1C	1C	1C	1CD	1C	1HE	1D	1D		
41			1D	1D	1ME	1C	1C	1C	1HE	1C	1C	1C	1C	1C	1ME	1D	1D		
40				1D	1RE	1	1C	1D	1RE	1C	1ME	1D	1C	3	1RE	1D			
39					1RE	1D	1D	1D	1RE	1C	1HE	1D	1D	1ME	1RE	1C			
38						1D	1D	1HE	1ME	1D	1D	1D	1D	1HE					
37									1D	1D	1D								

Figure 1.8A Assembly 22 Reference Core Loading (Fissile Elements)

The plutonium metal plates used in different types of element are as follows. In the 1C elements type PuVIII8 plutonium plates are used and in 1D elements type PuIX8. Most elements are in the form of double elements.

Mark PuX8 plates are used in the paired instrumented elements (of type E) containing resistance-bulbs which measure temperature (RE, 10 double elements), thermocouples (TE, 4 double elements) and chambers of the multichamber scanning system (HE, ME and NE; 20 double elements, with HE being the element partnering the multichamber element. Elements ME hold 5 fission chambers and the element NE holds 9). (See ZTN22-11 for more details of core loadings and element compositions.) Elements A, B and Z are used in special experiments and these contain plates PuIV4, PuVII8 and PuII8 respectively. CD denotes a C element with a demountable sheath which permits the positions of the plates in the column of plates to be measured.

The numbers 1 to 9 denote the control rods. These contain approximately the same quantities of plutonium and uranium as the normal core elements and measurements were made of the reactivity equivalence between these and standard core elements.

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	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53						0BZ	0CZ	0DZ	0DZ	0DZ	0CZ	0CZ						
52					0DZ	0DZ	0DY	0DY	0DY	0MY	0HY	0DZ	0DZ					
51			0CZ	0RZ	0DY	0DY	0DY	0HY	0CX	0RY	0DY	0DY	0DY	0RZ	0CZ			
50			0DZ	0RY	4	0CY	0DY	0MY	0CX	0RY	0DY	0CY	2	0RY	0DZ			
49		0DZ	0DY	0MY	0CY	0CY	0CX	0CX	0CY	0HX	0CX	0CY	0CY	0MY	0DY	0DZ		
48	0CZ	0DZ	9	0HY	0CY	0CX	0CX	0CX	0CY	0MX	0CX	0CX	0CY	0HY	0DY	0DZ		
47	0CZ	0DY	0CY	0RY	0SX	0CX	0RX	0CX	0CX	0CX	0CX	0CX	0TX	0RY	0CY	0DY	0CZ	
46	0DZ	0DY	6	0RY	0SX	0CX	0RX	0MX	0HX	0CX	0CX	0CX	0TX	0RY	8	0DY	0DZ	
45	0DZ	0DY	0MY	0HY	0MX	0CX	0MX	0CX	0NX	0HX	0MX	0CX	0MX	0HY	0MY	0DY	0DZ	
44	0DZ	0DY	7	0CY	0HX	0CX	0HX	0CX	0HX	0MX	0HX	0CX	0HX	0CY	5	0DY	0DZ	
43	0CZ	0DY	0CY	0CY	0TX	0TX	0CX	0CX	0CX	0RX	0RX	0TX	0TX	0CY	0CY	0DY	0CZ	
42		0DZ	0DY	0HY	0CY	0CX	0CX	0MX	0CX	0CX	0CX	0CX	0CY	0HY	0DY	0DZ	0CZ	
41		0DZ	0DY	0MY	0CY	0CY	0CX	0HX	0CX	0CX	0CX	0CY	0CY	0MY	0DY	0DZ		
40			0DZ	0RY	1	0CY	0RY	0CY	0CY	0MY	0DY	0CY	3	0RY	0DZ			
39			0CZ	0RZ	0DY	0DY	0RY	0CY	0CY	0HY	0DY	0DY	0MY	0RZ	0CZ			
38					0DZ	0DZ	0HY	0MY	0DY	0DY	0DY	0DZ	0HZ					
37						0CZ	0CZ	0DZ	0DZ	0DZ	0CZ	0BZ						

Figure 1.8B Assembly 24 Reference Core Loading (Fissile Elements)

The final letter in the identifier, X, Y and Z denotes the type of "dummy" (or voided) sodium plate used. The elements which do not form part of an instrumented double element have identifiers beginning with 0C and 0D. Consistently with the Assembly 22 notation the 0C elements contain the PuVIII8 plates and 0D the PuIX8 plates. Again most elements are in the form of double elements.

The instrumented elements are denoted by 0R (resistance bulbs), 0S and 0T (thermocouples), and 0M, 0N, 0H for the elements of the multi-chamber scanning system, all these instrumented elements having the plutonium plates of the type E elements. 0S differs from 0T in having a special connecting box in the lower plenum, the region below the lower reflector region (so-called because it simulated the plenum region of a fast reactor fuel element in reactor mock-up studies).

Dimensions of plate geometry components

The plates are illustrated in Figures 1.9 to 1.15.

The nominal width of all plates, other than the control rod plates is 5.067 cm (unless otherwise stated).

Note concerning the numbering of Tables. Tables giving Dimensions have the form 1.Dx those giving Material data the form 1.Mx, etc.

Table 1.D1 Dimensions of the Core Region Plates. (cm)

	Plate thickness	Core thickness	Core width
Pu metal *	0.3274	0.236	4.671
UO ₂	0.6313	0.558	4.851
Sodium **	0.613694	0.541	4.963
STNAVR4 (X)	0.616	ring	
STNAVS4 (Y)	0.616	ring	
STNAV4 (Z)	0.616	honeycomb	
40%steel, STSTF8	0.317	void regions	
Multiscan chamber	0.95		

* Note 1: These are the dimensions of the PuVIII8 plutonium plate used in the 1C element (the reference element) which occupies the central region and the majority of the core. The other plutonium plates, PuIX8 and PuX8, have a slightly different thickness, 0.3265 ± 0.0005 cm and 0.3264 ± 0.0005 cm respectively (a difference of ~ 0.001 cm or $\sim 0.3\%$, see Table 1M.18). The dimensions of the PuVIII8 plate are used in the subsequent general descriptions of the dimensions of core regions. The differences in thickness of the alternative plutonium plates, compared with the PuVIII8 plate, result in a difference in the core height of ~ 0.02 cm, a difference which is small compared with the assumed uncertainty in the core height of ± 0.05 cm. Measurements are made to correct the k_{eff} values of the cores for the differences from the reactivity of the 1C element.

** Note 2: the nominal height of the sodium plate is 0.616 cm. The value of 0.613694 cm corresponds to the measured core height. It has been assumed by the measurers that the difference in height from the value calculated using the nominal plate dimensions is because the sodium plates have been compressed by the weight of plates above.

The sodium "dummy" plates, STNAV, (or sodium voided plates) have nominally the same thickness and weight as the cans of the sodium plates. STNAVR4 and S4 are ring shaped (outer diameter 5.067 cm, inner diameter 4.6 cm) and STNAV4 is "honeycomb" shaped.

The 40% steel plate has cut-out sections (see Figure 1.15).

The 22 standard core cells of Assembly 22 have a height of 3.748082 cm and the two upper and lower cells a height of 3.431082 cm making a total core height of 89.32 cm.

In Assembly 24 each cell is 0.006918 cm higher (3.755 cm and 3.438 cm, respectively for the two cell types) and the core height is 0.166 cm higher, a total measured core height of 89.486 cm.

The heights were measured in special demountable subassemblies.

Table 1.D2 Dimensions of the Axial Blanket Region Natural Uranium Plates and Shield Region

Plate	Material	Thickness (cm)
Axial Blanket		
U8	Natural Uranium	0.317
U2		1.2723
U3		7.6225
Axial Shield (or Plenum) Region		
MST3	Mild Steel	7.60628
ALSC3	Aluminium	7.62
Axial Spacer Regions		
ALSR1		2.54
MSTST3	Mild steel	7.62
MSTST12		30.48

The axial blanket sections consist of 31 U8 plates followed by 10 U2 plates and 1 U3 block, a height of 30.1725 cm.

Above the upper axial blanket and below the lower axial blanket are the mild steel blocks MST3 and the 2 aluminium cylinders, ALSC3.

Above and below these are the mild steel spacer tubes MSTST12 (12 inches long) and MSTST3 (3 inches long) together with aluminium plates such as the 2.54 cm thick ALSR1. The total length of an element is 3 m. There are variations in the aluminium and mild steel Upper Plenum region (the reduced density shielding region simulating a fast reactor plenum region) and Spacer Region components used in different elements and electronic equipment is included in the top region of the instrumented elements (see ZTN22-11, Tables 3 and 5). The components used in the majority of elements are as follows (using the region naming convention of ZTN22-11)

REGION	Components	Component Height	Region Height
Upper Spacers	MSTST12	30.48 cm	38.1 cm
	MSTST3	7.62 cm	
Upper Plenum (or Shield)	2xALSC3	15.24 cm	22.84628 cm
	MST3	7.60628 cm	
Upper Unat Blanket	U3	7.6225 cm	30.1725 cm
	10xU2	12.723 cm	
	31xU8	9.827 cm	
CORE			
Lower Unat Blanket	31xU8	9.827 cm	30.1725 cm
	10xU2	12.723 cm	
	U3	7.6225 cm	
Lower Plenum (or Shield)	MST3	7.60628 cm	22.84628 cm
	2xALSC3	15.24 cm	
Lower Spacers	MSTST12	30.48 cm	35.56 cm
	2xALSR1	5.08 cm	

Radial blanket and reflector regions (or radial shielding).

The cores are surrounded by about 5 rings of radial blanket elements, each element containing 20 U3 blocks, 152.45 cm in height, above and below which are the mild steel blocks. The centre of this region is closely aligned with the centre of the core region so that the upper and lower extremities of the uranium region are close to those of the axial blanket regions. Surrounding the radial blanket elements are about 3 rings of radial reflector (or shielding) elements.

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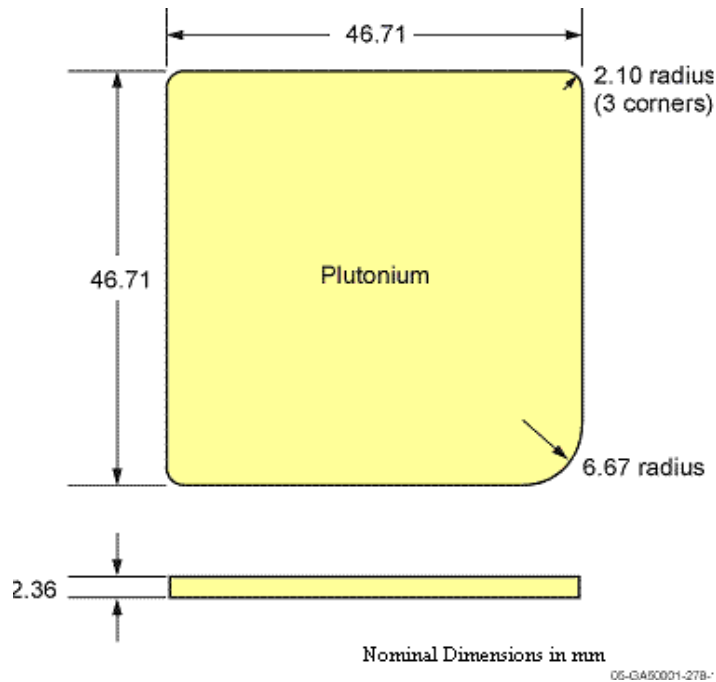
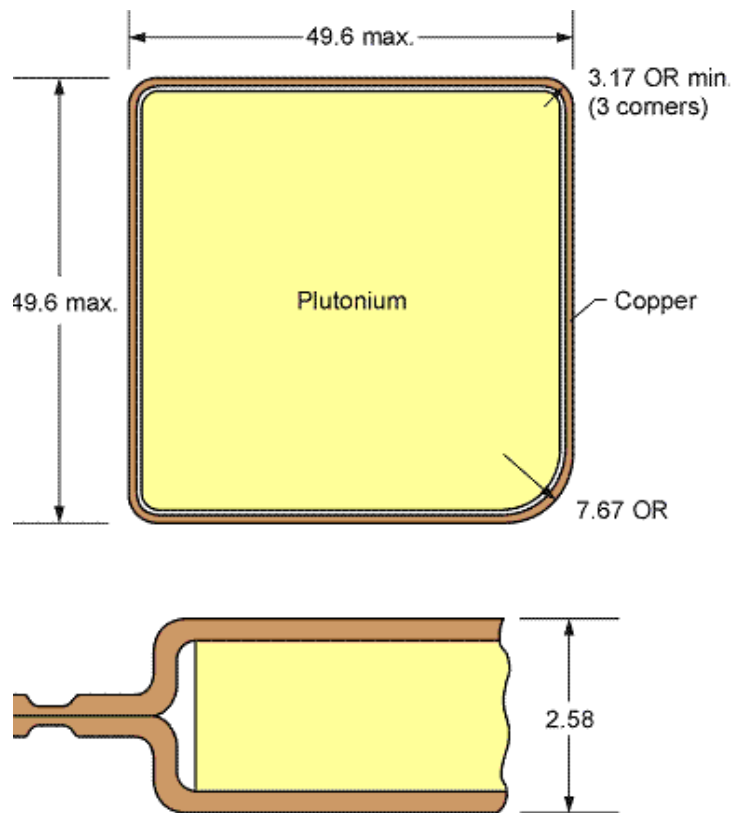


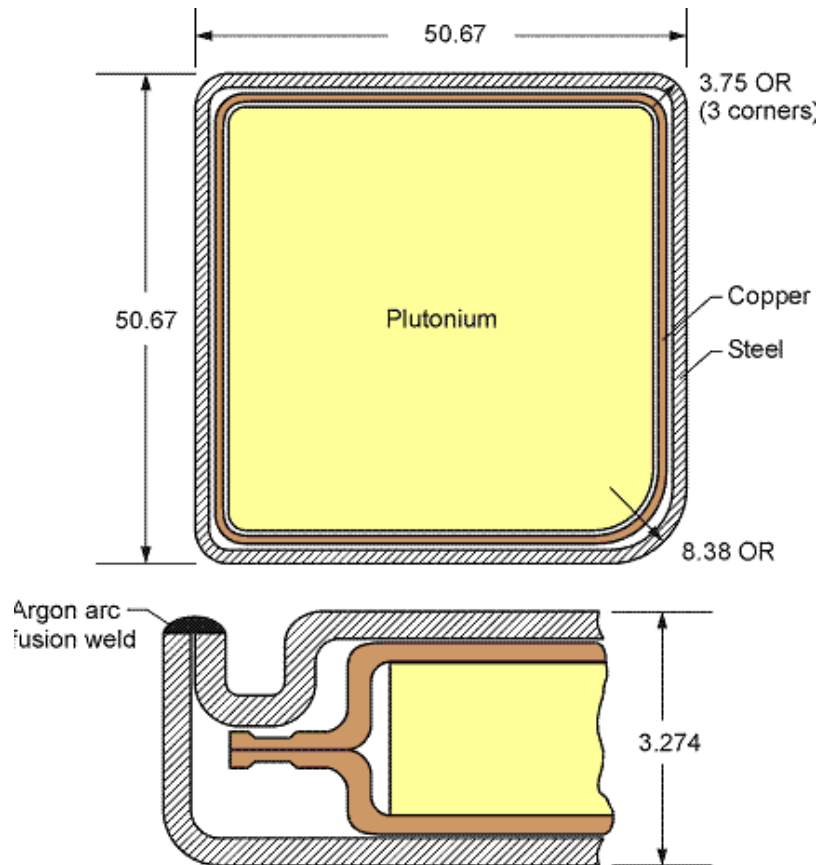
Figure 1.9 Core of the Plutonium Metal Fuel Plate, PuVIII8.



Drawing not to scale. Nominal dimensions in mm.

Figure 1.10 Core and Copper Clad of the Plutonium Metal Fuel Plate.

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Drawing not to scale. Nominal dimensions in mm.

Figure 1.11 Core, Copper and Steel Clad of the Plutonium Metal Fuel Plate, PuVIII8.

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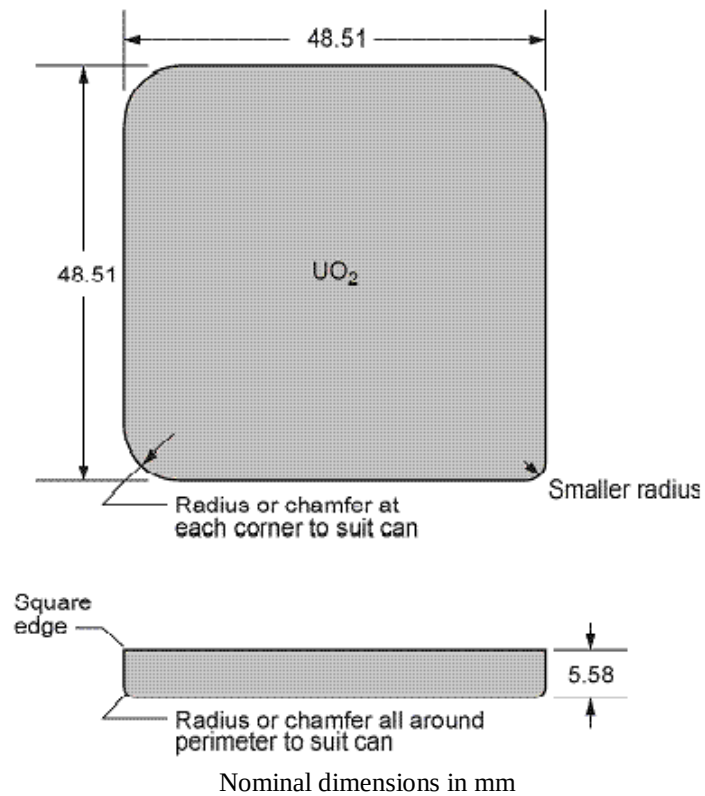
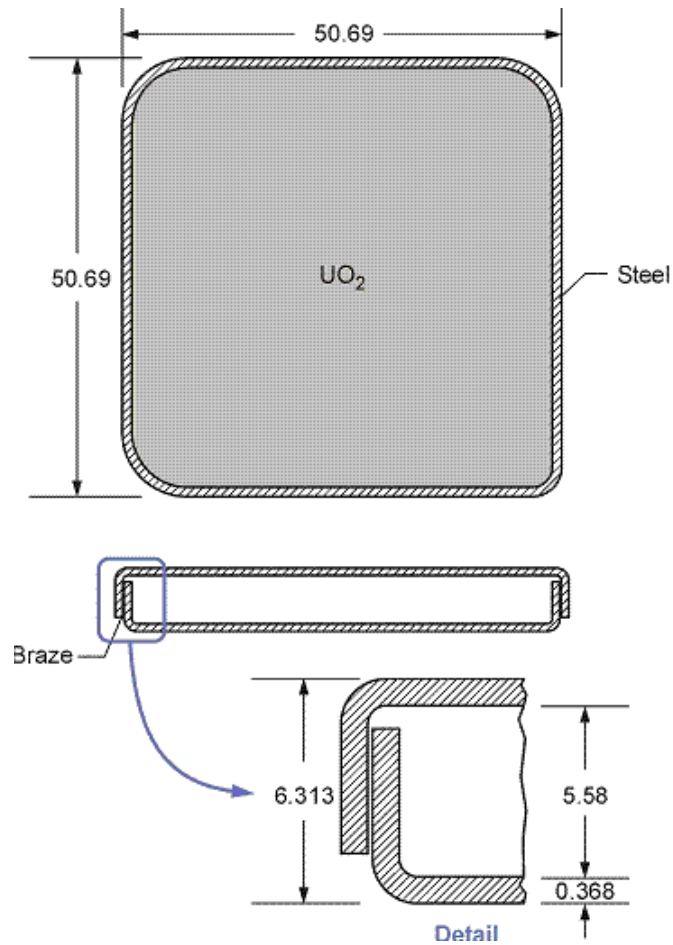


Figure 1.12 Core Region of the Uranium Oxide Plate.

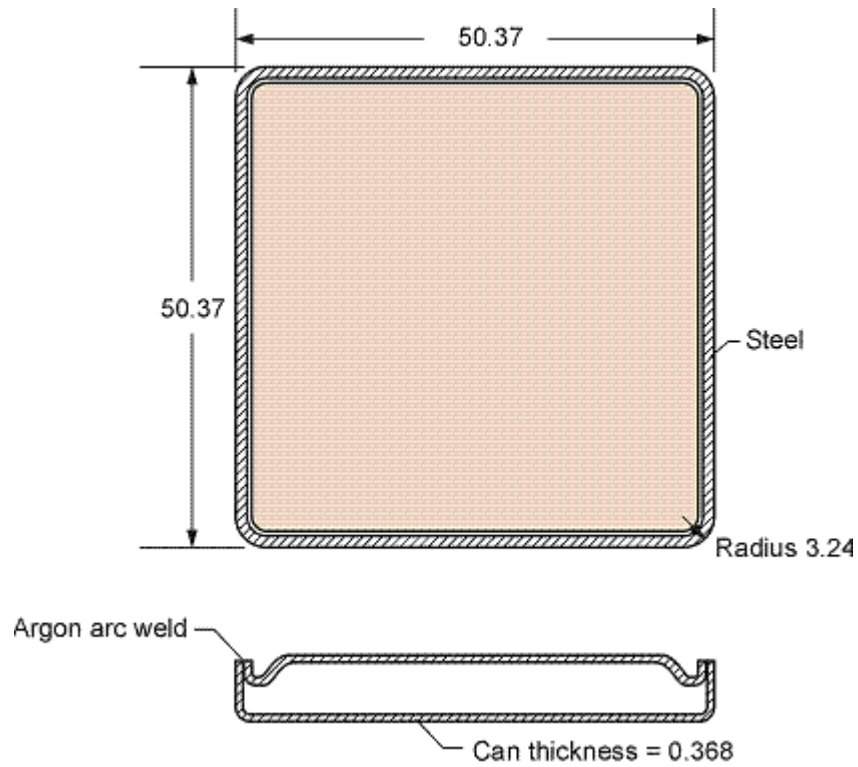
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Drawing not to scale. Nominal dimensions in mm.

Figure 1.13 Core and Can Regions of the Uranium Oxide Plate.

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Drawing not to scale. Nominal dimensions in mm.

Figure 1.14 Core Plus Can Regions of the Sodium Plate.

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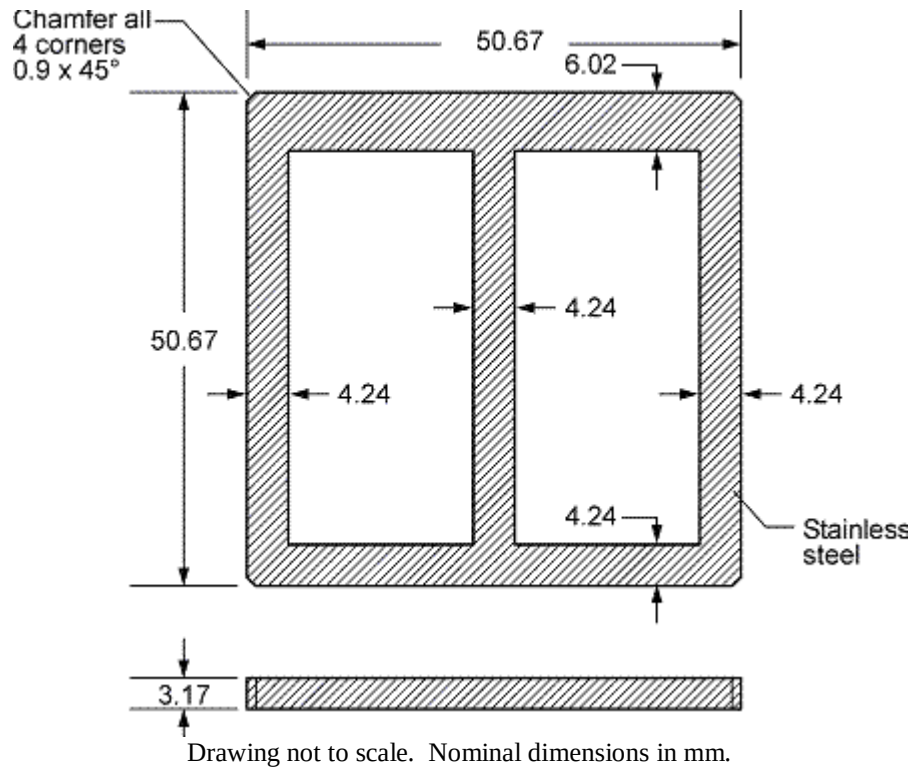


Figure 1.15 The 40% Steel Plate.

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Table 1.D3 Dimensions of a Radial Blanket (or Radial Breeder) Element

		Height of section (cm)
Upper Axial Steel Reflector	1 MST3	7.60628
Radial Blanket section	20 x U3	152.45
Lower Axial Steel Reflector	1 MST3	7.60628
Total		167.66256

These elements are contained in the mild steel element sheaths.

Table 1.D4 Radial Shield Element, MST9F10

		Width of square section bar (cm)	Height of bar (cm)
Steel bar	MST9F10.	5.08	300

The bar is not contained in a sheath.

Table 1.D5 The Element Sheaths, Superlattice Grid Plate and the Lattice Spacings

	(cm)
SHEATH WALL THICKNESS	0.0762
SHEATH INSIDE WIDTH	5.1020
SHEATH OUTSIDE WIDTH	5.2544
AVERAGE PITCH WITHIN GROUPS OF 5x5 ELEMENTS	5.3721
GAP BETWEEN GROUPS OF 5x5 ELEMENTS	0.2665
SUPERLATTICE PLATE THICKNESS	0.25
AVERAGE PITCH OVERALL	5.4254

However, it must be noted that the components forming most elements are contained in the "double element" sheath which has the same outer dimensions but a provision to hold an instrument, and about one third of the double elements in the plate geometry cores contain an instrument (the proportion being fewer in the pin geometry cores). The Zebra Database gives the same dimensions for the double sheath (per element) as for the single sheath but the fractions of steel in each of the walls and in the central vertical channel could differ. In the "standard" double element the central steel partition, separating the two columns of plates or mini-calandria, has the same weight as the two side walls of a single element. In the case of a double element containing an instrument the central partition is V-shaped to accommodate the electrical cables. (The weight of the partition in this case is not given in the documentation.)

Superlattice Grid Plate dimensions

Nominally the two lower grid plates extend between 50.2 cm and 80.6 cm above and below the mid plane, each being 30.4 cm high and 0.25 cm thick. The third grid plate is at the top of the facility, beyond the range of the assembly modelled.

Assemblies 23 and 25, the Pin Geometry Cores.

The compositions of the axial and radial blanket and reflector regions are the same as in the plate geometry Assembly 22. It is only the core cells which are different.

The core regions of the pin geometry elements contain three mini-calandria, one above the other, each a little under 30 cm in height, and each containing 16 mixed uranium-plutonium oxide pins on a 4x4 square array. The pins fit into the 4x4 array of tubes which pass through the calandria and are fixed to the top and bottom plates of the calandria. The space around the tubes can be occupied by sodium (the sodium filled calandria used in Assembly 23) or left empty (the voided calandria used in Assembly 25). The average plutonium enrichment of the 4x4 array of pins in each mini-calandria is 24% Pu/(Pu+U). However, the individual pins can differ. All three mini-calandria in an element are the same.

The Core 23 was also built in two versions, 23A and 23B. The pins have a small axial asymmetry because of the end regions and the steel shims which adjust the height of the stack of pellets. In version 23A some of the pins were inverted but in 23B the orientation of all of the pins was the same. Again the difference in reactivity between the two versions was found to be negligibly small compared with the uncertainties $(-4 \pm 4) \times 10^{-5}$ dk.

The mixed uranium-plutonium oxide pins are of several different enrichments and are denoted by the names PUPINA to PUPINF. There are also natural uranium oxide pins, UO2PINC. There are 5 different types of mini-calandria, containing sodium, denoted by NACLI to NACLV. These have differing steel compositions. Eight different types of cell have to be distinguished, numbered 3A to 3L. There are also sodium voided mini-calandria which are used for the sodium voiding studies.

Table 1.3 Contents of the 168 Mini-calandria Elements used in Assembly 23.

Cell Number	Mini-Calandria Type	Pin Types and Numbers	Numbers of elements
3A	NACLI	16 x PUPINC	16
3B	NACLI	11 x PUPINB, 5 x PUPINF	24
3C	NACLI	8 x PUPINA, 8 x PUPINE	53
3D	NACLI	8 x PUPIND, 8 x PUPINF	17
3E	NACLI	8 x PUPIND, 8 x PUPINF	34
3H	NACLV	11 x PUPINB, 5 x PUPINF	10
3J	NACLV	12 x PUPINE, 4 x UO2PINC	4
3L	NACLV	11 x PUPINB, 5 x PUPINF	10

PUPINA and PUPIND have an enrichment Pu/(Pu + U) of 0.16

PUPINB has an enrichment of 0.21

PUPINC has an enrichment of 0.24

PUPINE and PUPINF have an enrichment of 0.33.

Thus all 4x4 pin cells have a very similar average composition.

The instrumented elements 3RA, 3RC and 3TE contain the cells 3A, 3C and 3E respectively.

In addition to the pin-fuelled elements in Core 23 there are the 9 control rods (which are the Assembly 22 control rods) and, around the circumference of the core, there are 49 plate elements, making an array of 226 elements (including the control rods) in the core. Type 3C occupy the central area. The core plan is shown in Figure 1.16 and the mini-calandria are illustrated in Figures 1.17 and 1.18.

The core plan for Assembly 25, the sodium voided core, is shown in Figure 1.19. The element changes on going from Assembly 23 to Assembly 25 are also shown. The number and positions of pin geometry elements is the same and the pin arrays are the same the difference being that mini-calandria not containing sodium replace the sodium filled mini-calandria. These are not the same mini-calandria but are closely matched in weight of steel. Effectively, the change is the removal of the sodium from the mini-calandria of Assembly 23. Also, the plate geometry elements surrounding the pin geometry elements are now the sodium voided plate elements (denoted by X, Y and Z) and the number of these has increased.

The pin cell arrangements in the cells of the mini-calandria.

Cell 3A The pin arrangement is:

C	C	C	C
C	C	C	C
C	C	C	C
C	C	C	C

where C = PUPINC and the mini-calandria is NACLI

Cells 3B, 3H and 3L The pin arrangements are the same but the mini-calandria differ.

B	F	B	B
F	B	F	B
B	B	B	F
B	B	F	B

where B = PUPINB and F = PUPINF

The mini-calandrias are as follows:

Cell Type	Mini-calandria Type
3B	NACLI
3H	NACLV
3L	NACLIV

Cell 3C The pin arrangement is:

E	A	E	A
A	E	A	E
E	A	E	A
A	E	A	E

where A = PUPINA and E = PUPINE and the mini-calandria is NACLIII

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Cells 3D and 3E The pin arrangement has the same pattern as cell 3C being the same in 3D and 3E:
(D = PUPIND and F = PUPINF)

F	D	F	D
D	F	D	F
F	D	F	D
D	F	D	F

The mini-calandrias differ between 3D and 3E

Cell Type	Mini-calandria Type
3D	NACLI ^{III}
3E	NACLI ^{IS}

Arrangements for *Cell 3J* This mini-calandria contains UO₂ pins and U/PuO₂ pins. The pin arrangement is:

E	U	E	E
E	E	E	U
E	U	E	E
E	E	E	U

where U = UO₂PINC and E = PUPINE. The mini-calandria is NACLIV

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53								1CD	1D	1D	1D	1CD	1C						
52						1D	1D	3L	3L	3L	3L	3L	1D	1D					
51				1CD	1C	3H	3H	3B	3B	3B	3B	3B	3H	3H	1CD	1CD			
50				1D	3A	4	3D	3B	3B	3B	3B	3B	3D	2	3A	1D			
49			1D	3B	3D	3RC	3E	3C	3C	3C	3RC	3C	3E	3RC	3D	3B	1D		
48			1D	9	3D	3RC	3E	3C	3C	3C	3RC	3C	3E	3RC	3D	3D	1D		
47		1C	3A	3J	3RA	3TE	3E	3RC	3C	3C	3C	3C	3E	3TE	3RA	3J	3A	1CD	
46		1D	3A	6	3RA	3TE	3E	3RC	3C	3C	3C	3C	3E	3TE	3RA	8	3A	1D	
45		1D	3B	3E	3E	3E	3E	3C	3C	3C	3C	3C	3E	3E	3E	3E	3B	1D	
44		1D	3A	7	3D	3E	3E	3C	3C	3C	3C	3C	3E	3E	3D	5	3A	1D	
43		1CD	3A	3J	3D	3TE	3TE	3C	3C	3C	3RC	3RC	3TE	3TE	3D	3J	3A	1CD	
42			1D	3D	3D	3RC	3E	3C	3RC	3C	3C	3C	3E	3RC	3D	3E	1D		
41			1D	3D	3D	3RC	3E	3C	3RC	3C	3C	3C	3E	3RC	3D	3E	1D		
40				1D	3A	1	3H	3B	3B	3B	3B	3B	3H	3	3A	1D			
39				1CD	1C	3H	3H	3B	3B	3B	3B	3B	3H	3H	1C	1CD			
38						1D	1D	3L	3L	3L	3L	3L	1D	1D					
37								1CD	1D	1D	1D	1C							

Figure 1.16 Assembly 23 Reference Core Loading (Fissile Elements)

See Figure 1.8A for information on the plate geometry elements, 1C, 1D and 1CD (demountable). These are shown in blue.

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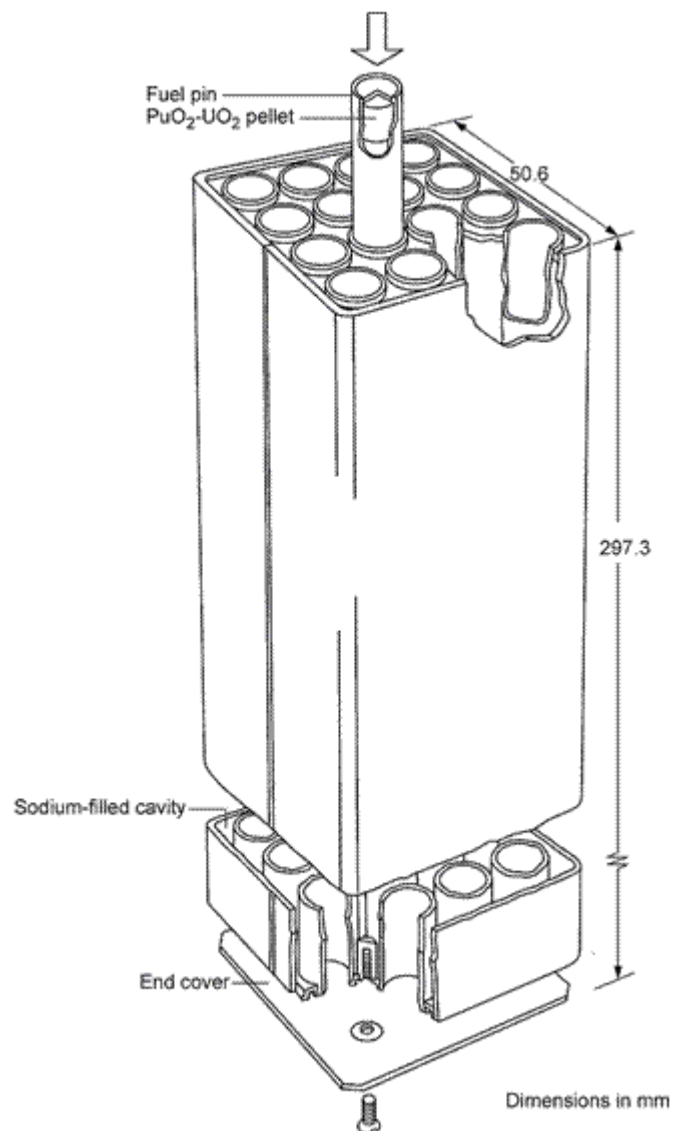


Figure 1.17 Diagram of a Mini-calandria

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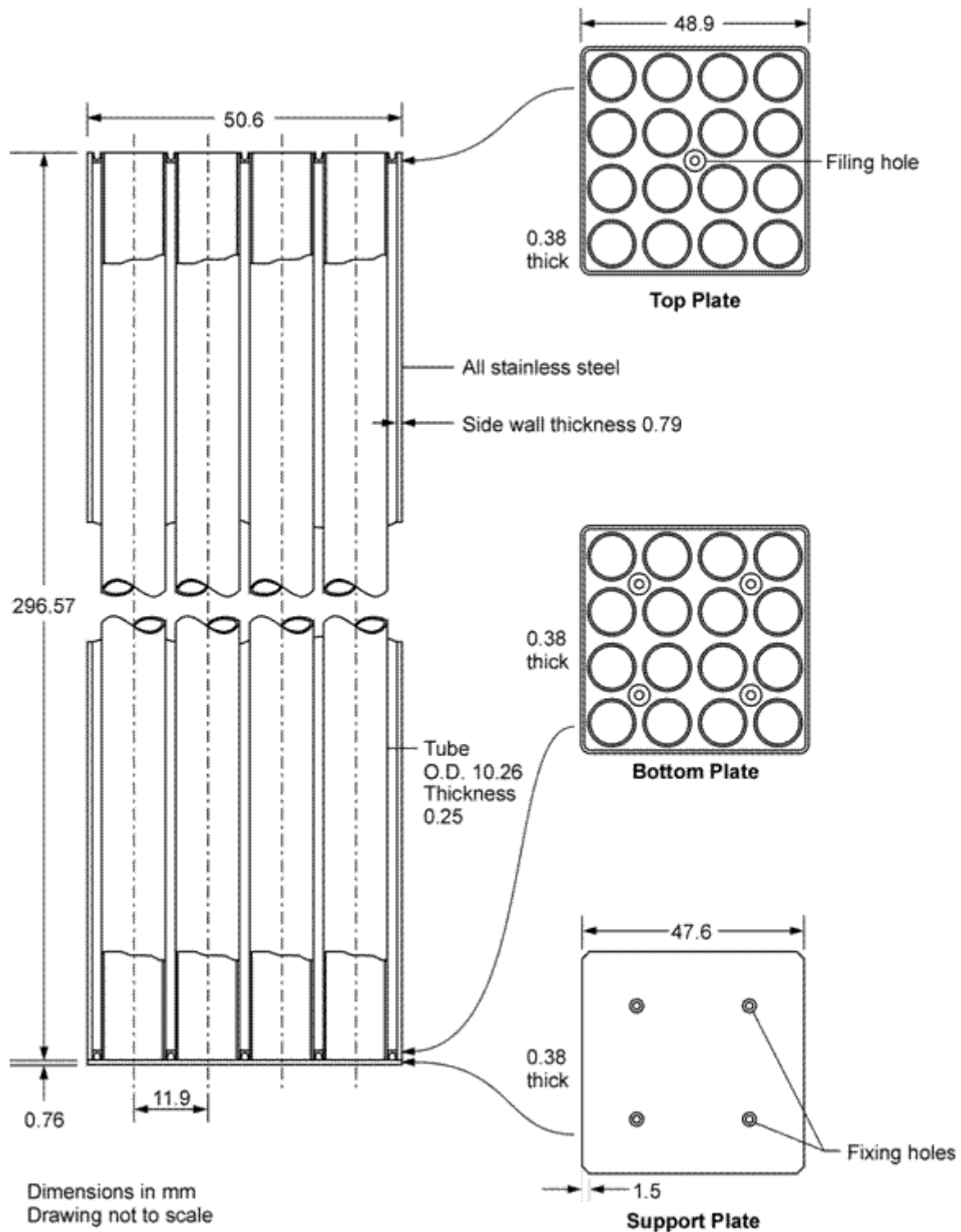


Figure 1.18 Mini-calandria Components

Note: The thickness of the support plate is given as 0.38 mm but the fitting of the support plate by means of the counter-sunk indentations adds 0.76 mm (NEACRP A445 p8). Note also: the overall length given here is 296.57 + 0.76 mm = 297.33 mm but the generally adopted value is 297.3 mm)

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53							Z	Z	Z	Z	Z	Z	Z						
52					Y	Z	Z	387	387	387	387	387	Z	Z	Y				
51				Z	Y	387	387	387	387	387	387	387	387	387	Y	Z			
50			Y	Y	3A1	4	303	387	387	387	387	387	303	2	3A1	Y	Y		
49		Z	Z	387	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	387	Z		
48		Y	Z	9	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	303	Z	Y	
47		Y	3A1	3J6	3A1	305	304	3C3	3C3	3C3	3C3	3C3	301	305	3A1	3J2	3A1	Y	
46		Z	3A1	6	3A1	305	304	3C3	3C3	3C3	3C3	3C3	305	305	3A1	8	3A1	Z	
45		Z	387	304	304	305	304	3C3	3C3	3C3	3C3	3C3	301	304	305	301	387	Z	
44		Z	3A1	7	303	305	304	3C3	3C3	3C3	3C3	3C3	301	304	303	5	3A1	Z	
43		Y	3A1	3J6	303	305	305	3C3	3C3	3C3	3C3	3C3	305	305	303	3J2	3A1	Y	
42		Y	Z	303	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	304	Y	Y	
41			Z	303	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	304	Z	Z	
40			Y	Y	3A1	1	387	387	387	387	387	387	387	3	3A1	Y	Y		
39				Z	Y	387	387	387	387	387	387	387	387	387	Y	Z			
38					Y	Z	Z	387	387	387	387	387	Z	Z	Y				
37							Z	Z	Z	Z	Z	Z	Z						

Figure 1.19 Assembly 25. Fissile Elements

X, Y and Z denote the plate geometry elements containing the sodium replacement "dummy" plates, X, Y and Z respectively (that is, STNAVR4, STNAVS4 and STNAV4).
The pin geometry element replacement in going from Assembly 23 to 25 is as follows (the pin arrays being the same in the corresponding elements of the two assemblies):

3A and 3RA	--> 3A1	16 elements using calandria VCLI
3B, 3H and 3L	--> 387	44 elements using calandria VCLVIIS
3C and 3RC	--> 3C3	53 elements using calandria VCLIII
3D	--> 303	17 elements using calandria VCLIII
3E and 3TE	--> 301, 304 and 305	34 elements using calandria VCLI, VCLIVH and VCLV
3J	--> 3J2 and 3J6	4 elements using calandria VCLII and VCLVI

The Assembly 25 pin geometry elements contain the same fuel pin arrays as the corresponding Assembly 23 elements, the difference being that the "sodium filled" calandria used in Assembly 23 are replaced by "sodium voided" calandria. The type of calandria used is denoted by the final number in the name of the element type. Thus the 3A1 elements use the "voided" calandria VCLI, the 3C3 elements use the "voided" calandria VCLIII and the elements 303 also use the voided calandria VCLIII. These calandria are very similar, in the composition of the steel components, to the sodium filled calandria, NACLI and NACLIII, used by the 3A, 3C and 3D elements of Assembly 23. The match in the case of the other elements is not so close but it was considered to be sufficiently close for the difference between the Assembly 23 and Assembly 25 calandria to be treated as simply the removal of the sodium (and the associated trace elements in the sodium).

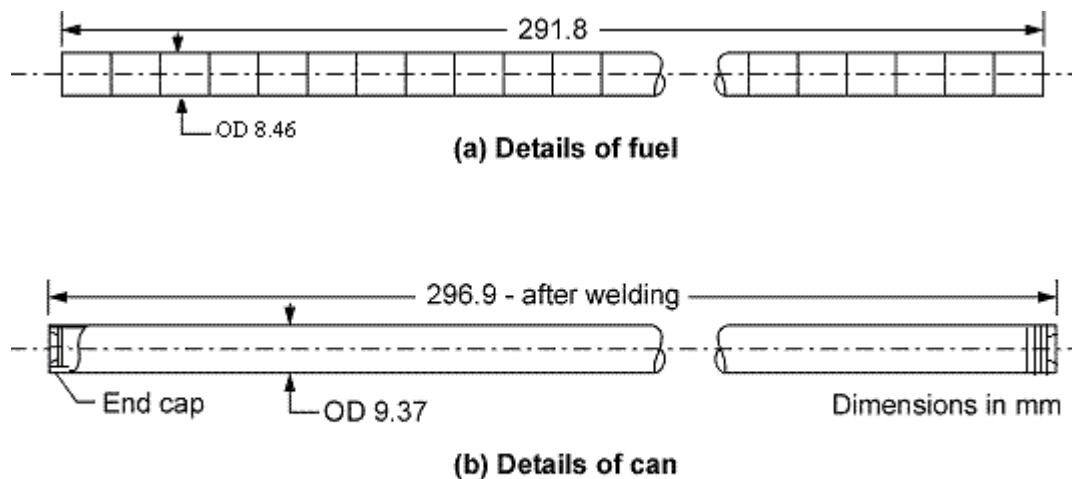


Figure 1.20 Dimensions of an Oxide Fuel Pin

Table 1.D6 Dimensions of the Components used in the Pin-geometry Elements

The pins and mini-calandria all have the same nominal dimensions, as follows (in cm):

<i>Fuel pin dimensions</i>	(cm)
Length of fuel column of 30 pellets	29.18
Uncertainty in fuel column length (Range)	± 0.25
Fuel column diameter	0.846
Total inside pin length	29.464
Total pin length (including welded end caps)	29.690
Average total thickness of the spacer discs used to make up the length	0.287
Pin outer diameter	0.937
Pin can thickness	0.038
Pin pitch	1.19
<i>Mini-calandria dimensions</i>	
Total mini-calandria length	29.730
Mini-calandria length excluding support plate	29.657
Mini-calandria nominal width	5.06
Mini-calandria side wall thickness	0.079
End plate thickness	0.038
Bottom support plate thickness	0.038
Height added to the mini-calandria by the attachment of the bottom support plate (by means of countersunk indentations) (see NEACRP A445 page 8)	0.076
Distance of fuel column from the bottom of the calandria (NEACRP A445)	0.434
Distance of fuel column from the top of the calandria (NEACRP A445)	0.111
Calandria tube outer diameter	1.026
Calandria tube thickness	0.025

Note, the uncertainty on the height of the three calandria which make up the core region of an element is given as ± 0.15 cm (± 0.05 cm per calandria).

The pins rest on the support plate of the mini-calandria. The lower extremity of the oxide pellets is given as $0.038 + 0.109 + 0.287 = 0.434$ cm from the bottom of the assembled mini-calandria. Similarly, the upper extremity of the oxide pellets is given as 0.111 cm from the top of the assembled mini-calandria (see NEACRP A445 page 8). The calandria length is 29.73 cm and so this implies a length of the fuel column of 29.185 cm. In BTN/19 there is a note saying that the pellet stack lengths range from 289.3 mm to 294.4 mm. However, the value given in the documentation is rounded from the mean value of 291.85 mm to 291.8 mm (see NEACRP A445 Figure 18) and this is the value adopted here. There is a similar small discrepancy between the thickness of the spacer discs and the inside and total pin lengths, but again within 0.01 cm.

In MTN/54 the total height of the mini-calandria is given as 29.73 cm (page 18) but in the drawing on page 30 of MTN/54 (dimensions in inches, converted here to cm) the overall length of the mini-calandria is given as 29.698 cm plus 0.078 cm = 29.776 cm (before welding). Note also that the value given in Figure 1.18 is 29.733 cm. However, in the Zebra Database the value is given as 29.73 cm and this is also the value given in the NEACRP benchmark specification, NEACRP A-445, and the figure adopted here. These differences are within the uncertainty of ± 0.05 cm.

In some Zebra assemblies the mini-calandria pellets were contained in steel clad capsules, with 6 pellets per capsule and 5 capsules per pin. The total mass of steel in the end caps is combined with the mass of the steel pin cladding and the steel spacers and the capsule steel (when present) and only the total value is quoted.

Components of the Cells used in Additional Elements and Experiments.

Additional plutonium and uranium plates

The plutonium plates used in the cells D (PUIX8) and E (PUX8) are compared here with the plate used in the cells of the reference element cells C (PUVIII8) (the 8 denoting that these have 1/8 inch nominal thickness). The elements containing these are replaced in the reference model for the critical cores by "standard elements".

PUJ16 is the half thickness plutonium plate used in the heterogeneity measurements (the 16 denotes 1/16 inch nominal thickness) and the PUIV4 plate is the double thickness mixed oxide plate used in the enrichment experiments and the element replacement measurements (1/4 inch nominal thickness).

Also used in the element replacement experiments is the uranium oxide plate UO24R4 (which has "4 radiused corners"). This has the same core width as the UO23R4 plate used in standard elements but is slightly thinner, 0.6279 cm compared with 0.6313 cm and the core thickness is 0.55424 cm compared with 0.558 cm for the UO23R4 plate.

Table 1.D7 Dimensions of the Alternative Plutonium and Uranium Plates (in cm)

	PUVIII8	PUIX8	PUX8	PUII8	PUJ16	PUIV4	UO23R4	UO24R4
	Standard						Standard	
Plate Thickness	0.3274 ± 0.0005	0.3265 ± 0.0005	0.3264 ± 0.0005	0.3175 ± 0.0005	0.155	0.6278 ± 0.0005	0.6313	0.6279 ± 0.0005
Plate width	5.067	5.067	5.067	5.067	5.067	5.067	5.067	5.067
Can thickness	0.0457	0.0457	0.0457	0.0508	0.02	0.03734	0.03665	0.03683
Core thickness	0.2360	0.2351	0.2350	0.2159	0.115	0.55312	0.558	0.55424
Core width	4.671	4.671	4.671	4.671	4.76	4.953	4.851	4.851

(The plate width quoted in the database for the PUJ16 plate is 5.07 cm, and for the PUIV4 plate is 5.062 cm, but since the edge region is not precisely defined the value 5.067 cm has been adopted here, this being the nominal value for all the plates.)

Alternative stainless steel plate.

The mixed oxide element C22±04A, used in the element replacement measurements, contains the "dull" stainless steel plate STSTD8 with thickness 0.3236 cm.

Components used in the Zebra Control Rods and their Dimensions.

The materials used in the control rods were chosen to match the core and blanket regions of the neighbouring elements but with a boron absorber section above a narrow upper blanket region. The blanket regions consist of natural uranium plates. The 9 control rods occupy the places of single elements. The same rods were used in all four cores, and included sodium.

The control rods were loaded so that when raised the centre line of the core section coincided with the centre line of the core section of the standard core elements. When lowered, the centre line of the boron absorber section took that position.

The control rods comprise a square tube moving within an outer square tube. The inner tube is loaded with plates. All plates are assumed to be 4.318 cm square (an area of 18.6451 cm²). The outer control rod tube has a nominal outer dimension of 5.2544 cm square, the same as the standard elements.

Table 1.D8 Control Rod Plate Identifiers and Dimensions

(All plates are nominally 4.318 cm square)

Identifier	Type of Plate	Thickness (cm)	Core thickness	Core width
PUXIVC8	Pu metal Mk.XIV	0.3207	0.2191	3.922
U02C4R4	U02 (4 radiused corners)	0.6279	0.55424	4.100
NASTMC4	Sodium	0.616	0.54234	4.244
STSTCF8	Stainless steel	0.3180		
UC8	Natural uranium	0.3167		
ALCG8	45% aluminium	0.3167		
B10C2	B10	1.27	1.19634	4.244

Control rod sheath

Identifier	Type of sheath
CRSHEATH	Single element rod

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Control Rod Cells

Core region		Boron absorber region cell patterns		
Cell CC22-04A		Cell CB22-02A	Cell CB22-03A	Cell CB22-04A
NASTMC4		ALCG8	3 x ALCG8	10 x ALCG8
U02C4R4		B10C2	B10C2	B10C2
PUXIVC8		2 x ALCG8	5 x ALCG8	19 x ALCG8
U02C4R4		B10C2	B10C2	B10C2
STSTCF8		2 x ALCG8	5 x ALCG8	10 x ALCG8
NASTMC4		B10C2	B10C2	
U02C4R4		ALCG8	3 x ALCG8	
PUXIVC8		B10C2		
U02C4R4		2 x ALCG8		
NASTMC4		B10C2		
		2 x ALCG8		
		B10C2		
		ALCG8		
Height		Height	Height	Height
5.319 cm		11.104 cm	8.877 cm	14.891 cm

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Control Elements

Region	Element Type C22-02B Rods 1, 2, 3, 4, 5, 6	Element Type C22-02C Rods 7, 8	Element Type C22-02D Rod 9	Height (cm)
Top blanket	23 x UC8	23 x UC8	22 x UC8	See note (a)
Absorber	8 x CB22-02A	10 x CB22-03A	6 x CB22-04A	See note (b)
Middle blanket	95 x UC8	95 x UC8	94 x UC8	See note (c)
Core	17xCC22-04A	17xCC22-04A	17xCC22-04A	90.42
Lower blanket	178 x UC8	178 x UC8	178 x UC8	56.37

Notes:

(a) 23 UC8 plates have a height of 7.28 cm and 22 a height of 6.97 cm.

(b) Absorber section lengths are:

C22-02B 88.83 cm

C22-02C 88.77 cm

C22-02D 89.35 cm

(c) Upper axial blanket heights:

Control rods 1 to 8 95 UC8 plates - height 30.09 cm

Control rod 9 94 UC8 plates - height 29.77 cm

Note: The heights of the UC8 regions differ from those given in ZTN22-1 and ZTN22-11, the thickness of the plates used here being the PLATEDATA value of 0.3167 cm (and not the value 0.3176 given in ZTN22-1). The height of the core section also differs by 0.03 cm per cell. There are also small differences in the heights of the absorber sections which have here been kept consistent with the PLATEDATA plate thicknesses.

1.1.2B The Measured k-effective Values for the Assemblies, 22, 23, 24 and 25.

The standard procedure for determining the critical condition of an assembly was to withdraw all of the control rods excepting for the regulating rod, the fine control rod, FR9, adding core elements at the core radial boundary when necessary to achieve criticality. The subcritical reactor was balanced at a series of power levels and the position of the regulating rod plotted versus inverse power level (as monitored on the in-core array of fission chambers and the ex-core safety circuit flux monitors). Extrapolating to infinite power level gave the rod insertion at critical. The excess reactivity of the core for the regulating rod in the withdrawn position was then calculated from the rod insertion and the calibration of the rod in absolute reactivity units (see Section 1.4.6).

The experimental k-effective values in Table 1.4 are those given in ZTN22/2 and ZTN22/10. The uncertainties in reactor balances, which are $\pm 1 \times 10^{-6}$ dk, are negligible compared with the other uncertainties.

The uncertainties in control rod movements were taken to be $\pm 1\%$ arising from uncertainties in the rod profile and $\pm 1\%$ arising from the absolute calibration by inverse kinetics (these figures, being the ones used in the ZTN22 documentation, are larger than the random uncertainty quoted in BTN-75, and described in Section 1.4.6). In addition there is the systematic uncertainty in the calibration of the control rod movements in terms of reactivity, (which is taken into account in the Tables when all reactivity effects have been combined, because it is systematic). This is dominated by the uncertainties in the delayed neutron data used to interpret the inverse kinetics measurements of rod reactivity worth.

Corrections are made for the decay of Pu241 to Am241 to give values for June 1981, (the reference date for the plutonium compositions given in Section 1.1.3). The measured reductions in reactivity were $2.71 \pm 0.12 \times 10^{-6}$ dk per day for the plate geometry cores and $2.60 \pm 0.05 \times 10^{-6}$ dk per day for the pin geometry cores (ZTN22/10) (to which the additional $\pm 5\%$ systematic uncertainty in the reactivity scale must be added).

Corrections were also made for differences in the core temperature distribution from the reference temperature of 300K. The procedure, which is based on the temperature measurements made at points in the core and measurements of the changes in reactivity with changes in temperature, is described in Section 1.1.4. The corrections are of the order of 5×10^{-4} and have a $\pm 20\%$ uncertainty.

The additional uncertainties in the experimental k-values given in ZTN22/10 arise from the uncertainties in the core height and the plutonium content of the fuel. For the plate cores these are ± 0.0002 and ± 0.0005 respectively; and for the pin cores ± 0.0006 and ± 0.0010 respectively.

The uncertainties in compositions are based on the measurements made at UKAEA Winfrith, and Harwell. (Data for the pin components are given in BTN-19, -132 and -134, and are summarised in Section 1.1.3.) The problem was how to translate these measurements into estimates of the systematic uncertainties applying to the whole core reactivity. In the ZEBRA documentation a conservative view has been taken and the uncertainties in fissile material content are treated as systematic to the whole core. This is clearly an overestimate because several different sources are used for the fissile materials. Also many different components contain steel (the different types of plate and the element sheaths) and so the various sources of uncertainty in the steel content will tend to average out. The assessments made by the ZEBRA Team were that the conservative estimate of the fissile material content (Pu239 content) uncertainty was the dominant source of uncertainty, the effects of the other uncertainties, uranium, steel, sodium content, being negligible in comparison. This point is considered further in Section 2.1.

Measurements were made of the heights of the core sections of the plate geometry elements using special sheaths in which the plate loadings could be viewed along the length of an element. The estimated uncertainties in the heights of the plate geometry cores are based on these measurements.

For the plate geometry Assemblies 22 and 24 the uncertainties in k_{eff} values are based on an uncertainty of ± 0.5 mm in core height (with ± 1.0 mm in core height corresponding to ± 0.0004 dk) and $\pm 0.1\%$ in the plutonium content of the fuel, corresponding to ± 0.0005 dk. (The plates tend to flatten slightly with time, reducing the core height by about 0.6mm (ZTN22-10).) The uncertainties for Assemblies 23 and 25 are based on ± 1.5 mm in core height, corresponding to ± 0.0006 dk, and $\pm 0.2\%$ in the plutonium content of the fuel, corresponding to ± 0.0010 dk. These were considered by the measurement team to be the predominant sources of uncertainty in the quoted measured k-values. Uncertainties are discussed in more detail in Section 2.1.

There is no discussion in the ZTN22 documentation about possible uncertainties in the core radial dimensions. An additional uncertainty of ± 0.0005 dk has been added here to allow for the gaps between the components being irregular and not continuous. This estimate is based on the calculated differences between different representations of the void gaps (described in Section 3.1).

Other potential sources of uncertainty are discussed in Section 2.1.

Some uncertainties are systematic to the Cores 22 and 24, and to Cores 23 and 25 (the plutonium content and radial dimensions, for example) and so when differences between the cores are considered the uncertainties can be reduced.

It is considered by the Evaluator that the only satisfactory way to use benchmark data of this sort is to analyse several similar systems, built on different facilities, and examine the consistency of the C/E values obtained. The fact that the Cadenza series used materials in different forms, plate and pin, provides the basis for some intercomparison, but some sources of uncertainty will be common to the two types of assembly.

There is the further $\pm 5\%$ which is systematic to all measured reactivities and is due to the uncertainties in the delayed neutron data, relative fission rates and delayed neutron importance weighting used in the calibration of the control rods. This is not included with the random errors given in the Table but is added at the end (because it is systematic to all the reactivity corrections).

The corrections made to derive the benchmark models are summarised later, in Section 3. The corrections for replacing control rods and special elements by standard double elements to produce the reference models are based on measurements and are described in this section.

In addition to the direct measurements of the k values of the cores the changes in reactivity on going from one core to another were also measured and are described in Section 1.4.7. The uncertainties quoted for these differences are smaller than for the differences between the k values given in Table 1.4.

The differences between the k_{eff} values of versions A and B of both assemblies 22 and 23 were found to be negligibly small, being $(-1 \pm 4) \times 10^{-5}$ dk for assembly 22 and $(-4 \pm 4) \times 10^{-5}$ dk for assembly 23 (ZTN22/2). These uncertainties are indicative of the core reproducibility uncertainties.

(In ZTN22/13 the measured k_{eff} value for Assembly 24 has been increased by 0.0004 to allow for the actual core height being ~ 1 mm greater than that in the flooded core (ZTN22/10) which has been used in the calculational models for both plate assemblies in that document. The actual height of Assembly 24 is used in the present description.)

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Table 1.4 The Experimental keff Values Corrected to the Reference Temperature of 300K and the Reference Date, June 1981, with Control Rods Withdrawn.

Assembly	22A	23A	24	25
Type	Na-Flooded Plate	Na-Flooded Pin	Na-Voided Plate	Na-Voided Pin
Number of fissile elements in the core	215	226	231	243
<i>Date of reference loading</i>	<i>(SU13, 3.12.80)*</i>	<i>(SU176, 10.2.81)</i>	<i>(SU16, 16.10.81)</i>	<i>(SU3, 7.1.82)</i>
k-value of Reference Loading	1.00000 ± 0.000001	1.00000 ± 0.000001	1.00000 ± 0.000001	1.00000 ± 0.000001
Corrections				
Fully raising control rods	+ 0.00140 ± 0.00002	+ 0.00118 ± 0.00003	+ 0.00165 ± 0.00002	+ 0.00089 ± 0.00002
Reducing core temperature to 300K	+ 0.00048 ± 0.00010	+ 0.00037 ± 0.00007	+ 0.00026 ± 0.00005	+ 0.00035 ± 0.00007
Extrapolation to June 1981 (Pu241 decay)	- 0.00047 ± 0.00004	- 0.00031 ± 0.00004	+ 0.00031 ± 0.00004	+ 0.00055 ± 0.00004
Uncertainty in fissile material content	± 0.00050	± 0.00100	± 0.00050	± 0.00100
Uncertainty in axial dimensions	± 0.00020	± 0.00060	± 0.00020	± 0.00060
Uncertainty in radial dimensions	± 0.00050	± 0.00050	± 0.00050	± 0.00050
k-value at 300K, June 1981, control rods withdrawn	1.00141 ± 0.00074	1.00124 ± 0.00127	1.00222 ± 0.00074	1.00179 ± 0.00127
Addition of the ± 5% systematic uncertainty in the reactivity scale	1.00141 ± 0.00074	1.00124 ± 0.00127	1.00222 ± 0.00075	1.00179 ± 0.00127

* The loading is denoted by the Start-up number, SU13 etc. and the date in the form (day.month.year)

Measured Corrections to the k-effective Values to Produce Reference Models.

The objective of the ZEBRA measurements was to enable models to be set up to test methods and nuclear data. The aim was to enable simplified models to be set up by measuring the effects of making the required simplifications. Thus simplified criticality models were set up based on measurement. Measurements were made of the reactivity changes resulting from replacing control rods and special elements (the double elements containing fission chambers, thermocouples, etc) by standard core elements. Corrections were then applied to the measured k values to produce simplified reference models containing cores with the control rods and special elements replaced by standard core elements. The corrections and the revised k values are presented in Table 1.5.

In the case of the plate geometry Core 22 the "standard" elements were the C22+01C elements (or denoted more simply as 1C or C) containing the Mark VIII plutonium plate, PUVIII8. The Mark X plutonium plate, PUX8, was used in instrumented elements and the elements A, B and Z, used in special experiments, contained the plates PuIV4, PuVII8 and PuII8 respectively. Corrections to the k value for replacing these elements by the C elements were made based on the measured differences in reactivity between these elements and the C elements and these are shown in Table 1.5. Material data are included in Section 1.1.3 for these alternative Pu plates so that the unmodified cores can also be calculated. Similar corrections were made for the reactivity effects of replacing the special elements in the other cores.

The plate geometry element C22+01D, which used the Mark IX plutonium plate, was also replaced in the reference model of Core 22, and the corresponding reference model of Core 24. Measurements were made of the reactivity change resulting from replacing nine 1C elements by 1D elements at the centre of Core 22 (9 elements centred on position (X,Y) = (50,45)), the change being a reduction in reactivity of $(4.8 \pm 4.7) \times 10^{-5}$ dk/k (ZTN22-2). The 68 elements of type 1D are in the outer regions of the core and so the reactivity addition resulting from their replacement by 1C elements is less than 36×10^{-5} dk/k. Since they are in the outer region of the core the probable weighting is about 0.5, resulting in an estimated increase of $(+18 \pm 18) \times 10^{-5}$. The same increase is applied to the Core 24 k value.

Effect of the Multi-chamber Elements on k-effective

In Assembly 22 there are 20 elements containing fission chambers, 19 with 5 chambers and one at the core centre with 9 chambers, making 104 chambers in all. This compares with the total number of core cells of $215 \times 24 = 5160$. The number of sodium plates removed in the ME element is 8 per element and in the single NE element 14 plates and so in the whole core the number is 166 out of a total of $3 \times 5160 = 15480$ sodium plates; that is, about 1% are removed. The effect of the loss of this amount of sodium is a small reduction in reactivity equal to about 1% of the measured change resulting from voiding sodium from the core (which is measured to be a reduction of 1.33 % dk/k, ZTN22-10, page 13); that is the removal of the sodium to make way for the chambers results in a reduction in reactivity of about 1.4×10^{-4} dk/k. In addition there is the effect of the change in steel content. The amount of steel removed in the case of an ME element is equivalent to 8 sodium cans per element and 2 steel plates (40% steel) per element (total weight $8 \times 17 \text{ g} + 2 \times 24.7 \text{ g} = 185.4 \text{ g}$) and for the NE element is equivalent to 14 sodium cans plus 4 steel plates ($14 \times 17 \text{ g} + 4 \times 24.7 \text{ g} = 336.8 \text{ g}$). The steel of the chambers more than compensates for this removal, being an addition per chamber of 108 g or a net addition of 355 g in the 5 chamber elements and 635 g in the case of the 9 chamber element. For 20 elements the net weight of steel added is 7.38 kg. An approximate estimate of the worth per kg of steel, averaged over the core is -0.66×10^{-4} dk/k per kg. The reactivity effect of adding this quantity of steel is therefore a reduction in reactivity of 4.9×10^{-4} dk/k. As is seen from Table 1.5 the measured effect of replacing these by C22+01C elements is smaller, $(2.8 \pm 0.4) \times 10^{-4}$ dk/k. However, there is also the change in the steel content of the partition between the two columns of

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plates in the double element and the effect of the electric cables and their covering as well as the difference between the plutonium plates used in these elements and in the reference elements.

In the versions of Assemblies 23 and 25 on which the k_{eff} measurements were made there were no multi-chamber elements.

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Table 1.5 Corrections to the Experimental k-effective Values for Replacing Non-standard Elements to Produce Reference Cores

Assembly	22A	23A	24	25
Type	Plate (Na)	Pin (Na)	Plate(Na-Void)	Pin (Na-Void)
Number of fissile elements	215	226	231	243
k-value corrected to 300K and the reference date, with control rods withdrawn	1.00141 ± 0.00074	1.00124 ± 0.00127	1.00222 ± 0.00074	1.00179 ± 0.00127
Standard elements (identifiers in parenthesis) replacing the 9 control rods	(9 x C22+01C) + 0.00040 ± 0.00002	(9 x C22+03D) + 0.00032 ± 0.00002	(9 x C24+20C) - 0.00012 ± 0.00002	(9 x C25+03C3) - 0.00050 ± 0.00002
Replacing 4 pulse counter elements by B22-01A elements	+ 0.00003 ± 0.00000	+ 0.00003 ± 0.00000	+ 0.00004 ± 0.00000	+ 0.00006 ± 0.00000
Replacing resistance bulb and thermocouple double elements by standard double elements (numbers and identifiers in parenthesis)	(14 x C22+01C) - 0.00007 ± 0.00001	(14 x C22+03A,C) + 0.00003 ± 0.00001	(14 x C24+20C) - 0.00015 ± 0.00001	(16 x C25+03A1, B7,C3) + 0.00002 ± 0.00001
Replacing 20 multichamber double elements by standard double elements (identifiers in parenthesis)	(20 x C22+01C) + 0.00028 ± 0.00004	-	(20 x C24+20C) + 0.00021 ± 0.00004	-
Replacing aspirated elements by standard elements (numbers and element identifiers in parenthesis)	(20 x C22+01C) - 0.00006 ± 0.00003	-	(30 x C24+20C) - 0.00009 ± 0.00006	(18 x C25+03C) - 0.00005 ± 0.00003
Removing sealing strip from aspirated elements and multi-chamber elements (the numbers of elements are in parenthesis)	(20 elements) - 0.00000 ± 0.00001	-	(39 elements) - 0.00001 ± 0.00002	(18 elements) - 0.00000 ± 0.00001
Replacing D plate elements with C plate elements	+ 0.00018 ± 0.00018		+ 0.00018 ± 0.00018	
Total of the corrections to k made to produce reference models	+ 0.00076 ± 0.00019	+ 0.00038 ± 0.00002	+ 0.00006 ± 0.00020	- 0.00047 ± 0.00004
5% Systematic uncertainty associated with reactivities	± 0.00008	± 0.00005	± 0.00008	± 0.00004
k-values of Reference Models	1.00217 ± 0.00077	1.00162 ± 0.00127	1.00228 ± 0.00077	1.00132 ± 0.00127

Reactivity Differences Between Different CADENZA Assemblies.

An essential component of the benchmark studies is the intercomparison of differences between calculation and experiment for the criticality of the four systems, that is, the consistency between the calculations made for plate geometry and pin geometry cores and between the calculations made for cores containing sodium and voided of sodium. The uncertainties affecting the differences are lower than those for the k_{eff} values themselves because some components affect the values in a systematic way. When comparing pin and plate geometry cores this is the case for the superlattice grid correction and the radial dimensions uncertainty. When comparing the sodium filled and voided cores the plutonium content uncertainty affects the results in a systematic way and so can be omitted. However, an estimate of the uncertainty due to the differences in the steel and sodium content is then required. (The relative uncertainty in the axial dimensions of the pin geometry cores might also be reduced.) The uncertainties affecting the differences between plate and pin geometry cores are summarised in Table 1.6 and those affecting the sodium filled and voided cores in Table 1.7.

The transition from one core to another was made in stages, with the changes being balanced using the control rods. The rod worths were recalibrated at points during the transitions. In this way the reactivity change in going from one assembly to another was measured. These reactivity differences are given in Section 1.4. The quoted uncertainties arise from the uncertainty of $\pm 0.1\%$ of the worth of the elements moved, the uncertainty in the reactivity scale and due to the uncertainties in the composition and axial dimensions of core components.

Measurements were also made of the reactivity changes resulting when zones of plate geometry elements were introduced in the central regions of the pin geometry cores 23 and 25. These measurements are described in Section 1.4.7. Additional critical cores are then defined based on these.

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Table 1.6 Uncertainties affecting the Comparison of k_{eff} Values for Pin versus Plate Geometry Cores

Assembly	22A	23A	24	25
Type	Na-Flooded Plate	Na-Flooded Pin	Na-Voided Plate	Na-Voided Pin
k of Reference Loading	± 0.000001	± 0.000001	± 0.000001	± 0.000001
Fully raising control rods	± 0.00002	± 0.00003	± 0.00002	± 0.00002
Temperature correction	± 0.00010	± 0.00007	± 0.00005	± 0.00007
Pu241 decay	± 0.00004	± 0.00004	± 0.00004	± 0.00004
Uncertainty in fissile content	± 0.00050	± 0.00100	± 0.00050	± 0.00100
Uncertainty in axial dimensions	± 0.00020	± 0.00060	± 0.00020	± 0.00060
Replacing the 9 control rods	± 0.00002	± 0.00002	± 0.00002	± 0.00002
Replacing 4 pulse counter	± 0.00000	± 0.00000	± 0.00000	± 0.00000
Replacing thermocouple elements	± 0.00001	± 0.00001	± 0.00001	± 0.00001
Replacing multichamber elements	± 0.00004	-	± 0.00004	-
Replacing aspirated elements	± 0.00003	-	± 0.00006	± 0.00003
Removing sealing strip	± 0.00001	-	± 0.00002	± 0.00001
Replacing D plate elements	± 0.00018		± 0.00018	
5% Systematic uncertainty	± 0.00008	± 0.00005	± 0.00008	± 0.00004
Total systematic uncertainty	± 0.00059	± 0.00117	± 0.00058	± 0.00117
Total relative uncertainty	± 0.00131		± 0.00130	

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Table 1.7 Uncertainties affecting the Comparison of k_{eff} Values for Sodium Filled versus Sodium Voided Cores

Assembly	22A	24	23A	25
Type	Na-Flooded Plate	Na-Voided Plate	Na-Flooded Pin	Na-Voided Pin
k of Reference Loading	± 0.000001	± 0.000001	± 0.000001	± 0.000001
Fully raising control rods	± 0.00002	± 0.00002	± 0.00003	± 0.00002
Temperature correction	± 0.00010	± 0.00005	± 0.00007	± 0.00007
Pu241 decay	± 0.00004	± 0.00004	± 0.00004	± 0.00004
Uncertainty in steel content	± 0.00005	± 0.00005	± 0.00010	± 0.00010
Uncertainty in sodium content	± 0.00007	± 0.00000	± 0.00007	± 0.00007
Uncertainty in axial dimensions	± 0.00020	± 0.00020	± 0.00060	± 0.00060
Replacing the 9 control rods	± 0.00002	± 0.00002	± 0.00002	± 0.00002
Replacing 4 pulse counter	± 0.00000	± 0.00000	± 0.00000	± 0.00000
Replacing thermocouple elements	± 0.00001	± 0.00001	± 0.00001	± 0.00001
Replacing multichamber elements	± 0.00004	± 0.00004	-	-
Replacing aspirated elements	± 0.00003	± 0.00006	-	± 0.00003
Removing sealing strip	± 0.00001	± 0.00002	-	± 0.00001
Replacing D plate elements	± 0.00000	± 0.00000		
5% Systematic uncertainty	± 0.00008	± 0.00008	± 0.00005	± 0.00004
Total systematic uncertainty	± 0.00026	± 0.00024	± 0.00062	± 0.00062
Total relative uncertainty	± 0.00036		± 0.00088	

1.1.3 Description of Material Data

The composition information for all the components of the assemblies is presented in this section. The dimensions and weights of the constituents of ZEBRA components are held in the ZEBRA PLATEDATA Database and this is the source of the data presented here.

(The number of significant figures has been reduced when it was considered that the extra numbers in the Database were a consequence of computer manipulation.)

Concerning the percentage weights, these are provided in the Zebra Database for cladding materials but not for core materials, in which case they have been calculated here.

Details of the original and repeated measurements of the compositions of the fuel pins, cans and mini-calandria are given in BTN-19, BTN-132 and BTN-134 (for the UO_2 pins). These also give information on uncertainties in the compositions.

The detailed compositions for both plate and pin geometry components are also given in the NEACRP benchmark specification documents (issued in the 1980s) although these are limited to the data for the models specified as benchmarks.

The available documentation does not include information on the uncertainties in the compositions of the plate geometry components, however, although the overall uncertainties in the fissile material content and the height of the stacks of fuel plates are given in the ZTN22 documentation describing the assessment of uncertainties in k_{eff} values.

The Pu241 and Am241 content of components in the ZEBRA database is a decay-corrected value from the time of chemical analysis up to the reference date of the database. Except when it is stated, in the following tables these components have been adjusted (decay time corrected) to refer to the reference date for the CADENZA assemblies, June 1981.

Compositions of the Components in Assemblies 22 and 24.

When given in the ZEBRA PLATEDATA Database the uncertainty in the thickness of a plate is ± 0.0005 cm.

Table 1.M1 The Plutonium Metal Plate, PUVIII8.

Figures 1.9, 1.10 and 1.11 illustrate the core region and the two layers of canning, copper and steel, of the plutonium plates.

Core region:

Nuclide	Weight (g)	Percentage of weight
H	0.0011	0.0014
C	0.0434	0.0560
N	0.0029	0.0037
O	0.0121	0.0156
AL	0.0053	0.0068
SI	0.0034	0.0044
CR	0.0016	0.0021
MN	0.0007	0.0009
FE	0.0078	0.0101
NI	0.0043	0.0055
GA	1.2022	1.5513
U238	0.0014	0.0018
PU238	0.0620	0.0800
PU239	59.1110	76.2773
PU240	14.1820	18.3006
PU241	1.5244	1.9671
PU242	0.3870	0.4994
AM241	0.9423	1.2160
Total	77.4949	100.0000

Can region:

Nuclide	Weight (g)	Percentage of weight
H	0.000075	0.0004
C	0.0074	0.0357
SI	0.0556	0.2682
P	0.0023	0.0111
CR	2.6435	12.7526
MN	0.2553	1.2316
FE	10.7342	51.7831
NI	1.3218	6.3765
CU	5.7090	27.5409
Total	20.7292	100.0000

Table 1.M2 The Natural Uranium Oxide Plate, UO₂3R4.

The core region is illustrated in Figure 1.12 and the plate in Figure 1.13.

Core region

Nuclide	Weight (g)	Percentage of weight
H	0.0007	0.0005
C	0.0031	0.0023
O	16.0900	11.8488
AL	0.0020	0.0015
SI	0.0141	0.0104
MN	0.0001	0.0001
FE	0.0016	0.0012
NI	0.0016	0.0012
MO	0.0007	0.0005
U235	0.8500	0.6259
U238	118.8300	87.5076
Total	135.7939	100.0000

Can region

Nuclide	Weight (g)	Percentage of weight
H	0.0001	0.0005
C	0.0078	0.0386
SI	0.0916	0.4539
P	0.0549	0.2723
S	0.0058	0.0290
CR	3.6330	18.0110
MN	0.2377	1.1782
FE	13.6399	67.6212
NI	2.5003	12.3953
Total	20.1710	100.0000

Table 1.M3 The Sodium Plate, NASTDL4.

Thickness of the sodium plate.

Figure 1.14 illustrates the plate.

The thickness of the sodium plate has been reduced from its nominal value of 0.616 cm to 0.613694 cm to give a total core height of 89.32 cm for the 24 plate cells, equal to that actually measured. The sodium plate was chosen for adjustment because these components have a tendency to compress. The plate width has also been changed to be consistent with that of the other plates, the core dimensions remaining unaltered.

Core region

Nuclide	Weight (g)	Percentage of weight
H	0.0003	0.0026
O	0.0020	0.0169
NA	11.8150	99.9517
CA	0.0032	0.0271
FE	0.0002	0.0017
Total	11.8207	100.0000

Can region

Nuclide	Weight (g)	Percentage of weight
H	0.0001	0.0005
C	0.0142	0.0802
SI	0.0690	0.3899
P	0.0041	0.0232
S	0.0043	0.0243
CR	3.0975	17.5016
MN	0.3009	1.7002
FE	12.4100	70.1194
NI	1.6815	9.5009
NB	0.1168	0.6599
Total	17.6984	100.0000

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Table 1.M4 Sodium Dummy Plates.

The plates STNAVR4 and STNAVS4 are rings and STNAV4 is “honeycomb” shaped.

Nuclide	Weight (g)	Percentage of weight		Weight (g)	Percentage of weight
PLATENAME	STNAVR4			STNAVS4	
H	0.0001	0.0005		0.000088	0.0005
C	0.0120	0.0678		0.011	0.0621
SI	0.0770	0.4348		0.076	0.4291
P	0.0051	0.0288		0.002	0.0113
S	0.0014	0.0079		0.002	0.0113
CR	3.1294	17.6703		3.064	17.3009
MN	0.2329	1.3151		0.299	1.6883
FE	12.0002	67.7595		12.129	68.4864
NI	2.1146	11.9402		2.001	11.2986
NB	0.1373	0.7753		0.126	0.7115
TOTAL	17.7100	100.0000		17.71009	100.0000

The honeycomb plate, STNAV4, is treated as uniform.

ISOTOPE	Weight (g)	Percentage of weight
PLATENAME:	STNAV4	
H	0.0001	0.0005
C	0.0106	0.0600
SI	0.0898	0.5100
P	0.0041	0.0230
S	0.0021	0.0120
CR	3.3651	19.1199
MN	0.2816	1.6000
FE	11.8386	67.2647
NI	1.8797	10.6799
NB	0.1285	0.7300
TOTAL	17.6001	100.0000

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Table 1.M5 The 40% Stainless Steel Plate, STSTF8.

The plate is illustrated in Figure 1.15.

ISOTOPE	Weight (g)	Percent weight
H	0.0001	0.0004
C	0.0057	0.0231
AL	0.0173	0.0700
SI	0.1210	0.4899
P	0.0067	0.0271
S	0.0025	0.0101
TI	0.0642	0.2599
CR	4.4710	18.1012
MN	0.4446	1.8000
FE	16.7141	67.6684
NI	2.7910	11.2996
CU	0.0173	0.0700
NB	0.0025	0.0101
MO	0.0420	0.1700
Total	24.7000	100.0000

The Uranium Blanket and Steel Reflector Regions.

Immediately above and below both the pin and plate geometry core cells there is a region of natural uranium metal pieces, about 30 cm in length. Next to the core there are 31 U8 plates followed by 10 U2 plates and 1 U3 block. Above and below the uranium regions there is a single mild steel block, MST3.

The cores are surrounded by radial blanket elements, each containing 20 U3 blocks, 152.45 cm in height. The centre of this region is closely aligned with the centre of the core region so that the upper and lower extremities of the uranium region are close to those of the axial blanket regions.

The radial blanket elements are surrounded by steel bars, MST9F10, 5.08 cm square and 3 m long, extending axially beyond the region of interest in the core and radial blanket. These bars are not contained in sheaths. (The data for these are given in the Table as weight per 1 cm length).

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Table 1.M6 Blanket Region Natural Uranium Components

Natural Uranium Plate, U8.

Nuclide	Weight (g)	Percent weight
H	0.0006	0.0004
C	0.0800	0.0536
SI	0.0800	0.0536
FE	0.0800	0.0536
U235	1.0600	0.7097
U238	148.0600	99.1292
Total	149.3606	100.0000

Natural Uranium Plate, U2.

Nuclide	Weight (g)	Percent weight
H	0.0024	0.0004
C	0.3000	0.0492
SI	0.3000	0.0492
FE	0.3000	0.0492
U235	4.3300	0.7106
U238	604.1099	99.1413
Total	609.3423	100.0000

Natural Uranium Block, U3.

ISOTOPE	Weight (g)	Percent weight
H	0.0146	0.0004
C	1.8400	0.0500
SI	1.8400	0.0500
FE	1.8400	0.0500
U235	26.1300	0.7101
U238	3648.0000	99.1395
Total	3679.6646	100.0000

Table 1.M7 Axial Reflector Mild Steel Block.

Mild Steel Block, MST3.

Nuclide	Weight (g)	Percentage of weight
H	0.0084	0.0005
C	1.9890	0.1300
AL	1.2240	0.0800
TI	0.6120	0.0400
CR	0.4590	0.0300
MN	5.8140	0.3800
FE	1517.7600	99.1995
NI	0.9180	0.0600
CU	0.9180	0.0600
MO	0.3060	0.0200
Total	1530.0084	100.0000

Table 1.M8 The Radial Steel Reflector Region.

The width of the square section steel bar is 5.08 cm.

Steel bar MST9F10. (Weight per 1 cm length) Total length ~3 m

Nuclide	Weight (g)	Percentage of weight
H	0.0020	0.0010
C	0.3550	0.1798
SI	0.3750	0.1900
P	0.0570	0.0289
S	0.0510	0.0258
MN	1.6780	0.8500
FE	194.8830	98.7244
Total	197.4010	100.0000

Table 1.M.9 Mild Steel Sheath and Superlattice Grid Plates.

(The quoted weights are per 1 cm length and corresponding to a single column of plates).

The double element mild steel sheath, DSHEATH A.

Note: The weight figures for the double sheath, DSHEATH A, are per single element.

DSHEATHA

Nuclide	Weight (g)	Weight percent
H	0.0002	0.0018
C	0.0075	0.0658
AL	0.0014	0.0123
CR	0.0005	0.0044
MN	0.0370	0.3246
FE	11.3470	99.5395
NI	0.0022	0.0193
CU	0.0037	0.0325
Total	11.3995	100.0000

The single element mild steel sheath is MSHTH

MSHTH

Nuclide	Weight (g)	Percent weight
H	0.0007	0.0061
C	0.0098	0.0854
SI	0.0034	0.0296
P	0.0010	0.0087
S	0.0039	0.0340
MN	0.0396	0.3452
FE	11.4140	99.4910
Total	11.4724	100.0000

The single element mild steel sheath weighs 0.6% more (per element) than the double element sheath.

The Mild Steel Superlattice Grid Plates.

These are assumed to have the same composition as the mild steel sheath, MSHTH

Table 1.M10 Mild Steel Cylindrical Spacer Material, MSTST3 and MSTST12 used above and below the Steel Reflector or Shield Region.

Weight per 1 cm length: 33.23 g

Table 1.M11 Multiscan Fission Chambers

The compositions are described in RPD/DWS/100.

The chamber materials consist of:

Stainless steel	106.8 g
Alumina rod (Al_2O_3)	3.69 g

There is a lead glass seal, 0.14 g,
a PTFE insulated screen cable in a copper tube along the chamber edge, 0.9 g
and a brass cable support, 0.66 g

The weight of the 99.0% Pu239 deposits is about 150 micro-g

Details of the Components used in the Pin Geometry Assemblies, 23 and 25.

The weights of the fuel pin materials are given in BTN/132 and the details of the calandria in BTN/19. The dimensions of a fuel pin are illustrated in Figure 1.20. The pins rest on the support plate of the mini-calandria. The lower extremity of the oxide pellets is $0.038 + 0.109 + 0.287 = 0.434$ cm from the bottom of the assembled mini-calandria. Similarly, the upper extremity of the oxide pellets is 0.111 cm from the top of the assembled mini-calandria.

The average weight of each endcap is 0.18 g and of each spacer disc is 1.30 g, the total weight of steel in a fuel pin can be about 26 g. The calandria top plate plus filler boss weighs 6.0 g, and the bottom support plate plus 4 screws weighs 7.9 g. Thus the upper plus lower plate regions weigh 23.3 g.

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Table 1.M12 Compositions of the Fuel Pins.

Weight in g (with the Pu241 and Am241 data adjusted to June 1981, the reference date for the cores)

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
U234	0.0088	0.0084	0.0082	0.0090	0.0072	0.0073
U235	0.9036	0.8615	0.8321	0.9133	0.7340	0.7379
U236	0.0051	0.0048	0.0047	0.0051	0.0041	0.0041
U238	125.6506	119.7712	115.6943	126.9800	102.0531	102.6017
Pu238	0.0245	0.0382	0.0448	0.0307	0.0615	0.0616
Pu239	19.3308	24.3131	29.1105	19.6565	39.3525	39.1400
Pu240	4.3973	6.2246	6.9319	4.9327	9.8753	9.9942
Pu241	0.4619	0.7353	0.7615	0.5807	1.1626	1.2950
Pu242	0.1153	0.1845	0.1981	0.1382	0.2766	0.2926
Am241	0.3142	0.3663	0.3794	0.2675	0.5355	0.4467
O	20.3101	20.4786	20.6709	20.6188	20.6120	20.6918
H	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Al	0.0086	-	0.0145	0.0139	0.0070	0.0105
Si	-	0.0069	0.0061	0.0192	0.0350	-
Ca	0.0086	-	-	0.0174	0.0350	0.0737
Cr						0.0070
Fe	0.0086	-	0.0117	0.0105	0.0157	0.0175
Ni	-	0.0087	0.0175	0.0226	-	0.0035
Total	171.549	173.003	174.687	174.217	174.768	175.386
s.d.	± 1.4	± 1.3	± 0.8	± 0.7	± 1.1	± 1.2

PUPIN denotes a mixed plutonium-uranium oxide fuel pin. There are 6 different types of fuel pin, denoted PUPINA to PUPINF, having the same dimensions but different compositions.

Mean uranium isotopic composition:

U234 (0.007)%, U235 (0.714 ± 0.002)%, U236 (0.004)%, U238 (99.275 ± 0.003)%

The U236 is produced by Pu240 decay and so the U236 content depends on the Pu240 content of the fuel and the decay time.

The standard deviations are for the weight of the pellet stack in a single pin. For an element (which contains 3 calandria each containing 16 pins) the standard deviations of the total weight are correspondingly reduced. Uncertainties are discussed in BTN/132. On the basis of differences between analyses carried out at Winfrith and Harwell it is assumed (probably pessimistically) that the systematic uncertainty in the plutonium content is $\pm 0.2\%$. It is considered that the other uncertainties in the compositions are negligible compared with this in the assessment of the uncertainty in k_{eff} . In addition to the systematic uncertainty, when small batches of pins are involved there is a batch to batch variation which must be taken into account. For a single element the random uncertainty is given as $\pm 0.2\%$, with an additional $\pm 0.1\%$ random uncertainty when data for the weights of the individual pins are not used in the analysis.

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Table 1.M12 continued. Percentage Compositions by Weight of the Fuel

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
U234	0.0051	0.0049	0.0047	0.0052	0.0041	0.0042
U235	0.5267	0.4980	0.4763	0.5242	0.4200	0.4207
U236	0.0030	0.0028	0.0027	0.0029	0.0023	0.0023
U238	73.2448	69.2307	66.2294	72.8861	58.3935	58.5005
PU238	0.0143	0.0221	0.0256	0.0176	0.0352	0.0351
PU239	11.2684	14.0536	16.6644	11.2828	22.5170	22.3165
PU240	2.5633	3.5980	3.9682	2.8314	5.6505	5.6984
PU241	0.2693	0.4250	0.4359	0.3333	0.6652	0.7384
PU242	0.0672	0.1066	0.1134	0.0793	0.1583	0.1668
AM241	0.1832	0.2117	0.2172	0.1535	0.3064	0.2547
O	11.8392	11.8371	11.8331	11.8351	11.7939	11.7979
H	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Al	0.0050		0.0083	0.0080	0.0040	0.0060
Si		0.0040	0.0035	0.0110	0.0200	
Ca	0.0050			0.0100	0.0200	0.0420
Cr						0.0040
Fe	0.0050		0.0067	0.0060	0.0090	0.0100
Ni		0.0050	0.0100	0.0130		0.0020
Total	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000

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Table 1.M13 Details of the UO₂ Pins

Note: The uranium used in UO₂PIND and UO₂PINE was obtained from two sources. The U²³⁵ content of one batch has been measured as 0.00722, 0.00717, 0.00724 and 0.00721 giving an average of 0.00721. The larger batch has U²³⁵ content determinations of 0.00705, 0.00695 and 0.00691, averaging 0.00697. The two batches were randomly mixed in making the pellets and an overall average U²³⁵ content of 0.0071 has been taken for these pins.

Compositions of the UO₂ Pellets in the UO₂ Pins (weight in g) (Data from BTN-134)

Nuclide	UO ₂ PINC	Percent by weight	UO ₂ PIND	Percent by weight	UO ₂ PINE	Percent by weight
U ²³⁴	0.0062	0.0035	0.0061	0.0035	0.0061	0.0035
U ²³⁵	1.0936	0.6256	1.0929	0.6258	1.0945	0.6258
U ²³⁸	152.926	87.4828	152.825	87.5069	153.050	87.5069
O	20.706	11.8451	20.6923	11.8483	20.7227	11.8483
FE	0.0017	0.0010	0.0035	0.0020	0.0035	0.0020
AL	0.0175	0.0100	0.007	0.0040	0.007	0.0040
SI	0.0306	0.0175	0.0105	0.0060	0.0105	0.0060
CA	0.0140	0.0080	0.0052	0.0030	0.0052	0.0030
C	0.0105	0.0060				
H	0.0009	0.0005	0.0009	0.0005	0.0009	0.0005
	174.807		174.643		174.9	
Total	174.807	100	174.643	100	174.9	100
s.d.	±0.673		±0.858		±0.657	

Hydrogen is assumed present at 5 ppm.

The mean isotopic composition of the uranium is U²³⁴ (0.004 ±0.001)%, U²³⁵ (0.711 ±0.001)%, U²³⁸ (99.285 ±0.001)%.

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Table 1.M14 Compositions of the Fuel Pin Cans and End Regions

(weights in g) .

- Notes: 1 These weights (in g) are obtained from the average total steel weight in a pin, average weights for an end cap and a spacer disc, the estimated average number of spacers in a pin and the bonded compositions of the various steels.
- 2 Hydrogen has been assumed present at 5 ppm, based on a survey for steel components. This figure has been used for all steels.

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
H	0.00014	0.00012	0.00014	0.00013	0.00013	0.00013
C	0.0083	0.0148	0.0085	0.0126	0.0046	0.0045
Al				0.0009	0.0009	0.0006
Si	0.135	0.179	0.132	0.141	0.163	0.164
P	0.0061	0.0067	0.0058	0.0055	0.0022	0.0022
S	0.0041	0.0038	0.0041	0.0015	0.0029	0.0030
Ti				0.0072	0.0072	0.0054
Cr	5.296	4.421	5.198	4.672	4.724	4.773
Mn	0.477	0.480	0.468	0.361	0.310	0.311
Fe	18.731	16.842	18.393	17.592	17.894	18.057
Co		0.0009		0.0013	0.0013	0.0010
Ni	2.911	2.880	2.861	2.520	2.647	2.676
Cu				0.0020	0.0020	0.0015
Nb		0.142				
Mo				0.0011	0.0107	0.0106
Total	27.57	24.97	27.07	25.32	25.77	26.01

Table 1.M15 Compositions of the Cans of the UO2 Pins (g)

Nuclide	U02PINC	U02PIND	U02PINE
H	0.00014	0.00013	0.00013
C	0.0083	0.0128	0.0046
AL		0.0008	0.0008
SI	0.135	0.144	0.164
P	0.0061	0.0056	0.0022
S	0.0041	0.0015	0.0030
TI		0.0066	0.0066
CR	5.306	4.773	4.749
MN	0.478	0.369	0.311
FE	18.765	17.966	17.983
CO		0.0012	0.0012
NI	2.917	2.575	2.662
MO		0.0010	0.0107
AU		0.0018	0.0018
Total	27.62	25.86	25.90

Table 1.M16 Details of the Mini-calandria - Weights of Steel and Sodium.

Mini-calandria identifier	Average Steel wt (g)	± std deviation (g)	Average Sodium wt (g)	± std deviation (g)
NACLI	653.9	5	289.8	1.8
NACLIIS	645.8	5	292.8	1.7
NACLIH	659.4	1.4	286.9	1.3
NACLIV	635.5	3.3	288.7	1.7
NACLIVH	650.1	1.8	285.4	0.6
NACLV	650.2	1.5	286.2	2.2
VCLI	661.0	1.8	-	
VCLIIS	645.8 *		-	
VCLIH	659.3	1.3	-	
VCLIV	636.3	3.3	-	
VCLIVH	647.8	2	-	
VCLV	651.0	2	-	
VCLVI	644.0	4.2	-	
VCLVII	647.0 *			

* Zebra PLATEDATA Database value

Note:- Identifiers beginning with NA indicate sodium filled calandria - those beginning with V indicate a voided calandria.

There are 168 mini-calandria elements, the total number of mini-calandria required being 504. The majority of sodium filled mini-calandria (210) are of type NACLIH. The corresponding voided mini-calandria, type VCLIH, have the same weight and can be taken to differ only in the sodium content. The differences between mini-calandria NACLIV and VCLIV, and between NACLV and VCLV, (0.8 g), are within the uncertainties of the weights and can be neglected. In fact, the PLATEDATA Database gives the same weights for the voided calandria as for the corresponding sodium filled calandria (and are as given above for the sodium filled calandria).

In the models defined in Section 3 the difference between the mini-calandria elements in Assembly 23 and Assembly 25 has been assumed to be the absence of the sodium region material in Assembly 25, although there is not a full correspondence between the sodium filled and the voided calandria used in the cores. The difference between the steel contents of the pin zones of the two assemblies is small (~0.1% overall).

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Element weights of steel in 16 mini-calandria tubes (g)

- Notes: 1. These weights have been obtained from average weights for 16 tubes and the bonded compositions of the steels. For NACLIIS the weights of the steel components of the calandria, other than the calandria tubes for NACLII have been taken to apply, and the weights of the NACLIIS tubes adjusted slightly to give the correct total steel weight.
2. Hydrogen has been assumed present at 5 ppm.

Nuclide	NACLI	NACLIIS	NACLIIS	NACLIV	NACLIV	VCLVI	VCLVII
H	0.0015	0.0014	0.0016	0.0015	0.0015	0.0016	0.0015
C	0.088	0.416	0.0504	0.153	0.153	0.0504	0.089
Si	1.440	1.936	1.986	1.687	1.687	1.986	1.358
P	0.061	0.027	0.0252	0.0675	0.0675	0.0252	0.068
S	0.043	0.054	0.0347	0.0153	0.0153	0.0347	0.032
Ti		0.960					
Cr	56.368	52.992	58.02	56.83	56.83	58.02	55.67
Mn	5.104	4.224	3.721	4.355	4.355	3.721	5.196
Fe	198.80	183.79	218.71	212.89	212.89	218.71	201.39
Co		0.054					0.472
Ni	31.056	31.456	32.63	30.70	30.70	32.63	30.94
Cu		0.054					
Mo		0.027	0.126			0.126	
Total	292.9615	275.9914	315.3049	306.6993	306.6993	315.3049	295.2165

For the voided calandria, VCLI, VCLII, VCLIII, VCLIV and VCLV the data for the corresponding sodium filled calandria have been used.

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Element weights of mini-calandria excluding the tubes (g)

- Notes: 1 These weights have been obtained from the average weights of the various components (with small adjustments to preserve the total weight of a calandria) and the bonded compositions of the steels.
- 2 Hydrogen has been assumed present at 5 ppm.
- 3 The element weights in the filled calandria should also be used in calculations for the equivalent voided calandria.

Nuclide	NACLI	NACLIIS	NACLIIS	NACLIV	NACLIV	VCLVI	VCLVII
H	0.0018	0.0018	0.0017	0.0016	0.0017	0.0016	0.0018
C	0.190	0.229	0.107	0.194	0.107	0.194	0.176
SI	1.95	2.317	1.802	2.210	1.799	2.209	1.357
P	0.126	0.094	0.108	0.091	0.107	0.091	0.090
S	0.054	0.033	0.030	0.028	0.030	0.028	0.043
TI							
CR	66.40	67.147	61.06	59.82	60.96	59.80	61.79
MN	5.41	5.769	5.030	5.171	5.021	5.170	3.902
FE	253.66	260.438	242.25	231.49	241.83	231.42	251.92
CO							
NI	33.18	33.786	33.64	29.73	33.58	29.72	32.450
CU							
MO			0.070	0.070	0.070	0.070	0.070
Total	360.9718	369.8148	344.0987	328.8056	343.5057	328.7036	351.80

Total steel content of the minicalandria (g).

Nuclide	NACLI	NACLIIS	NACLIIS	NACLIV	NACLIV	VCLVI	VCLVII
H	0.0033	0.0032	0.0033	0.0031	0.0032	0.0032	0.0033
C	0.278	0.645	0.1574	0.347	0.26	0.2444	0.265
SI	3.39	4.253	3.788	3.897	3.486	4.195	2.715
P	0.187	0.121	0.1332	0.1585	0.1745	0.1162	0.158
S	0.097	0.087	0.0647	0.0433	0.0453	0.0627	0.075
TI	0	0.96	0	0	0	0	
CR	122.768	120.139	119.08	116.65	117.79	117.82	117.46
MN	10.514	9.993	8.751	9.526	9.376	8.891	9.098
FE	452.46	444.228	460.96	444.38	454.72	450.13	453.31
CO	0	0.054	0	0	0	0	0.472
NI	64.236	65.242	66.27	60.43	64.28	62.35	63.39
CU	0	0.054	0	0	0	0	
MO	0	0.027	0.196	0.07	0.07	0.196	
Total	653.9333	645.8062	659.4036	635.5049	650.205	644.0085	646.946

Table 1.M17 Element Contents of the Sodium Regions of the Mini-calandria (g)

The impurity contents were all from measurements except the hydrogen and oxygen contents of NACLIII, NACLIV and NACLV which were assumed to be the same as the average contents of NACLI and NACLIIS.

Contents by weight (g)

Nuclide	NACLI	NACLIIS	NACLIII	NACLIV	NACLV
H	0.0029	0.0059	0.004	0.004	0.004
O	0.054	0.009	0.03	0.03	0.03
Na	289.8	292.8	286.9	288.7	286.2
K			0.007	0.007	0.007
Ca	0.0232	0.002	0.014	0.014	0.014
Fe	0.009				
Total	289.8891	292.8169	286.9550	288.7550	286.2550

Percentages by weight

Nuclide	NACLI	NACLIIS	NACLIII	NACLIV	NACLV
H	0.0010	0.0020	0.0014	0.0014	0.0014
O	0.0186	0.0031	0.0105	0.0104	0.0105
Na	99.9693	99.9942	99.9808	99.9810	99.9808
K			0.0024	0.0024	0.0024
Ca	0.0080	0.0007	0.0049	0.0048	0.0049
Fe	0.0031				
Total	100.0000	100.0000	100.0000	100.0000	100.0000

Components of Additional Elements.

The elements containing these components are replaced in the calculational models for the critical cores by "standard elements". These additional data are included here so that a model including a representation of the special elements can be set up. *Both the dimensions and compositions are given in this section (dimensions in cm).*

Table 1.M18 Weights of the Alternative Plutonium Plates

The plutonium plates used in the cells D (PUIX8) and E (PUX8) are compared here with the plate used in the standard element cells C (PUVIII8). Also given is the composition of the mixed oxide plate PUIV4.

CORE REGION DATA

	PUVIII8 (g)	percent weight	PUIX8 (g)	percent weight	PUX8 (g)	percent weight	PUIV4 (g)	percent weight
CORE								
U234							0.0040	0.003
U235							0.6120	0.468
U238	0.0014	0.0018	0.0107	0.0138	0.0029	0.0037	85.4890	65.419
NP237							0.0010	0.001
PU238	0.0620	0.0800	0.0720	0.0929	0.0690	0.0889		
PU239	59.1110	76.2773	59.0300	76.1827	59.2570	76.3249	25.7100	19.674
PU240	14.1820	18.3006	14.2030	18.3300	14.1300	18.1999	2.8860	2.208
PU241	2.4750	3.1938	2.4990	3.2251	2.4870	3.2033	0.2920	0.223
PU242	0.3870	0.4994	0.3720	0.4801	0.3820	0.4920	0.0260	0.020
AM241	-0.0083	-0.0107	-0.0343	-0.0443	-0.0861	-0.1109	0.1237	0.095
H	0.0011	0.0014	0.0013	0.0017	0.0009	0.0012		
C	0.0434	0.0560	0.0288	0.0372	0.0302	0.0389	0.0168	0.013
N	0.0029	0.0037	0.0011	0.0014	0.0012	0.0015		
O	0.0121	0.0156	0.0078	0.0101	0.0062	0.0080	15.4510	11.824
AL	0.0053	0.0068	0.0053	0.0068	0.0050	0.0064	0.0168	0.013
SI	0.0034	0.0044	0.0068	0.0088	0.0038	0.0049	0.0168	0.013
CR	0.0016	0.0021	0.0027	0.0035	0.0019	0.0024		
MN	0.0007	0.0009	0.0008	0.0010	0.0005	0.0006		
FE	0.0078	0.0101	0.0062	0.0080	0.0071	0.0091	0.0168	0.013
NI	0.0043	0.0055	0.0134	0.0173	0.0081	0.0104	0.0168	0.013
GA	1.2022	1.5513	1.2582	1.6238	1.3311	1.7145		
Total	77.4949		77.4848		77.6378		130.6787	
Core width (cm)	4.671		4.671		4.671		4.953	
Core thickness	0.2360		0.2351		0.2350		0.55312	

The data for Pu241 and Am241 relate to the reference date for the ZEBRA databank, *January 1971*, a date which is earlier than the date of manufacture of some of the plates. Hence the negative Am241 content (and a larger Pu241 content than at manufacture) which arises from extrapolation back to a date before the Pu241 in the plate started to decay.

To obtain values for June 1981, the reference date for the CADENZA programme, reduce the Pu241 content by multiplying by the Factor = 0.605 and add the difference, 0.395 times the original Pu241 content, to the Am241.

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CAN REGION

The can region weights are separated into the steel can and the copper plating region. (The PUIV4 plate does not contain a copper can.

The percentages are based on the combined weight of steel plus copper.

Steel Can	PUVIII8 (g)	weight percent	PUIX8 (g)	weight percent	PUX8 (g)	weight percent	PUIV4 (g)	weight percent
H	0.000075	0.0004	0.000075	0.0004	0.000074	0.0004	0.00008	0.0005
C	0.007360	0.0355	0.007342	0.0355	0.007821	0.0378	0.00858	0.05
SI	0.055574	0.2681	0.055437	0.2679	0.078954	0.3816	0.07036	0.41
P	0.002253	0.0109	0.002247	0.0109	0.004469	0.0216	0.00342	0.02
S					0.002681	0.0130	0.00343	0.02
TI					0.001490	0.0072		
CR	2.643516	12.7528	2.636999	12.7441	2.800630	13.5368	3.07163	17.90
MN	0.255340	1.2318	0.254711	1.2310	0.253249	1.2241	0.25568	1.49
FE	10.73419	51.7831	10.70775	51.7479	10.21330	49.3655	11.92100	69.47
NI	1.321758	6.3764	1.318502	6.3720	1.534389	7.4165	1.71428	9.99
NB							0.11154	0.65
Steel Can Wt.	15.020		14.983		14.897		17.16000	
CU region								
CU	5.709	27.5411	5.709	27.5904	5.792	27.9956		
Total can region. wt	20.729		20.692		20.689		17.16000	
Plate thickness (cm)	0.3274 ± 0.0005		0.3265 ± 0.0005		0.3264 ± 0.0005		0.6278 ± 0.0005	

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Table 1.M18B. The Alternative Natural Uranium Oxide Plate, UO₂R4.

This is the uranium oxide plate with “4 radiused corners” used in the core cells of the mixed oxide element, C22±04A. The core section of the element contains 11 cells CC22-06A. This plate includes silver-copper braze material.

Core region

Nuclide	Weight (g)	Percentage of weight
H	0.0005	0.0004
C	0.008	0.0060
O	15.847	11.8513
SI	0.008	0.0060
FE	0.008	0.0060
U234	0.006	0.0045
U235	0.838	0.6267
U238	117.000	87.4991
Total	133.7155	100.0000
Core width (cm)	4.851	
Core thickness	0.55424	

Can region

Nuclide	Weight (g)	Percentage of weight
H	0.000089	0.0005
C	0.008931	0.05
SI	0.087529	0.49
P	0.003573	0.02
S	0.003573	0.02
CR	3.286777	18.40
MN	0.275089	1.54
FE	12.393330	69.38
NI	1.804159	10.10
CU	0.265086	1.484
AG	0.682008	3.818
TOTAL	18.810100	105.3025
Plate thickness (cm)	0.6279	

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Table 1.M18C. The Stainless Steel Plate STSTD8 (dull steel).

This is used in the core cells of the mixed oxide element, C22±04A.

Nuclide	Weight (g)	Percent weight
H	0.0003	0.0005
C	0.1286	0.2000
AL	0.0643	0.1000
SI	0.5143	0.8000
TI	0.1929	0.3000
CR	11.6380	18.1000
MN	0.7071	1.1000
FE	44.6100	69.3995
NI	6.2350	9.7000
CU	0.0643	0.1000
MO	0.1285	0.2000
Total	64.2833	100.0000
Plate thickness (cm)	0.3236	

Zebra Control Rods

The benchmark models, specified for the calculation of the core k_{eff} values and the central spectral indices, have been corrected for the replacement of the Zebra control rods by core elements. However, for the calculation of the axial reaction rate scans and axial variation of reactivity worths (such as sodium reactivity worths) account should be taken of a possible asymmetry introduced by the asymmetrical loadings of the control rods, with an absorber section being at the top ends of the rods. For this reason the control rod compositions are given here.

The materials used in the control rods were chosen to match the core and blanket regions of the neighbouring elements but with a boron absorber section above a narrow upper blanket region. The blanket regions consist of natural uranium plates. The 9 control rods occupy the places of single elements. The plate geometry control rods were the same in all four cores and contained sodium.

The Compositions of the Control Rod Components.

Table 1.M19 Control Rod Plutonium Metal Plate, PUXIVC8

PLATE CORE COMPOSITION (Pu241/Am241 content refers to the PLATEDATA Database date)

Nuclide	Weight, g	Weight %
H	0.001	0.002
C	0.015	0.028
N	0.001	0.002
O	0.006	0.011
AL	0.004	0.007
SI	0.003	0.006
TI	0.001	0.002
CR	0.002	0.004
FE	0.003	0.006
NI	0.005	0.009
CU	0.001	0.002
ZN	0.001	0.002
GA	0.952	1.766
U238	0.012	0.022
NP237	0.001	0.002
PU238	0.057	0.106
PU239	41.791	77.511
PU240	9.290	17.231
PU241	1.746	3.238
PU242	0.284	0.527
AM241	-0.260	-0.482
Total	53.916	

To obtain values for June 1981 revise the values for Pu-241 and Am-241

(Pu-241 Reduction Factor = 0.605, transfer 0.395 times Pu241 to Am241)

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PU PLATE CAN COMPOSITION

Nuclide	Weight, g	Weight %
H	0.00005	0.0005
C	0.0060	0.060
SI	0.0310	0.310
P	0.0035	0.035
S	0.0017	0.017
CR	1.8245	18.250
MN	0.1560	1.560
FE	6.9639	69.660
NI	1.0107	10.110
Cu	4.2	
Total	14.19735	

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Table 1.M20 Control Rod Uranium Oxide Plate , UO₂C₄R₄

PLATE CORE COMPOSITION

Nuclide	Weight, g	Weight %
H	0.00037	0.0004
C	0.0056	0.0059
SI	0.0056	0.0059
FE	0.0056	0.0059
O	11.1554	11.8513
U234	0.0042	0.0045
U235	0.59	0.6268
U238	82.3612	87.4992
Total	94.12797	

PLATE CAN COMPOSITION

Nuclide	Weight, g	Weight %
H	0.000065	0.0005
C	0.0065	0.05
SI	0.064	0.49
P	0.0026	0.02
S	0.0026	0.02
CR	2.390	18.4
MN	0.200	1.54
FE	9.012	69.38
NI	1.312	10.1
CU	0.230	1.77
AG	0.580	4.465
Total	13.80	

Table 1.M21 Control Rod Uranium Metal Plate, UC8

PLATE COMPOSITION

Nuclide	Weight, g	Weight %
C	0.058	0.054
SI	0.058	0.054
FE	0.058	0.054
U235	0.767	0.710
U238	107.080	99.129
Total	108.021	

Table 1.M22 Control Rod Stainless Steel Plate, STSTCF8
("Reduced density" steel plate, i.e. plate with holes.)

PLATE COMPOSITION

ISOTOPE	Weight (g)	Percent weight
Volume		
H	0.0001	0.0004
C	0.0040	0.0231
AL	0.0122	0.0700
SI	0.0850	0.4899
P	0.0047	0.0271
S	0.0018	0.0101
TI	0.0451	0.2599
CR	3.1422	18.1012
MN	0.3125	1.8000
FE	11.7467	67.6684
NI	1.9615	11.2996
CU	0.0122	0.0700
NB	0.0018	0.0101
MO	0.0295	0.1700
Total	17.3592	100.0000

COMMENT IN DATABASE: Weights calculated by scaling STSTF8 (Table 1.M.5) by 0.7028, the ratio of sizes.

Table 1.M23 Control Rod Sodium Plate, NASTMC4

PLATE CORE COMPOSITION

Nuclide	Weight, g	Weight %
H	0.0002	0.002
O	0.0014	0.017
NA	8.216	99.953
CA	0.0022	0.027
FE	0.0001	0.001
Total	8.22	

CAN COMPOSITION

Nuclide	Weight, g	Weight %
H	0.0001	0.0005
C	0.0078	0.06
SI	0.0665	0.51
P	0.0030	0.023
S	0.0016	0.012
CR	2.4913	19.12
MN	0.2085	1.6
FE	8.7646	67.265
NI	1.3916	10.68
NB	0.0951	0.73
Total	13.03	

COMMENTS IN DATABASE: NA + STEEL COMPOSITION AS NASTDM4

Control rod absorber regions

The absorber regions are made up from aluminium plates, ALCG8 and the boron plates, B10C2.

Table 1.M24 Control Rod Aluminium Plate, ALCG8

PLATE COMPOSITION

Material	Weight, g	Weight %
AL	7.0644	99.500
SI	0.0133	0.187
MN	0.00225	0.032
FE	0.01773	0.250
CU	0.00225	0.032
Total	7.1	

Table 1.M25 Control Rod Boron Absorber Plate, B10C2

PLATE CORE COMPOSITION

Material	Weight, g	Weight %
H	0.0082	0.04
B10	17.90	85.13
B11	1.57	7.47
C	0.3154	1.50
O	0.4333	2.06
AL	0.0841	0.40
SI	0.1577	0.75
K	0.0841	0.40
CR	0.0841	0.40
FE	0.1472	0.70
NI	0.1577	0.75
CU	0.0841	0.40
Total	21.0259	

PLATE CAN COMPOSITION

Material	Weight, g	Weight %
NI	37.05	100

(Dimensions are described as being nominal and the can material is assumed to be the same as for the plate NASTBRC4.)

Table 1.M26 The Control Rod Sheath.

IDENTITY CRSHEATH (weight per unit length of the inner plus outer tube)
Weight per 1 cm of length

Material	Weight, g	Weight %
H	0.0015	0.00
C	0.05	0.13
SI	0.04	0.11
P	0.01	0.03
S	0.01	0.03
MN	0.22	0.59
FE	36.82	99.11
Total	37.1515	

(All plates are nominally 4.318 cm square and the outer control rod sheath has a nominal outer dimension of 5.2544 cm square, the same as the standard elements. The area occupied by the sheath material (between the plate edges and the outer tube boundary) is then 8.9636 cm²).

1.1.4 Temperature Information.

Measurements were made in each of the assemblies to relate changes in the control rod setting to changes in the core temperature in order to correct the measured reactivities to values at **300K, the reference temperature.**

The temperatures at points throughout the core were measured and a core average value obtained by weighting with calculated values of the flux squared for the region of the core in which each of the temperature measurements was made. The basis for this is the assumption that the reactivity effects of the temperature rises (thermal expansion and Doppler effects) are proportional to flux times adjoint flux, (approximated here as flux squared).

The procedure is detailed in BTN-119. Weighting factors equivalent to flux-squared values, averaged over each of the nine super-lattice positions covering the core region and for each axial third of the core height, were obtained from an Assembly 22 RZ-diffusion theory calculation. The adequacy of these data was confirmed by comparison of calculated Pu239 fission rates with multi-chamber scans for each assembly. The weighting factors were directly applicable to all the sodium filled assemblies as a result of the similarity of the fission-rate distributions. Despite the variations produced by sodium removal the nature of the temperature correction procedure allowed the same set of weighting factors to be used for all the CADENZA assemblies, without introducing any significant error.

The influence of temperature variations in the radial blanket on reactivity changes was investigated in Core 25. Although the quantity of U238 in the blanket was considerably greater than in the core, the average flux levels were such that the resulting overall weighting factors for the blanket super-lattice positions were lower than any of the core values. There were, however, approximately 16 super-lattice positions to be considered in the blanket region compared with 9 in the core. Estimates of the influence of the radial blanket were based on the measurements in the four resistance bulbs in the double elements positioned at 59/60-45, 51-35/36, 49-54/55 and 40/41-45. The temperature in the blanket region between lattice coordinates Y-38 and Y-58 was always fairly stable at 300K whereas, due to the flow of cooling air through the core, the lattice positions below Y-38 had a mid-plane temperature of about 315K, compared with an average core value of about 330K. The contribution from the blanket region in converting the temperature distribution of a reference balance to an overall uniform temperature of 300K is comparable with the quoted uncertainty of 0.0001 dk/k. The maximum contribution to the reactivity change resulting from the comparison of two balances is about 0.00002dk/k. In relation to the overall experimental uncertainties in reactivity measurements, the influence of the radial blanket temperature is generally small and was therefore not included in the analysis.

The balances for the temperature calibrations for each assembly are summarised in ZTN22/10 Table 12 together with the final calibration factors. The reactivity change per weighted temperature difference is lower in the case of the voided cores, consistent with a lower Doppler effect due to a harder spectrum in the absence of sodium.

The validity of the procedure depends on the assumption that the reactivity effects are proportional to the measured temperature increase and to flux squared.

The temperature corrections to k_{eff} are at most 5×10^{-4} dk/k and have a $\pm 20\%$ uncertainty.

1.1.5 Additional Information Relevant to Criticality Measurements.

Refer to Section 1.4 for information on the calibration of control rods and the reactivity scale.

1.2 Description of Bucklings and Extrapolation Length Measurements

These were not derived for the CADENZA cores.

1.3 Description of Spectral Characteristics Measurements

1.3.1 Overview of the Experiment

Reaction rate ratio measurements were made in the plate geometry Assembly 22 using both fission chambers and foils. The measurements are described in detail in ZTN22-9. The fission chamber measurements were made for U235, U238, Pu239, Pu240 and Pu241. A special element was placed at the centre of the core (at position (X,Y)=(50,45)) containing the normal cells in the lower half but space above for a fission chamber. The plate stack contained twelve core cells with a sodium plate at the top. The fission chambers (illustrated in Figure 1.21A) were located 1.0 ± 0.5 mm above the sodium plate (see Figure 1.21B). For the measurements with a half element at the core centre 2 extra edge elements were added to the normal 206 element core at (56,51) and (44,39) (plus 9 control rods, with the standard core being modelled as a 215 element core).

The foil measurements were made for fission in U235, U238 and Pu239 and capture in U238. The foil measurements for U235 and U238 were made across the uranium oxide plates and the Pu239 fission was measured using a foil held adjacent to the plutonium plate in a special steel plate which replaced the standard stainless steel plate. The rate in the plutonium plate was then obtained from a cell calculation to relate the fission rate on the surface of the plate to the average value in the plate. Cell averaged reaction rate ratios were thus derived from the foil measurements.

1.3.2A Description of the Experimental Configuration

The experiments were conducted at the centre of Assembly 22. The assembly configuration and the experimental geometry of the environment of the measurements is described fully in Section 1.1.

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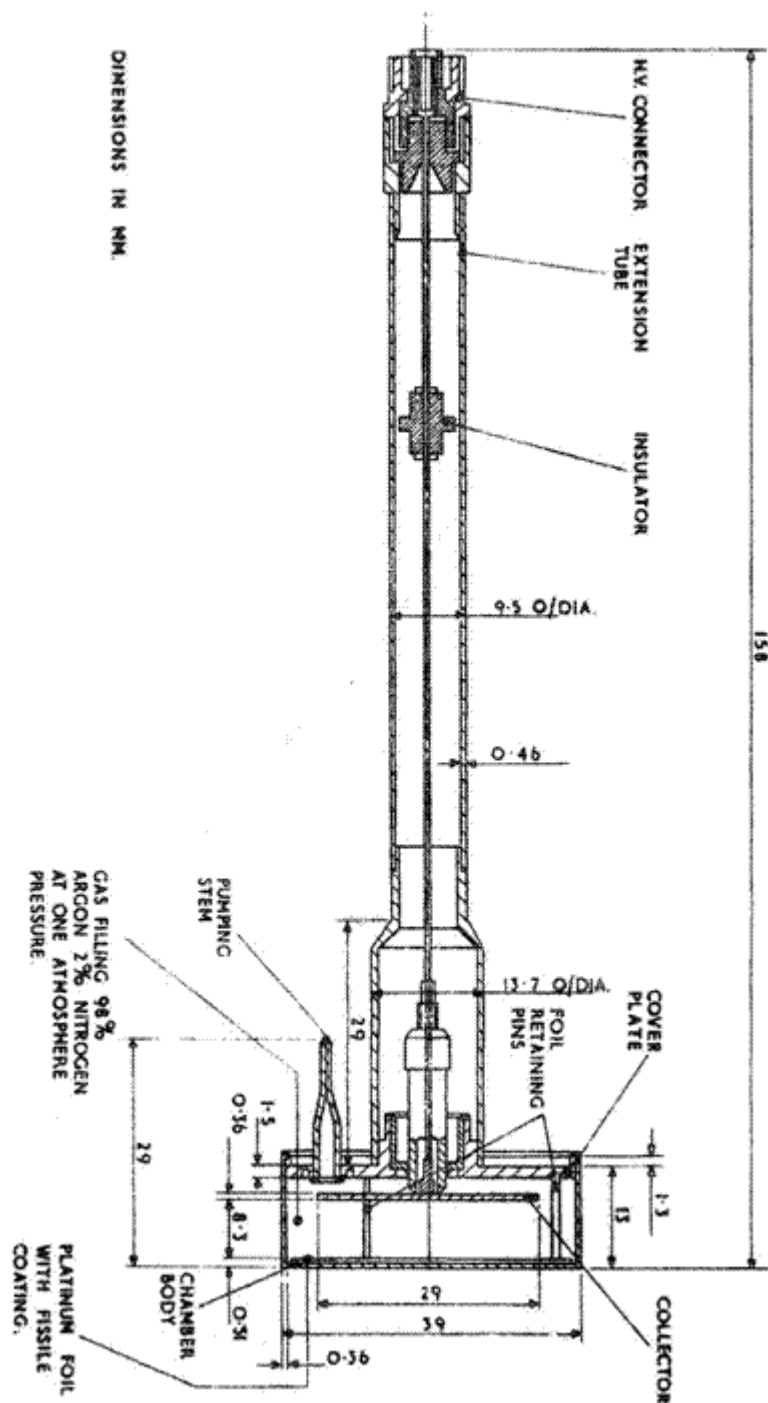


Figure 1.21A The Zebra Parallel Plate Fission Chamber.
(dimensions in mm.)

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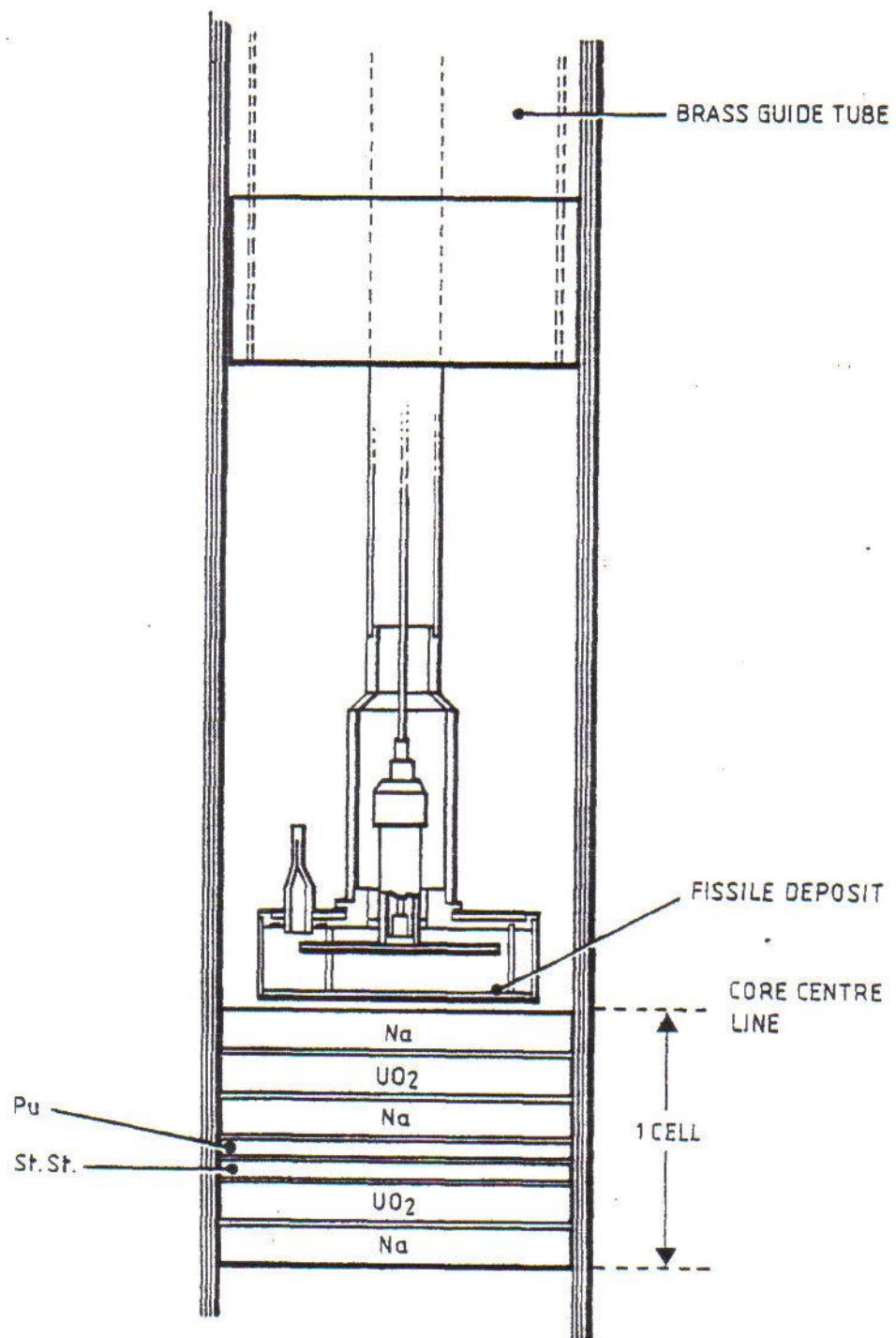


Figure 1.21B Fission Chamber Location on the Mid-plane of a Central Element.

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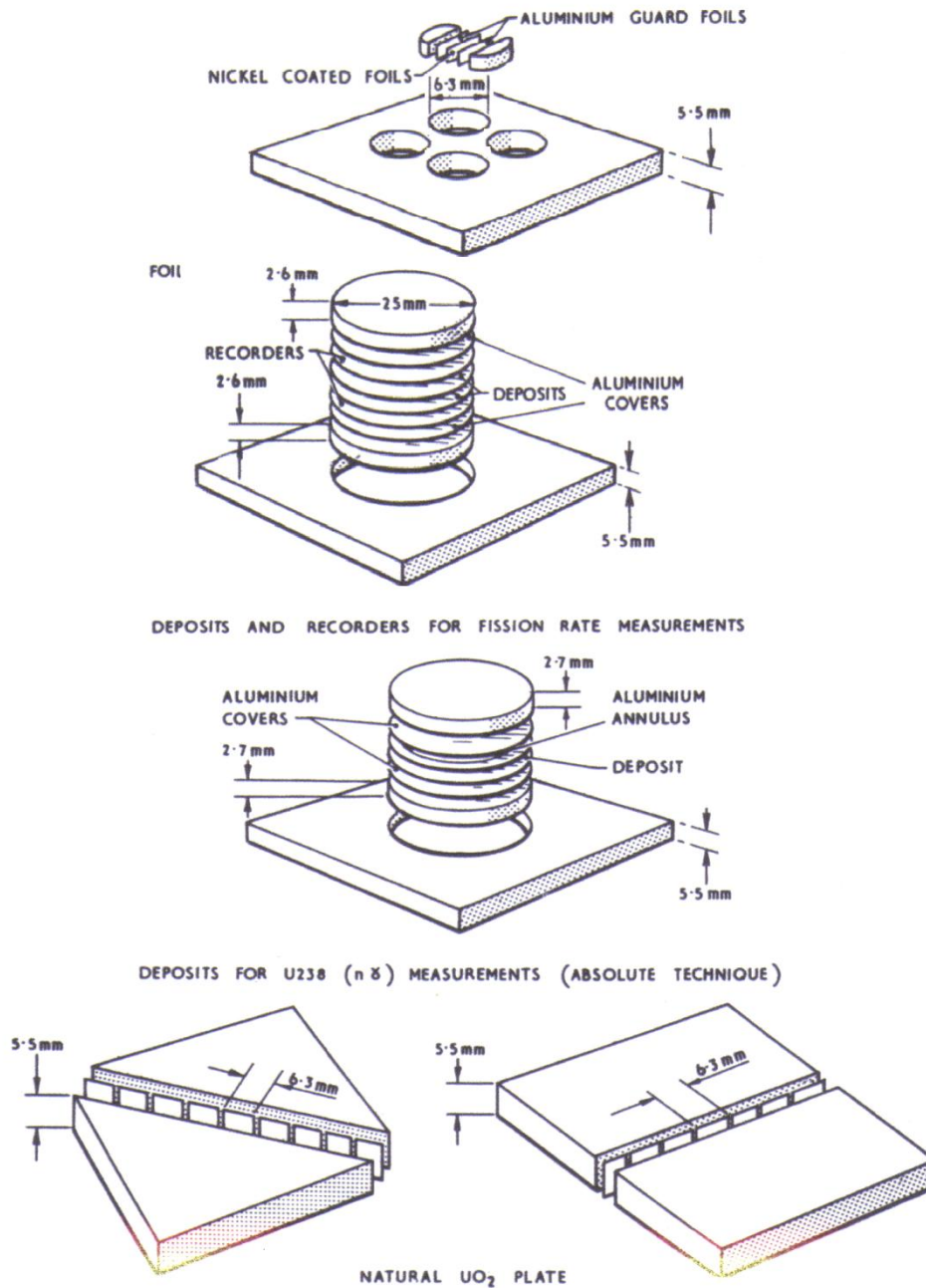


Figure 1.21C Location of Foils in the UO₂ plates

1.3.2B Methods

The details of the foils and deposits, and the measurements, corrections and sources of uncertainty are given in ZTN22/9 with only the essential information being reproduced in the present document. The ways in which foils were positioned in the UO_2 plates are shown in Figure 1.21C. The UO_2 plates were standard Zebra plates machined for foil location. The special stainless-steel plate holding the plutonium foils consisted of an integral base and sides (0.38mm and 0.76mm thick respectively) and a separate lid (0.56mm thick). A stainless-steel foil (0.13mm thick) on which the plutonium foils were located was positioned inside, small features on the lid keeping it in contact with the plate base. When assembled, the total plate thickness was 3.18mm (the thickness of the standard 40% steel plate, STSTF8, being 3.17 mm). The total mass of components was 24.9g, i.e. close to the average mass (24.7g) of the STSTF8 plate that it replaced. This type of special plate was used for two reasons. Firstly, the frame-like geometry of the STSTF8 plate did not lend itself to easy foil location and secondly, the special plate more closely matched the representation in the cell calculations made using the MURAL cell geometry, collision probability routine. At all non-foil bearing locations standard Zebra plates were used.

For the foil measurements of fission rates, the technique involved measuring the induced fission-product gamma-activities above a threshold of 1.28 MeV and applying a factor, $P(t)$, which depends on the fission product yields for the fissioning isotope for the reactor spectrum, and on the time, t , which has elapsed between irradiation and detection. $P(t)$ was derived by comparing the gamma activity ratio of foils irradiated inside a dummy fission chamber with the corresponding fission ratio obtained with chambers. These calibration measurements were made in a half-element which had a chamber above a half core. The fissile deposit was then adjacent to the core centre line.

All the foils were irradiated for the standard period of 2 hours. During the measurements the temperature of the assembly in the region containing the foils was between 330 and 340K. The F28/F25 results were obtained using 93% U^{235} and 0.04% U^{235} nickel-coated uranium metal foils. The F25/F49 results were obtained using the nickel-coated 93% U^{235} uranium metal and 20% PuO_2 /nickel foils.

The technique used to measure C28/F49 was essentially that developed by Chawla and is described in ZTN22/9. Natural UO_2 deposits were irradiated in UO_2 plates and the absolute U^{238} capture rate established by comparison of the induced Np^{239} activity with that emitted by an Am^{243} standard source of the same geometry. The deposits were counted on an automatic foil comparator containing a pair of NaI (Tl) detectors, 75mm diameter by 25mm thick, to establish the coincidence rate of the 99, 104 and 117 keV X-rays and the 106 keV gamma-ray. The corresponding value of F49 was measured with an absolute fission chamber located in a half-element (identical to that used in the fission ratio measurements) at lattice position (53,48), where it would not significantly affect the in-cell spectrum at location (50,45). The F49 measurement was related to the C28 measurement with the aid of flux monitors, seven Pu^{239} chambers from the multi-chamber scanning system being used for this purpose. Subsidiary measurements, using foils, established the small corrections to allow for the orientation of the deposits and the difference in fission rate between the chamber position and the stainless-steel plate in the cell.

Corrections were applied to the foil measurements for the radial and axial variations in the reaction rates to obtain cell average values. The corrections for F25, F28 and C28 were based on measurements made of the radial and axial variations within the uranium oxide plates and on the surfaces, for the different plates in a cell. The correction for F49 was based on calculations made using the MURAL collision probability cell code, which represents the individual regions of the plates in a cell, and the FGL5 fine group cross-section library (a one-dimensional slab model being used in these calculations). The calculated correction was an increase of $0.65\% \pm 0.3\%$.

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Table 1.8A Location of Foils

Cell 13	13/7	NASTDL4	
	13/6	UO23R4	F25, F28, C28
	13/5	NASTDL4	
	13/4	PUVIII8	
	13/3	STSTF8	F49
	13/2	UO23R4	F25, F28, C28
	13/1	NASTDL4	
Cell 12	12/7	NASTDL4	
	12/6	UO23R4	F25, F28, C28
	12/5	NASTDL4	
	12/4	PUVIII8	
	12/3	STSTF8	F49
	12/2	UO23R4	F25
	12/1	NASTDL4	
Cell 11	11/7	NASTDL4	
	11/6	UO23R4	F25, F28, C28
	11/5	NASTDL4	
	11/4	PUVIII8	
	11/3	STSTF8	
	11/2	UO23R4	
	11/1	NASTDL4	

The axial variation of the U238 fission rate and capture rate are shown in Table 1.8B. (f28 denotes the measured gamma activity.) The rates were measured using 0.04% U235 foils, 25.3mm diameter x 0.08mm thick, located horizontally at the centres of the UO₂ plates and have been normalised to unity at the core centre. There are two UO₂ plates in each cell, at plate positions 2 and 6, counting the plates from the lower surface of the cells. Cell 12 is below the centre plane of the core and cell 13 above. (Cell/Plate) = (13/2) denotes the plate in position 2 in cell 13. The measurements were made in version A of Core 22 with the axial orientation of all the cells being the same. On the basis of measurements made using foils held horizontally and vertically, as shown in Table 1.9, the cell average value of F28/F25 was obtained.

Sources of uncertainty in the measurements are summarised in Tables 1.10 and 1.11.

Table 1.8B Axial Variations of the U238 Fission and Capture Rates Measured on the Mid-planes of UO₂ Plates using 25.3 mm diameter Foils.

(r denotes a random uncertainty and s a systematic uncertainty, all being in percent)

Examples of the sources of the systematic errors are the foil and chamber mass calibrations and the corrections made to obtain the cell averaged values. These would be common to the measurements in other cell configurations and in other ZEBRA assemblies.

Plate Position (Cell/Plate)	Distance Above Core Centre-Plane (mm)	f28 (s.d. in %)	C28 (s.d. in %)
UO ₂ (15/6)	103.4	0.958 ±0.2r	0.965 ±0.2r
UO ₂ (15/2)	84.5	0.982 ±0.2r	0.975 ±0.2r
UO ₂ (14/6)	65.8	0.978 ±0.2r	0.988 ±0.2r
UO ₂ (14/2)	46.9	0.998 ±0.2r	0.992 ±0.2r
UO ₂ (13/6)	28.2	0.992 ±0.2r	0.998 ±0.2r
UO ₂ (13/2)	9.3	1.008 ±0.2r	0.999 ±0.2r
UO ₂ (12/6)	-9.3	0.992 ±0.2r	1.001 ±0.2r
UO ₂ (12/2)	-28.2	1.005 ±0.2r	0.995 ±0.2r
UO ₂ (11/6)	-46.9	0.984 ±0.2r	0.993 ±0.2r
UO ₂ (11/2)	-65.8	0.991 ±0.2r	0.987 ±0.2r
UO ₂ (10/6)	-84.5	0.973 ±0.2r	0.983 ±0.2r
UO ₂ (10/2)	-103.4	0.976 ±0.3r	0.969 ±0.2r

Table 1.9 U238/U235 Fission Ratios in the Central Region of the Element located at (50,45).

Plate Position (Cell/Plate)	Foil orientation	F28/F25 (s.d. in %)
UO ₂ (12/6)	Vertical	0.03635 ± 0.8r 0.6s
UO ₂ (13/2)	Vertical	0.03707 ± 0.9r 0.6s
UO ₂ (13/6)	Horizontal	0.03610 ± 1.0r 0.6s
UO ₂ (11/6)	Horizontal	0.03627 ± 1.0r 0.6s

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Table 1.10 Sources of Uncertainty in the Cell Averaged Fission Ratio Measurements.

Sources of uncertainty	F25/F49	F28/F25
	(% s.d.)	(% s.d.)
<u>P(t) Measurements</u>		
Relative masses of fission chambers	1.0 s	0.6 s
Fission chamber counting rates	0.4 r	0.4 r
Statistics of foil counting	0.1 r	0.1 r
Mass uncertainties of foil counting	0.1 r	0.07 r
Resonance shielding in the foil	0.1 r	0.06 r
Relating absolute gamma-activities	0.3 r	0.6 r
<u>Plate Measurements</u>		
Statistics of foil counting	0.1 r	0.2 r
Mass uncertainties of foil counting	0.1 r	0.05 r
Flux corrections (Macroscopic; Global)	0.2 r	0.2 r
Perturbation produced by the use of 93% U5 foils	0.2 r	0.2 r
Radial fine structure variations	0.4 r	0.5 r
Cell average correction	0.3 r	
Relating absolute U235 and Pu239 gamma-activities	0.8 r	0.5 r
TOTAL	1.1%r, 1.0%s	1.1%r, 0.6%s

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Table 1.11 The Sources of Uncertainty for the Cell-averaged value of C28/F49.

<u>Absolute C8 Measurements</u>	(%)
Deposit counting	0.5r, 0.3s
Macroscopic flux correction	0.1r
Axial fine structure correction	0.1r
Radial fine structure correction	0.4r
Foil orientation correction	0.2r
Irradiation timing	0.1r
<u>Absolute F9 Measurements</u>	(%)
Resonance shielding in foil (chamber)	0.1r
Zebra plate/chamber foil counting	0.3r
Zebra absolute chamber counting	0.2r, 0.4s
Radial fine structure correction	0.4r
Macroscopic flux correction	0.1r
Zebra SS/plutonium plate correction	0.2r
Secondary isotope correction	0.1r
TOTAL	0.9r, 0.5s

1.3.2C Results of the Measurements

Reaction rate ratio measurements were made both by the AEEW ZEBRA Group and by a team of scientists from ANL. The results are given in Table 1.12 for both the cell averaged values and the chamber measurements.

The effects of uncertainties in the compositions and dimensions of core components have not been included in the above assessments. Also, account has not been taken of the discrepancies found between the measurements made by different teams participating in intercomparison experiments, such as the IRMA intercomparisons. These are discussed in Section 2.3.

Table 1.12 Reaction Rate Ratio Measurements in Assembly 22

Reaction rate ratio	Measured by AEEW	Measured by ANL	(ANL/AEEW -1)%
F28/F25 (Cell Average)	0.03634 ($\pm 1.1\%$ r 0.6% s)	0.03757 ($\pm 0.6\%$ r 1.6% s)	$+3.4 \pm 2.0$
F25/F49 (Cell Average)	0.959 ($\pm 1.1\%$ r 1.0% s)	0.941 ($\pm 0.6\%$ r 1.0% s)	-1.9 ± 1.8
C28/F49 (Cell Average)	0.1266 ($\pm 0.9\%$ r 0.5% s)	0.1226 ($\pm 0.6\%$ r 1.2% s)	-3.2 ± 1.5
F28/F25 (Chamber)	0.03483 ($\pm 0.4\%$ r 0.6% s)	0.03566 ($\pm 0.4\%$ r 1.6% s)	$+2.4 \pm 1.8$
F25/F49 (Chamber)	0.960 ($\pm 0.4\%$ r 1.0% s)	0.948 ($\pm 0.3\%$ r 1.6% s)	-1.3 ± 1.9
F40/F49 (Chamber)	0.2594 ($\pm 0.9\%$ r 1.8% s)		
F41/F49 (Chamber)	1.217 ($\pm 0.5\%$ r 3.8% s)		

'r' denotes a random uncertainty and 's' a systematic uncertainty.

The F25/F49 and C28/F49 measurements (which involved measurements using the Pu239 fission chamber) have been revised because of a 1% revision in the Pu239 alpha decay half-life relative to the value used when the fission chambers were calibrated by alpha assay. Ratios to Pu239 fission have been reduced by 1%. Both the fission chamber and the foil measurements have been revised. The value used at that time was $(24.35 \pm 0.02) \times 10^{+3}$ years and the revised value is $(24.11 \pm 0.01) \times 10^{+3}$. Note, however, that there is no mention of the correction having been applied to the F40/F49 and F41/F49 values.

Uranium deposits were calibrated by measuring the U234 alpha decay and so there was a dependence on isotopic analysis as well as on the accuracy of the U234 half-life. The half-life value used was $0.2442 \times 10^6 \pm 0.6\%$ years which compares with the current value of $0.2455 \times 10^6 \pm 0.2\%$, a difference of 0.5%, which is within the assumed uncertainty.

1.3.3 Description of the Material Data

The material data for the environment of the measurements is that described in Section 1.1.

1.3.4 Description of Temperature Data

Measurements with foils were typically in the range 330 to 340K. Corrections were made for departure from 300 K by the measurers.

1.3.5 Additional Relevant Information

The results of international intercomparison studies and other intercomparisons are described in section 2.3.

1.4 Description of Reactivity Effects Measurements

1.4.1 Overview of the Experiment

The difference in reactivity between two core loadings was measured by the compensating change in the balance position of a calibrated control rod (usually FR9). The control rods were calibrated in terms of the delayed neutron scale by inverse kinetics measurements, as described in Section 1.4.6. The inverse kinetics method is described in BTN-75. (Alternative reactivity scales could be considered, such as that based on the comparison of the measured and calculated effect of changes in the plutonium content of cells, and this scale has been used in the interpretation of some reactivity measurements made in the ZEBRA facility.)

The differences in reactivity between different types of element, such as the plate geometry and pin geometry elements, were measured for single elements and groups of 9 elements. The transition from one core to another core was made in stages, with the change in reactivity in each stage being measured. This required the calibrated control rod to be recalibrated at each stage.

Measurements involving changes to the contents of a single central cell were made using the special Large Sample Changer element, LSC. This was a special element about 4m long, filled with standard core cells. It moved axially between two positions about 1.6m apart. The cells which are aligned with the core centre when the LSC is in the "Down" position are exposed above the top of the surrounding elements when the LSC is in the "Up" position and the contents of these central cells could then be easily modified. The LSC could be moved up and down with little reactivity change with the reactor at power. The reactivity difference between a perturbed cell and a reference cell was measured to give the reactivity of the perturbation. The LSC needed a position in the reactor base plate having a special removable plug. As the central position, (X,Y)=(50,45), was not one of these positions, the LSC was installed in position (50,46).

Measurements of larger region perturbations were made by replacing standard elements with modified elements, either singly or in groups of 9, or in larger groups of elements. In the case of the sodium void measurements the changes were made separately in axial sections, in the central third of the core region of an element and in the two outer thirds sections of the core region. In this way the leakage dependent effects could be separated from the moderation plus absorption effects.

Details of the sodium worth measurements, enrichment changes and the cell heterogeneity and small sample worth measurements made in Assembly 22 are given in ZTN22/4 and ZTN22/8. Measurements made in the voided plate geometry Core 24 are described in ZTN22/5 and in the pin geometry cores in ZTN22/6. The calibration of control rods is described in ZTN22/3. The information needed for specification and evaluation of the benchmarks is reproduced in the present document

1.4.2A Description of the Experimental Configuration

The assembly configurations are described in Section 1.1.

The dimensions of the additional components used in the measurements are as follows:

Plates used in reactivity worth measurements (all have nominal width 5.067 cm)

ALF2 45% Aluminium

PLATE THICKNESS ----- 1.27 cm

These plates replace two sodium (or sodium replacement “dummy”) plates at the interface of each pair of cells (i.e. between the first and second cell, the third and fourth cell, etc). The 40% steel plates, STSTF8, in the central 22 cells, were replaced by the slightly thinner plates, STSTF8T, to correct for the difference in thickness. The ALF2 plates were then replaced, in turn, by 4 full density aluminium plates (AL8), 4 stainless steel plates (STSTBR8), 2 alumina plates (AL2034) and 4 graphite plates (GII8).

STSTF8T Stainless steel

PLATE THICKNESS ----- 0.2963 cm

STSTBR8 Stainless steel

PLATE THICKNESS ----- 0.3172 ± 0.0005 cm

GII8 Graphite

PLATE THICKNESS ----- 0.31775 ± 0.0005 cm

AL2034 Aluminium oxide

PLATE THICKNESS 0.6317 ± 0.0005 cm

AL8 Aluminium

PLATE THICKNESS ----- 0.3167 cm

STSTSR4 This is a stainless steel plate corresponding approximately, in weight and dimensions, to the can of a sodium plate, or a "dummy" plate (weight 17.60 g). It replaces a UO₂ plate in the reactivity perturbation measurements.

The steel, aluminium and graphite pins used in the reactivity worth measurements

For all pins the total length is 29.5 cm.

For all pins the radial dimensions are given in the Zebra Database as:

CAN THICKNESS ----- 0.025 cm

TOTAL PIN DIAMETER ----- 0.938 cm

PIN CORE DIAMETER ----- 0.937 cm

It is probable that in fact there was no canning on these pins (no compositions are given for a canning region) and the weights correspond to pins of the single material of length 29.5 cm and diameter 0.937 cm when calculated using the densities of the plate geometry components. A pin diameter of 0.937 would be consistent with the size of the other pins used in the mini-calandria and it is proposed that this diameter should be adopted.

MSTPINA The mild steel pin

2ALPINA The aluminium pin (the 2 in front of the component identifier denotes that it consists of two "6 inch" length pins giving a total length of 29.5 cm)

2ALOPINA The aluminium oxide pin

2CPINA The graphite pin

1.4.2B Methods

Reactivity Scale and Delayed Neutron Data used

Movement of the fine control rod (FR9) was calibrated in the reference loading for Core 22 (std cm worth 0.5148×10^{-4} dk/k). A repeat measurement with the Large Sample Changer installed showed negligible difference, and the same rod worth was used throughout for the measurements made in this assembly and in the first analysis for the other assemblies. In ZTN22/13 the reactivity worths were revised, following a recalculation of the kinetics parameters for each core, and applying the correction factors: 0.999 in Core 22, 1.016 in Core 23, 1.012 in Core 24 and 1.025 in Core 25. These factors are not precisely the changes in beta-effective because of the different contributions of Pu239 and U238 to the kinetics and the differences between these components in the normal and voided cores. The beta-effective values (calculated using 37 group RZ diffusion theory and the FGL5 nuclear data set) were 0.003628 in Core 22, 0.003677 in Core 23, 0.003737 in Core 24 and 0.003775 in Core 25.

The reactivity worths of the control rods were obtained by measuring the absolute reactivity change due to rod movements of a few centimetres and using the appropriate rod profile to obtain the value for the full rod movement. The absolute reactivity measurements were made by the inverse kinetics method using counts collected from the four reactor pulse channels. Two measurements were made for each rod, movements being chosen to give reactivity changes of about 3×10^{-4} and 6×10^{-4} dk/k for different rod combinations (see ZTN22/3).

Prior to the ZEBRA BIZET Programme the rods were calibrated by positive period measurements. During the BIZET programme the inverse kinetics method was introduced and comparisons are made with the period method in BTN-39. The inverse kinetics method can be carried out in a shorter time than the period method. The two methods were found to agree on average to $0.9\% \pm 0.9\%$. An analysis of the uncertainties is also made, separating the random components and the systematic component of $\pm 5\%$ due to the choice of delayed neutron data and uncertainties in relative fission rates and importances. For the calibration of a single rod the sum of the random components is given as $\pm 1.3\%$. In BTN-75 the random error is reassessed, based on the large number of measurements which had been carried out by then, giving the smaller figures of $\pm 0.6\%$ and $\pm 0.4\%$. The systematic uncertainty due to the choice of delayed neutron data therefore determines the total uncertainty. This assessment of the uncertainty due to the delayed neutron data is discussed in detail in the paper by J M Stevenson (page 1) in the Proceedings of the 1986 Specialists Meeting on Delayed Neutron Properties held at Birmingham University in the UK.

The delayed neutron data used in evaluating these reactivity worths were Smith's (1974) revision of Tomlinson's (AERE-R6993) delayed neutron evaluation. The total fast spectrum yields in the delayed neutron data set (n/100F) are as follows:

U235, 1.65 ± 0.03 ; U238, 4.58 ± 0.16 ; Pu239, 0.633 ± 0.026 ; Pu240, 0.88 ± 0.09
Pu241, 1.59 ± 0.16 ; Pu242, 1.5 ± 0.5 .

U238 and Pu239 are the dominant components. If we compare these values with a recent evaluation (d'Angelo and Rowlands, Prog. Nucl. Energy 41 p391 (2002)) we see that the more recently recommended value for U238 is 4.65, or 1.5% higher, and for Pu239 fast fission is 0.651, or 2.8% higher (the Smith-Tomlinson values for Pu240, 241 and 242 being similar to values currently in use). This could imply that the reactivity worths calculated using these more recent data would be about 2% higher, this difference being within the uncertainty of $\pm 5\%$ associated with the reactivity measurements.

The recommended relative abundances in the Smith-Tomlinson evaluation are Keepin's 1957 fission spectrum averaged data for U235, U238 and Pu239. The data are summarised in the following Tables 1.13 to 1.15.

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Delayed neutron spectra were specified for each of the 6 time groups, being the same for all fissioning isotopes in these time groups. The values are based on Keepin's six group spectra modified for the 37 group data set used in the analyses.

Table 1.13 Delayed Neutron Fractions and Total Yields used in the Inverse Kinetics Analyses

	U235	U238	Pu239	Pu240	Pu241	Pu242
Time group						
1	0.038	0.013	0.038	0.025	0.010	0.004
2	0.213	0.137	0.280	0.270	0.229	0.195
3	0.188	0.162	0.216	0.184	0.173	0.162
4	0.407	0.388	0.329	0.358	0.390	0.411
5	0.128	0.225	0.103	0.135	0.182	0.218
6	0.026	0.075	0.035	0.027	0.016	0.010
n/F	0.0165	0.0458	0.00633	0.0088	0.0159	0.015

The 6 group fractions for U235, U238 and Pu239 are the fission spectrum averaged values of Keepin et al.

Table 1.14 Delayed Neutron 6 Time Group Decay Constants (sec⁻¹) used in the Analyses

	U-235	U-238	Pu-239	Pu-240	Pu-241	Pu-242
Time group						
1	0.0127	0.0132	0.0129	0.0129	0.0128	0.0129
2	0.0317	0.0321	0.0311	0.0313	0.0299	0.0295
3	0.115	0.139	0.134	0.135	0.124	0.131
4	0.311	0.358	0.331	0.333	0.352	0.338
5	1.40	1.41	1.26	1.36	1.61	1.39
6	3.87	4.02	3.21	4.04	3.47	3.65

Table 1.15 Delayed Neutron Energy Spectra used in the Inverse Kinetics Analyses

Lower E (MeV)	Upper E (MeV)	Group1	Group2	Group3	Group4	Group5	Group6
2.2313	3.6788	0	0.01	0	0.02	0.01	0.01
1.3534	2.2313	0.03	0.04	0.03	0.04	0.04	0.04
0.82085	1.3534	0.06	0.12	0.08	0.12	0.14	0.14
0.49787	0.82085	0.13	0.27	0.22	0.24	0.23	0.23
0.30197	0.49787	0.20	0.26	0.30	0.24	0.23	0.23
0.18316	0.30197	0.23	0.15	0.19	0.19	0.17	0.17
0.11109	0.18316	0.16	0.08	0.09	0.09	0.11	0.11
0.06738	0.11109	0.19	0.07	0.09	0.06	0.07	0.07

There was found to be no significant variation in worth/std-cm with size of rod movement or detector channel. The spread of the results indicated that the random uncertainty on the worth/std-cm. was about 0.2%. The assessment of errors followed the principles laid down in BTN-75, the inclusion of errors due to drift, the dead-time etc. increasing this to 0.4%.

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To recalculate the reactivity scales an estimate of the change in reactivity made when calibrating the rods is required, because this affects the variation of flux with time, which is measured and interpreted using the "effective" delayed neutron data. Details are given in ZTN22-3, the changes in reactivity being in the range 2.5 to 6.5×10^{-4} dk/k.

The delayed neutron fractions calculated using the Smith-Tomlinson delayed neutron data and the FGL5 cross-section set are given in Table 1.15A, broken down by nuclide and time-group. To recalculate the reactivity scales using different delayed neutron data and cross-sections the period for a reactivity change of 4×10^{-4} dk/k should be calculated using the data in the Table and then the reactivity corresponding to this period calculated using the new data. The ratio of this reactivity to the value of 4×10^{-4} dk/k is the correction factor to be applied to the control rod reactivity scales.

Table 1.15B Total Beta-effective Values Calculated for the CADENZA Cores (ZTN22/13)
(delayed neutron data of Smith-Tomlinson and FGL5 cross-sections)

	Core 22B	Core 23A	Core 24	Core 25
Total = β_{eff}	0.003628	0.003677	0.003737	0.003775

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Table 1.15A Delayed Neutron Parameters Calculated for the CADENZA Cores (ZTN22/13)
(calculated using the delayed neutron data of Smith-Tomlinson and FGL5 cross-sections)

Isotope	Delayed Neutron Group	α_i (x 10 ⁻⁸)				λ_i (sec ⁻¹)
		Core 22B	Core 23A	Core 24	Core 25	
U235	1	709	704	717	711	0.0127
	2	4153	4106	4214	4169	0.0317
	3	3598	3563	3647	3612	0.115
	4	7967	7876	8084	7997	0.311
	5	2485	2458	2520	2494	1.40
	6	507	501	514	508	3.87
	Total	19419	19208	19696	19491	
Pu239	1	5006	5123	4848	4944	0.0129
	2	37866	38617	36655	37295	0.0311
	3	28966	29589	28037	28563	0.134
	4	44573	45452	43163	43912	0.331
	5	13885	14164	13445	13680	1.26
	6	4700	4794	4551	4630	3.21
	Total	134996	137739	130699	133024	
U238	1	2333	2345	2522	2527	0.0132
	2	25355	25393	27455	27427	0.0321
	3	29497	29588	31921	31927	0.139
	4	71931	72026	77898	77808	0.358
	5	41506	41575	44936	44896	1.41
	6	13849	13873	14995	14981	4.02
	Total	184471	184800	199727	199566	
Pu240	1	291	289	307	306	0.0129
	2	3237	3190	3403	3380	0.0313
	3	2177	2149	2289	2277	0.135
	4	4291	4229	4513	4483	0.333
	5	1616	1593	1700	1688	1.36
	6	326	321	343	341	4.04
	Total	11938	11771	12555	12475	
Pu241	1	109	130	100	118	0.0128
	2	2650	3160	2434	2866	0.0299
	3	1974	2357	1812	2137	0.124
	4	4510	5376	4143	4878	0.352
	5	2103	2508	1931	2275	1.61
	6	189	225	173	204	3.47
	Total	11535	13756	10593	12478	
Pu242	1	2	2	2	2	0.0129
	2	89	89	93	95	0.0295
	3	73	73	77	78	0.131
	4	187	188	197	200	0.338
	5	99	100	104	106	1.39
	6	5	5	5	5	3.65
	Total	455	457	478	486	

Uncertainties in Reactivity Worth Measurements

In addition to the uncertainty in the conversion of the measured control rod movement into absolute reactivity units (via the inverse kinetics measurements) there are the uncertainties arising from reproducibility and drift. For the measurements involving changes to single elements or groups of nine elements the uncertainties are given in the following Table 1.16.

Table 1.16 Uncertainties arising from Reproducibility and Drift
(in units of std cm of FR9 1 std cm $\sim -0.5 \times 10^{-4}$ dk/k and units of dk/k)

	In units of std. cm. of FR9		In units of 10^{-4} dk/k.	
Core	Single Element Measurements	Nine Element Sodium Voiding Measurements	Single Element Measurements	Nine Element Sodium Voiding Measurements
22	0.045	0.16	0.023	0.08
23	0.036	0.10	0.018	0.05
24	0.025		0.013	
25	0.025		0.013	

For the plate cores, the uncertainties for the single element measurements are for a comparison of two different elements, without reloadings between balances, (a second comparison with a similar uncertainty was necessary to allow for any differences in the element contents). They do not include the uncertainty associated with core height variations, (0.03 std cm for Core 22 and 0.02 std cm for Core 24). For the pin cores, the errors are for a comparison of the two loadings of the same element with reloadings between balances.

For both core 22 and 23 nine element measurements, the comparisons are between two loadings of the same nine elements with reloadings between balances. Only one "nine element" measurement was made in Core 24, and three in Core 25. The uncertainties were assumed to be the same as for Cores 22 and 23.

Measurements were made with different thickness steel plates to determine the correction for changes in core height resulting from the interchange of plates. Changes in the associated steel content also accompanied the sodium voiding and flooding measurements. The components were weighed and the effects of the changes in the steel contents of elements were assessed.

There is also the possibility of an interaction between the perturbation and the control rod worth. Corrections of up to 1.6% were required for this effect in the case of the enrichment perturbation measurements.

Relative reactivity worth measurements are only affected by these uncertainties. The uncertainties arising from the delayed neutron reactivity scale conversion will not apply to the relative values.

1.4.2C Results of the Measurements

These are presented sequentially for each type of measurement in turn.

1.4.2C.1 Reactivity Differences between Assemblies Containing Sodium and Voided of Sodium.

The transition from one core to another was made in stages, with the changes being balanced using the control rods. Changes to the numbers of edge elements were also made progressively. The rod worths were recalibrated at points during the transition. In this way the reactivity change in going from one assembly to another was measured. Corrections were made for temperature differences from 300K and Pu241 decay (maximum corrections of 0.3×10^{-4} dk/k and 0.7×10^{-4} dk/k respectively). The measurements are described in ZTN22-10, which gives the results for each stage of the transition. The total reactivity change is a combination of the effects of changes to the elements and the addition or removal of edge elements, with compensating movements of the control rods. *To calculate the measured effects it would be preferable to calculate each step, or correct for the effects of the changes in the numbers of edge elements. These measurements are not being proposed as benchmarks.*

The reactivity worth of sodium in the plate geometry Core 22 was measured by changing from Core 22B to Core 24 in several stages, at each stage sodium-filled plates being replaced by stainless-steel components selected to closely match the thickness and steel weights of the sodium plates. The net effect was to remove sodium but to retain approximately the same mass of stainless steel. The measurements are complicated by the addition of edge elements which are also either voided or flooded. Details of the component changes are given in ZTN22-10 Appendix 1. The weight of sodium removed was 173.4 kg and there was an associated reduction in weight of steel in the 206 standard core elements, by about 1 kg. Three types of "dummy" plate replaced the sodium filled plate, two being ring shaped and the third "honeycomb" (or "egg-box") shaped.

The core with 231 fissile elements (the voided Core 24) has a reactivity $(125.9 \pm 3.6) \times 10^{-4}$ dk/k lower than a hypothetical 231 element flooded core. However, it is not clear whether corrections are needed for the special elements and the uncertainties associated with these and so this result has not been recommended as a benchmark measurement.

Because of compression of the sodium filled plates, and to a lesser degree of the "honeycomb" shaped "dummy" plates, the height of the core section of an element containing the ring shaped "dummy" plates was 1.2 mm greater than the height of the standard sodium containing elements. Elements containing the "honeycomb" shaped "dummy" plates were on average 0.3 mm higher. (Note: the difference in average core height between Core 22 and Core 24 has been represented in the core models described in Sections 1.1.2 and 3.1.2.)

The sodium voiding procedure was reversed when the 66 plate elements and 168 voided mini-calandria elements in Core 25 were progressively replaced by sodium filled elements. The weight of sodium added to the mini-calandria elements was 145.4 kg and the associated change in weight of steel was about 0.01 kg. The overall reactivity gain due to flooding with sodium was $+131.6 \times 10^{-4}$ dk/k. This included the "flooding" of the plate elements at the radial boundary of the core. Combining this with the correction of $+9 \times 10^{-4}$ dk/k, to allow for the differences in corrections for control rods, instrumented elements and aspirated elements, brings the total reactivity gain to $(+141 \pm 13) \times 10^{-4}$ dk/k on changing from the sodium-voided 168 pin, 66 plate element loading of Core 25 to a sodium-flooded core.

Because of the complication of treating the edge element "flooding" it might be more appropriate to consider the core with the plate elements already "flooded". This is a core of 237 elements, 168 flooded pin elements and the remainder flooded plate elements.

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The reactivity change resulting from voiding just the 168 pin elements (in the core with 237 elements) is $(-71.9 \pm 5) \times 10^{-4} dk/k$ which when combined with the experimentally based correction for the special elements and account taken of the uncertainties becomes $(-81 \pm 13) \times 10^{-4} dk/k$.

1.4.2C.2 Element Replacement Measurements for Single Elements and Groups of 9 Elements.

Various measurements were made of the reactivity effect of replacing one type of element by another. This included groups of sodium voided elements in Cores 22 and 23 and sodium flooded elements in Cores 24 and 25. The effect of replacing plate elements by pin elements at various positions and interchanging the different types of pin element were also measured.

Measurements were made for both single elements and groups of 9 elements and at both the central position and off-central positions.

In Core 22 the standard plate elements were replaced by pin geometry elements, 3A or 3C. The results are summarised in Tables 1.17 to 1.20.

Table 1.17 Measured values of the Reactivity Effects of Replacing Standard Plate Elements C22±01C (PUVIII8 plates) by Alternative Plate and by Pin Elements in Core 22 ($\times 10^{-4}$ dk/k)

Element	Central position of group of 9, or position of single element	9 elements	1 element
C22±03A (pins)	(50,45)	-18.16 $\pm$ 0.27	-2.10 $\pm$ 0.05
C22±03A	(50,42)	-14.43 $\pm$ 0.21	-1.52 $\pm$ 0.04
C22±03A	(50,39)	-5.36 $\pm$ 0.10	-0.575 $\pm$ 0.03
C22±03C (pins)	(50,42)	-9.48 $\pm$ 0.21	
C22±04A (PUIV4 mixed oxide plates)	(50,45)	-35.02 $\pm$ 0.51	-4.10 $\pm$ 0.06
C22±04A	(50,42)	-27.55 $\pm$ 0.40	-3.09 $\pm$ 0.05
C22±04A	(50,39)	-13.31 $\pm$ 0.20	-1.51 $\pm$ 0.03
C22-01A (PUII8 plates)	(50,45)		-3.166 $\pm$ 0.06
C22-01A	(50,42)		-2.64 $\pm$ 0.05
C22-01A	(50,39)		-1.465 $\pm$ 0.02
C22±01D (PUIX8 plates)	(50,45)	-0.482 $\pm$ 0.11	

The C22±04A elements

The core regions of the C22±04A elements contain 11 C22-06A cells comprising 5xPUIV4 mixed oxide plates, one UO24R4 plate, 6xNASTDL4 plates, an STSTF8 plate and an STSTD8 plate. The order of the plates in a cell, from the bottom upwards, is:

NA, PU IV4, STSTD8, NA, PU IV4, NA, UO2, PU IV4, NA, PU IV4, NA, STSTF8, PU IV4, NA

Table 1.18 Measured values of the Reactivity Effects of Replacing 9 Standard Plate Elements, or a Single Element (C24±20CY), by Pin or Alternative Plate Elements in Core 24
(centred about or in the position specified in column 2) (x10⁻⁴ dk/k)

Element	Central position	9 elements	1 element
C22±30A (pins)	(50,45)	-17.24 ± 0.27	-2.105 ± 0.05
C22±30A (pins)	(50,42)	-13.74 ± 0.21	-1.662 ± 0.04
C22±30A (pins)	(50,39)	-6.059 ± 0.10	-0.707 ± 0.03
C24±40A(MOX plates)	(50,45)	-31.52 ± 0.45	-3.663 ± 0.06
C24±40A(MOX plates)	(50,42)	-25.98 ± 0.38	-3.000 ± 0.05
C24±40A(MOX plates)	(50,39)	-13.81 ± 0.20	-1.548 ± 0.03
C24-20ZX(PUII8 pl)	(50,45)		2.715 ± 0.05
C24-20ZX(PUII8 pl)	(50,42)		2.377 ± 0.05
C24-20ZX(PUII8 pl)	(50,39)		1.537 ± 0.03

Table 1.19 Measured values of the Reactivity Effects of Replacing Standard Pin Elements (C25+03A1) by Plate Elements (C24+20CY) in Core 25
(centred about, or in the position specified in column 2) (x10⁻⁴ dk/k)

Element	Central position	9 elements	1 element
C24+20CY (plates)	(50,45)	17.79 ± 0.27r ± 0.69s	2.11 ± 0.05r ± 0.08s
C24+20CY (plates)	(50,42)	14.57 ± 0.23r ± 0.63s	1.735 ± 0.04r ± 0.07s
C24+20CY (plates)	(50,39)	6.32 ± 0.11r ± 0.39s	0.737 ± 0.02r ± 0.04s

Table 1.20 Reactivity change resulting from Replacing 9 (C22-03C) Elements at the Centre of Core 23 by the Element Named in Column 1
(x10⁻⁴ dk/k)

Element	Reactivity change
C22-03A	-6.5 ± 0.8
C22-03B	-3.9 ± 0.8
C22-03D	+3.1 ± 0.8
C22-03E	+2.5 ± 0.8

The experimental uncertainties in these tables are the random contributions from the rod profile and reproducibility and drifts during the measurements. The systematic uncertainties due to the plutonium contents of the fuel ((0.08 to 0.04) x 10⁻⁴ dk/k per element for the pin element replacements and (0.10 to 0.06) x 10⁻⁴ dk/k per element for the oxide plate element replacements) and the ± 5% systematic uncertainty in reactivity measurements is to be applied to all of these measured values.

1.4.2C.3 Plutonium Enrichment Measurements.

To measure the reactivity effects of changing the plutonium content of cells in Core 22A, twenty-four PUIV4 mixed oxide plates displaced a UO₂ plate in each of the 24 core cells of the chosen element. In Assemblies 22B and 24 they replaced the lower UO₂ plate in the cells 1,3,5, ...,23 (cells numbered from the bottom of the core) and the upper UO₂ plate in cells 2,4, ...,24 (see ZTN22-10).

In Core 23A, 12 x PUPINF pins replaced 12 x UO₂PINC pins in a C22-03J element. The mini-calandria of the C22-03J element contained 12 PUPINE pins and 4 UO₂PINC pins. These latter 4 pins were replaced by the PUPINF pins in the three mini-calandria of the element.

The recalibration of the control rods used for these measurements in the maximum perturbed cases (i.e. enrichment at the centre) showed that these were the same as in the unperturbed cores, within the accuracy of the measurements. A correction (by up to 1.6%) was made for the interaction between the reactivity increase effect and the control rod.

The systematic uncertainties arise from a $\pm 0.3\%$ uncertainty in the plutonium content of a mixed-oxide plate and a $\pm 0.2\%$ uncertainty for a mixed-oxide pin. Other sources of error are associated with the control rod profile, the inverse kinetics measurements and the rod interaction corrections, giving a total uncertainty of $\sim 1.5\%$. The measured plutonium worth could be used as an alternative reactivity scale, based on the calculated reactivity worth of the measured change.

Additionally, the 5% systematic uncertainty in the reactivity scale is to be combined with the above uncertainties.

Table 1.21 Reactivity Changes resulting from the Enrichment Changes

($\pm 1.5\%$) (The data in this table are from ZTN22-13; slightly different data are given in ZTN22-10)

Lattice Position	Reactivity Change (10^{-4} dk/k)			
	Assembly 22B	Assembly 23B	Assembly 24	Assembly 25
(50,45)	19.45	16.09	17.25	14.13
(50,42)	16.40	13.32	14.79	12.09
(50,51) + (50,39)	17.49	14.58	9.13 *	14.66

* Only the one position, (50,39), was used in Core 24.

1.4.2C.4 The Reactivity Effects of Changes in Cell Heterogeneity in Assembly 22

The changes made were to combine pairs of standard plutonium plates and to replace the standard plates by pairs of half-thickness plates (PUJ16) and then to separate them. The changes were made in cells bordering the mid-plane in either 1 element or groups of 9 elements.

In the case of the combined pairs of standard plates, four standard cells were involved, two on either side of the mid-plane. These were replaced by two symmetrical cells, one on either side of the mid-plane. The sequence of plates in each cell was:

Na, UO₂, Na, Na, UO₂, SS, Pu, Pu, SS, UO₂, Na, Na, UO₂, Na

Two different patterns were used in the case of the half-thickness plates. These were first introduced paired in the positions of the standard plutonium plates in three cells, two above and one below the mid-plane (C22+22K). They were then separated into the following two patterns:

Na, UO₂, Pu, SS, Na, Pu, UO₂, Na, repeated three times (C22+21K) (PNC1)
and

Na, Pu, UO₂, SS, Na, Pu, UO₂, Na, repeated three times (C22+23K) (PNC2).

Table 1.22 Reactivity Effects of Changes in Heterogeneity
($\times 10^{-4}$ dk/k)

Cell change	Cells per element	9 elements	1 element
Standard to pairs of standard Pu plates	4	2.945 ± 0.09	0.304 ± 0.005
Standard to pairs of thin Pu plates	3		0.257 ± 0.023
Pairs of thin Pu plates separated I	3	0.43 ± 0.08	0.042 ± 0.004
Pairs of thin Pu plates separated II	3	0.56 ± 0.08	

(There is a further systematic uncertainty of $\pm 5\%$ from the delayed neutron reactivity scale.)

1.4.2C.5 Small Sample Reactivity Worth Measurements.

The materials used in the reactivity perturbation measurements included UO_2 , sodium, carbon, oxygen, aluminium, steel, and copper (see ZTN22-13 for an analysis of the measurements).

Measurements were made using aluminium and alumina in order to derive the reactivity worth of oxygen and hence the contribution of the different oxygen contents of the plate and pin geometry cores to the difference between the k_{eff} values calculated for the two types of core. However, the measurement uncertainties, when the C/E values were scaled up to give the estimated error in the difference between the calculated k_{eff} values for the two cores due to the oxygen data, resulted in an uncertainty of ± 0.002 dk/k, too large to be helpful in resolving discrepancies. Approximations in the analysis methods would increase this uncertainty further.

The measurements made in Core 22B (the symmetrical cell version) are described in ZTN22-4 and are summarised in Tables 1.23 to 1.25. Corrections were made for element differences and changes in core height. The uncertainties arise from the uncertainties in control rod profile, reproducibility and the changes in core height.

The corresponding programme of measurements made in Core 24 are described in ZTN22-5 and are summarised in Tables 1.26 and 1.27.

The measurements involved the replacement of either a UO_2 plate in each of a set of cells or were made relative to 45% density aluminium plates, ALF2. These replace two sodium (or “dummy”) plates at the interface of each pair of cells (i.e. between the first and second, the third and fourth, etc). The 40% steel plates, STSTF8, in the central 22 cells, were replaced by the slightly thinner plates, STSTF8T, to correct for the difference in thickness between the ALF2 plates and two sodium plates. The ALF2 plates were then replaced, in turn, by 4 full density aluminium plates (AL8), 4 stainless steel plates (STSTBR8), 2 alumina plates (AL2034) and 4 graphite plates (GII8).

The measurements made in the pin cell cores are described in ZTN22-6 and are summarised in Tables 1.28 and 1.29. All the measurements with pin samples were made in element type C22=03J in the flooded pin core and element type C25=03J6 in the voided core. The four positions in the minicalandria normally occupied by the UO_2 pins were used. The U02PINC, ALPINA, CPINA and MSTPINA were compared in turn with empty positions. Alumina ALOPINA pins were compared with ALPINA in Core 23 (the alumina pins were not available when the Core 25 measurements were made). For the enrichment measurements, the U02PINC pins were replaced by PUPINF pins.

The method of making these measurements in single element positions was similar to that in Cores 22B and 24. In this case, however, changes were made to the chosen element between each start-up and balance. This was preferred to the method of comparing two different elements (one perturbed, the other unperturbed) with a subsequent comparison of the elements in the same (unperturbed) state. Four balances gave two estimates of the perturbation, after interpolation to allow for drifts with time. Because the changes only involved the pins inside the mini-calandria, there were no core height changes and no associated reactivity corrections.

The uncertainties in the single element measurements made in the pin geometry cores have the following components:

(a) Rod Profile:

This was taken to be $\pm 1\%$ in all of the cores.

(b) Reproducibility and Drifts:

The rms differences (in terms of the control rod movements) between repeat measurements of perturbations were as follows:

In Core 23, 0.032 std cm for measurements in (50,45) or in {(50,39) + (50,51)};

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In Core 25, 0.022 std cm in (50,45) and 0.010 std cm for the 4 measurements in {(50,39) + (50,51)}.

The associated uncertainties on the mean were taken to be $1.12 \times 0.032 = 0.04$ std cm in Core 23 and $1.12 \times 0.022 = 0.025$ std cm in Core 25.

These are very similar to the errors on the mean std cm movements found using the four balance technique for central single-element exchanges in the corresponding plate cores. For the plate cores, pairs of elements were used which were not reloaded between balances so the core height remained unchanged. In the pin cores, because of the robust construction of the mini-calandria, core height changes are small when pins are exchanged. Thus these uncertainties of about 0.04 std cm in the flooded cores and 0.025 std cm in the voided cores arise mainly from variations in the flow of the core-cooling air and in the cooling of elements when out of the core.

For the enrichment experiments, the control rod profile uncertainty (1% of the signal) dominated. For the other materials, the reproducibility and drift uncertainties were more dominant and gave typical uncertainties of $\pm 0.020 \times 10^{-4}$ dk/k in Core 23 and $\pm 0.014 \times 10^{-4}$ dk/k in Core 25.

For the plate cores, the uncertainties due to reproducibility and drifts were larger by a factor of $\sqrt{2}$ because a second comparison was necessary for pairs of elements in the same loading to allow for differences in fuel plates, etc. There were also uncertainties in the core height for different loadings of the plate elements. Thus typical final uncertainties for the single-element perturbations were $\pm 0.04 \times 10^{-4}$ dk/k for Core 22 and $\pm 0.02 \times 10^{-4}$ dk/k for Core 24, both being somewhat higher than for the pin cores.

The average compensating movements of the fine control rod FR9 for each perturbation have been converted to reactivity units using std cm worths of 0.5315×10^{-4} dk/k in Core 23 and 0.5218×10^{-4} dk/k in Core 25.

In addition to the above uncertainties there is the systematic uncertainty of $\pm 5\%$ associated with the absolute calibration of the control rods in terms of the delayed neutron scale.

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Table 1.23 Changes in Reactivity for Plate Replacements in Position (50,45) in Core 22B
Reactivity perturbations in units of 10^{-4} dk/k (1 std cm = -0.5094×10^{-4} dk/k)

Change to Perturbed Element (S013)				Reactivity Perturbation
Plates Introduced	Plates Removed	Cells Perturbed	No. of Plates Introduced	
PUIV4	U023R4	All 24	24	+19.61 $\pm$ 0.20
		Top 8	8	+5.31 $\pm$ 0.06
		Bottom 8	8	+5.36 $\pm$ 0.06
STSTSR4	U023R4	Middle 8	16	+3.21 $\pm$ 0.05
		Top 8 + Bottom 8	32	+1.87 $\pm$ 0.04
GII8	ALF2	Middle 8	16	-0.34 $\pm$ 0.04
		Top 8 + Bottom 8	32	+0.02 $\pm$ 0.04
AL8	ALF2	Middle 8	16	-0.35 $\pm$ 0.04
		Top 8 + Bottom 8	32	-0.10 $\pm$ 0.04
AL2O34	ALF2	Middle 8	8	-0.67 $\pm$ 0.04
		Top 8 + Bottom 8	16	-0.18 $\pm$ 0.04
STSTBR8	ALF2	Middle 8	16	-1.09 $\pm$ 0.04
		Top 8 + Bottom 8	32	-0.10 $\pm$ 0.04
STSTF8 (Height change)	STSTF8T	Middle 22	22	(see ZTN22-4)

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Table 1.24 Changes in Reactivity for Plate Replacements in Position (50,42) in Core 22B
Reactivity perturbations in units of 10^{-4} dk/k (1 std cm = -0.5094×10^{-4} dk/k)

Change to Perturbed Element (S019)				Reactivity Perturbation
Plates Introduced	Plates Removed	Cells Perturbed	No. of Plates Introduced	Position (50,42)
PUIV4	U023R4	All 24	24	+16.52 $\pm$ 0.17
STSTSR4	U023R4	Middle 8	16	+3.32 $\pm$ 0.05
GII8	ALF2	Middle 8	16	-0.14 $\pm$ 0.04
		Top 8 + Bottom 8	32	+0.15 $\pm$ 0.04
AL8	ALF2	Middle 8	16	-0.19 $\pm$ 0.04
		Top 8 + Bottom 8	32	+0.02 $\pm$ 0.04
AL2O34	ALF2	Middle 8	8	-0.41 $\pm$ 0.04
		Top 8 + Bottom 8	16	+0.07 $\pm$ 0.04
STSTBR8	ALF2	All 24	24	-1.19 $\pm$ 0.04

Table 1.25 Changes in Reactivity for Plate Replacements in Position (50,39) and (50,51) in Core 22B

Reactivity perturbations in units of 10^{-4} dk/k (1 std cm = -0.5094×10^{-4} dk/k)

Change to Perturbed Element (SO13 and SO19)				Reactivity Perturbation
Plates Introduced	Plates Removed	Cells Perturbed	No. of Plates Introduced	Positions (50,39)+(50,51)
PUIV4	U023R4	All 24	24	+17.72 ±0.18
STSTSR4	U023R4	All 24	24	-0.58 ±0.05
GII8	ALF2	All 24	24	-0.14 ±0.04
AL8	ALF2	All 24	24	-0.19 ±0.04
AL2O34	ALF2	All 24	24	-0.41 ±0.04
STSTBR8	ALF2	All 24	24	-1.19 ±0.04

(Elements SO13 and SO12 were used in (50,39), SO19 and SO10 in (50,51))

Table 1.26 Changes in Reactivity for Plate Replacements in Position (50,45) in Core 24

Reactivity perturbation in units of 10^{-4} dk/k (1 std cm = -0.5022×10^{-4} dk/k)

Change to Perturbed Element (S008)				Reactivity Perturbation
Plates Introduced	Plates Removed	Cells Perturbed	No of Plates Introduced	(10^{-4} dk/k)
STSTSR4	U023R4	Middle 8	16	+2.311 ± 0.03
		Top 8 + Bottom 8	32	+1.122 ± 0.02
GII8	ALF2	Middle 8	16	-0.509 ± 0.02
		Top 8 + Bottom 8	32	-0.329 ± 0.02
AL8	ALF2	Middle 8	16	-0.386 ± 0.02
		Top 8 + Bottom 8	32	-0.210 ± 0.02
AL2O34	ALF2	Middle 8	8	-0.788 ± 0.02
		Top 8 + Bottom 8	16	-0.415 ± 0.02
STSTBR8	ALF2	Middle 8	16	-1.058 ± 0.02
		Top 8 + Bottom 8	32	-0.844 ± 0.02

The height change correction is based on measurements made by replacing the STSTF8T plate by the STSTF8 plate.

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Table 1.27 Reactivities of Material Perturbations in Elements in Off-central Positions in Core 24

Reactivity perturbation in units of 10^{-4} dk/k (1 std cm = -0.5094×10^{-4} dk/k)

Plates Introduced	Plates Removed	Cells Perturbed	No of Plates Introduced	Element position (50,42) (S014)	Element position (50,39)+ (50,51) (S008, S014)
STSTSR4	U023R4	All	48	$+2.192 \pm 0.03$	-0.884 ± 0.02
GII8	ALF2	All	48	-0.460 ± 0.02	$+0.242 \pm 0.02$
AL8	ALF2	All	48	-0.351 ± 0.02	$+0.255 \pm 0.02$
AL2034	ALF2	All	24	-0.692 ± 0.02	$+0.495 \pm 0.02$
STSTBR8	ALF2	All	48	-1.388 ± 0.02	-0.482 ± 0.02

Table 1.28 Material Worth Measurements in Position (50,45) in Cores 23 and 25.

Reactivity changes in units of $(10^{-4}$ dk/k)

Material introduced	Minicalandria used	Core 23	Core 25
U02PINC	Middle	-1.164 ± 0.020	-0.928 ± 0.016
	Top + Bottom	-0.716 ± 0.020	-0.527 ± 0.014
ALOPINA Replacing ALPINA	Middle	-0.174 ± 0.020	-
	Top + Bottom	$+0.082 \pm 0.020$	-
ALPINA	Middle	-0.342 ± 0.020	-0.329 ± 0.013
	Top + Bottom	$+0.035 \pm 0.020$	$+0.013 \pm 0.013$
CPINA	Middle	-0.213 ± 0.020	-0.338 ± 0.013
	Top + Bottom	$+0.249 \pm 0.020$	$+0.055 \pm 0.013$
MSTPINA	Middle	-0.767 ± 0.020	-0.747 ± 0.015
	Top + Bottom	-0.271 ± 0.020	-0.385 ± 0.014

The materials were introduced in the four positions of each minicalandria normally occupied by U02PINC pins in the C22-05J and 25C-05J6 cells. The Al203 pins replaced aluminium pins, the others were measured relative to empty positions.

Table 1.29 Material Worth Measurements in Positions (50,39) plus (50,51) in Cores 23 and 25
Reactivity worth in units of $(10^{-4} dk/k)$

Material introduced	Minicalandria used	Core23	Core 25
UO2PINC	All 3	-0.223 ±0.020	0.037 ±0.013
ALOPINA replacing ALPINA	All 3	+0.317 ±0.020	-
ALPINA	All 3	+0.364 ±0.020	0.362 ±0.014
CPINA	All 3	+1.322 ±0.022	0.942 ±0.016
MSTPINA	All 3	+0.373 ±0.020	0.178 ±0.013

The measurements with the alumina and aluminium pins were made in (50,39) only.

1.4.2C.6 Sodium Voiding Reactivity Measurements.

In Core 22 the sodium plates were replaced by the voided plates, the so-called "dummy" plates, which have nominally the same thickness and steel content as the sodium plates. All the plates being interchanged were weighed and the differences in thickness measured. The changes were made either over the whole core section or in the central 8 cells and the upper and lower 8 cells (in some cases separately and in other cases combined).

Only one set of elements was used at each position, with the special elements removed from the area. The measurements were made as a sequence of four conversions of the elements (voiding, flooding, voiding and flooding) each followed by a reactor balance using the fine control rod, FR9. The four balances were achieved in a cycle of about 2 hours. The assumption that drift rates are linear with time was tested by comparing the two values for the rod movement.

Reproducibility and Drifts

The drifts between repeat balances varied from -0.4 to +0.6 std. cms. of FR9, arising from perturbations to the core cooling flow and temperature changes resulting from elements being modified. The differences between pairs of measured results for the compensating movement, derived from the four balances, were up to 0.35 std cm. The average (rms) value of the difference was 0.14 std cm. Consideration of the partially systematic nature of the derivation of the two values shows that the uncertainty on the mean is ~ 1.12 times this expected average value of this difference, therefore taken to be ± 0.16 std cm. It is interesting to compare these values with the uncertainty of $\pm 0.1\%$ of an element worth which has been found appropriate for element reloadings in uranium-fuelled Zebra cores where there were no temperature rises from alpha-activity. With a central element worth of 36×10^{-4} dk/k, and nine elements in the measurement, this uncertainty becomes $\sqrt{9} \times 36 \times 10^{-4} \times 1 \times 10^{-3} = 0.1 \times 10^{-4}$ dk/k = 0.2 std cm FR9.

Plate thickness and Core Height

The effect of voiding on the core height was studied during the complete core voiding to produce Core 24. For those elements which were voided using the STNAVR4 rings, the core height increased by ~ 1.9 mm. (The measurements during the conversion to Core 24 showed a much smaller change in core height when the STNAVR4 dummies were used, as described above.)

To determine the effect of core height changes on reactivity, the 22 STSTF8T plates in the "perturbed-reference" element were replaced by the thicker STSTF8 plates, at the core-centre position. The correction for the height change in the case of middle group of 8 cells, for the group of 9 elements centred on (50,45), was $(-0.16 \pm 0.05) 10^{-4}$ dk/k. The corrections were similar for the other changes.

Weight of steel

The differences between the weights of steel in the sodium filled plates and in the "dummy" plates which replaced them were measured and the differences are given in Table 1.30. The correction for this difference is small compared with the uncertainties.

The reactivity changes resulting from the voiding of cells in Core 22 elements are summarised in Table 1.31.

A single "nine element" measurement was made in Core 24. This involved "flooding" just the central group of 8 cells in each of the nine elements, centred on position (50,45). The reactivity change was measured to be about 15% smaller than the corresponding value in Core 22, and this could be partly due to the larger size of Core 24.

As in Cores 22 and 24, the measurements in Cores 23 and 25 were carried out as a sequence of four conversions of the elements (voiding, flooding, voiding and flooding in Core 23 and vice-versa in Core 25). Each conversion was followed by a reactor balance using the fine control rod, FR9. Six voiding measurements were made in Core 23, the middle, the top plus bottom mini-calandria in the 9

elements centred on (50,45), (50,42) and (50,39). Only three flooding measurements were made in Core 25, the middle and then the top plus bottom mini-calandria in the elements centred on (50,45) and the middle mini-calandria in the elements centred on (50,39). In Core 23, element types C22+03C were used; and in Core 25, type C25+03C3. In both cases, some exchange of core elements was required for the measurements around (50,39).

The uncertainties were as follows:

(a) Rod Profile:

This was $\pm 1\%$ in all cores.

(b) Reproducibility and Drifts:

The rms difference between the six pairs of repeat results for voiding in Core 23 was 0.09 std cm. For flooding in Core 25, there were only two pairs of results and although there was some evidence of a smaller average difference, the value from Core 23 was adopted. Applying the factor of 1.12 to obtain the standard deviation gives an uncertainty on the mean of ± 0.10 std cm, i.e. $\pm 0.05 \times 10^{-4}$ dk/k. For the single result for the top plus bottom mini-calandria in (50,45) in Core 25, the uncertainty was taken to be $\pm 0.06 \times 10^{-4}$ dk/k.

The uncertainty of $\pm 0.05 \times 10^{-4}$ dk/k for this flooded pin core compares with the value of $\pm 0.08 \times 10^{-4}$ dk/k for the flooded plate core. The greater error for the plate core is probably a consequence of the poorer reproducibility of the core height on reloading the plate cells, which include the compressible sodium plates in the flooded case, compared with the rigid mini-calandria.

(c) Core height:

The height of a mini-calandria before welding (and excluding the support plate) has a tolerance of ± 0.08 mm. The 0.38mm thick support plate, because of the way it fits-to the base of the mini-calandria, adds 0.76mm to the total length with an associated uncertainty, which is assumed to be ± 0.13 mm. Thus the tolerance in the total length of the assembled mini-calandria is $\sim \pm 0.15$ mm. A *random* difference of ± 0.15 mm between the lengths of two mini-calandria which replace each other compares with a *systematic* difference of 0.6mm when a third of the core height is voided in a plate cell element. Hence the reactivity uncertainty associated with the core height changes in 9 elements in the sodium measurements in the pin cores is $\sim 10\%$ of the corrections applied during the measurements in the plate cores, i.e. up to 0.015×10^{-4} dk. This is barely significant compared with the uncertainties arising from reproducibility and drifts.

(d) Weight of steel:

The weights of steel in the sodium filled mini-calandria NACLIII and the corresponding voided mini-calandria, VCLIII used in these experiments show only small variations. The largest difference in total steel weights between the voided and flooded versions in any of these experiments is 7g. Based on the measured specific weights of steel these differences give rise to reactivity effects of less than $\sim 0.01 \times 10^{-4}$ dk/k, and can be ignored.

The uncertainties from the rod profile, reproducibility and drifts, and height uncertainties have been combined to give the uncertainties in the sodium measurements in the pin cell elements given in Table 1.32. The typical value of the uncertainty, $\pm 0.06 \times 10^{-4}$ dk/k is somewhat smaller than the uncertainties of $\pm 0.10 \times 10^{-4}$ dk/k given for the plate geometry elements.

In addition to the above uncertainties there is the systematic uncertainty of $\pm 5\%$ associated with the absolute calibration of the control rods in terms of the delayed neutron scale.

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Table 1.30 Comparison of Steel Weights in Sodium Plates and Dummy Rings

This table is included for completeness but is not required for the benchmark calculations because the effect of the differences in the weight of steel is estimated to be negligible compared with the uncertainties.

Lattice position of centre of 9	Cells Voided	Total Number of Plates	Mass of Na Plates (g)	Mass of Steel in Na Plates (g)	Mass of Steel in Dummies (g)	Dummy Steel - Can Steel (g)
(50,45)	Top 8	216	6395	3842	3822	-20
	Middle 8	216	6377	3824	3822	-2
	Bottom 8	216	6393	3840	3822	-18
(50,42)	Top 8	216	6394	3841	3822	-19
	Middle 8	216	6395	3842	3822	-20
	Bottom 8	216	6396	3843	3822	-19
(50,39)	Top 8	216	6389	3836	3822	-14
	Middle 8	216	6382	3829	3822	-7
	Bottom 8	216	6382	3829	3822	-7

1. The average weight of sodium in a NASTDM4 sodium plate is 11.82g, giving a total of 2553g in 216 plates.
2. The expected difference between the steel weights using the average component data from the ZEBRA Database is +2.2g. (The expected weight of 216 dummies is 3825g; the expected weight of 216 sodium cans is 3823g).

Table 1.31 Comparison of Axially Symmetric Void Worths in Cores 22A and 22B (10^{-4} dk/k)

Lattice Position (Centre of 9 elements.)	Cells Voided	Core Loading		
		Core 22A	Core 22A with central 25 elements symmetrised axially	Core 22B
(50,45)	Middle 8 Top 8 + Bottom 8 All 24 * (measured)	+3.79 $\pm$ 0.08 -0.85 $\pm$ 0.11 +2.94 $\pm$ 0.14 (+2.81 $\pm$ 0.08)*	+3.86 $\pm$ 0.08 -1.12 $\pm$ 0.11 +2.74 $\pm$ 0.14	+3.86 $\pm$ 0.08 -0.98 $\pm$ 0.11 +2.88 $\pm$ 0.14
(50,42)	Middle 8 Top 8 + Bottom 8 All 24	+1.73 $\pm$ 0.08 -2.39 $\pm$ 0.11 -0.67 $\pm$ 0.14		+1.66 $\pm$ 0.08 -2.48 $\pm$ 0.11 -0.82 $\pm$ 0.14
(50,35)	Middle 8 Top 8 + Bottom 8 All 24	-2.36 $\pm$ 0.08 -5.15 $\pm$ 0.11 -7.51 $\pm$ 0.14		-2.46 $\pm$ 0.08 -5.15 $\pm$ 0.11 -7.61 $\pm$ 0.14

* The value in brackets is for a direct measurement of all 24 cells voided together. The other figures for "All 24" are a sum of the values for "Middle 8" and "Top 8 + Bottom 8".

Table 1.32 Reactivity Changes resulting from Sodium Voiding in Core 23 and Sodium Flooding in Core 25

Reactivity worth in units of (10^{-4} dk/k)

Lattice Position	Minicalandria used	Voiding in Core 23	Flooding in Core 25
(50,45)	Middle Top + Bottom	+3.47 $\pm$ 0.06 -2.11 $\pm$ 0.05	-3.23 $\pm$ 0.06 +0.80 $\pm$ 0.06
(50,42)	Middle Top + Bottom	+1.63 $\pm$ 0.05 -3.21 $\pm$ 0.06	-
(50,39)	Middle Top + Bottom	-1.97 $\pm$ 0.05 -4.98 $\pm$ 0.07	+1.08 $\pm$ 0.05

1.4.2C.7 Reactivity Equivalence of Arrays of Plate Elements at the Centres of the Pin Geometry Assemblies 23 and 25.

Arrays of pin geometry elements were replaced with plate elements in central zones of the cores. The changes were made in stages, with reactivity being balanced in each stage using the control rods. Firstly 25 plate elements were introduced into the central 5x5 area of the reference cores. Then the number was increased in a symmetrical pattern. Then plate elements at the core boundary were replaced with pin elements and, in the final stage, a number of edge elements were removed. The overall reactivity change of the replacement of pin elements by plate elements was thus measured.

The control rods were recalibrated at stages throughout. The regulating rod worth did not change significantly when the number of edge elements remained the same and it was only in the final step, when edge elements were removed, that there was a significant change in rod worth.

The reactivity effect of the interchange of the pin and plate elements is compensated by the removal of edge elements. In addition there is the change in the positions of the combined pair of control rods, CR7+CR8. A final correction is made for the difference between the worth of the rod insertion at the beginning of the sequence and at the end.

Arrays of Plate Elements at the Centre of Assembly 23

The changes were made in three stages, with criticality being balanced using the control rods. The reactivity changes are given in Table 1.33. Firstly 25 plate elements were introduced into the central 5x5 area of the reference core, Figure 1.22, replacing the pin elements. Then the number was increased to 45, in a symmetrical pattern. Then 44 plate elements at the core boundary were replaced with pin elements and, in the final stage, 5 core elements were removed at the core boundary and replaced by radial blanket elements. This resulted in a symmetrical core pattern.

Table 1.33 Reactivity Changes, Replacing Pin Elements by Plate Elements in Core 23
(ZTN22-2, Table 11).

Date	Start-up S.U. No	State		CR7+8 (std cm)	Temp. Correction (std cm)	Pu241 Decay Correction (std cm)	Corrected CR7+8 (std cm)
		Plate elements at centre	Changes of elements at core edge				
13.5.81	351	Reference		85.607			85.607
	352	25		70.663	0.117	-0.001	70.779
14.5.81	353	45		62.630	0.060	-0.002	62.628
	354	45		62.479	-0.320	-0.009	62.470
	355		44 pin elements	63.145	-0.333	-0.010	62.802
	356		5 elements removed	80.174	-0.315	-0.011	79.848
15.5.81	357	Reference		85.286	+0.039	-0.018	85.307
18.5.81	358	Reference		85.439	-0.019	-0.047	85.373

The criticality of each configuration was expressed in terms of the positions of the two control rods CR7 and CR8, these positions being expressed in standard cm (denoted by std cm). Corrections were then applied for differences in temperature from the reference temperature and for Pu241 decay from the reference date.

The plate elements added were the standard C22+01C elements. The edge elements were removed from positions 53-53, 56-51, 56-39, 44-39 and 44-51. The locations of the pin elements at the edge of the core are shown in Figure 1.22, which shows startup number S.U.356.

Calibration of control rods CR7+8 with 45 plate elements at the centre gave for the std cm 2.151×10^{-4} dk/k, which is not significantly different from the reference Core 23 value of 2.141×10^{-4} dk/k and this latter value is the one used in converting std cm to reactivity units for the changes which do not affect the core size. With edge elements removed the calibration gave 2.205×10^{-4} dk/k for the reactivity worth of 1 std cm.

Taking a mean value of the reactivity held down by the control rods in the reference cores at the beginning and end of the sequence of changes CR7+CR8 balance of $(85.607+85.373)/2 = 85.490$ std cm, yields the following:

For the element replacements:

Plate replacing pin geometry elements in the central region

- a) Worth of 25 plate elements at centre = $(85.490-70.779) \times 2.141 \times 10^{-4} = 31.48 \times 10^{-4}$ dk/k
- b) Worth of 45 plate elements at centre = $(85.490-62.470) \times 2.141 \times 10^{-4} = 49.28 \times 10^{-4}$ dk/k

Pin replacing plate geometry elements at the core boundary

- c) Worth of 44 pin elements at edge = $(62.470-62.802) \times 2.141 \times 10^{-4} = -0.71 \times 10^{-4}$ dk/k

Radial blanket elements replacing core elements at the core boundary

- d) Worth of 5 edge elements = $(90.339-79.848) \times 2.205 \times 10^{-4} - (90.339-62.802) \times 2.141 \times 10^{-4} = 35.82 \times 10^{-4}$ dk/k

where 90.339 std. cm is the position of the fully withdrawn rod pair

Resulting total reactivity change

The reactivity change resulting from replacing the 45 pin elements by plate elements at the core centre, the 44 plate elements by pin elements at the core boundary and removing the 5 edge elements is $(49.28 - 0.71 - 35.82) \times 10^{-4} = + 12.75 \times 10^{-4} \text{ dk/k}$.

This change can also be written in terms of the difference between the worth of the rod insertion at the beginning and at the end of the sequence:

$$(90.339 - 79.848) \times 2.205 \times 10^{-4} - (90.339 - 85.490) \times 2.141 \times 10^{-4} = 12.75 \times 10^{-4} \text{ dk/k}$$

(To within the accuracy of the measurements, this is the difference in rod positions at the beginning and end of the sequence multiplied by the average of the rod worths in the core before and after the removal of the edge elements,

$$\sim (85.490 - 79.848) \times 2.173 \times 10^{-4} \text{ dk/k} = \sim 12.26 \times 10^{-4} \text{ dk/k})$$

Uncertainty in the reactivity change

The random uncertainties in the pin/plate values, arising primarily from reproducibility errors, are about $\pm 0.5 \times 10^{-4} \text{ dk/k}$. The systematic uncertainties arising from uncertainties in the compositions of the pin and plate elements are about $\pm 3 \times 10^{-4} \text{ dk/k}$. The systematic uncertainty arising from the uncertainty in the control rod calibration ($\pm 5\%$) is $\pm 0.6 \times 10^{-4} \text{ dk/k}$.

Combining these uncertainties quadratically gives a total uncertainty in the reactivity change of $\pm 3.1 \times 10^{-4} \text{ dk/k}$.

On the above basis a critical core configuration can be defined. This is the core shown in Figure 1.22. It is the difference in k_{eff} relative to the value for Assembly 23 which is to be calculated, the measured value of this difference being $+ 12.75 \pm 3.1 \times 10^{-4} \text{ dk/k}$. It is included with the criticality benchmarks in Section 3.1.1.

Arrays of Plate Elements at the Centre of Assembly 25

A similar series of measurements was made in Assembly 25, as shown in Figure 1.23. The changes were made in several stages, with reactivity again being balanced using the control rods. Firstly 25 plate geometry elements were introduced into the central 5x5 area of the reference core followed by the replacement of 24 plate elements by pin elements at the core edge. Then the number in the central array was increased to 45, in a symmetrical pattern, followed by the replacement of a further 20 plate elements by pin elements at the core edge. Then the number of plate elements at the core centre was increased to 69 and more of the core boundary plate elements replaced. Finally 8 elements were removed from the core boundary, being replaced by radial blanket elements.

The final loading of core start-ups numbered S.U. 92 and 93 is shown in Figure 1.23. The order of the element changes is shown in Figure 1.24. The changes in control rod positions, and the corrections for temperature and Pu-241 decay are shown in the following Table 1.34.

Table 1.34 Reactivity Changes, Replacing Pin Elements by Plate Elements in Core 25
(ZTN22/10 Table 17)

Date	Start-up. (SU) No.	State		CR7+8 (std cm)	Temp. Correction (std cm)	Pu-241 Decay Correction (std cm)	Corrected CR7+8 (std cm)
		Plate elements at centre	Pin elements at core edge				
18.2.82	85	0	0	87.380	0	0	87.380
	86	25	0	71.700	+0.211	-0.002	71.909
	87	25	24	73.055	+0.058	-0.003	73.110
19.2.82	88	45	24	63.602	+0.122	-0.013	63.711
	89	45	44	64.492	-0.031	-0.015	64.446
22.2.82	90	69	44	56.012	-0.033	-0.053	55.926
	91	69	66	55.214	-0.082	-0.054	55.078
	92	69	66 - 8	87.122	-0.105	-0.055	86.962
23.2.82	93	69	66 - 8	87.131	-0.077	-0.065	86.989
24.2.82	95	0	0	87.523	+0.076	-0.078	87.521

Taking a mean value of the control rod positions in the reference cores at the beginning and end of the measurement sequence, startup numbers SU 85 and SU 95, gives the critical position of the control rods in the reference core as $(87.380 + 87.521)/2 = 87.450$ std cm.

The mean balance position for the core with 69 plate elements in the core centre and 8 elements removed at the core edge, startup numbers SU 92 and SU 93 is $(86.962+86.989)/2 = 86.975$ std cm. Using these values the following changes in reactivity are obtained:

- a) Worth of 25 central plate elements (denoted 1 in Figure 1.24.)

$$= (87.450 - 71.909) \times 1.990 \times 10^{-4} = 30.93 \times 10^{-4} \text{ dk/k}$$
- b) Worth of 24 edge pin elements (denoted A in Figure 1.24.)

$$= (71.909 - 73.110) \times 1.990 \times 10^{-4} = -2.39 \times 10^{-4} \text{ dk/k}$$
- c) Worth of next 20 central plate elements (denoted 2 in Figure 1.24.)

$$= (73.110 - 63.711) \times 1.990 \times 10^{-4} = 18.70 \times 10^{-4} \text{ dk/k}$$
- d) Worth of next 20 edge pin elements (denoted B in Figure 1.24.)

$$= (63.711 - 64.446) \times 1.990 \times 10^{-4} = -1.46 \times 10^{-4} \text{ dk/k}$$
- e) Worth of next 24 central plate elements (denoted 3 in Figure 1.24.)

$$= (64.446 - 55.926) \times 1.990 \times 10^{-4} = 16.95 \times 10^{-4} \text{ dk/k}$$
- f) Worth of next 22 edge pin elements (denoted C in Figure 1.24.)

$$= (55.926 - 55.078) \times 1.990 \times 10^{-4} = 1.69 \times 10^{-4} \text{ dk/k}$$
- g) Worth of the 8 edge pin elements removed = $(92.080 - 86.975) \times 1.900 \times 10^{-4} - (92.080 - 55.078) \times 1.990 \times 10^{-4} = -63.93 \times 10^{-4} \text{ dk/k}$

Resulting total reactivity change

Assuming separability, the worth of replacing 69 central pin elements by plate elements is 66.58×10^{-4} dk/k and the worth of replacing 66 edge plate elements by pin elements is -2.16×10^{-4} dk/k. The reactivity change resulting from replacing the pin elements by plate elements at the core centre, the plate elements by pin elements at the core boundary and removing the 8 elements at the core edge is 0.49×10^{-4} dk/k.

(As in the case of the Assembly 23 measurement we can express this approximately as the difference in rod positions at the beginning and end of the sequence multiplied by the average of the rod worths in the core before and after the removal of the edge elements,

$$\sim (87.450 - 86.975) \times 1.945 \times 10^{-4} \text{ dk/k} = \sim 0.92 \times 10^{-4} \text{ dk/k}$$

The difference due to the difference in worth of absolute rod insertion in the two different sized cores is negligible.)

Uncertainty in the reactivity change

The random uncertainties on each reactivity measurement are $\sim \pm 0.5 \times 10^{-4}$ dk/k arising primarily from reproducibility. Systematic uncertainties arise from the errors in the plutonium contents of the mixed oxide pins ($\pm 0.2\%$) and the metal plates ($\pm 0.1\%$) and are about $\pm 0.05 \times 10^{-4}$ dk/k per element at the core centre (which for 69 elements is $\pm 3.5 \times 10^{-4}$) and $\pm 0.03 \times 10^{-4}$ dk/k per element at the core edge (which for 66 elements is $\pm 2 \times 10^{-4}$).

The systematic uncertainty associated with the calibration of the control rods is ($\pm 5\%$) or $\pm 0.03 \times 10^{-4}$ dk/k.

Combining these uncertainties quadratically gives a total uncertainty of $\pm 4.1 \times 10^{-4}$ dk/k.

On the above basis a critical core configuration can be defined. This is the core shown in Figure 1.23. It is the difference in k_{eff} relative to the value for Assembly 25 which is to be calculated, the measured value of this difference being $0.49 \pm 4.1 \times 10^{-4}$ dk/k. It is included with the criticality benchmarks in Section 3.1.1.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53								3C	3C	3C	3C	3C							
52						3E	3E	3L	3L	3L	3L	3L	3C	3C					
51					3E	3H	3H	3B	3B	3B	3B	3B	3H	3H	3E				
50				3E	3A	4	3D	3B	3B	3B	3B	3B	3D	2	3A	3E			
49			3C	3B	3D	3RC	3E	3C	3C	3C	3RC	3RC	3E	3RC	3D	3B	3RC		
48			3C	9	3D	3RC	3E	1C	1C	1CD	1C	1C	1C	3E	3RC	3D	3D	3RC	
47		3C	3A	3J	3RA	3TE	1C	1RE	1C	1C	1C	1C	1C	3TE	3RA	3J	3A	3C	
46		3C	3A	6	3RA	3TE	1C	1RE	1C	1C	1C	1C	1C	3TE	3RA	8	3A	3C	
45		3C	3B	3E	3E	3E	1C	1C	1C	1C	1C	1C	1CD	3E	3E	3E	3B	3C	
44		3C	3A	7	3D	3TE	1C	1C	1C	1C	1C	1C	1C	3E	3D	5	3A	3C	
43		3C	3A	3J	3D	3TE	1C	1C	1C	1CD	1RE	1RE	1C	3TE	3D	3J	3A	3C	
42			3RC	3D	3D	3RC	3E	1C	1C	1CD	1C	1C	3E	3RC	3D	3E	3C		
41			3RC	3D	3D	3RC	3E	3RC	3RC	3C	3C	3C	3E	3RC	3D	3E	3C		
40				3C	3A	1	3H	3B	3B	3B	3B	3B	3H	3	3A	3C			
39					3E	3H	3H	3B	3B	3B	3B	3B	3H	3H	3E				
38						3C	3C	3L	3L	3L	3L	3L	3E	3E					
37								3C	3C	3C	3C	3C							

Figure 1.22 Central Plate Zone in Assembly 23A

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53							387	3C3	3C3	3C3	3C3	387							
52					303	3C3	3C3	387	387	387	387	387	3C3	3C3	303				
51				3C3	303	387	387	387	387	387	387	387	387	387	303	3C3			
50			3C3	3C3	3A1	4	303	387	387	387	387	387	303	2	3A1	304	304		
49			3C3	387	303	3C3	304	Z	Z	Z	Y	Z	304	3C3	303	387	3C3		
48			3C3	9	303	3C3	Z	Z	Z	Z	Y	Z	Z	3C3	303	303	3C3		
47		3C3	3A1	3J6	3A1	Z	Z	Y	Y	Y	Y	Y	Z	Z	3A1	3J2	3A1	3C3	
46		3C3	3A1	6	3A1	Z	Z	Z	Y	Y	Y	Y	Z	Z	3A1	8	3A1	3C3	
45		3C3	387	304	304	Y	Y	Y	Y	Y	Y	Y	Y	Z	305	301	387	3C3	
44		3C3	3A1	7	303	Y	Y	Y	Y	Y	Y	Y	Z	Z	303	5	3A1	3C3	
43		3C3	3A1	3J6	303	Z	Z	Y	Y	Y	Y	Z	Z	Y	303	3J2	3A1	3C3	
42			3C3	303	303	3C3	Y	Z	Y	Z	Z	Z	Z	3C3	303	304	3C3		
41			3C3	303	303	3C3	304	Z	Y	Z	Z	Z	304	3C3	303	304	3C3		
40			3C3	3C3	3A1	1	387	387	387	387	387	387	387	3	3A1	3C3	3C3		
39				3C3	304	387	387	387	387	387	387	387	387	387	303	3C3			
38					304	3C3	3C3	387	387	387	387	387	3C3	3C3	303				
37								3C3	3C3	3C3	3C3	3C3	301						

Figure 1.23 Central Plate Zone in Assembly 25

The plate geometry elements are denoted by Y and Z, the difference between these two types being in the “dummy” plates which replace the sodium plates.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53							<i>C</i>	<i>B</i>	<i>B</i>	<i>A</i>	<i>A</i>	<i>B</i>	<i>D</i>						
52					<i>C</i>	<i>A</i>	<i>A</i>						<i>A</i>	<i>A</i>	<i>C</i>				
51				<i>B</i>	<i>C</i>										<i>C</i>	<i>B</i>			
50			<i>B</i>	<i>B</i>												<i>C</i>	<i>C</i>		
49		<i>D</i>	<i>A</i>					2	2	2	2	2					<i>A</i>		
48		<i>D</i>	<i>A</i>				3	2	2	2	2	2	3				<i>A</i>	<i>D</i>	
47		<i>B</i>				3	3	1	1	1	1	1	3	3				<i>B</i>	
46		<i>A</i>				3	3	1	1	1	1	1	3	3				<i>B</i>	
45		<i>A</i>				3	3	1	1	1	1	1	3	3				<i>A</i>	
44		<i>B</i>				3	3	1	1	1	1	1	3	3				<i>A</i>	
43		<i>B</i>				3	3	1	1	1	1	1	3	3				<i>B</i>	
42		<i>D</i>	<i>A</i>				3	2	2	2	2	2	3				<i>A</i>	<i>D</i>	
41			<i>A</i>					2	2	2	2	2					<i>A</i>	<i>D</i>	
40			<i>C</i>	<i>C</i>												<i>B</i>	<i>B</i>		
39				<i>B</i>	<i>C</i>										<i>C</i>	<i>B</i>			
38					<i>C</i>	<i>A</i>	<i>A</i>						<i>A</i>	<i>A</i>	<i>C</i>				
37							<i>D</i>	<i>B</i>	<i>A</i>	<i>A</i>	<i>B</i>	<i>B</i>	<i>C</i>						

Figure 1.24 Sequence of Element Changes in Assembly 25

The order of replacement of the central pin elements by plate elements is the 25 elements denoted by 1, followed by the 20 elements denoted by 2 and then the 24 elements denoted by 3. The edge element replacements follow the sequence A, B and C, with the fuelled elements denoted by D being replaced by blanket elements.

1.4.3 Description of the Material Data

Components of Special Elements used for Reactivity Worth and Cell Reaction Rate Distribution Measurements.

Table 1.M27 The Half-thickness Plutonium Plate, PUJ16
Pu241/Am241 corrected to JULY 1982

Nuclide	Weight (g)	Percentage weight
AL	0.472	1.317
PU238	0.008	0.022
PU239	32.253	89.987
PU240	2.816	7.857
PU241	0.271	0.756
PU242	0.016	0.045
AM241	0.006	0.017
Total	35.842	

Can region:

Nuclide	Weight (g)	Percentage weight
C	0.0040	0.040
SI	0.0607	0.600
P	0.0020	0.020
S	0.0015	0.015
TI	0.0303	0.300
CR	1.8198	18.000
MN	0.1264	1.250
FE	7.0037	69.275
NI	1.0615	10.500
Total	10.099	

Table 1.M28 The Mixed Oxide Plate, PUIV4.

This is used in the Plutonium Enrichment Measurements and in the plutonium oxide element C22 04A

The reference date for Pu241/Am241 is 25.1.71 (*not corrected for Pu241 decay*)

Core region:

Nuclide	Weight (g)	Percentage weight
C	0.0168	0.013
O	15.4510	11.824
AL	0.0168	0.013
SI	0.0168	0.013
FE	0.0168	0.013
NI	0.0168	0.013
U234	0.0040	0.003
U235	0.6120	0.468
U238	85.4890	65.419
NP237	0.0010	0.001
PU239	25.7100	19.674
PU240	2.8860	2.208
PU241	0.2920	0.223
PU242	0.0260	0.020
AM241	0.1237	0.095
Total	130.6786	

For Pu241 and Am241, to obtain values for June /1981 reduce the Pu241 content by multiplying by the factor = 0.605 and add the difference, 0.395 times the original Pu241 content, to the Am241.

Can region

Nuclide	Weight (g)	Percentage by weight
H	0.000086	0.0005
C	0.008580	0.05
SI	0.070356	0.41
P	0.003432	0.02
S	0.003432	0.02
CR	3.071630	17.90
MN	0.255683	1.49
FE	11.921030	69.47
NI	1.714280	9.99
NB	0.111540	0.65
Total	17.159970	

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Table 1.M29 The Plutonium Plate PUII8
(not corrected for Pu-241 decay)

Core region:

Nuclide	Weight (g)	Percentage by weight
H	0.0012	0.002
C	0.0098	0.013
AL	0.0098	0.013
SI	0.0098	0.013
FE	0.0098	0.013
NI	0.0098	0.013
GA	1.2800	1.762
NP237	0.0230	0.032
PU239	67.4920	92.924
PU240	3.5100	4.833
PU241	0.1920	0.264
AM241	0.0845	0.116
Total	72.6316	

Pu241 and Am241 Values for June /1981 (Correction Factor Pu241 = Pu241 x 0.605)

Can region:

Nuclide	Weight (g)	Percentage by weight
Steel region		
H	0.000081	0.0005
C	0.011291	0.07
SI	0.054842	0.34
P	0.003226	0.02
S	0.003226	0.02
CR	2.925974	18.14
MN	0.151622	0.94
FE	11.494230	71.26
NI	1.485571	9.21
Total	16.130040	
Copper region		
CU	5.87	
Overall total	22.00	

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CRIT-SPEC-REAC-RRATE

Table 1.M30 Plates used in the Reactivity Worth Measurements

STSTBR8 Stainless steel

PLATE THICKNESS ----- 0.3172 ± 0.0005 cm

Nuclide	Weight (g)	Weight (%)
H	0.0003	0.0005
C	0.1268	0.2000
AL	0.0635	0.1000
SI	0.5074	0.8000
TI	0.1903	0.3000
CR	11.4821	18.1000
MN	0.6977	1.1000
FE	44.0116	69.3995
NI	6.1513	9.7000
CU	0.0635	0.1000
MO	0.1268	0.2000
Total	63.4213	100.0000

STSTF8T Stainless steel

PLATE THICKNESS ----- 0.2963 cm

Nuclide	Weight (g)	Weight (%)
H	0.0001	0.0004
C	0.0053	0.0230
AL	0.0162	0.0702
SI	0.1130	0.4894
P	0.0063	0.0273
S	0.0023	0.0100
TI	0.0600	0.2598
CR	4.1800	18.1028
MN	0.4156	1.7999
FE	15.6250	67.6691
NI	2.6090	11.2991
CU	0.0162	0.0702
NB	0.0023	0.0100
MO	0.0390	0.1689
Total	23.0903	100.0000

STSTSR4

This is a stainless steel plate corresponding approximately, in weight and dimensions, to the can of a sodium plate, or a "dummy" plate (weight 17.60 g). It replaces a UO₂ plate in the reactivity perturbation measurements. It is recommended to use the data in Table 1.M.4.

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GII8 Graphite

PLATE THICKNESS ----- 0.31775 ± 0.0005 cm

Nuclide	Weight (g)	Weight (%)
H	0.0003	0.002
C	13.8470	99.984
S	0.0005	0.004
FE	0.0014	0.010
TOTAL	13.8492	100.000

ALF2 45% Aluminium

PLATE THICKNESS ----- 1.27 cm

Nuclide	Weight (g)	Weight (%)
AL	32.8400	99.690
SI	0.0033	0.010
MN	0.0020	0.006
FE	0.0955	0.290
CU	0.0014	0.004
TOTAL	32.9422	100.000

AL2O34 Aluminium oxide

PLATE THICKNESS 0.6317 ± 0.0005 cm

Nuclide	Weight (g)	Weight (%)
H	0.0014	0.0023
B10	0.0012	0.0020
B11	0.0049	0.0081
O	28.6050	47.0786
AL	32.1476	52.9090
TOTAL	60.7601	100.0000

AL8 Aluminium

PLATE THICKNESS ----- 0.3167 cm

Nuclide	Weight (g)	Weight (%)
AL	21.6200	99.690
SI	0.0022	0.010
MN	0.0013	0.006
FE	0.0629	0.290
CU	0.0009	0.004
Total	21.6873	100.000

Table 1.M.31 The Pins used in the Reactivity Worth Measurements

MSTPINA The mild steel pin

Note: The hydrogen content assumes that it was present as 5 ppm of the steel and as 4 mg/cm² in the MkII blacking.

Nuclide	Weight (g)	Percent Weight
H	0.00118	0.0007
C	0.25	0.1527
SI	0.08	0.0489
P	0.026	0.0159
S	0.075	0.0458
MN	1.28	0.7819
FE	162.0	98.9542
Total	163.7122	

The compositions given in the ZEBRA Database do not include trace impurities for the following components.

Two "6 inch" pins were used, giving a total length of 29.5 cm. To indicate that the weights refer to the two pins a number 2 is placed in front of the component identifier.

2ALPINA

AL 55.34 g
TOTAL CORE WEIGHT IS 55.34 g

2ALOPINA

O 35.88 g
AL 40.32 g
TOTAL CORE WEIGHT IS 76.20 g

2CPINA

C 35.04 g
TOTAL CORE WEIGHT IS 35.04 g

1.4.4 Description of Temperature Data

Where information has been given the measurements have been corrected to a temperature of 300K and this temperature should be assumed. Measurements could have been made at temperatures up to about 340K.

1.4.5 Additional Relevant Information.

None.

1.5 Description of Reactivity Coefficient Measurements

Measurements were made of the variation of reactivity with time (associated with Pu241 decay) and the variation with temperature. These were used to correct reactivity measurements but are not proposed as benchmarks.

Pu241 Decay.

The variation of reactivity with time, associated with the decay of Pu241 to Am241, was measured and found to be -78×10^{-6} dk per month (ZTN22/10). *This measurement was made to correct the measured reactivity of cores to the reference date, June 1981 and is not proposed as a benchmark measurement.*

Temperature Corrections

Measurements were made in each of the assemblies to relate changes in the control rod setting to changes in the core temperature in order to correct the measured assembly reactivities to values at 300K, the temperature applicable to calculation. These are described in Section 1.1.4. These are not proposed as benchmark measurements.

1.6 Description of Kinetics Measurements

The measurements made to calibrate the control rod reactivity worths in terms of delayed neutron data are described in Section 1.4.6. The control rods were calibrated by inverse kinetics (see ZTN22-3 for details). These are part of the reactivity scale calibration and are not proposed as benchmark experiments.

1.7 Description of Reaction-Rate Distribution Measurements

1.7.1 Overview.

Axial Reaction Rate Scans Through Cells

To provide additional data for checking cell calculation methods reaction rate scans were measured in the standard cells of Assembly 22 and in modified cells. One modification involved combining the plutonium plates from two cells, thus forming a double sized cell. Another consisted of replacing the plutonium plate by two half-thickness plates and then separating them in the cell. The reaction rates which were measured were F49, F28, C28, Rh103(n,n') and In115(n,n') (and F40 in the standard cell). These measurements are described in ZTN22-14 together with the MURAL/FGL5 calculations made to compare with them.

Multichamber Scanning Measurements

Measurements of the Pu239 fission rate distributions using the installed multichamber scanning system were made in each assembly, and in the intermediate assemblies. The measurements were made in 20 core elements and at 5 axial levels (-38.03 cm, -19.23, -0.52, 18.31 and 37.06cm, the core half height in Assembly 22 being 44.66 cm). These positions correspond to the sodium plate at the top of the plate geometry cell which is 11 cells below the centre line, 6 cells below, 1 cell below, 5 cells above and 10 cells above.

It is necessary to model the control rods in calculations of these distributions. The boron absorber sections at the tops of the rods can cause an axial asymmetry. Details of the compositions of the rods have been given in Section 1.1 but have not been prepared, in the present document, in a form suitable for direct use in the calculation of the reaction rate distributions.

Axial and Radial Reaction Rate Scan Measurements through Assemblies made using Foils .

A series of axial and radial reaction rate scans were made for Pu239 fission, U238 fission, and capture, in Assemblies 24 and 25 and the provisional results were presented in graphical form in ZTN22-10 Figures 11 to 14. The measurements extended through the core and axial and radial blanket regions. The uncertainties had not been assessed in detail, but on the basis of previous experience the uncertainties were judged to be less than 1% in the core region rising to about 3% in the outer blanket regions.

These have not been analysed in the present document.

1.7.2A Description of the Experimental Configuration

The assembly configurations and the experimental geometry of the environment of the measurements are described in Section 1.1.

The positions and dimensions of the multichambers are shown in Figure 1.7B and described in Section 1.1.2.

1.7.2B Methods

Details of the foils used in the scan measurements are given in ZTN22-14. (These foil measurements are not being proposed as benchmark measurements.)

The multichamber scanning system is described in BTN/30 and the measurements in the Cadenza cores in ZTN22-10.

1.7.2C Results

Reaction Rate Scan Measurements in the Standard Plate Geometry Cells of Assembly 22 and in Modified Cells.

In the standard cell the Pu239 fission rate is about 2% higher in the plutonium plate than in the UO₂ plate, the standard deviation on individual measurements being about $\pm 0.4\%$. For U238 fission the range is about 25%, the value in the plutonium plate being about 20% higher than in the UO₂ plate (the standard deviation being about $\pm 0.5\%$). For Rh103(n,n') the variation is also large, about $\pm 8\%$, and for In113(n,n') it is about $\pm 10\%$ with a larger standard deviation of about $\pm 1\%$ to $\pm 2\%$. For U238 capture the variation is not significant.

For the cell with the half-thickness plutonium plates the variations are not significant for Pu239 fission and U238 capture, and are correspondingly smaller for the other reactions. In the case of the double thickness plutonium plate the variations are correspondingly greater.

In ZTN22-14 the measurements were compared with calculations made using a one-dimensional cell model and the variation was underestimated for the threshold reactions, in particular for U238 fission. A calculation for this reaction made using a three-dimensional cell model was indicating satisfactory agreement.

It is probably sufficient to calculate the U238 fission rate distribution as part of the validation of a cell calculation method. The measurements were corrected for the global axial variation of the cell fluxes in the reactor. Reference should be made to ZTN22-14 for a comprehensive description of the measurements and the MURAL/FGL5 cell code analysis.

Measurements made using the Multichamber Scanning System.

Results are presented in ZTN22-10. A scan made in Core 22B (scan 285) is reproduced in Figures 1.25 A to E and the loading and control rod positions are given below the Figure 1.25A. The chambers were located in the same positions in all assemblies and the differences between the fission rates were small and understandable in terms of the changes in core dimensions. Normalisation is to the value 10000 at the core centre.

The differences between the measurements made in Core 24 and Core 22A are presented in Figs 1.26 A to E (scan 291 in Core 24 compared with scan 238 in Core 22A, these having similar control rod settings) and the core loadings and control rod positions are given below Figure 1.26A. In this case the normalisation of each set of measurements is to the same total counts. In the analyses of these scan measurements the ZEBRA team took into account the control rod insertion. A comparison is also made in ZTN22-10 between a scan measurement made in Core 25 and one in Core 23.

The installed fission chamber system is shown in Figure 1.27. It has a limitation when used for the accurate determination of axial distributions. It is difficult to locate and measure chamber deposits to better than ~ 1 mm, and this is further complicated by the effects of settling and thermal expansion. A 1mm shift in the effective core centre plane is equivalent to an approximate change of 0.5% in the fission-rate at the 37.06 position.

The uncertainties in the relative fission rates are

$\pm 0.4\%$ (from the relative mass determination)

$\pm 0.1 - 0.3\%$ (from the uncertainty in axial position, the uncertainty depending on the flux gradient)

$\pm 0.25\%$ (counting statistics)

a total uncertainty of about $\pm 0.6\%$

The insertion of the chamber in the element results in a change in the local cell composition, although the effect of this on the relative fission rates is considered to be negligibly small.

The measurements show that the CADENZA cores appear symmetrical in the all-rods-raised configuration.

1.7.3 Description of the Material Data

The material data for the environment of the measurements is that described for the criticality models in Section 1.1

The details of the compositions of the chambers used to make the multichamber scan measurements are given in Section 1.1.4.

1.7.4 Description of Temperature Data

Temperature data for the measurements have not been documented. They are probably in the range 300K to 340K.

1.7.5 Additional Relevant Information.

None.

1.8 Description of Power Distribution Measurements

Not measured.

1.9 Description of Isotopic Measurements

Not measured.

1.10 Other Miscellaneous Types of Measurements

None measured.

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CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52									3291						
51															
50							4588								
49			3799										3780		
48									5470						
47															
46							6005								
45		4007		5157		5853		6048		5871		5131		4031	
44									6021						
43															
42							5486								
41			3760										3822		
40									4602						
39												3263			
38							3334								
37															

Figure 1.25A The Plutonium Fission Rate Distribution, Assembly 22B Level 1 (z = -38.03 cm)

Assembly 22B scan number 285. (25.09.1981) 215 element core. Normalised to 10,000 at core centre.

Initial control rod settings:

CR7 119.443 cm

CR8 119.738 cm

CR9 92.612 cm

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52									4990						
51															
50							6831								
49			5701										5615		
48									8148						
47															
46							8857								
45		6017		7651		8703		8961		8714		7628		6046	
44									8827						
43															
42							8115								
41			5641										5729		
40									6862						
39												4897			
38							4997								
37															

Figure 1.25B The Plutonium Fission Rate Distribution, Assembly 22B Level 2 (z = -19.23 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52									5562						
51															
50							7594								
49			6307										6280		
48									9107						
47															
46							9892								
45		6653		8511		9597		9999		9708		8530		6709	
44									9857						
43															
42							9079								
41			6217										6356		
40									7632						
39												5435			
38							5574								
37															

Figure 1.25C The Plutonium Fission Rate Distribution, Assembly 22B Level 3 (z = -0.52 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52									4978						
51															
50							6799								
49			5650										5643		
48									8131						
47															
46							8825								
45		5964		7601		8525		8930		8690		7654		6042	
44									8871						
43															
42							8028								
41			5579										5732		
40									6878						
39												4886			
38							4977								
37															

Figure 1.25D The Plutonium Fission Rate Distribution, Assembly 22B Level 4 (z = +18.31 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52									3306						
51															
50							4544								
49			3740										3794		
48									5506						
47															
46							5997								
45		3993		5087		5832		6066		5887		5164		4083	
44									6032						
43															
42							5445								
41			3771										3846		
40									4584						
39												3212			
38							3317								
37															

Figure 1.25E The Plutonium Fission Rate Distribution, Assembly 22B Level 1 (z = +37.06 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52															
51															
50							535								
49			889										931		
48									176						
47															
46							12								
45		831		308		23		22		58		361		752	
44									121						
43															
42							141								
41			998										873		
40									535						
39												1193			
38							1350								
37															

Figure 1.26A The Plutonium Fission Rate Distribution in Core 24 relative to that in Core 22.

Fractional differences in units of 1 in10000, $((\text{Core24}/\text{Core22A}) - 1) \times 10^4$

The measurements in each core are normalised to the same total counts.

Level 1 (z = -38.03 cm)

Assembly 22A scan number 238. (20.01.1981) 215 element core loading.

Initial control rod settings: CR7 119.441 cm CR8 119.751 cm CR9 71.204 cm

Assembly 24 scan number 291. (20.01.1981) 222 element core loading.

Initial control rod settings: CR7 119.443 cm CR8 119.739 cm CR9 66.331 cm

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52															
51															
50							-25								
49			360										427		
48									-388						
47															
46							-500								
45		253		-281		-526		-566		-502		-259		235	
44									-545						
43															
42							-468								
41			366										375		
40									-28						
39												722			
38							826								
37															

Figure 1.26B The Plutonium Fission Rate Distribution in Core 24 relative to that in Core 22.

Fractional differences in units of 1 in10000, $((\text{Core24}/\text{Core22}) - 1) \times 10^4$
Level 2 (z = -19.23 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52															
51															
50							-148								
49			247										227		
48									-529						
47															
46							-703								
45		157		-393		-657		-694		-658		-370		123	
44									-723						
43															
42							-528								
41			244										197		
40									-115						
39												566			
38							682								
37															

Figure 1.26C The Plutonium Fission Rate Distribution in Core 24 relative to that in Core 22.

Fractional differences in units of 1 in10000, $((\text{Core24}/\text{Core22}) - 1) \times 10^4$
Level 3 (z = -0.52 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52															
51															
50							-19								
49			388										444		
48									-404						
47															
46							-559								
45		333		-248		-503		-531		-468		-254		241	
44									-528						
43															
42							-611								
41			419										349		
40									-35						
39												766			
38							810								
37															

Figure 1.26D The Plutonium Fission Rate Distribution in Core 24 relative to that in Core 22.

Fractional differences in units of 1 in10000, $((\text{Core24}/\text{Core22}) - 1) \times 10^4$
Level 4 (z = +18.31 cm)

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
53															
52															
51															
50							613								
49			1030										1071		
48									334						
47															
46							81								
45		964		391		112		103		131		355		949	
44									37						
43															
42							276								
41			1049										917		
40									636						
39												1419			
38							1500								
37															

Figure 1.26E The Plutonium Fission Rate Distribution in Core 24 relative to that in Core 22.

Fractional differences in units of 1 in10000, $((\text{Core24}/\text{Core22}) - 1) \times 10^4$
Level 5 (z = +37.06 cm)

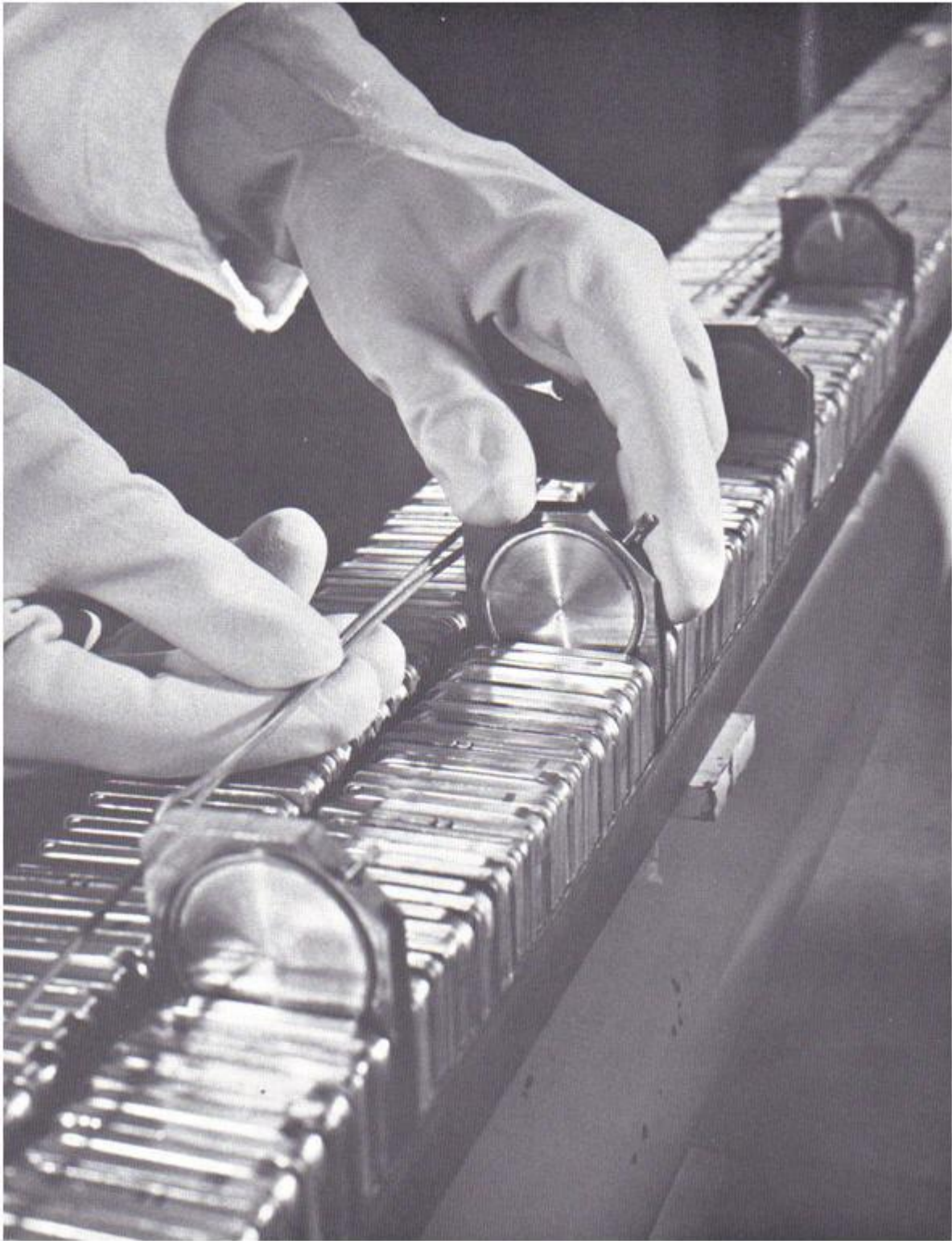


Figure 1.27 The Chambers of the Multi-chamber Scanning System being Loaded into a Double Element.

2. EVALUATION OF EXPERIMENTAL DATA

2.1 Evaluation of Critical or Subcritical Configuration Data

2.1.1 k_{eff} Values of the Four Assemblies, 22, 23, 24 and 25.

The experimental k_{eff} values given in Section 1.1 include corrections for raising the control rods out of the core, for the decay of Pu241 to Am241 (to give k_{eff} values for the reference date of June 1981) and for differences in temperature from 300K. Corrections were also made to simplify the reference core models by replacing the control rods and special elements by standard core elements. The uncertainties include allowances for the uncertainties in core height, diameter and plutonium content. These were considered to be the major sources of uncertainty in the dimensions and composition (as it affects the calculation of the k_{eff} values). Additional uncertainties have been included for the uncertainty in the core radius and the treatment of the inter-element gaps. The total uncertainties are 7.7×10^{-4} for the plate geometry cores and 12.7×10^{-4} for the pin geometry cores.

The resulting k_{eff} values and uncertainties based on the measured corrections made to derive measured reference assembly models are reproduced below in Table 2.1 (and are as given in Table 1.5).

Table 2.1 K-effective values and Uncertainties based on the Analyses made by the Measurers

	Core 22	Core 23	Core 24	Core 25
	Plate geometry Sodium present	Pin geometry Sodium present	Plate geometry Sodium voided	Pin geometry Sodium voided
k-values of Reference Models	1.00217 ± 0.00077	1.00162 ± 0.00127	1.00228 ± 0.00077	1.00132 ± 0.00127

The steel super-lattice grid plates were omitted from the reference model of the assemblies derived by the ZEBRA measurement team but are included in the models proposed in the present document. The plates are 0.25 cm thick and 30.4 cm long, and coincide approximately with the axial blankets, being (nominally) between the planes at 50.2cm and 80.6 cm above and below the mid-plane. They correspond to a horizontally smeared density of 0.154 g/cc. The effect of including the steel homogeneously was calculated in ZTN22-13 (page 10) as 0.00008 and so was ignored as a correction. However, it should be noted that this is in contrast to the effect calculated for Zebra Assembly MZA using a spherical model - being 10 times larger at 0.0008 ± 0.0004 dk (MTN-45). A smaller figure was calculated for the larger core, Zebra Assembly MZB, -0.00056 ± 0.0003 dk (MTN-60) using an improved cylindrical model. These values are both significantly higher than the value calculated in ZTN22-13. Because of this uncertainty it is proposed to model these grid plates.

Other potential sources of uncertainty are discussed below. These concern the uncertainties in the other constituents of the core, in addition to the plutonium for which an uncertainty estimate has been made.

Calculations have been made using a simplified RZ geometry model and the core compositions of the Assembly 23 C type pin (using ERANOS with CARNAVAL-IV nuclear data). The core composition (reproduced in Appendix A.3) has been varied by increasing the plutonium, uranium oxide, and steel contents by 1% in turn. The results are as follows:

Table 2.2 Sensitivity of k-effective values to Changes in Composition.

Core Composition	k_{eff}	difference relative to the reference or voided core
Reference core (without H)	0.98393	
Sodium voided core (without H)	0.97029	-0.01364
Ref. +1% plutonium	0.98905	+0.00512
Voided core . +1% plutonium	0.97545	+0.00516
Ref. +1% uranium oxide	0.98360	-0.00033
Voided core . +1% uranium oxide	0.97006	-0.00023
Ref. +1% steel	0.98405	+0.00012
Voided core . +1% steel	0.97036	+0.00007
Reference core with H	0.98445	+0.00052
Voided core with H	0.97059	+0.00030

It can be seen that the k_{eff} values and sodium voiding reactivity change are insensitive to changes in uranium oxide and steel compositions below the 1% level. If the uncertainty in the hydrogen content is assumed to be $\pm 30\%$ the associated uncertainty in the k_{eff} value of the reference core is $\sim \pm 2 \times 10^{-4} \text{ dk/k}$ and in the sodium voiding effect it is $\pm 0.7 \times 10^{-4} \text{ dk/k}$.

In the course of the sodium removal experiments the sodium plates were weighed (ZTN22-4). The weight of the plates in the 27 elements studied (1944 plates in all) was 0.2% higher than the value corresponding to the ZEBRA Database weight, 29.58 g per plate compared with the database figure of 29.52 g per plate (11.82 g sodium plus 17.70 g steel). This could imply a systematic error of $\pm 0.5\%$ in the sodium content or $\pm 0.3\%$ in the steel content of the sodium plates (or a combination of systematic errors in both the sodium and steel content).

The total steel in a plate geometry cell is made up as follows:

Pu plate	20.73 g
2 x UO ₂ plates	40.34 g
3 x Na plates	51.1 g
Steel plate	24.7 g
Sheath	42.73 g
 Total	 181.6 g

Because of probable cancellations of uncertainties between the systematic errors in the different steel components it is proposed to take the uncertainty in the total steel content of the plate cells to be $\pm 0.2\%$ the associated uncertainty in k_{eff} being about $0.2 \times 10^{-4} \text{ dk/k}$.

The uncertainties on the sodium contents of the pin cell mini-calandria are given with the mini-calandria data. They range from about $\pm 0.2\%$ to $\pm 0.8\%$. Taking the systematic uncertainty to be $\pm 0.5\%$ is probably an overestimate. The uncertainties quoted for the steel of the mini-calandria also range from about $\pm 0.2\%$ to $\pm 0.8\%$ and a systematic uncertainty of $\pm 0.5\%$ is again probably an overestimate. When this is combined with the uncertainties in the other steel components, cans, tubes

and sheath, the net systematic uncertainty in the steel content of the pin cells will reduce to about $\pm 0.3\%$ or about $0.4 \times 10^{-4} \text{ dk/k}$.

The measured differences in reactivity between the Cores 22 and 24, and between Cores 23 and 25, due to the removal or addition of sodium are about $-130 \times 10^{-4} \text{ dk/k}$. An uncertainty of $\pm 0.5\%$ in the sodium content of Cores 22 and 23 would result in an uncertainty of $\pm 0.7 \times 10^{-4} \text{ dk/k}$ which is not significant in comparison with the uncertainties on the k_{eff} values given in Table 1.5.

Concerning the modelling of the plate geometry components (using a three dimensional square section representation of the plate) the MONK-JEF-2.2 Monte Carlo calculations (described in Section 3.1.1) of the difference between a three dimensional representation and a smeared two-dimensional representation gave differences of $40 \times 10^{-4} \text{ dk/k}$. The uncertainties in the plate core dimensions have not been documented (and there is also the effect of the rounded corners of some of the plate core components). However, it is judged that the uncertainty would not contribute more than about $1 \times 10^{-4} \text{ dk/k}$ and so can be ignored. In the case of the pin geometry cells the effect of modelling simplifications, representing the cells as single cylindrical geometry pin cells rather than pin clusters, gave differences of about $20 \times 10^{-4} \text{ dk/k}$ and so it is again considered that uncertainties in the dimensions of the minicalandria components do not significantly add to the uncertainties in k_{eff} .

A possible additional source of uncertainty is the alignment of the core sections of neighbouring elements but there are no estimates of this.

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It can be mentioned that in the original analysis extrapolated all pin geometry cores were defined, based on measurements. These have the following k_{eff} values. However, these models have not been evaluated in the present document.

Core	Extrapolated Experimental k_{eff} values
Extrapolated Flooded Pin Core	1.0010 ± 0.0013
Extrapolated Voided Pin Core	1.0003 ± 0.0013

Possible effect of Back Scattering from the Materials Beyond the Axial and Radial Shielding.

The steel shielding is sufficiently thick to effectively isolate the core and blanket regions from the small fraction of neutrons scattered back from the structure of the facility lying beyond the assembly as defined here. These, as can be seen in Figures 1.1, 1.2, are the continuations of the element sheaths above and below the assembly, the spacer tubes in the elements and the base plate and top shield doors. To the side there is the space between the assembly and the biological shield. A calculation was made using the MONK-JEF-2.2 Monte Carlo code for Core 22 in which the thickness of the steel shield was increased by 3.4 cm on the radial shield radius and 6 cm at the top and bottom. This gave an increase in k_{eff} from 1.0001 ± 0.0001 to 1.0004 ± 0.0001 , an increase of 0.0003 ± 0.00014 . It is considered that the reflection of neutrons from the structures beyond the steel reflector/shielding would be less than this.

It is concluded that all of the significant corrections and sources of uncertainty have been included in Table 1.5 and these data are recommended as the measured critical assembly data.

2.1.2 Reactivity Differences between Assemblies.

An essential component of the benchmark is the comparison of calculation with the differences between the k_{eff} values of the four Assemblies, that is the differences between the values of (C-E) calculated for the different assemblies. The uncertainties in the differences between the k_{eff} values are as shown in Tables 2.3 and 2.4 (reproduced from Tables 1.6 and 1.7).

Table 2.3 Uncertainties affecting the values of the Differences between the k_{eff} values for Pin versus Plate Geometry Cores

Assembly	22A	23A	24	25
Type	Na-Flooded Plate	Na-Flooded Pin	Na-Voided Plate	Na-Voided Pin
Total relative uncertainty	± 0.00131		± 0.00130	

Table 2.4 Uncertainties affecting the values of the Differences between the k_{eff} values for Sodium Filled versus Sodium Voided Cores

Assembly	22A	24	23A	25
Type	Na-Flooded Plate	Na-Voided Plate	Na-Flooded Pin	Na-Voided Pin
Total relative uncertainty	± 0.00036		± 0.00088	

In the case of the sodium filled versus the sodium voided cores the effects of possible uncertainties in the differences between the material contents of the normal and voided cores have been judged to be negligible. Even with an uncertainty of 0.2% in the difference in total steel content between the cores the contribution to the uncertainty in the differences in k_{eff} is negligibly small (see Table 2.2).

The k_{eff} values, and the associated k_{eff} difference values, and uncertainties given in Table 2.1, 2.3 and 2.4 are recommended as the measured values and uncertainties to use with the specified benchmark assembly descriptions.

The transition from one core to another was made in stages, with the changes being balanced using the control rods. The rod worths were recalibrated at points during the transition. In this way the reactivity change in going from one assembly to another was measured. The measurements are described in ZTN22-10, which gives the results for each stage of the transition. *However the quoted uncertainties on the resulting differences are larger than the values given in Tables 2.3 and 2.4 and so they are not recommended as benchmarks.*

2.1.3 The Two Intermediate Assemblies having Plate Zones at the Centres of the Pin Geometry Cores.

In Section 1.4.7 the measurements made of the reactivity difference between Core 23 and the modified core with the central plate geometry zone are described. This modified core is also specified as a critical core, as is the corresponding modified version of Core 25 with the central plate geometry zone. The cores are defined by Figures 1.22 and 1.23. **The differences between the values of reactivity for the intermediate cores and the reference cores, Core 23 and Core 25, as given in Table 2.5, are the recommended benchmarks.**

Table 2.5 The Reactivity Differences between the Reference Assemblies and the Versions with the central Plate Geometry Zones.

Difference between Assembly 23 and the plate zone version	$(12.8 \pm 3.1) \times 10^{-4} \text{ dk/k.}$
Difference between Assembly 25 and the plate zone version	$(0.5 \pm 4.1) \times 10^{-4} \text{ dk/k.}$

2.2 Evaluation of Buckling and Extrapolation Length Data

These were not derived for the CADENZA cores.

2.3 Evaluation of Spectral Characteristics Data

2.3.1 Spectral Index Measurements in the Plate Geometry Assembly 22

As described in Section 1.3 the measurements were made using both fission chambers and foils. Fission chamber measurements were made for U235, U238, Pu239, Pu240 and Pu241. The foil measurements were made for fission in U235, U238 and Pu239 and capture in U238. As described in ZTN22-9, corrections were applied for the radial and axial variations in the reaction rates to obtain cell average values. The corrections for F25, F28 and C28 were based on measurements made of the radial and axial variations within the uranium oxide plates and on the surfaces, for the different plates in a cell, whereas the correction to the measurement made for F49 in the steel plate next to the plutonium plate was based on calculations made using the MURAL collision probability cell code. This was an increase of $0.65\% \pm 0.3\%$.

The fission chamber measurements of F28/F25, F25/F49, F40/F49 and F41/F49 were made using absolutely-calibrated fission chambers in a half-element in the central core location (50,45). The fission chamber foils were located 1.0 ± 0.5 mm above the sodium plate.

It is possible to approach the question of the assessment of uncertainties by looking at the consistency between the measurements made in Core 22 and in other ZEBRA cores and also at the consistency between the measurements made by the ZEBRA team and also by other teams (using their own equipment) in both ZEBRA and in the IRMA intercomparison measurements made in the French Assembly MASURCA.

2.3.2A Comparisons with Measurements made in other ZEBRA assemblies.

Measurements were made in a region of basically identical core cells to those in Core 22 in the annular core region of the radially heterogeneous assembly BZD. This had a large central blanket region and was built in three versions. BZD/1 contained half inserted mock-up control rods in the core region, BZD/2 contained control rod followers and BZD/3 had a uniform annular core region. These environmental effects could result in the overall spectrum being different from that in Assembly 22 but the results of the fission chamber measurements are broadly consistent with the Assembly 22 values as can be seen from the results of the comparison of the chamber measurements presented in Table 2.6. The measurements made in BZD/1 are described in BTN-131 and those in BZD/3 in BTN-118.

Table 2.6 Comparison of Fission Chamber Measurements made in Core 22 and the cores BZD/1 and BZD/3 which used the Same Core Cell as Core 22 but in a Radially Heterogeneous Core Arrangement (central blanket zone).

	Core 22	BZD/1	BZD/3	Percent diff BZD/1 - Core22	Percent diff BZD/3 - Core22
F28/F25 Chamber	0.03483 ($\pm 0.4\%$ r 0.6% s)	0.03473 ($\pm 0.7\%$)	0.03398 ($\pm 0.4\%$ r 0.6% s)	-0.3%	-2.2
F25/F49 Chamber	0.960 ($\pm 0.4\%$ r 1.0% s)	0.975 ($\pm 1.1\%$)	0.9775 ($\pm 0.1\%$ r 1.0% s)	+1.5%	+1.8%
F40/F49 Chamber	0.2594 ($\pm 0.9\%$ r 1.8% s)	0.2574 ($\pm 2.0\%$)	0.2578 ($\pm 0.1\%$ r 2.2% s)	-0.8%	-0.6%
F41/F49 Chamber	1.217 ($\pm 0.5\%$ r 3.8% s)	1.229 ($\pm 3.2\%$)	1.237 ($\pm 0.1\%$ r 3.4% s)	+1.0%	+1.6%

'r' denotes a random uncertainty and 's' a systematic uncertainty. Examples of the sources of the systematic errors are the foil and chamber mass calibrations and the corrections made to obtain the cell averaged values. These would be common to the measurements in other cell configurations and in other ZEBRA assemblies.

The conclusion drawn from these comparisons is that the chamber measurements made in the Zebra 22 assembly are consistent with those made in the earlier cores to within the quoted uncertainties (bearing in mind the possible effects on the neutron spectrum of the differences in core geometry, such as the nearness of blanket elements).

The BZD values of F25/F49 ratios have been reduced by 1% to take account of the revised value of the Pu239 half-life used in the alpha assay.

However, it is stated in BTN-131, that the threshold fission ratios have been increased to allow for inelastic scattering in the surrounding steel, the increase being 1.5% for F28/F25 and 0.6% for F40/F49. Because of difficulties in modelling the chambers and their surroundings it is also proposed there that additional modelling uncertainties should be included, these being $\pm 1.0\%$ for F25/F49 and F41/F49 and $\pm 4.0\%$ for F28/F25 and F40/F49.

These comparisons with the measurements made in the BZD cores show that the measured values have only a small sensitivity to changes in core geometry and dimensions.

A similar good consistency of the measurements is found between other assemblies which had the same, or similar, core region cells. The comparison can be extended to earlier cores with different basic cells, comparing the (C-E)/E% values. These are not as consistent but this could be a consequence of the differences in composition.

2.3.2B Intercomparisons with the Measurements made by Other Groups.

The reaction rate ratio measurements were made in Core 22 by the AEEW ZEBRA Group and also by a team of scientists from ANL. The results are given in Table 2.7 for both the cell average values and the chamber measurements.

Table 2.7 Reaction Rate Ratio Measurements in Assembly 22

Reaction rate ratio	Measured by AEEW team	Measured by ANL team	(ANL/AEEW –1)%
F28/F25 (Cell Average)	0.03634 ($\pm 1.1\%$ r 0.6% s)	0.03757 ($\pm 0.6\%$ r 1.6% s)	$+3.4 \pm 2.0$
F25/F49 (Cell Average)	0.959 ($\pm 1.1\%$ r 1.0% s)	0.941 ($\pm 0.6\%$ r 1.0% s)	-1.9 ± 1.8
C28/F49 (Cell Average)	0.1266 ($\pm 0.9\%$ r 0.5% s)	0.1226 ($\pm 0.6\%$ r 1.2% s)	-3.2 ± 1.5
F28/F25 (Chamber)	0.03483 ($\pm 0.4\%$ r 0.6% s)	0.03566 ($\pm 0.4\%$ r 1.6% s)	$+2.4 \pm 1.8$
F25/F49 (Chamber)	0.960 ($\pm 0.4\%$ r 1.0% s)	0.948 ($\pm 0.3\%$ r 1.6% s)	-1.3 ± 1.9
F40/F49 (Chamber)	0.2594 ($\pm 0.9\%$ r 1.8% s)		
F41/F49 (Chamber)	1.217 ($\pm 0.5\%$ r 3.8% s)		

The agreement is not within the estimated standard deviations for the F28/F25 and C28/F49 measurements.

A further insight into the confidence one can have in the measurements made by the AEEW Winfrith team is provided by the IRMA inter-comparison exercise carried out in the MASURCA facility at Cadarache in France. Several teams participated in the exercise and Table 2.8 compares their measurements with those made by the AEEW team (ZTN/IRMA/1 and 2, 1988).

Table 2.8 Comparison of the Reaction Rate Ratio Measurements made in MASURCA by different Participants in the IRMA Intercomparisons.

Comparisons are with the measurements made by the AEE Winfrith, UK, team.
 $\{(Participant/AEEW)-1\}\%$

Participant	Relative Cell Average Ratios $\{(Participant/AEEW)-1\}\%$			
	C28/F25 Thermal	C28/F25 Absolute	F28/F25	F49/F25
KfK Karlsruhe, Germany		+9.1	+4.8	+ 2.3
CEN-SCK Mol, Belgium (Chambers) (Foil)		+4.7	+2.7 +0.7	+0.3
ENEA, Italy		+5.3	+0.2	-
CEA, Cadarache, France	+4.0	+5.0	+0.6	+1.7
EIR, Switzerland	+2.4	+4.0	+2.5	+0.8, +1.0
ANL, USA(CEA Foils) (ANL Foils)	+4.5 -4.1		+2.9 +0.7	-1.0
CEA/SEN France	-1.0		-	-
Mean of the IRMA measurements relative to AEEW measurement	$+3.4 \pm 3.6$		$+1.9 \pm 1.6$	$+0.8 \pm 1.3$

The final row compares the averages of all of the measurements with those of the AEEW team. What one sees is that the measurements of the AEEW team are broadly consistent with the averages but are near the lower limit of the range (for the measurements relative to U235 fission). Also one sees that the uncertainties in the average values are larger than those given for the ZEBRA Assembly 22 measurements in Table 2.6.

A reduction of 2% in the U235 fission rate in the AEEW measurements would result in a better consistency with the other IRMA participants and also with the ANL measurements in the Cadenza core, Assembly 22. However, a discrepancy in the C28/F49 ratio would remain (+2.6% in the case of the IRMA measurements and -3.2% in the case of the ANL measurement in Assembly 22. Note, however the large discrepancy between the ANL measurement using the CEA foils and the ANL foils in the IRMA measurements).

Comparison measurements were made in the ZEBRA Bizet programme with KfK and CEN teams and the results are summarised in Table 2.9. The differences presented here are not consistent with those obtained in the IRMA intercomparisons.

Table 2.9 Intercomparisons made in the ZEBRA Bizet Programme. Differences relative to the Winfrith Measurements (in percent).

Participant	Relative Cell Average Ratios $\{(Participant/AEEW)-1\}\%$		
	C28/F25	F28/F25	F49/F25
KfK	-0.5	-3.8	+0.8
CEN	-4.0	+0.5	-0.2

An inter-calibration of AEEW and KfK U235 and Pu239 fission chambers has also been made (BTN-38). In this inter-calibration it was concluded that to give consistency with the KfK chambers the masses in the AEEW chambers should be increased (or in the KfK chambers reduced) by $1.3\% \pm 0.3\%$ (U235) and $0.6\% \pm 0.2\%$ (Pu239). However, measurements were also made comparing the absolute

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fission rate in the AEEW U235 fission chamber with a gold absolute activation measurement. It was concluded that there was consistency between the two.

Table 2.10 Summary of Differences Relative to AEEW/ZEBRA Measurements.

Ratio	ANL (Core 22)	IRMA mean	KfK Bizet	CEN Bizet	Systematic Uncertainty
F28/F25	+2.9%	+1.9%	-3.8%	+0.5%	± 3%
F25/F49	-1.6%	-0.8%	-0.8%	+0.2%	± 1%
C28/F49	-3.2%	+2.6%	-1.3%	-3.8%	± 3%

On the basis of these comparisons an estimate is made of the possible systematic errors in the AEEW/ZEBRA measurement techniques, and this is given in the final column.

2.3.3 Effects of Uncertainties in Composition and Dimensions.

In BTN-23 calculations of the effects of changing cell components in the core BZA are described. Fundamental mode calculations, using a specified buckling, for the inner core and outer core of the assembly are made replacing core components with alternatives. Changing the plutonium plate in an inner core cell from the Mk VIII plate (the standard plutonium plate used in Core 22) to a Mk V plate gave the largest effect for changes to the plutonium plate. Replacing the double sheath by a single sheath gave effects of a few tenths of a percent as did removing the trace quantities of hydrogen from the cell. Calculations were also made changing the sodium plate in an outer core cell. However, the main effect in this case was from the associated changes in the steel canning and H content.

The changes to k_{eff} and the reaction rate ratios for the inner core cell are given in Table 2.11. These were generally less than about 0.5%, with the largest effect being from removing the trace quantities of hydrogen from all the components. The hydrogen content has been estimated to be 5 ppm in many of the materials and it is considered that this estimate could be uncertain by about 50% and so an uncertainty in reaction rate ratios of 0.3%, arising from this source, is proposed. Uncertainties in the UO_2 , steel and sodium contents could add similar uncertainties bringing the total uncertainty from uncertainties in the composition to about $\pm 0.5\%$.

Table 2.11 Effects of Changes from the Standard Loading of the Inner Core Cell in BZD

	Change	k_{eff} ($\times 10^{-4}$)	Changes in percent				
			F25/F49	F28/F49	C28/F49	F40/F49	F41/F49
Mk V Pu plate	1% increase in Pu239 + reductions in Pu240 and Pu241	+18.6	-0.01	0.09	-0.03	0.19	-0.01
H removed	H removed	-0.5	-0.40	0.18	-0.12	0.58	-0.38
Steel sheath changed	Double sheath replaced by the single sheath	-0.6	-0.13	0.12	-0.06	0.32	-0.13

2.3.4 Recommended Spectral Index Values

The conclusions drawn from the above comparisons are that the measurements made in Core 22 by the AEEW (ZEBRA) team are typical of those made in other ZEBRA cores. For consistency it is proposed that these should be adopted for the benchmark. The decision about uncertainties has to balance the consistency argument against what is clearly a question over a possible systematic error in the AEEW measurement techniques. The recommended values are given in Table 2.12.

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Table 2.12 Recommended Reaction Rate Ratio Measurements in Assembly 22

Reaction rate ratio	Measured by AEEW team (s.d. in percent)	Addition for chamber location and casing	Addition for core material contents	Total uncertainty in Benchmark Values		<i>(Possible systematic uncertainty in Zebra techniques)</i>
F28/F25 (Cell Average)	0.03634 ($\pm 1.1\%$ or 0.6% _s)		$\pm 0.5\%$	$\pm 1.3\%$		<i>($\pm 3\%$)</i>
F25/F49 (Cell Average)	0.959 ($\pm 1.1\%$ or 1.0% _s)		$\pm 0.5\%$	$\pm 1.6\%$		<i>($\pm 1\%$)</i>
C28/F49 (Cell Average)	0.1266 ($\pm 0.9\%$ or 0.5% _s)		$\pm 0.5\%$	$\pm 1.1\%$		<i>($\pm 3\%$)</i>
F28/F25 (Chamber)	0.03483 ($\pm 0.4\%$ or 0.6% _s)	$\pm 4.2\%$	$\pm 0.5\%$	$\pm 4.3\%$		<i>($\pm 3\%$)</i>
F25/F49 (Chamber)	0.960 ($\pm 0.4\%$ or 1.0% _s)	$\pm 1\%$	$\pm 0.5\%$	$\pm 1.6\%$		<i>($\pm 1\%$)</i>
F40/F49 (Chamber)	0.2594 ($\pm 0.9\%$ or 1.8% _s)	$\pm 4.1\%$	$\pm 0.5\%$	$\pm 4.6\%$		
F41/F49 (Chamber)	1.217 ($\pm 0.5\%$ or 3.8% _s)	$\pm 1\%$	$\pm 0.5\%$	$\pm 4.0\%$		

In column 5 the recommended uncertainties to be associated with the Zebra 22 benchmark measurements are given. However, these ignore the differences found in the intercomparisons with the results obtained by other measurement teams and the figures in the final column (figures in italics) gives an indication of the magnitude of the effect of these differences.

Because such intercomparisons are not taken into account in the benchmark measurements reported for other facilities these are not included in the uncertainties associated with the recommended Zebra benchmark values, this being considered to be the more consistent approach. When the C/E values obtained in the analyses of measurements made in different reactor facilities are compared these additional uncertainties should be borne in mind.

2.4 Evaluation of Reactivity Effects Data

Reactivity changes were measured relative to the change in insertion of a calibrated control rod, usually FR9, required to maintain criticality, and expressed in terms of standard cms of movement of the rod. The standard cm is the reactivity change resulting from a 1 cm movement at the point of maximum reactivity change with movement of the rod. Other control rod movements are then expressed in terms of equivalent standard cms. This requires the "rod profile" to be measured, the relative changes in reactivity with rod movement at different levels of insertion.

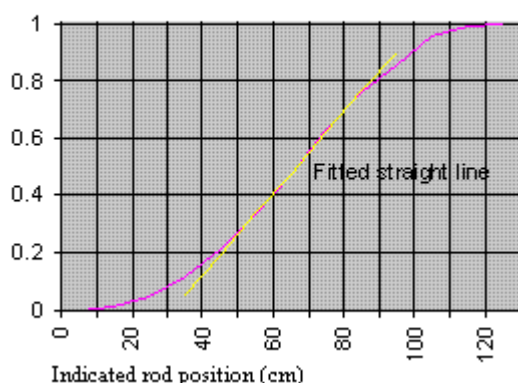


Figure 2.1 The Measured Relative Reactivity Worth Profile of FR9 and the Fitted Straight Line giving the "Standard cm" Equivalence.

The "standard cm" of movement was calibrated by "inverse kinetics" measurements to give reactivity changes in absolute terms. This equivalence depends on the delayed neutron data used to interpret the measurements, and uncertainties in relative fission rates and importances, and introduces a systematic uncertainty of $\pm 5\%$. The delayed neutron data used are tabulated in Section 1.4.6. Relative reactivity worth measurements are not affected by this uncertainty. For the calibration of a single rod the sum of the random components is given as $\pm 1.3\%$, as described in Section 1.4.

Alternative reactivity scales could be considered, such as that based on the comparison of the measured and calculated effect of changes in the plutonium content of cells.

The differences in reactivity between different types of element, such as the plate geometry and pin geometry elements, were measured for single elements and groups of 9 elements. Sodium voiding and "flooding" measurements were also made, with the changes being made to the central group of cells or mini-calandria, and the upper and lower groups of core cells or mini-calandria. Different materials were also introduced into these groups of cells and the resulting changes in reactivity measured.

The transition from one core to another core was made in stages, with the change in reactivity in each stage being measured. This required the calibrated control rod to be recalibrated at each stage.

In addition to the uncertainty in the conversion of the measured control rod movement into absolute reactivity units there are the uncertainties in the measured control rod movement arising from reproducibility and drift. These have been assessed for the measurements presented in Section 1.4.

Some changes in components produce a change in core height. This has been taken into account in the measured values and the associated uncertainties assessed. Measurements were made with different thickness steel plates to determine the correction

Changes in the associated steel content also accompanied the sodium voiding and flooding measurements. The components were weighed and the effects of the changes in the steel contents assessed.

There is also the possibility of an interaction between the perturbation and the control rod worth. Corrections of up to 1.6% were required for this effect in the case of the enrichment perturbation measurements.

The effects of uncertainties in the dimensions and compositions of core components in the environment of the measurements will act via the neutron flux and importance spectrum. As has been seen in the discussion on the reaction rate ratio measurements the uncertainty resulting from the calculated flux spectrum uncertainty is considered to be 0.5% at most. The effect associated with the neutron importance spectrum is considered to be even smaller and thus these are negligible compared with the other uncertainties. However, we note that the reason for making measurements in both plate and pin geometry has been to make it possible to include in the assessment of uncertainties an examination of the consistency between measurements made using completely independent core materials.

The sources of uncertainty and their values for each type of measurement have been evaluated by the measurers and their values have been adopted. They are described in Section 1.4.

2.4.1 Delayed Neutron Data and the Reactivity Scale.

Details of the calibration of the control rods are given in ZTN22-3. For the absolute calibration of the rods the applied step changes in reactivity were in the range 2.5 to 6.5×10^{-4} dk/k. The measurements could be reanalysed using updated effective delayed neutron data, if required.

Analyses of the plutonium enrichment experiments give confidence in the accuracy of the reactivity scale. Calculations have been made using the MONK Monte Carlo code and both the JEF-2.2 and ENDF/B-VI-version 6 nuclear data libraries for the cores with and without the MOX plate replacing a UOX plate in each cell of an element. The standard deviation of each calculation is $\pm 1 \times 10^{-4}$ dk and so the difference has a standard deviation of $\pm 1.4 \times 10^{-4}$. This corresponds to an accuracy of about $\pm 7\%$ and the accuracy of the average for two measurements made in a core is about $\pm 5\%$. The agreement with measurement is in all cases within this range of uncertainty. (The uncertainties quoted for the measured worths do not include the $\pm 5\%$ systematic uncertainty in the reactivity scale.)

MONK-JEF-2.2 Calculations of Plutonium Enrichment measurements

	MONK-Jef-2.2 k_{eff}	Measured worth
Core 22B Full height model	1.0004 ± 0.0001	
Core 22 with central Pu enriched element	1.0023 ± 0.0001	
Reactivity worth of added Pu	0.0019 ± 0.00014	0.001945 ± 0.00003
Core 22 with 2 off-central Pu enriched elements	1.0023 ± 0.0001	
Reactivity worth of added Pu	0.0019 ± 0.00014	0.00175 ± 0.00003
Core24 Full height model using the X dummy	0.9997 ± 0.0001	
Core 24 with central Pu enriched element	1.0013 ± 0.0001	
Reactivity worth of added Pu	0.0016 ± 0.00014	0.00173 ± 0.00003

MONK-ENDF/B-VI -6 Calculations of Plutonium Enrichment Measurements

	MONK-B-VI-6 k_{eff}	Measured worth
Core 22B Full height model	1.0083 ± 0.0001	
Core 22 with central Pu enriched element	1.0103 ± 0.0001	
Reactivity worth of added Pu	0.0020 ± 0.00014	0.001945 ± 0.00003
Core 22 with 2 off-central Pu enriched elements	1.0100 ± 0.0001	
Reactivity worth of added Pu	0.0017 ± 0.00014	0.00175 ± 0.00003
Core24 Full height model using the X dummy	1.0092 ± 0.0001	
Core 24 with central Pu enriched element	1.0110 ± 0.0001	
Reactivity worth of added Pu	0.0018 ± 0.00014	0.00173 ± 0.00003

To summarise, these calculations give confidence in the reactivity scale and its estimated systematic uncertainty of $\pm 5\%$.

2.4.2 Reactivity Differences between Assemblies.

The transition from one core to another was made in stages, with the changes being balanced using the control rods. The rod worths were recalibrated at points during the transition. In this way the reactivity change in going from one assembly to another was measured. Corrections were made for temperature differences from 300K and Pu241 decay.

In the case of the transition from Core 22 to Core 24 there is an associated change in core height and a small change in steel content. The difference in core height has been taken into account in the core criticality models and the uncertainties in these models have been assessed more fully and so are preferred.

In the case of the transition from Core 25 to Core23 there is no change in core height and the change in steel content is very small. Because of the complication of treating the plate elements at the core edge one can consider the core with the plate elements already "flooded". This is a core of 237 elements, 168 flooded pin elements and the remainder flooded plate elements.

The reactivity change resulting from voiding just the 168 pin elements in this 237 element version of Core 23 can then be considered as a benchmark measurement.

2.4.3 Measurements Replacing Elements either Singly or in Groups of 9.

Measurements were made of the reactivity effect of replacing one type of element by another, both single elements and groups of 9 elements and at both the central position and off-central positions. The changes were made in a region free from non-standard elements.

The uncertainties treated arise from reactor drift due to temperature changes, uncertainties in control rod profile, changes in core height and material composition uncertainties. In addition there is the systematic uncertainty in the reactivity scale.

The results given in Section 1.4.7.2, Tables 1.17 to 1.20, treat these sources of uncertainty and are recommended as benchmarks.

2.4.4 Enrichment Measurements.

To measure the reactivity effects of changing the plutonium content of cells mixed-oxide plates displaced a set of UO₂ plates in the core cells of elements in Core 22. In Core 23A, plutonium oxide pins replaced UO₂ pins in an element.

A correction was made for the interaction between the reactivity perturbation and the control rod movement.

The systematic uncertainties arise from the uncertainty in the plutonium content of a mixed-oxide plate and in a mixed-oxide pin. Other sources of error are associated with the control rod profile, and the inverse kinetics measurements. There is also the systematic uncertainty in the reactivity scale which is to be combined with the above uncertainties.

The measurements described in Section 1.4.7.3, Table 1.21, are recommended as benchmarks.

The analyses of these experiments give confidence in the accuracy of the reactivity scale, as is described in Section 2.4.1. There is agreement with calculation for the average of the two measurements to within the $\pm 5\%$ standard deviation of the combined Monte Carlo statistics.

2.4.5 The Reactivity Effects of Changes in Cell Heterogeneity in Assembly 22

The changes made were to combine pairs of standard plutonium plates and also to replace the standard plates by pairs of half-thickness plates and then to separate them. The changes were made in central cells of either one element or a group of 9 elements.

The uncertainties arose from the sources described above.

The measurements described in Section 1.4.7.4, Table 1.22 are recommended as benchmarks.

2.4.6 Small Sample Reactivity Worth Measurements.

The materials used in the reactivity perturbation measurements included UO₂, sodium, carbon, oxygen, aluminium, steel, and copper.

Measurements were made in all four cores. Corrections were made for element differences and changes in core height. The uncertainties arise from the uncertainties in control rod profile, reproducibility and drifts, and the changes in core height (in the case of the plate geometry cores). In addition there is the systematic uncertainty of $\pm 5\%$ associated with the absolute calibration of the control rods in terms of the delayed neutron scale.

These measurements described in Section 1.4.7.5, Tables 1.23 to 1.29, are recommended as benchmarks.

2.4.7 Sodium Voiding Reactivity Measurements.

In Core 22 and Core 24 the sodium plates were replaced by the voided plates, which have nominally the same thickness and steel content as the sodium plates. All the plates being interchanged were weighed and the differences in thickness measured. The changes were made either over the whole core section or the central group of core cells and the upper and lower two groups of core cells. Uncertainties were assessed for the effects of Rod Profile, Reproducibility and Drifts, Core Height Changes, and Weight of Steel (which was taken to be a negligible correction).

Measurements were also made in Cores 23 and 25 involving the middle, and the top plus bottom mini-calandria in the 9 elements. The uncertainties arose from the same sources as for the plate geometry measurements although they differed in magnitude. Essentially there was no change in core height and the differences in steel weights were negligibly small.

These measurements, described in Section 1.4.2C.6, Tables 1.30 to 1.32, are recommended as benchmarks.

2.4.8 Reactivity Equivalence of Arrays of Plate Elements at the Centres of the Pin Geometry Assemblies 23 and 25.

In these measurements arrays of pin geometry elements were replaced with plate elements in central zones of the cores and the plate geometry elements at the core boundary were replaced by pin geometry elements and the numbers of edge elements reduced to maintain the critical system. The changes were made in stages, with the change in reactivity being measured at each stage using the recalibrated control rods. The overall reactivity change of the replacement of pin elements by plate elements, and the removal of edge elements, was thus measured by adding the individual components.

It is recommended that these measurements, described in Section 1.4.2C.7, be used to define two additional critical core configurations, as shown for the final configurations of the changes. The differences between the k_{eff} values calculated for these two critical configurations and the corresponding Cores 23 and 25, respectively, are then to be compared with the measured differences presented in Section 1.4.2C.7.

2.5 Evaluation of Reactivity Coefficients Data

The reactivity effects of Pu241 decay, and temperature changes, given in the ZTN documents have been adopted for the corrections made to the measured k_{eff} values. *They are not recommended as benchmark measurements.*

2.6 Evaluation of Kinetics Data

The control rods were calibrated using inverse kinetics. *The data are not recommended as benchmark measurements.*

2.7 Evaluation of Reaction-Rate Distributions

2.7.1 Reaction Rate Scan Measurements in Standard Plate Geometry Cells and in Modified Cells.

To provide additional data for checking cell calculation methods axial reaction rate scans were measured in the standard cells of Assembly 22 and in modified cells. One modification involved combining the plutonium plates from two cells, thus forming a double sized cell. Another consisted of replacing the plutonium plate by two half-thickness plates and then separating them in the cell. The reaction rates which were measured were F49, F28, C28, Rh103(n,n') and In115(n,n'), and F40 in the standard cell. These measurements are presented in ZTN22-14 together with the MURAL/FGL5 cell calculations made to compare with them. The measured rates were corrected for the global axial variation of the reaction rates. Agreement was found between the 3D cell model calculations and measurement.

These are not being evaluated as benchmarks because of uncertainty about their usefulness. The largest variation, and the most statistically significant set of measurements is for the U238 fission rate and this would be the most suitable reaction to calculate. Reference should be made to ZTN22-14 for details of the foils and their positions in the cells, together with the results of the measurements and the associated uncertainties.

2.7.2 Multi-chamber Scanning System Measurements.

Measurements of the Pu239 fission rate distributions using the installed multi-chamber scanning system were made in each assembly, and in the intermediate assemblies. Results are given in Section 1.7.2C for the measurement in Core 22B and also the differences between the measurements in Core 24 and Core 22A, these being the most comparable from the point of view of control rod insertion. The uncertainties in the measurements, as estimated by the measurers, are also summarised, the total uncertainty being about $\pm 0.6\%$. The normalisation for the Core 22B measurement is to a central value of 10,000 and for the comparison between the Core 24 measurement and the Core 22A measurement it is normalised to the sum of the measured values being the same in each assembly.

These Core 22 and Core 24 measurements are considered suitable to be adopted as benchmarks. However the modelling of the specific control rod insertion in these measurements has not been derived for these measurements in the present document (Section 3) although the detail of the rods has been included.

The additional measured values for Core 25 relative to Core 23 can be found in ZTN22-10 but have not been evaluated here as benchmarks.

2.7.3 Axial and Radial Reaction Rate Scan Measurements.

A series of axial and radial reaction rate scans were made for Pu239 fission, U238 fission and capture, in Assemblies 24 and 25 and the provisional results were presented in graphical form in ZTN22-10, Figures 11 to 14. The measurements extended through the core and axial and radial blanket regions. The uncertainties had not been assessed in detail, but on the basis of previous experience the uncertainties were judged to be less than 1% in the core region, rising to about 3% in the outer blanket regions.

However, because the results reported in ZTN22-10 are only provisional, and are in graphical form, they have not been evaluated and recommended as benchmark measurements. Nevertheless, they could be useful.

2.8 Evaluation of Power Distribution Data

Not measured.

2.9 Evaluation of Isotopic Measurements

Not measured.

2.10 Evaluation of other Miscellaneous Types of Measurements

Not measured.

3. BENCHMARK SPECIFICATIONS

Overview of the Calculational Methodology and the Models.

The XYZ geometry models are based on XY geometry plans describing the arrays of square section elements which form the assemblies.

The elements consist of axial arrays of cells contained within the square element sheaths. The calculational models therefore involve setting up the data for the three stages:

- (a) the cells,
- (b) the elements
- (c) the arrays of elements.

In the following sections these three components are described in detail. The same approach is involved in the models used to calculate all assembly properties: criticality, spectral indices, reactivity worths and reaction rate distributions. The calculations of criticality require the most accurate modelling, with accuracies of better than 0.1%, whereas a less accurate model could be used for calculating the other properties. This could imply continuous energy Monte Carlo calculations of the criticality but deterministic methods are required for calculating the localised reactivity worth measurements (if accurate Monte Carlo perturbation methods are not available).

As described in Section 1 the elements are located on the base-plate and are arranged in groups of 5x5. These groups are separated by a small gap of 0.2665 cm by the mild steel super-lattice grids of width 0.25 cm which are above and below the core sections of the elements and hold the elements in place. These grids extend (nominally) between 50.2 cm and 80.6 cm above and below the mid plane and are 30.4 cm high, being situated in the blanket/shielding areas of the elements. The approximation is made that the grids fill the space of 0.2665 cm between the groups of 5x5 elements and the density of the mild steel plates is reduced by the factor 0.25/0.2665. These grid plates are represented in the more detailed calculational models but simplified uniform lattice models, in which they are not represented, have also been set up.

The distance between the centres of elements within a group of 5x5 is 5.3721 cm and the overall average spacing is 5.4254 cm (the distance between the centres of two superlattices divided by 5). The models which include the representation of the superlattice spacing have an irregular lattice layout and consequently are more suitable for Monte Carlo calculations. For deterministic calculations it is usual to assume that the elements are located in a regular lattice having the average spacing of elements in the assembly, 5.4254 cm.

Figure 3.1 illustrates the plan view of a plate cell in an element sheath. The plates are treated as square with a width of 5.067 cm. The plutonium, uranium oxide and sodium plates are treated as consisting of a square core region which is surrounded by canning material. As is shown in the Figures in Section 1.1.2A the edge regions of the canned plates do not have a simple geometry but they are represented in calculations as being rectangular parallelepipeds. The core region is also represented as being a rectangular parallelepiped, although the corners of some core regions are rounded. The width of the mini-calandria in the calculational model is also taken to be 5.067 cm.

The element sheath has an inner width of 5.102 cm and an outer width of 5.2544 cm. There is therefore a small gap between the edge of the plate, or minicalandria, and the inner face of the element sheath, a width of 5.067 cm compared with the inner width of the element of 5.102 cm, an average gap of $0.035/2 = 0.0175$ cm. This gap will not be aligned in all of the plates and mini-calandria in an element. Similarly, there is a small gap between the elements in the 5x5 arrays, the element outer width being 5.2544 cm compared with the lattice spacing of 5.3721 cm, a gap of 0.1177 cm, but again

this gap cannot be assumed to be regular because of possible bowing of elements over the 3 metre length.

The gaps between the plates, or mini-calandria, and element sheath, and between elements, are represented in the first calculational model, denoted as Model A and shown diagrammatically in Figure 3.1. Treating these as uniform streaming gaps is probably not a realistic physical model and an uncertainty to allow for this modelling approximation has been included in the overall uncertainty. Ignoring the streaming gaps by homogenising over them is also probably not realistic, the real effect being between the two models.

In Model B these gaps are eliminated and the steel of the element sheath is smeared over the space between the plate edges and the lattice square boundary. The gaps between the groups of 5x5 elements are preserved and the superlattice grid plates are included. Model B is considered to be as valid a model as Model A and the difference between calculations made using the two models is considered to be an uncertainty in the modelling applying to both models .

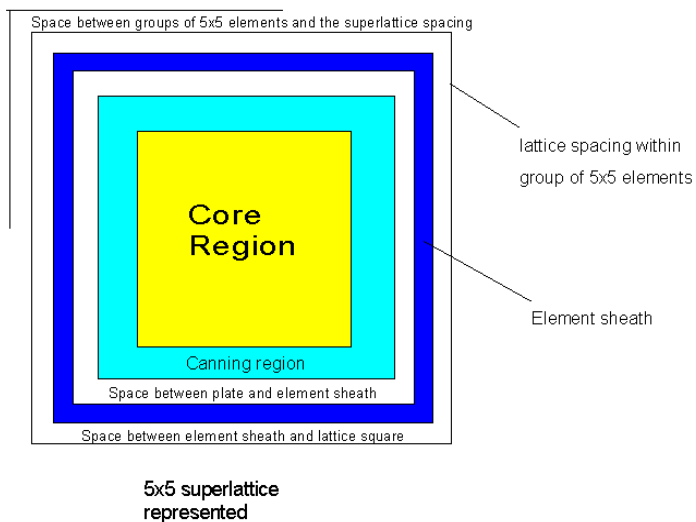
In Model C there is a further simplification. A lattice which is uniform over the whole assembly is adopted and the steel of the element sheath is smeared over the enlarged lattice spacing of 5.4254 cm square. The steel of the superlattice grid plates, separating the arrays of 5x5 elements, is ignored in this model.

For deterministic calculations a further simplification is adopted (Model E, see Figure 3.18). This is called the MURAL model because it is the representation developed for use in the MURAL collision probability cell code. In the case of the plate geometry cells the simplification is to combine the canning in the edge region of the plates with the element sheath material so that in each plane there are only two regions, the plate core region and the outer steel canning plus element sheath region. In the case of the mini-calandria the walls of the mini-calandria are combined with the element sheath and smeared over the lattice area between the pin cells and the lattice boundary.

When the original analyses were performed (in the early 1980s) the models were simplified still further. The material in each plate layer was homogenised transversely, combining the core material with the plate edge material and the associated element sheath steel for the layer having the thickness of the core region. The axial layers containing canning material were similarly homogenised. (The magnitude of the approximation involved is discussed in the paper “Calculations to compare different ways of modelling the plate geometry cells of the Zebra fast critical assembly, MZA”

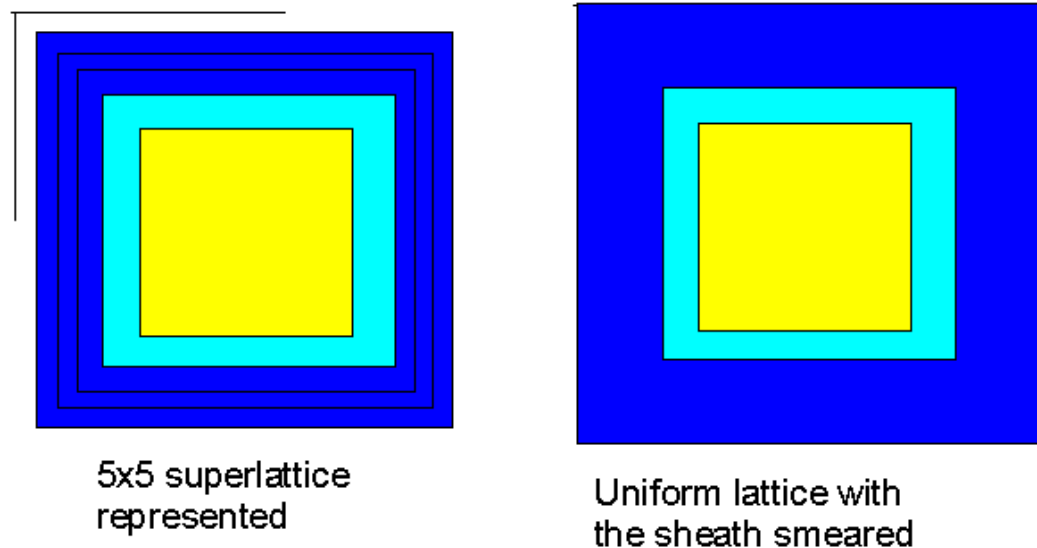
Rowlands, Annals of Nuclear Energy (2009)). The pin cells were approximated as coupled 1D cylindrical geometry cells with the calandria walls plus the element sheath treated as the outer region of the 1D cell representation. More refined multipin methods were developed during the course of the analysis. Streaming effects were treated separately and modified diffusion coefficients calculated. This approach is mentioned because it could guide the choice of deterministic cell modelling methods.

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Model A

Figure 3.1 Diagram of a Plate within an Element Sheath (Drawing not to scale)



Model B

Model C

Figure 3.2 Diagram of Simplified Models in which the Gaps between the Plates (or Mini-calandria), the Element Sheath and the Superlattice Grid are Eliminated.

In Model B the superlattice spacing is preserved (but the lattice plates are omitted) and in Model C a uniform lattice is adopted, eliminating the gaps between the groups of 5x5 elements. (Drawing not to scale.)

3.1 Critical or Subcritical Configuration Benchmark Specifications

3.1.1 Description of the Calculational Methodology and the Models

Critical configuration models are defined for the four Assemblies, 22, 23, 24 and 25 and also for the intermediate assemblies which have regions of plate geometry elements in central regions of Assemblies 23 and 25. The assemblies comprise a Core region, with Axial Blanket and Axial Steel Reflector regions above and below the core. The core is surrounded radially by the Radial Blanket region around which is the Radial Steel Reflector region. Both the axial and radial blanket regions (also called breeder regions in some documents) consist of natural uranium plates or blocks contained within the steel element tubes. The core height is approximately the same in all assemblies but the radial dimensions of the cores differ.

The regions beyond the steel reflector regions are calculated to have a negligibly small effect on k_{eff} . Increasing the steel region above and below the core by 6 cm and the radius by 3.4 cm increased k_{eff} by 0.0003 +/- 0.00014. These added dimensions were selected to overestimate the possible effect. (The different values for the axial and radial directions were chosen because of the different amounts of material in the two directions and they produce rounded numbers for the dimensions.)

There are two basic types of core region: plate geometry and pin geometry. Each of these is used in one of two forms, either containing sodium or "voided" of sodium.

The models are simplifications of the actual assemblies in that some elements have been replaced by "standard" core elements. This was done on the basis of measurements made on the cores and is described in Section 1.1.2B. The further simplification is that the geometries of the plates and pins are made more uniform. Plate cans are assumed to have rectangular shapes, in place of the actual irregular edge regions (which can be seen in Figures 1.9 to 1.15) and the canning material is distributed uniformly over the resulting volume. Also, the rounded corners of the core regions of plates are made square. The top and bottom end regions of the pins and calandria end plates are similarly treated as single uniform rectangular regions.

Two types of simplification of the reference model, Model A, are considered, simplifications of the cell geometries (preserving the total weights of materials) and changing from the superlattice arrangement of elements to a uniform array of elements. It is considered important, though, to preserve the separate representation of the core regions of the plates in the assembly core region and this implies the use of a "3D" model of the core cells (although this could be an approximate 3D model as was used in the earlier analyses made using the MURAL cell code and now included in the ECCO cell code in the ERANOS system).

Reference benchmark models are defined first, these being denoted as Model A. These require a full three dimensional representation at the cell level and are suitable for Monte Carlo calculations. Following this simplified models are defined more suitable for deterministic calculations. These are formed by homogenising selected neighbouring regions, such as the gaps on either side of the element sheaths (Model B), and changing to a plan model of the core in which the superlattice structure is replaced by a uniform lattice of elements (Model C). Further simplifications are considered (Model M) in which the edge regions of canned plates are combined with the steel of the element sheath, and the outer walls of the calandria are combined with the sheath in a similar way. Corrections to the k_{eff} values of the reference model (Model A) have been calculated using continuous energy Monte Carlo for these various simplifications.

To obtain accurate results, the heterogeneity of the cell structure and associated streaming effects must be treated.

The Arrangement of Elements in the Core Regions.

The arrangements of the core elements to form the core region arrays are shown in the following Figures. The core regions are surrounded by radial blanket elements. The outer radius of the radial blanket is the same in all of the assemblies and is surrounded by the radial shield elements, as shown in Figure 1.7A.

Core plans of the plate geometry Assemblies 22 and 24.

All of the core elements of Assembly 22 are taken to be of type 1C (or more fully described as type C22+01C) which use the Mark VIII plutonium plate, PUVIII8. In Section 1.1.2B corrections have been made to the k_{eff} values for the replacement of the control rods, the special elements and non-standard elements (in particular the element C22+01D which used the Mark IX plutonium plate) by these elements. The plan of the core is shown in Figure 3.3.

The core was built in two versions, 22A and 22B which differed in the axial orientation of the core cells. The individual core cells have an axial asymmetry. In Core 22A the core region cells all had the same orientation in an element whereas in Core 22B alternate cells were inverted. In this way axial symmetry was produced. The reactivity change was insignificant, as described in Section 1.1.2B. The symmetrical version, Core 22B, is modelled here, although comparison is sometimes made with measurements made in Core 22A. An advantage of the symmetrical version is that a half height model can be calculated.

In the case of Assembly 24, the three types of “dummy” plate, which replace the sodium plate of Assembly 22, are represented. These are denoted by X, Y and Z and the core plan is shown in Figure 3.4. Again the cells have been simplified to use just the one type of plutonium plate, PUVIII8, the same as in Core 22, with the corrections to k-effective having been based on measurements. The only change compared with the Core 22 element (1C) is the replacement of the sodium plate by a “dummy” plate having about the same thickness and steel content but no sodium. The differences are discussed later.

Core plans of the pin geometry Assemblies 23 and 25.

All of the core elements of Assemblies 23 and 25 are either mini-calandria elements (denoted by 3A, 3B, 3C etc in Core 23 and 3C3, 303 etc in Core 25, see Section 1.1.2B) or are the same plate elements as used in Cores 22 and 24 respectively. These plate elements are situated at the core radial boundary. Again the special elements, non-standard elements and control rods have been replaced by these standard core elements in the calculational model, with k-effective adjustments based on measurements, as described in Section 1.1.2B, and summarised in Table 1.5.

The core plan of Core 23 is shown in Figure 3.5A and Core 25 in Figure 3.5B.

Core plans of the arrays of plate elements at the centres of the Pin Geometry Assemblies 23 and 25.

These core plans are shown in Figures 3.6A and 3.6B.

Positions of the control rods

For accurate calculations of reaction rate distribution measurements, such as the multi-chamber Pu239 fission rate scans, account should be taken of the control rod insertion and the axial bias introduced by the boron absorber sections at the tops of the rods. For this purpose details of the control rod components were included in Section 1.1. The positions of the rods are shown in the Figures in Section 1 (Figures 1.8A, 1.8B).

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53									1C	1C	1C								
52						1C	1C	1C	1C	1C	1C	1C	1C	1C					
51				1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C				
50				1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C			
49			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
48			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
47			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
46		1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	
45		1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	
44		1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	
43			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
42			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
41			1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C		
40				1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C			
39					1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C	1C			
38						1C	1C	1C	1C	1C	1C	1C	1C	1C					
37									1C	1C	1C								

Figure 3.3 Calculational Model of the Assembly 22 Core (Fissile Elements)

In Assembly 22B the Elements 1C etc. are replaced by Elements 10C etc., the axially symmetrical versions of the core elements. The reactivity difference between the two versions, 22A and 22B, is negligibly small.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53							Z	Z	Z	Z	Z	Z	Z						
52						Z	Z	Y	Y	Y	Y	Y	Z	Z					
51				Z	Z	Y	Y	Y	Y	X	Y	Y	Y	Y	Z	Z			
50				Z	Y	Y	Y	Y	Y	X	Y	Y	Y	Y	Y	Z			
49			Z	Y	Y	Y	Y	X	X	Y	X	X	Y	Y	Y	Y	Z		
48		Z	Z	Y	Y	Y	X	X	X	Y	X	X	X	Y	Y	Y	Z		
47		Z	Y	Y	Y	X	X	X	X	X	X	X	X	X	Y	Y	Y	Z	
46		Z	Y	Y	Y	X	X	X	X	X	X	X	X	X	Y	Y	Y	Z	
45		Z	Y	Y	Y	X	X	X	X	X	X	X	X	X	Y	Y	Y	Z	
44		Z	Y	Y	Y	X	X	X	X	X	X	X	X	X	Y	Y	Y	Z	
43		Z	Y	Y	Y	X	X	X	X	X	X	X	X	X	Y	Y	Y	Z	
42			Z	Y	Y	Y	X	X	X	X	X	X	X	Y	Y	Y	Z	Z	
41			Z	Y	Y	Y	Y	X	X	X	X	X	Y	Y	Y	Y	Z		
40				Z	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Z			
39				Z	Z	Y	Y	Y	Y	Y	Y	Y	Y	Y	Z	Z			
38						Z	Z	Y	Y	Y	Y	Y	Z	Z					
37							Z	Z	Z	Z	Z	Z	Z						

Figure 3.4 Calculational Model of the Assembly 24 Core (Fissile Elements)

X, Y and Z denote the three types of “dummy” plate which replace the Assembly 22 sodium plates:
X = STNAVR4 and Y = STNAVS4 are steel rings and Z = STNAV4 is “honeycomb” shaped.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53								1C	1C	1C	1C	1C	1C						
52						1C	1C	3L	3L	3L	3L	3L	1C	1C					
51				1C	1C	3H	3H	3B	3B	3B	3B	3B	3H	3H	1C	1C			
50				1C	3A	3D	3D	3B	3B	3B	3B	3B	3D	3D	3A	1C			
49			1C	3B	3D	3C	3E	3C	3C	3C	3C	3C	3E	3C	3D	3B	1C		
48			1C	3D	3D	3C	3E	3C	3C	3C	3C	3C	3E	3C	3D	3D	1C		
47		1C	3A	3J	3A	3E	3E	3C	3C	3C	3C	3C	3E	3E	3A	3J	3A	1C	
46		1C	3A	3D	3A	3E	3E	3C	3C	3C	3C	3C	3E	3E	3A	3D	3A	1C	
45		1C	3B	3E	3E	3E	3E	3C	3C	3C	3C	3C	3E	3E	3E	3E	3B	1C	
44		1C	3A	3D	3D	3E	3E	3C	3C	3C	3C	3C	3E	3E	3D	3D	3A	1C	
43		1C	3A	3J	3D	3E	3E	3C	3C	3C	3C	3C	3E	3E	3D	3J	3A	1C	
42			1C	3D	3D	3C	3E	3C	3C	3C	3C	3C	3E	3C	3D	3E	1C		
41			1C	3D	3D	3C	3E	3C	3C	3C	3C	3C	3E	3C	3D	3E	1C		
40				1C	3A	3D	3H	3B	3B	3B	3B	3B	3H	3D	3A	1C			
39				1C	1C	3H	3H	3B	3B	3B	3B	3B	3H	3H	1C	1C			
38						1C	1C	3L	3L	3L	3L	3L	1C	1C					
37								1C	1C	1C	1C	1C							

Figure 3.5A Assembly 23 Model (Fissile Elements)

The control rods have been replaced by the 3D elements, and the special elements 3RA by 3A, 3TE by 3E, etc.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57		
53							Z	Z	Z	Z	Z	Z	Z						
52					Y	Z	Z	387	387	387	387	387	Z	Z	Y				
51				Z	Y	387	387	387	387	387	387	387	387	387	Y	Z			
50			Y	Y	3A1	3C3	303	387	387	387	387	387	303	3C3	3A1	Y	Y		
49		Z	Z	387	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	387	Z		
48		Y	Z	3C3	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	303	Z	Y	
47		Y	3A1	3J6	3A1	305	304	3C3	3C3	3C3	3C3	3C3	301	305	3A1	3J2	3A1	Y	
46		Z	3A1	3C3	3A1	305	304	3C3	3C3	3C3	3C3	3C3	305	305	3A1	3C3	3A1	Z	
45		Z	387	304	304	305	304	3C3	3C3	3C3	3C3	3C3	301	304	305	301	387	Z	
44		Z	3A1	3C3	303	305	304	3C3	3C3	3C3	3C3	3C3	301	304	303	3C3	3A1	Z	
43		Y	3A1	3J6	303	305	305	3C3	3C3	3C3	3C3	3C3	305	305	303	3J2	3A1	Y	
42		Y	Z	303	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	304	Y	Y	
41			Z	303	303	3C3	304	3C3	3C3	3C3	3C3	3C3	304	3C3	303	304	Z	Z	
40			Y	Y	3A1	3C3	387	387	387	387	387	387	387	3C3	3A1	Y	Y		
39				Z	Y	387	387	387	387	387	387	387	387	387	Y	Z			
38					Y	Z	Z	387	387	387	387	387	Z	Z	Y				
37							Z	Z	Z	Z	Z	Z	Z						

Figure 3.5B Assembly 25 Model (Fissile Elements)

The pin geometry elements are to be treated as being the same as the Assembly 23 elements occupying the same positions, minus the sodium region material in them (sodium plus associated trace elements), that is, the same as in the pin geometry elements shown in Figure 3.5A. The difference between the actual steel content of the core and that in this model is about 0.1%. The correspondence is as follows

3A1	3A
387	3B, 3L, 3H
3C3	3C
303	3D
301, 304, and 305	3E
3J2 and 3J6	3J

The elements 3B, 3L and 3H have the same pin cell pattern but different calandria.

Note, also, that a symmetrical pattern of 8 outer 3C3 elements have replaced 3D elements. These have pins of the same enrichment. Consequently it is considered to be an acceptable approximation to take the Assembly 23 pin geometry array with the sodium removed.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53								3C	3C	3C	3C	3C							
52						3E	3E	3L	3L	3L	3L	3L	3C	3C					
51					3E	3H	3H	3B	3B	3B	3B	3B	3H	3H	3E				
50				3E	3A	3D	3D	3B	3B	3B	3B	3B	3D	3D	3A	3E			
49			3C	3B	3D	3C	3E	3C	3C	3C	3RC	3RC	3E	3C	3D	3B	3C		
48			3C	3D	3D	3C	3E	1C	1C	1CD	1C	1C	3E	3C	3D	3D	3C		
47		3C	3A	3J	3A	3E	1C	1C	1C	1C	1C	1C	1C	3E	3A	3J	3A	3C	
46		3C	3A	3D	3A	3E	1C	1E	1C	1C	1C	1C	1C	3E	3A	3D	3A	3C	
45		3C	3B	3E	3E	3E	1C	1C	1C	1C	1C	1C	1C	3E	3E	3E	3B	3C	
44		3C	3A	3D	3D	3E	1C	1C	1C	1C	1C	1C	1C	3E	3D	3D	3A	3C	
43		3C	3A	3J	3D	3E	1C	1C	1C	1C	1C	1C	1C	3E	3D	3J	3A	3C	
42			3C	3D	3D	3C	3E	1C	1C	1C	1C	1C	3E	3C	3D	3E	3C		
41			3C	3D	3D	3C	3E	3C	3C	3C	3C	3C	3E	3C	3D	3E	3C		
40				3C	3A	3D	3H	3B	3B	3B	3B	3B	3H	3D	3A	3C			
39					3E	3H	3H	3B	3B	3B	3B	3B	3H	3H	3E				
38						3C	3C	3L	3L	3L	3L	3L	3E	3E					
37								3C	3C	3C	3C	3C							

Figure 3.6A Calculational Model of the Central Plate Zone in Assembly 23

The outer ring of plate geometry elements has been replaced by pin geometry elements.

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		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	
53							387	3C3	3C3	3C3	3C3	387							
52					303	3C3	3C3	387	387	387	387	387	3C3	3C3	303				
51				3C3	303	387	387	387	387	387	387	387	387	387	303	3C3			
50			3C3	3C3	3A1	3C3	303	387	387	387	387	387	303	3C3	3A1	304	304		
49			3C3	387	303	3C3	304	Z	Z	Z	Y	Z	304	3C3	303	387	3C3		
48			3C3	3C3	303	3C3	Z	Z	Z	Z	Y	Z	Z	3C3	303	303	3C3		
47		3C3	3A1	3J6	3A1	Z	Z	Y	Y	Y	Y	Y	Z	Z	3A1	3J2	3A1	3C3	
46		3C3	3A1	3C3	3A1	Z	Z	Z	Y	Y	Y	Y	Z	Z	3A1	3C3	3A1	3C3	
45		3C3	387	304	304	Y	Y	Y	Y	Y	Y	Y	Y	Z	305	301	387	3C3	
44		3C3	3A1	3C3	303	Y	Y	Y	Y	Y	Y	Y	Z	Z	303	3C3	3A1	3C3	
43		3C3	3A1	3J6	303	Z	Z	Y	Y	Y	Y	Z	Z	Y	303	3J2	3A1	3C3	
42			3C3	303	303	3C3	Y	Z	Y	Z	Z	Z	Z	3C3	303	304	3C3		
41			3C3	303	303	3C3	304	Z	Y	Z	Z	Z	304	3C3	303	304	3C3		
40			3C3	3C3	3A1	3C3	387	387	387	387	387	387	387	3C3	3A1	3C3	3C3		
39				3C3	304	387	387	387	387	387	387	387	387	387	303	3C3			
38					304	3C3	3C3	387	387	387	387	387	3C3	3C3	303				
37								3C3	3C3	3C3	3C3	3C3	301						

Figure 3.6B Calculational Model of the Central Plate Zone in Assembly 25

These Assembly 25 pin geometry elements are to be assumed to have the compositions of the following Assembly 23 pin geometry elements minus the sodium region material (sodium plus trace elements in the sodium).

3A1	3A
387	3B
3C3	3C
303	3D
301, 304, and 305	3E
3J2 and 3J6	3J

Note that the outer ring of plate geometry elements has been replaced by pin geometry elements.

3.1.2 Dimensions

Element Dimensions and the Lattice Spacing.

Within a group of 5x5 elements held between the superlattice grid plates the pitch of the elements in the square lattice is 5.3721 cm. The gap between the groups of 5x5 elements is 0.2665 cm. When a uniform grid is adopted over the whole assembly (as is done in some simplified models) the square lattice pitch becomes 5.4254 cm.

The dimensions of the steel element sheath which holds the core and blanket components is: inside width = 5.102 cm and outside width = 5.2544 cm, the thickness of the walls of the sheath being 0.0762 cm. There is a small gap between the element sheath and the lattice cell boundary. The width of the plates, and also of the calandria, which fit inside the element sheaths, is nominally 5.067 cm and this is the value adopted in Model A. There is thus a small gap between the plates, or calandria, and the sheath, equal to $0.035/2 = 0.0175$ cm. The gap between the elements within the arrays of 5x5 is $5.3721 - 5.2544 = 0.1177$ cm and the gap between the element sheath and the cell boundary is 0.05885 cm.

The steel bars of the radial reflector are not contained in an element sheath. They have a square section of width 5.08 cm.

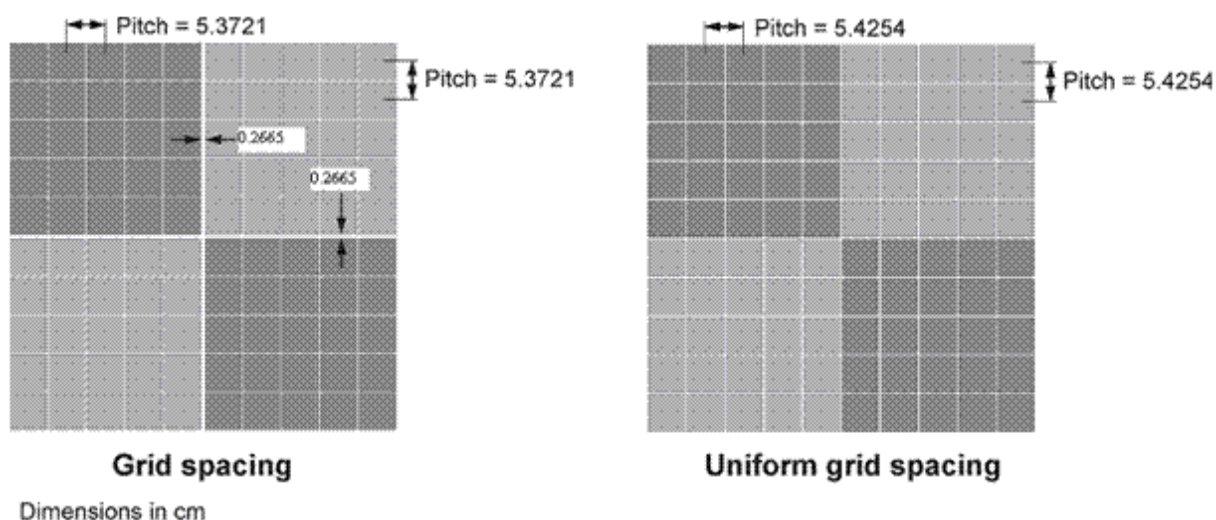


Figure 3.7 The Lattice Dimensions of Model A and of a Model with a Uniform Array of Elements

The Superlattice Grid Plates

In the core sections of the assemblies the space between the groups of 5x5 elements is a void but in the axial blanket and reflector regions superlattice grid plates are located. They are assumed to have a width of 0.2665 cm, so as to fill the width of the gaps. They are located, axially, between the planes 50.2 cm and 80.6 cm above and below the mid plane and are 30.4 cm high.

Dimensions of the Components used in the Plate Geometry Assemblies, 22 and 24.

Dimensions of the plates and plate cells used in the models.

Simplifications have been made to the dimensions and as a consequence some of the data are different from the dimensions and compositions given in other documents. The widths of all the plates have been assumed to be the same, 5.067 cm, whereas they can differ slightly from this value. Using the same value for all plates simplifies the representation of the outer region of the components. Also simplifications have been made to the dimensions of some plates, such as the sodium voided or "dummy" plates which replace the sodium plate in Core 24, with all plates of a particular type assumed to have the same dimensions.

Table 3.D1 Dimensions of the Core Region Plates.

	Plate height or thickness cm	Assumed Width cm	Volume cm ³	Core height or thickness cm	Core width cm	Core volume cm ³	Can volume cm ³
Pu metal	0.3274	5.067	8.4058	0.236	4.671	5.1491	3.2567
UO2	0.6313	5.067	16.2083	0.558	4.851	13.1310	3.0773
Sodium	0.613694	5.067	15.7563	0.541	4.963	13.3256	2.4307
STNAVR4	0.616	5.067	(ring)	0.616	4.6		2.1841
STNAVS4	0.616	5.067	(ring)	0.616	4.6		2.1841
STNAV4	0.616	5.067	15.8155				
40%steel	0.317	5.067	(8.1388)	0.317	*3.925	*4.8836	3.2552

**The core region is a void in the case of the 40% Steel plate. This has been assumed to be a square frame in place of the gate shaped frame (see Figure 1.15).*

The edge regions of the cans have been assumed to have the same density as the top and bottom regions whereas they are less dense because they do not completely fill the space between the core region of a plate and the outer 5.067 cm square boundary.

The thickness of the sodium plate has been reduced from the nominal value of 0.616 cm given in the ZEBRA Database to 0.613694 cm to be consistent with the measured core height, it being assumed that it is the sodium filled plate which is compressed.

There are three types of “voided sodium” plate replacement. STNAVR4 and STNAVS4 are circular rings and STNAV4 “honeycomb” shaped. The core regions are voids in the case of the ring shaped sodium replacement plates.

The 22 standard core cells of Assembly 22 have a height of 3.748082 cm and the two upper and lower cells a height of 3.431082 cm making a total core height of 89.32 cm. In Assembly 24 each cell is 0.006918 cm higher (3.755 cm and 3.438 cm, respectively) and the core height is 0.166 cm higher, a height of 89.486 cm.

The dimensions of the plates are shown in the following figures:

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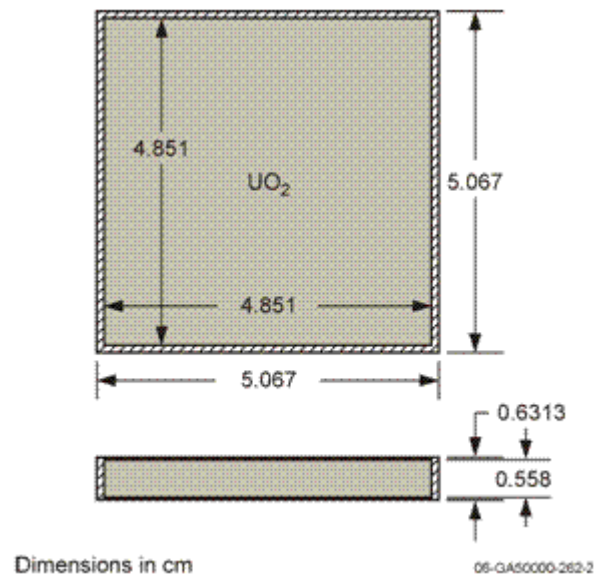
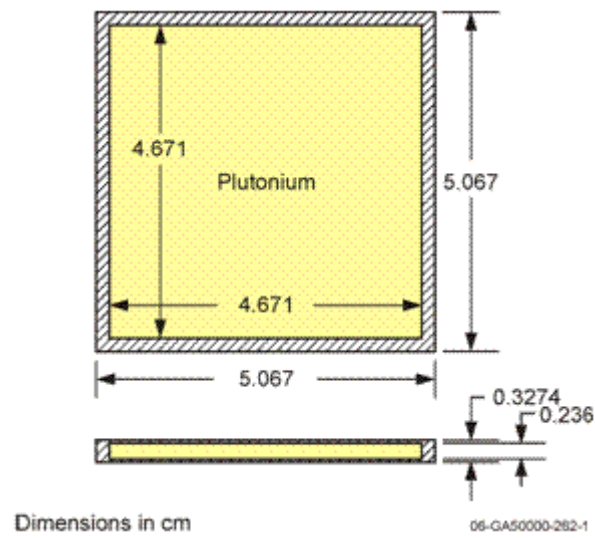


Figure 3.8 Dimensions of the Plutonium Metal and Uranium Oxide Plates

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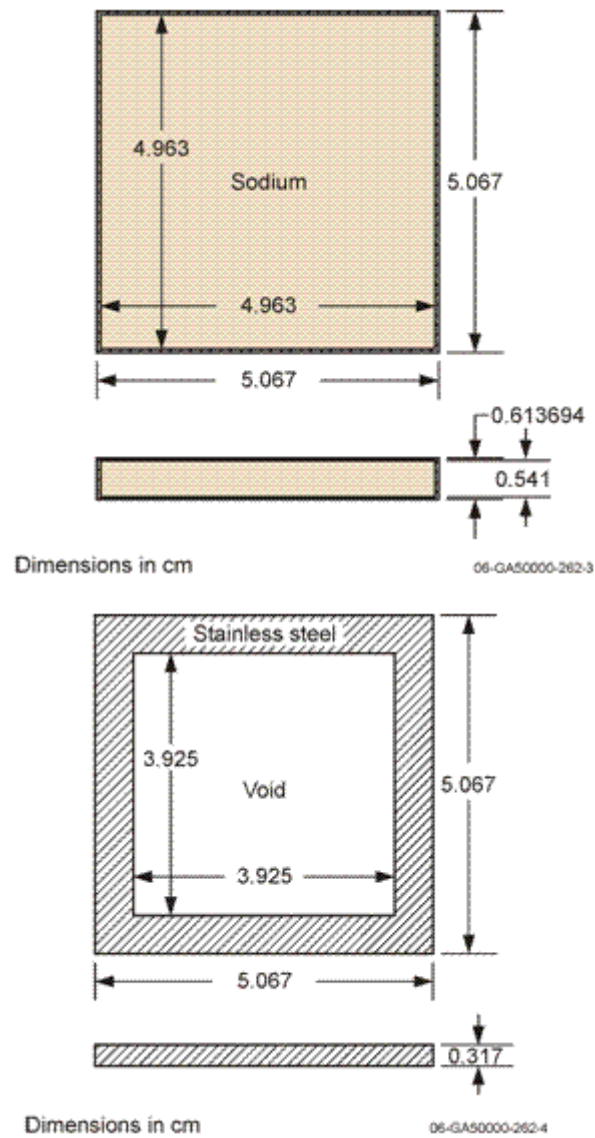


Figure 3.9 Dimensions of the Sodium and 40% Steel Plates

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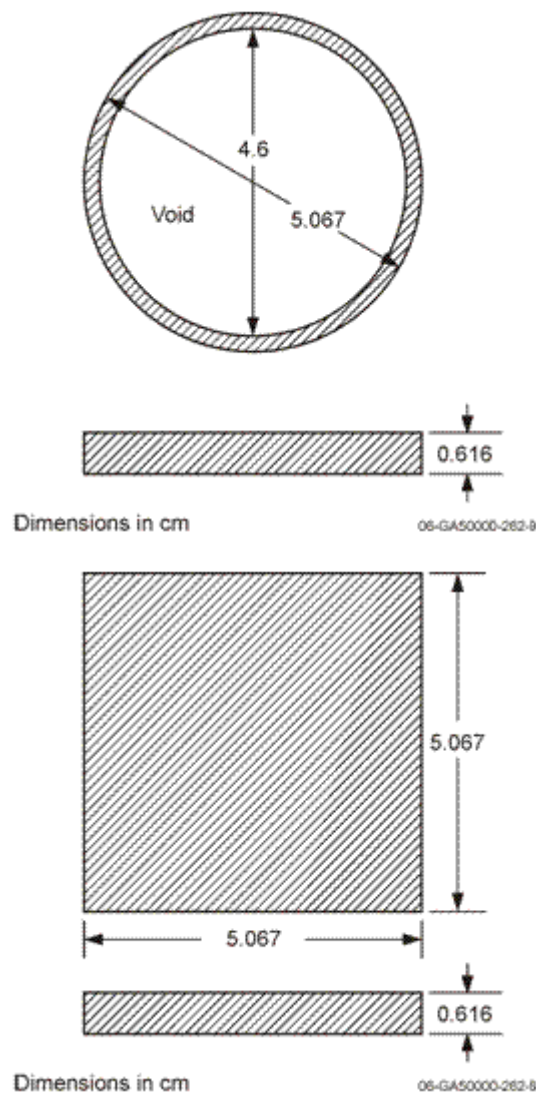


Figure 3.10 Dimensions of the two types of "Sodium Dummy" Plate, the Ring and "Honeycomb" Plates.

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Table 3.D2 Dimensions of the Axial Blanket Region Natural Uranium Plates

	Thickness cm	Width cm	Volume cm ³
U8	0.317	5.067	8.1388
U2	1.2723	5.067	32.6657
U3	7.6225	5.067	195.7038

The axial blanket sections consist of 31 U8 plates followed by 10 U2 plates and 1 U3 block, a height of 30.1725 cm.

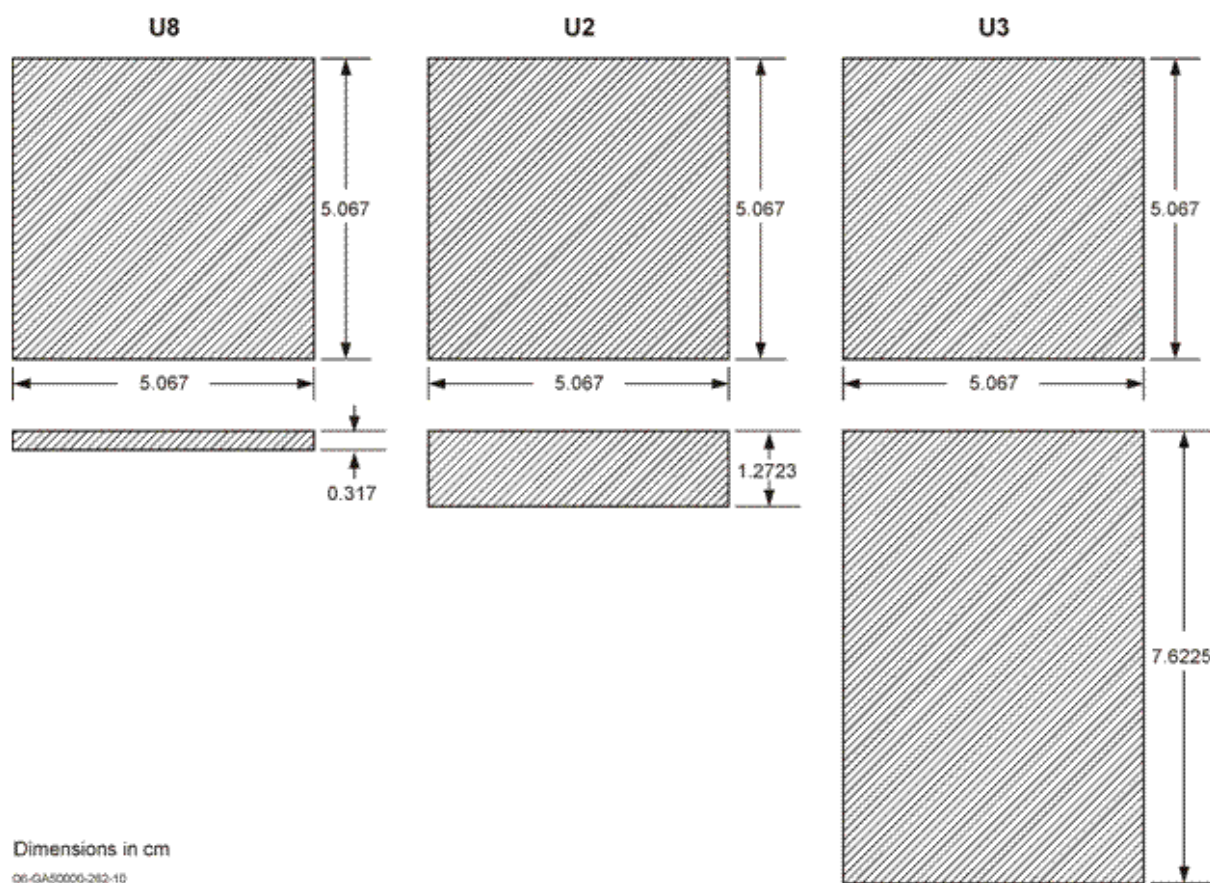
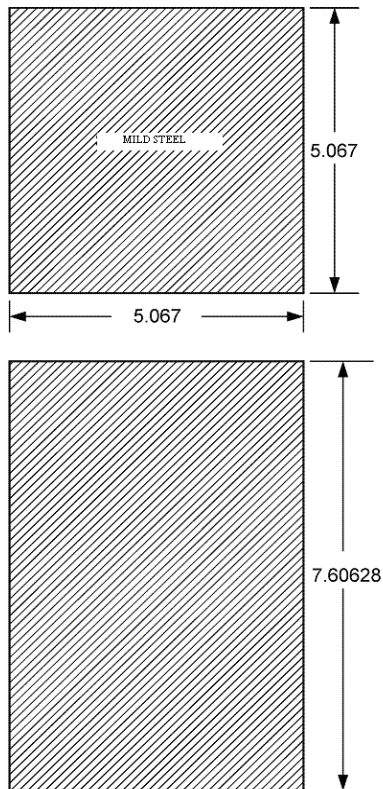


Figure 3.11 Dimensions of the Uranium Metal Plates.

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Table 3.D3 Dimensions of the Axial Shielding Region Mild Steel Blocks

	Thickness cm	Width cm	Volume cm ³
MST3	7.60628	5.067	195.2874



Dimensions in cm

Figure 3.12 Dimensions of the Mild Steel Blocks used in the Axial Shielding Region.

Table 3.D4 Dimensions of the Element Sheaths and the Lattice Spacings

	(cm)
WALL THICKNESS	0.0762
INSIDE WIDTH	5.1020
OUTSIDE WIDTH	5.2544
AVERAGE PITCH WITHIN GROUPS OF 5x5 ELEMENTS	5.3721
GAP BETWEEN GROUPS OF 5x5 ELEMENTS	0.2665
AVERAGE PITCH OVERALL	5.4254

The sheath is assumed to be the mild steel double element sheath, DSHEATH A, although some single sheaths were also used. These have a very similar average composition.

There are several ways in which the element sheath has been modelled in the past: firstly, over the region from the inside width of 5.102 cm to the outside width of 5.2544 cm (which is the representation used in the present Model A), secondly smeared over the space between the plate edges, 5.067 cm, and the average pitch within the lattice of 5.3721 cm and thirdly using the average pitch between elements of superlattices, 5.4254 cm. Based on the area between the plates, which have a width of 5.067 cm, and the overall average pitch of the uniform lattice, 5.4254 cm, the area is $(5.4254)^2 - (5.067)^2 = 3.76048 \text{ cm}^2$. The actual area of the steel is $(5.2544)^2 - (5.102)^2 = 1.57832 \text{ cm}^2$, less than half of the above figure. Smearing over the average pitch (as has been done in some previous calculational models) reduces the steel density by a factor of ~ 2.4 . However, representing the gaps in calculation also poses problems because the components might deflect or move to fill these gaps and so it is not evident that representing the gaps in the model treats the streaming effects any more correctly than smearing the steel of the sheath over the gaps.

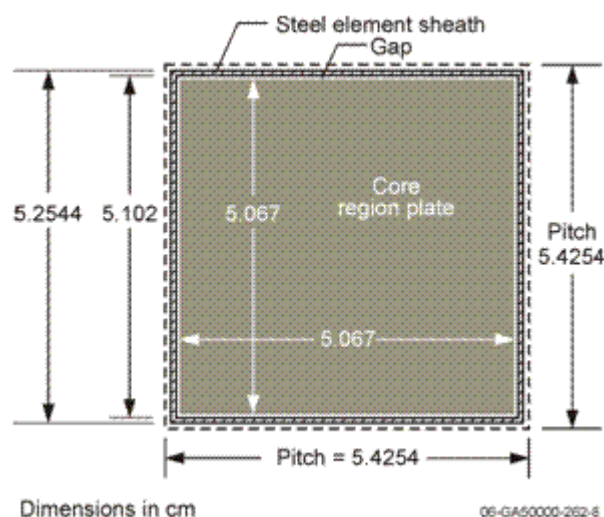


Figure 3.13 Radial Dimensions of the Element in a Model with a Uniform Lattice Spacing

Representation of components within an element sheath.

In the following Tables the dimensions of the cell components are summarised.

The core cells of Core 22B are denoted by Cell 1, 2, 11 and 12. Core cell 11 is the axial inverse of Core cell 1 and Core cell 12 is the axial inverse of Core cell 2. Cell 2 is the same as Core cell 1 but with the steel plate removed. The core section consists of 24 cells, the top and bottom cells having the steel plate removed to give a better height match with the pin geometry cores. The cells of Core 24 are similar and are denoted by Cell CC-24-1, etc.

The cell axial dimensions differ between Cores 22 and 24 because of the smaller thickness of the sodium plate compared with the voided plates (due to compression effects). Note, however, that in the analyses in the ZEBRA documentation the sodium plate has been taken to have the same thickness as the nominal value, which is the same as that of the "dummy" plates, and a correction made to the k_{eff} value. In the present document the axial dimensions of the two cores are different, with the thickness of the sodium plate corresponding to the measured core height.

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Table 3.D5 Model of Cell 1 in Assembly 22.

Cell 1		Gap	Steel Sheath	Gap	Plate Total Width and Core Region Widths	
Can and Core Regions of Individual Plates		5.3721 - 5.2544 cm	5.2544 - 5.102 cm	5.102 – 5.067 cm	Width 5.067 cm	
Height cm	Thickness cm				Edge region	Core region
3.748082	0.036347				Na can	
3.711735	0.541				Na can	Na core (width 4.963)
3.170735	0.036347				Na can	
3.134388	0.03665				UO2 can	
3.097738	0.558				UO2 can	UO2 core (width 4.851)
2.539738	0.03665				UO2 can	
2.503088	0.036347				Na can	
2.466741	0.541				Na can	Na core (width 4.963)
1.925741	0.036347				Na can	
1.889394	0.0457				Pu can	
1.843694	0.236				Pu can	Pu core (width 4.671)
1.607694	0.0457				Pu can	
1.561994	0.317				40% Steel	Void region (3.925)
1.244994	0.03665				UO2 can	
1.208344	0.558				UO2 can	UO2 core (width 4.851)
0.650344	0.03665				UO2 can	
0.613694	0.036347				Na can	
0.577347	0.541				Na can	Na core (width 4.963)
0.036347	0.036347				Na can	

Cell 11 is the inverse of this and cells 2 and 12 omit the 40%Steel plate.

Table 3.D6 Dimensions which Differ in Cell 2
(i.e. above the position of the 40%Steel plate in Cell 1)

Cell 2		Gap	Sheath	Gap		
Height cm	Thickness cm				Edge region	Core region
3.431082	0.036347				Na can	
3.394735	0.541				Na can	Na core (width 4.963)
2.853735	0.036347				Na can	
2.817388	0.03665				UO2 can	
2.780738	0.558				UO2 can	UO2 core (width 4.851)
2.222738	0.03665				UO2 can	
2.186088	0.036347				Na can	
2.149741	0.541				Na can	Na core (width 4.963)
1.608741	0.036347				Na can	
1.572394	0.0457				Pu can	
1.526694	0.236				Pu can	Pu core (width 4.671)
1.290694	0.0457				Pu can	
1.244994	0.03665				UO2 can	

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Table 3.D7 Model of Cell 11 in Assembly 22.

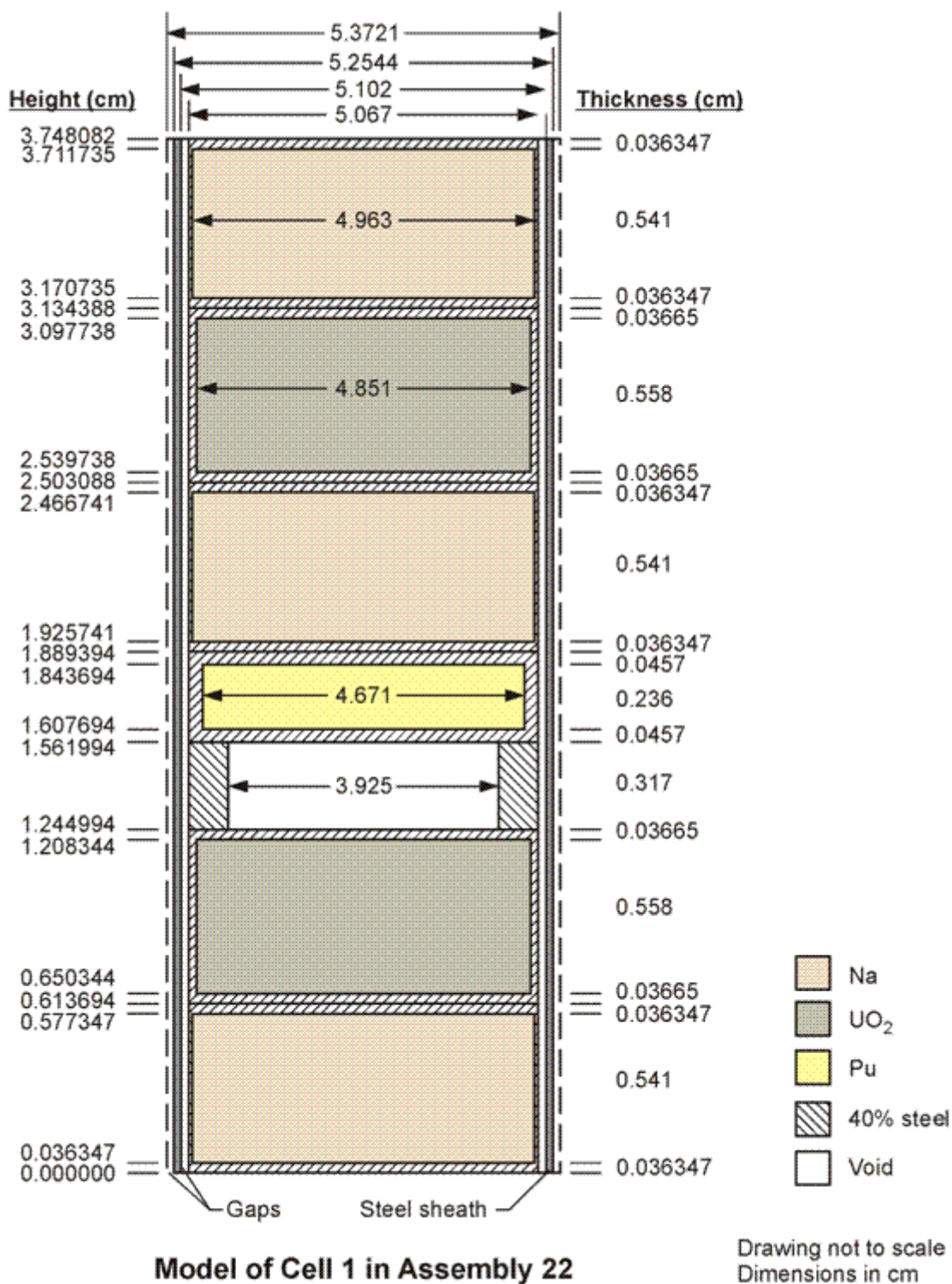
Cell 11		Gap	Steel Sheath	Gap	Plate Total Width and Core Region Widths	
Can and Core Regions of Individual Plates		5.3721 - 5.2544 cm	5.2544 - 5.102 cm	5.102 – 5.067 cm	Width 5.067 cm	
Height cm	Thickness cm				Edge region	Core region
3.748082	0.036347				Na can	
3.711735	0.541				Na can	Na core (width 4.963)
3.170735	0.036347				Na can	
3.134388	0.03665				UO2 can	
3.097738	0.558				UO2 can	UO2 core (width 4.851)
2.539738	0.03665				UO2 can	
2.503088	0.317				40% Steel	Void region (3.925)
2.186088	0.0457				Pu can	
2.140388	0.236				Pu can	Pu core (width 4.671)
1.904388	0.0457				Pu can	
1.858688	0.036347				Na can	
1.822341	0.541				Na can	Na core (width 4.963)
1.281341	0.036347				Na can	
1.244994	0.03665				UO2 can	
1.208344	0.558				UO2 can	UO2 core (width 4.851)
0.650344	0.03665				UO2 can	
0.613694	0.036347				Na can	
0.577347	0.541				Na can	Na core (width 4.963)
0.036347	0.036347				Na can	

Cell 12 omits the 40%Steel plate.

Table 3.D8 Dimensions which Differ in Cell 12
(i.e. above the position of the 40%Steel plate in Cell 11)

Cell 12		Gap	Sheath	Gap		
Height cm	Thickness cm				Edge region	Core region
3.431082	0.036347				Na can	
3.394735	0.541				Na can	Na core (width 4.963)
2.853735	0.036347				Na can	
2.817388	0.03665				UO2 can	
2.780738	0.558				UO2 can	UO2 core (width 4.851)
2.222738	0.03665				UO2 can	
2.186088	0.0457				Pu can	

Figure 3.14A Model A Dimensions of the Cells in Assembly 22. Cell 1.



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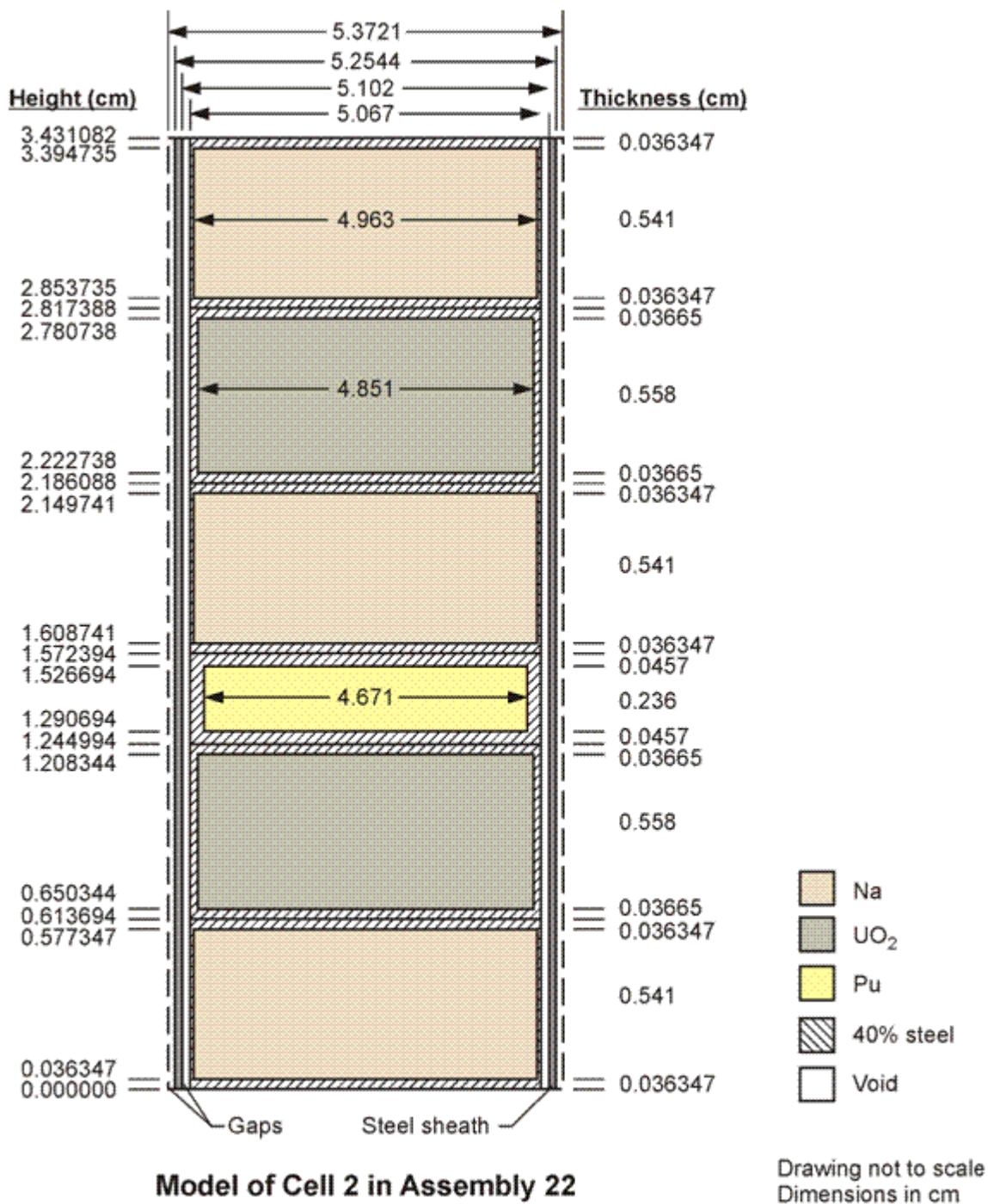


Figure 3.14D Model A Dimensions of the Cells in Assembly 22. Cell 2.

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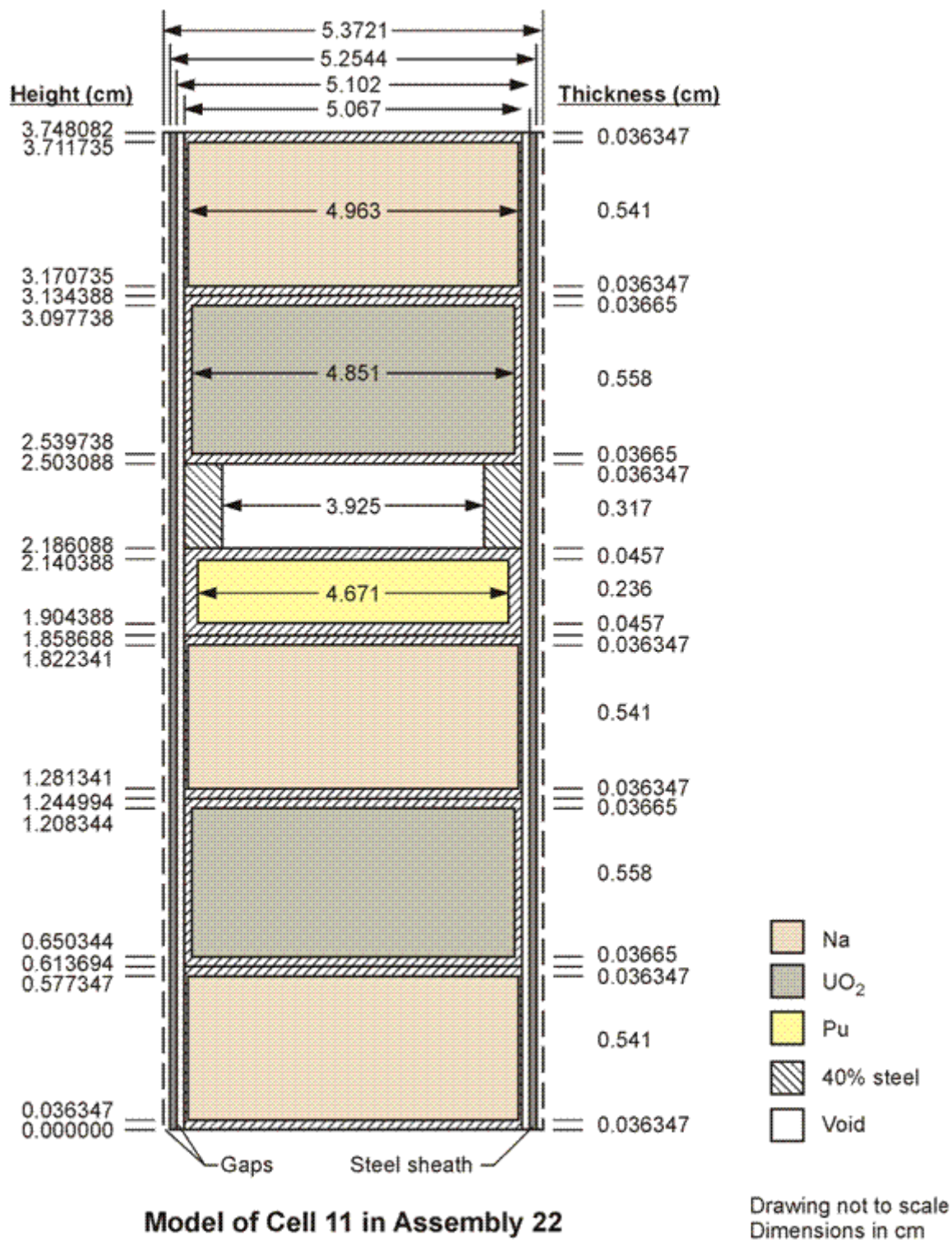


Figure 3.14C Model A Dimensions of the Cells in Assembly 22. Cell 11.

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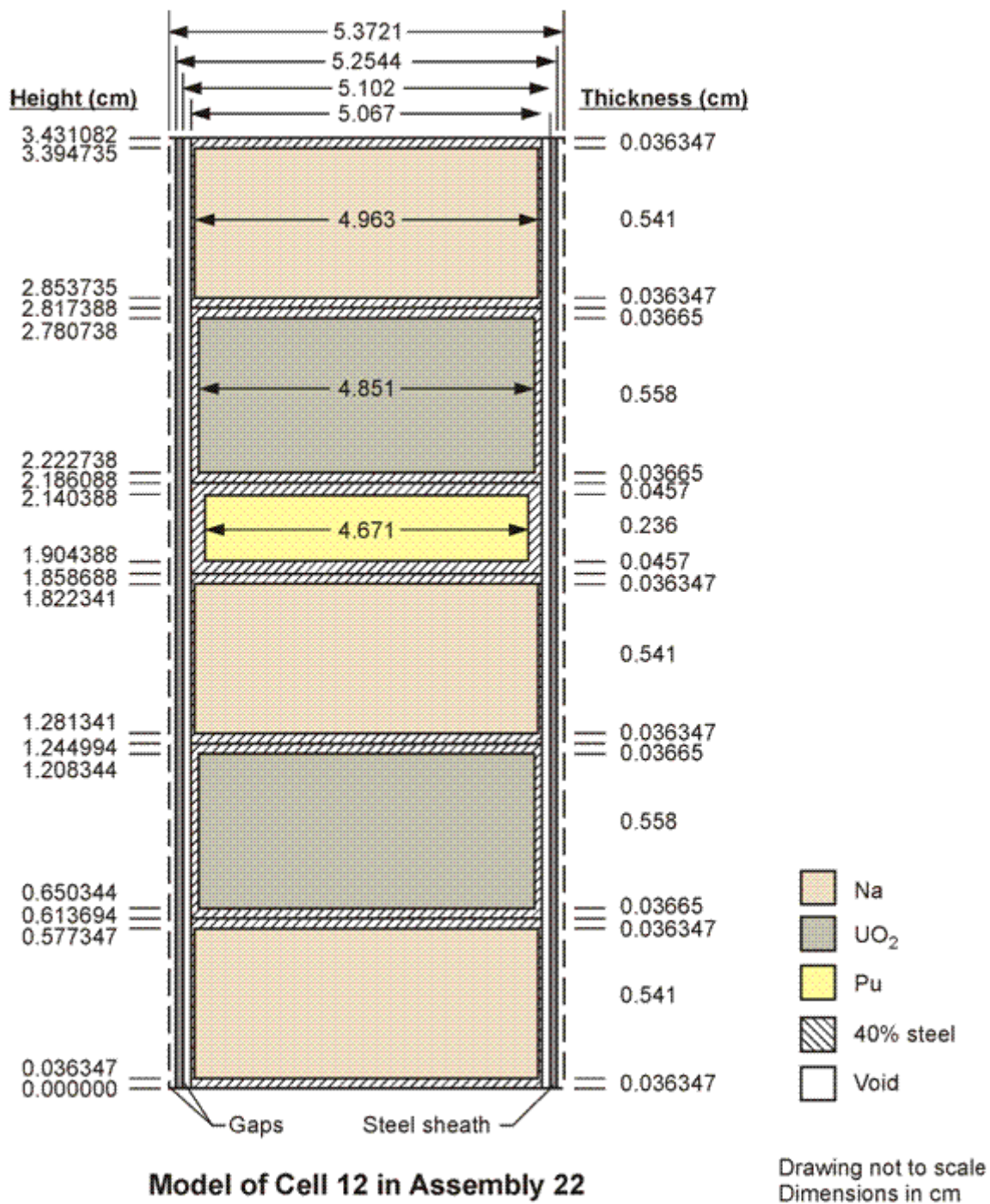


Figure 3.14D Model A Dimensions of the Cells in Assembly 22. Cell 12.

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Table 3.D9 Model of Cell CC-24-1 in Assembly 24.

Cell CC-24-1		5.3721 - 5.2544	5.2544 - 5.102 cm	5.102 – 5.067 cm	Width 5.067 cm	
Height cm	Thickness cm	Gap	Steel Sheath	Gap	Edge region	Core region
3.75500	0.616				Na plate replacement	
3.13900	0.03665				UO2 can	
3.10235	0.558				UO2 can	UO2 core (width 4.851)
2.54435	0.03665				UO2 can	
2.50770	0.616				Na plate replacement	
1.89170	0.0457				Pu can	
1.84600	0.236				Pu can	Pu core (width 4.671)
1.61000	0.0457				Pu can	
1.56430	0.317				40% Steel	Void region (3.925)
1.24730	0.03665				UO2 can	
1.21065	0.558				UO2 can	UO2 core (width 4.851)
0.65265	0.03665				UO2 can	
0.61600	0.616				Na plate replacement	

Cell 11 is the inverse of this and cells 2 and 12 omit the 40%Steel plate.

Table 3.D10 Dimensions which differ in Cell CC-24-2
(i.e. above the position of the 40%Steel plate in Cell CC-24-1)

Cell CC-24-2						
Height cm	Thickness cm	Gap	Sheath	Gap	Edge region	Core region
3.43800	0.616				Na plate replacement	
2.82200	0.03665				UO2 can	
2.78535	0.558				UO2 can	UO2 core (width 4.851)
2.22735	0.03665				UO2 can	
2.19070	0.616				Na plate replacement	
1.57470	0.0457				Pu can	
1.52900	0.236				Pu can	Pu core (width 4.671)
1.29300	0.0457				Pu can	
1.24730	0.03665				UO2 can	

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Table 3.D11 Model of Cell CC-24-11 in Assembly 24.

Cell CC-24-11		5.3721 - 5.2544	5.2544 - 5.102 cm	5.102 – 5.067 cm	Width 5.067 cm	
Height cm	Thickness cm	Gap	Steel Sheath	Gap	Edge region	Core region
3.75500	0.616				Na plate replacement	
3.13900	0.03665				UO2 can	
3.10235	0.558				UO2 can	UO2 core (width 4.851)
2.54435	0.03665				UO2 can	
2.50770	0.317				40% Steel	Void region (3.925)
2.19070	0.0457				Pu can	
2.14500	0.236				Pu can	Pu core (width 4.671)
1.90900	0.0457				Pu can	
1.86330	0.616				Na plate replacement	
1.24730	0.03665				UO2 can	
1.21065	0.558				UO2 can	UO2 core (width 4.851)
0.65265	0.03665				UO2 can	
0.61600	0.616				Na plate replacement	

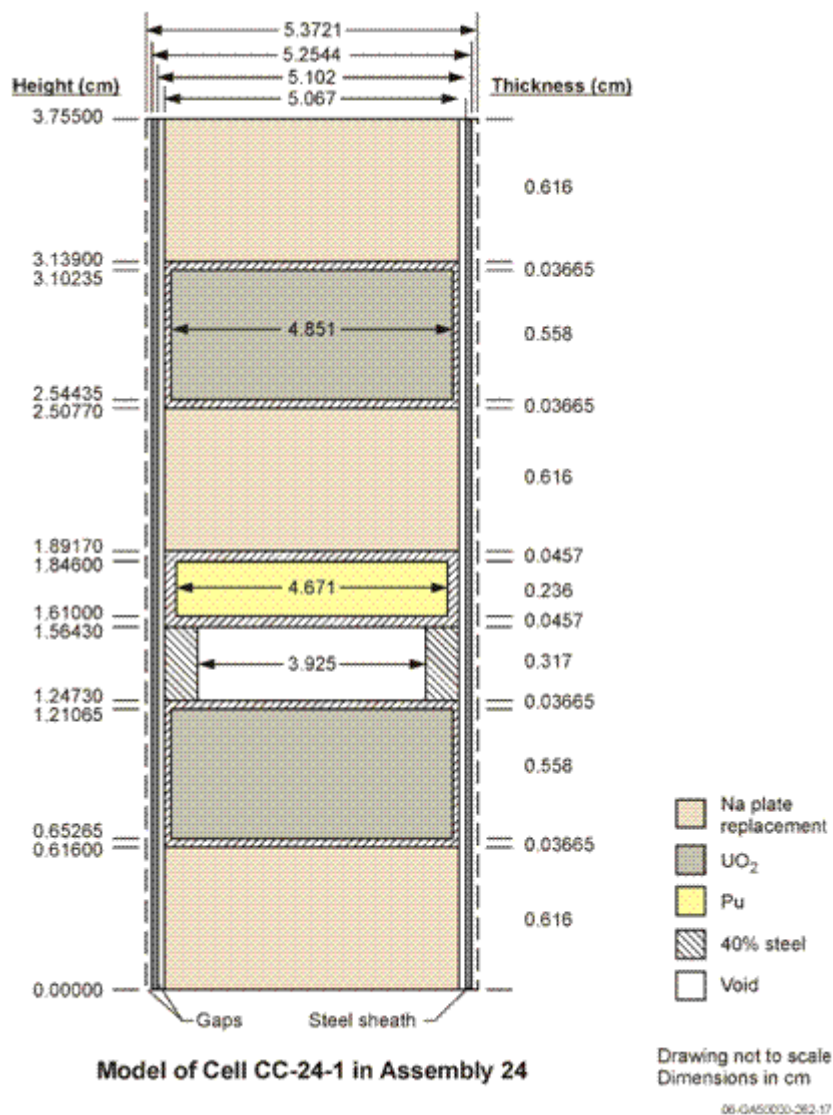
Cell 12 omits the 40%Steel plate.

Table 3.D12 Dimensions which differ in Cell CC-24-12
(i.e. above the position of the 40%Steel plate in Cell CC-24-11)

Cell CC-24-12						
Height cm	Thickness cm	Gap	Sheath	Gap	Edge region	Core region
3.43800	0.616				Na plate replacement	
2.82200	0.03665				UO2 can	
2.78535	0.558				UO2 can	UO2 core (width 4.851)
2.22735	0.03665				UO2 can	
2.19070	0.0457				Pu can	

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Figure 3.15A Model A Dimensions of the Cells in Assembly 24. Cell CC-24-1.



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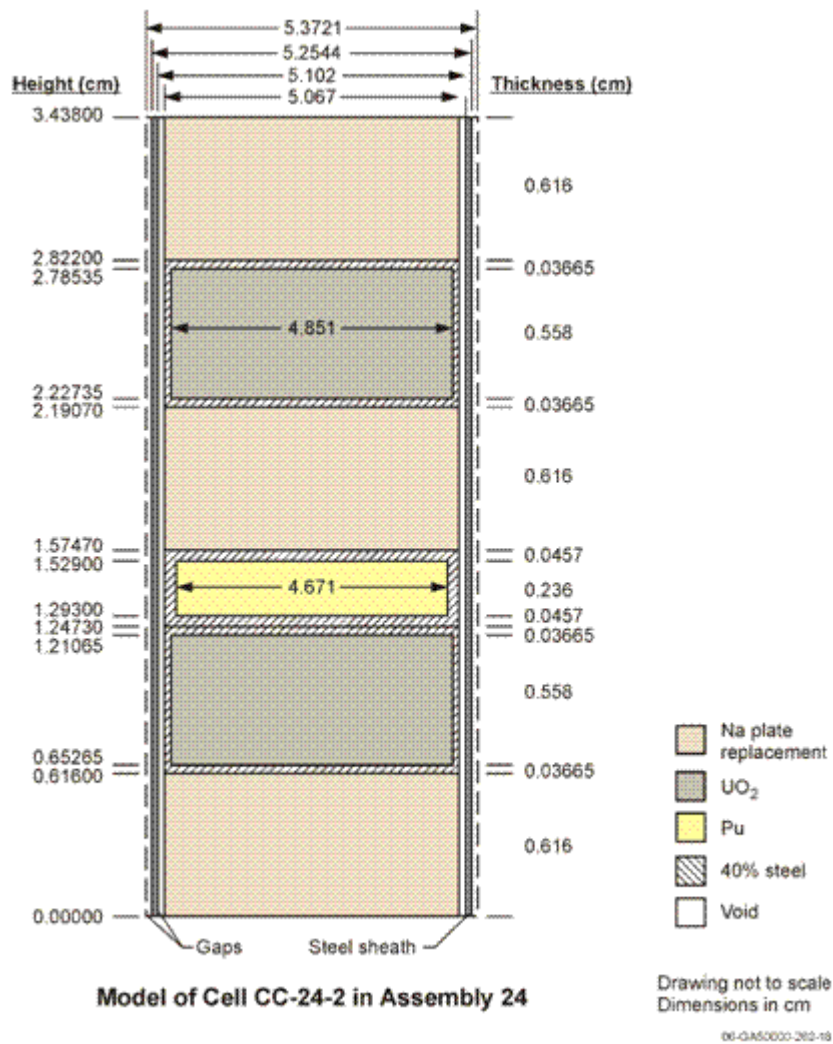


Figure 3.15B Model A Dimensions of the Cells in Assembly 24. Cell CC-24-2.

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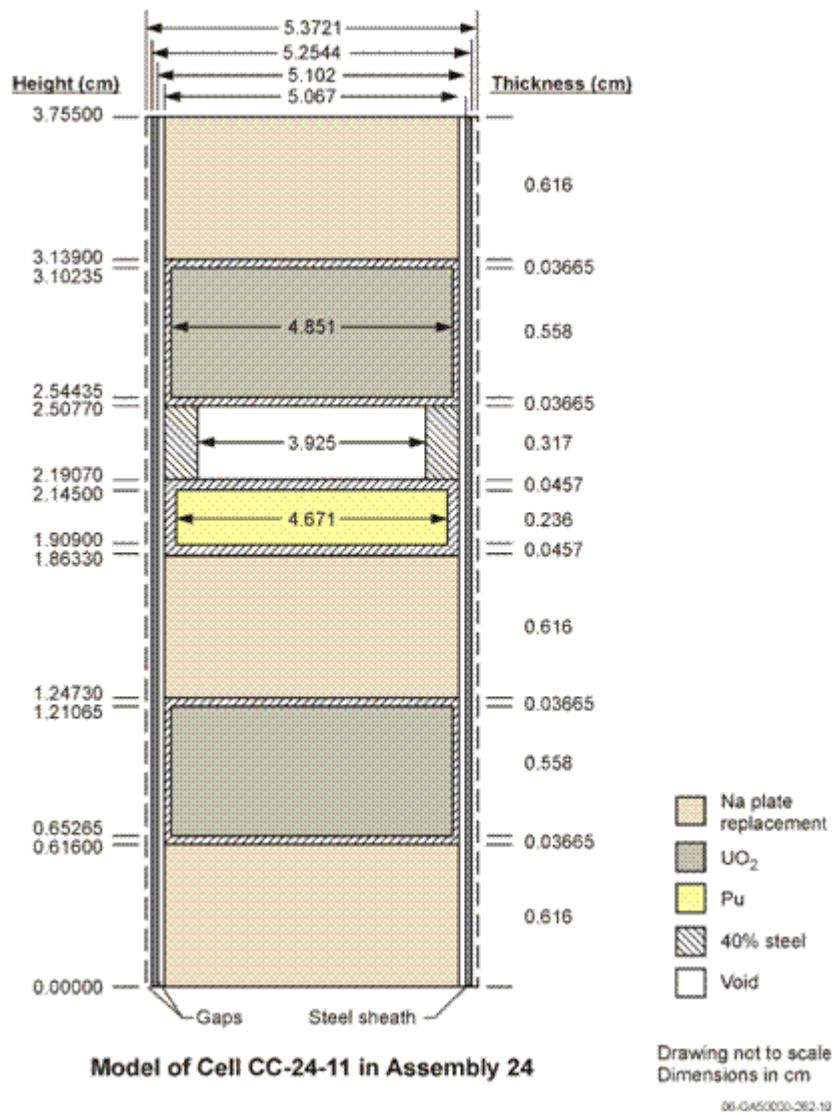


Figure 3.15C Model A Dimensions of the Cells in Assembly 24. Cell CC-24-11.

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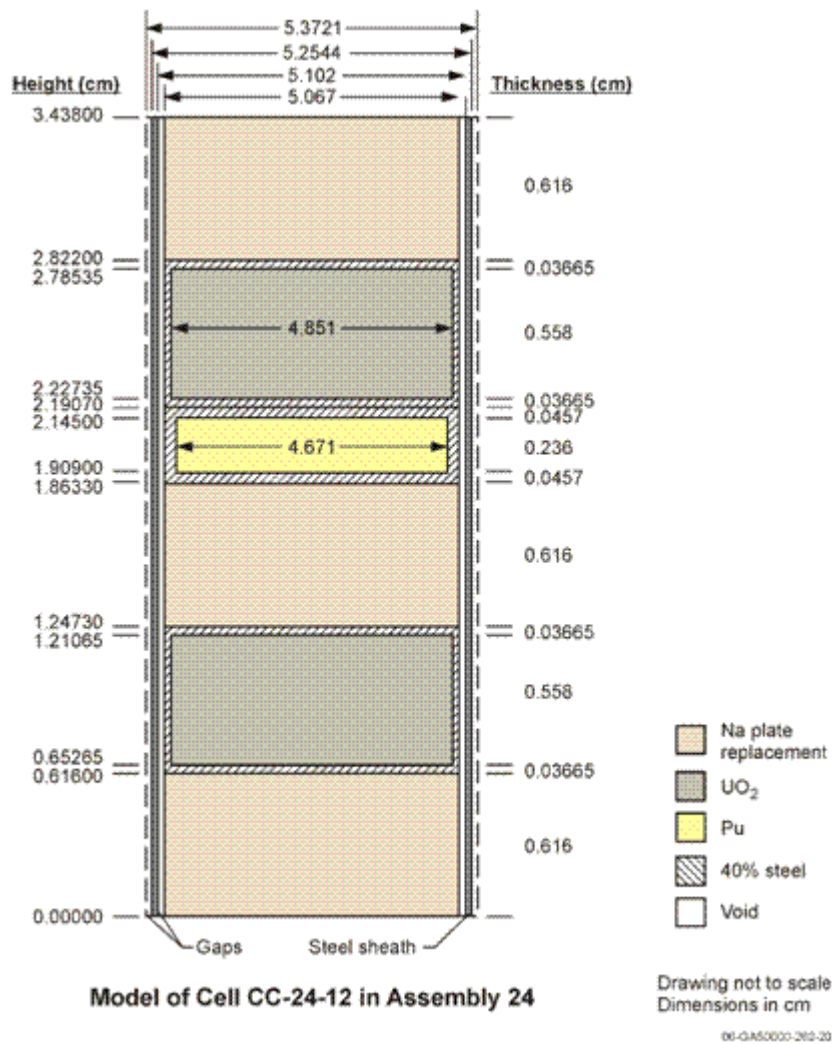
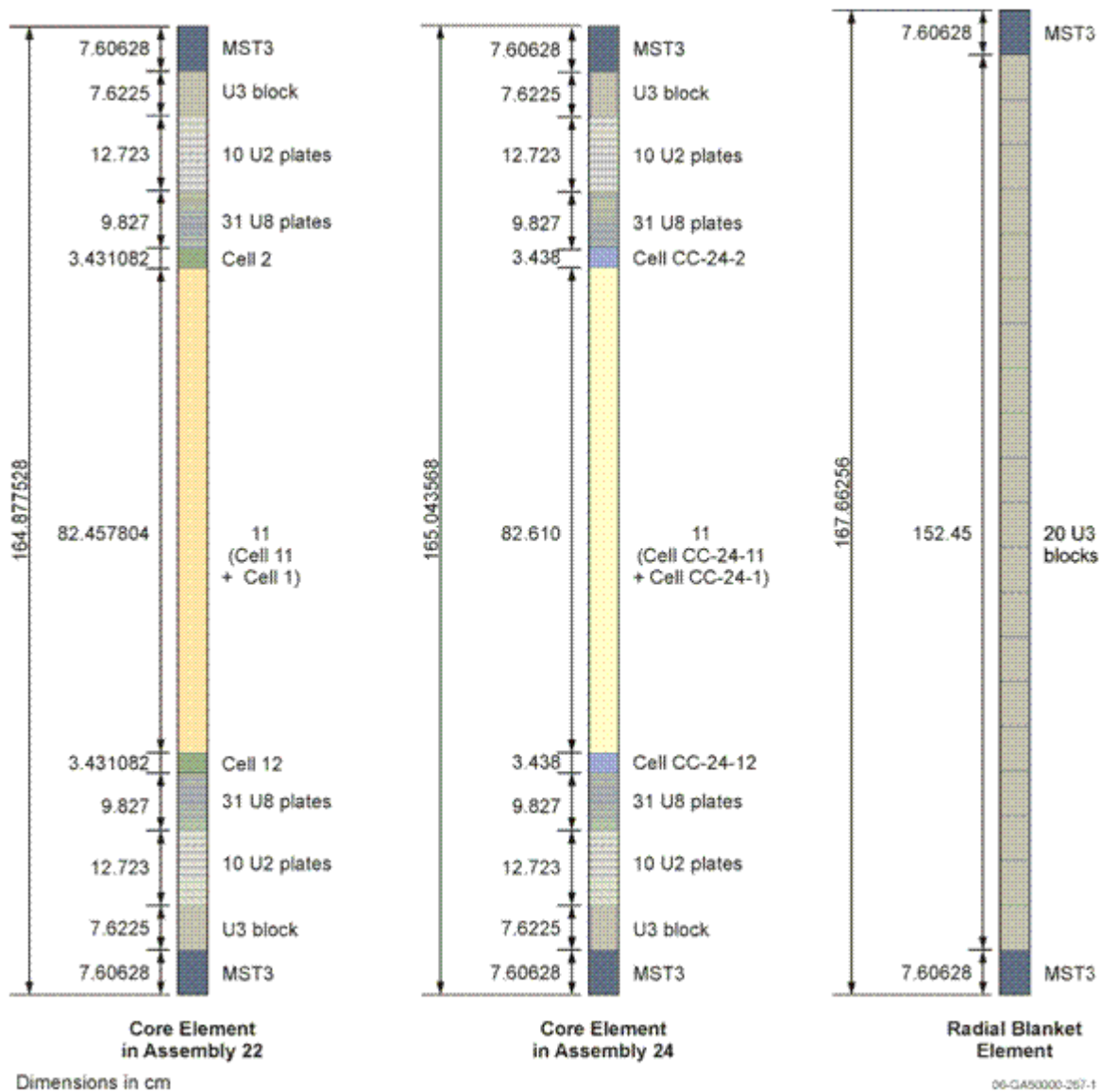


Figure 3.15D Model A Dimensions of the Cells in Assembly 24. Cell CC-24-12.

Figure 3.16 Dimensions of the Core Elements



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Table 3.D13 Axial Dimensions of a Core Element in Assembly 22

		Height of section (cm)
Upper Axial Steel Reflector	1 MST3	7.60628
Upper Axial Natural Uranium Blanket	1 U3 block	7.6225
	10 x U2 plates	12.723
	31 x U8 plates	9.827
Cell 2		3.431082
11 x (Cell 11 + Cell 1)	22 x 3.748082	82.457804
Cell 12		3.431082
Lower Axial Natural Uranium Blanket	31 x U8 plates	9.827
	10 x U2 plates	12.723
	1 U3 block	7.6225
Lower Axial Steel Reflector	1 MST3	7.60628
Total core		89.319968
Total upper blanket region		30.1725
Total height		164.877528
Half height		82.438764

Table 3.D14 Axial Dimensions of Assembly 24 Core Elements containing the Sodium Dummy Plates (thickness 0.616 cm)

		Height of section (cm)
Cell CC-24-2		3.438
11 x (Cell CC-24-11 + Cell CC-24-1)	22 x 3.755	82.610
Cell CC-24-12		3.438
Total core		89.486
Total upper blanket region		30.1725
Upper steel reflector region		7.60628
Total height		165.04356
Half height		82.52178

Table 3.D15 Axial Dimensions of a Radial Blanket Element

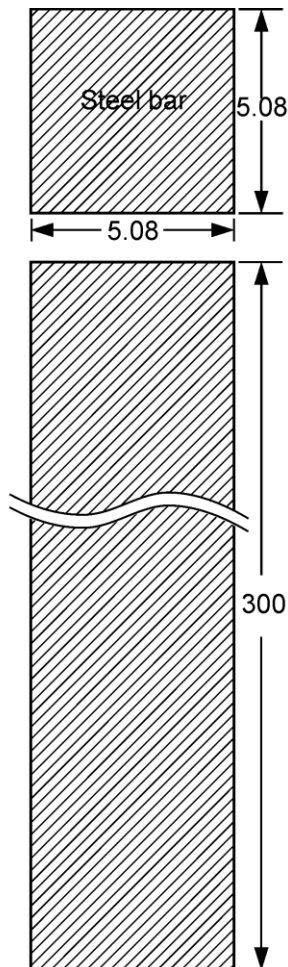
		Height of section (cm)
Upper Axial Steel Reflector	1 MST3	7.60628
Radial Blanket section	20 x U3	152.45
Lower Axial Steel Reflector	1 MST3	7.60628
Total		167.66256

These elements are contained in the mild steel element sheaths.

Table 3.D16 Dimensions of the Radial Shield Element

		Height of section (cm)
Steel bar	MST9F10.	300

The square bar is not contained in a sheath and has a width of 5.08 cm.



Dimensions in cm 06-GA50000-262-12

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Dimensions of the Components used in the Pin Geometry Assemblies, 23 and 25.

Table 3.D17 Dimensions of the Mini-calandria Components.

The calandria contain a 4x4 array of fuel pellet columns. The pellet columns are contained in cans which fit inside tubes in the calandria.

Calculational model. 4x4 array of pins in a square box.	(cm, cm ² or cm ³)
Fuel pellet column	
Fuel pellet radius	0.423
Fuel pellet column length	29.18
Fuel pellet area	0.562122
Fuel pellet column volume	16.4027
Volume of 16 fuel pellet columns	262.4432
Distance of fuel column from the bottom of the calandria	0.44
Distance of fuel column from the top of the calandria	0.11
Total height of the calandria	29.730
Pin pitch	1.19
Assumed length of the cans and tubes (same as fuel)	29.18
Fuel can	
Fuel can inner radius	0.4305
Fuel can outer radius	0.4685
Pin can area (pi x (0.4685 sq – 0.4305 sq))	0.107323
Pin can volume (area x 29.18 cm)	3.131685
Calandria tubes	
Calandria tube inner radius	0.488
Calandria tube outer radius	0.513
Tube area (pi x (0.513 sq – 0.488 sq))	0.078618
Volume of 16 tubes (length 29.18 cm)	36.7052
Total area enclosed by a Calandria tube (pi x 0.513 sq)	0.826770
Area occupied by the 16 calandria tubes plus fuel pins	13.2283
Volume occupied by tubes + fuel pins (length 291.8)	386.0018
Inner width of the calandria	4.90
Inner area of calandria	24.010
Sodium region	
Area assumed occupied by sodium (4.9 sq. minus tubes)	10.7817
Assumed volume of sodium (height same as fuel column)	314.6100
End regions	
Top end region volume (4.9 sq. x 0.11)	2.6411
Bottom end region volume (4.9 sq. x 0.44)	10.5644
Total end region volume	13.2055
Calandria walls	
Area of calandria outer walls (5.067 sq. – 4.9 sq.)	1.664489
Volume of calandria outer walls (length 29.73)	49.4853
Volume of walls plus end regions	62.6908
Width of calandria	5.067
Height of calandria	29.73
Total Volume of calandria	763.3026

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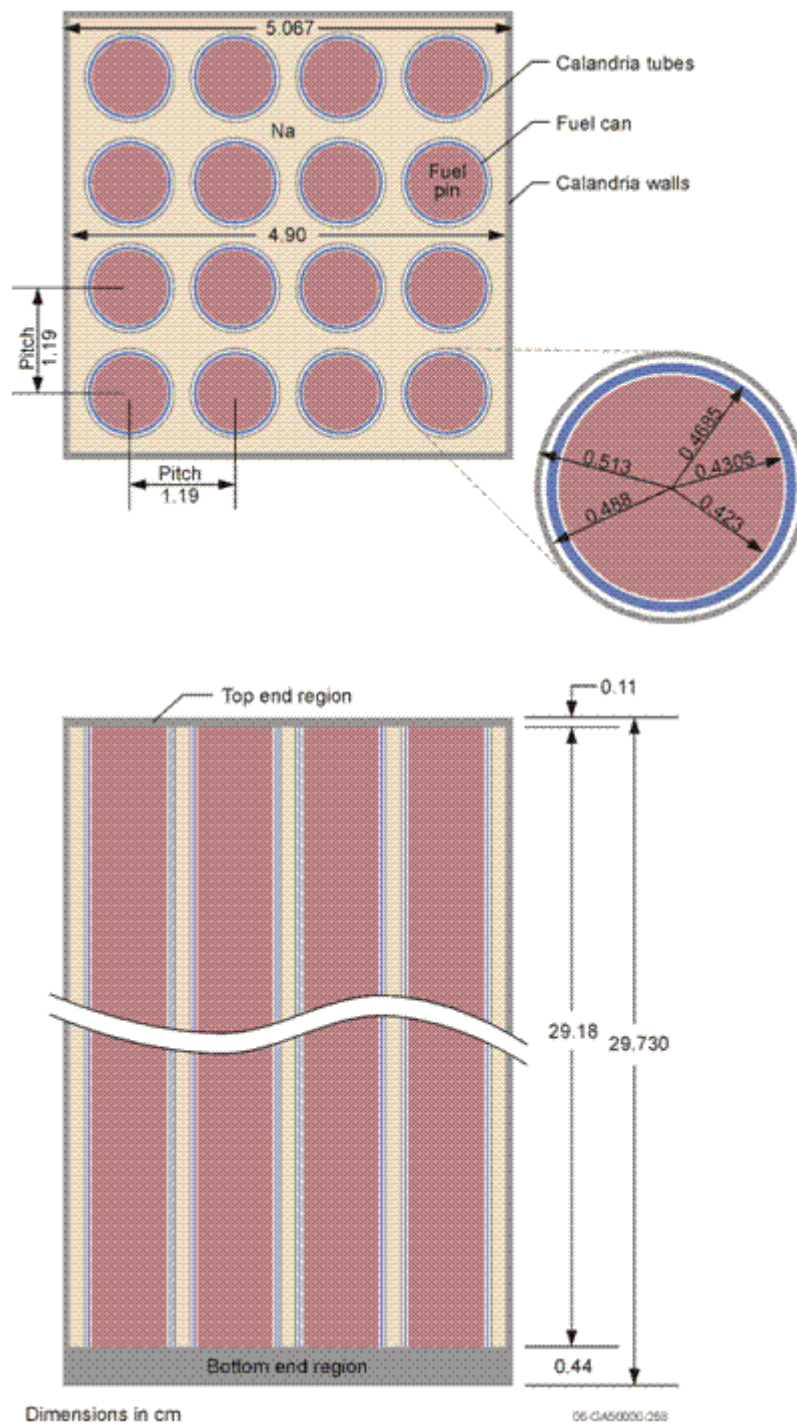


Figure 3.17 Dimensions of the Pin Geometry Cells.

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The calculational model assumes that the calandria outer wall extends the full height of 29.73 cm and that there is a top and bottom slab region of thickness 0.11 cm and 0.44 cm, respectively, within the calandria.

The fuel, cans and calandria tubes extend between these two slab regions. The sodium is also between these two slabs. Three calandria are contained in each mild steel sheath, one above the other.

The core sections of the elements consist of the three mini-calandria, making a total core height of $3 \times 29.73 = 89.19$ cm. This compares with the height of the Assembly 22 core of 89.32 cm. The axial blanket and shield regions are the same as in Assembly 22. The axial thickness of the natural uranium axial blanket sections is 30.1725 cm and the steel axial shielding regions are 7.60628 cm thick.

Core 23A represents the original version in which PUPINE and F fuel pins were inverted. To minimise variations in the fuel lengths from element to element these pins were turned round in Core 23B. This placed the steel shims, which adjust the stack-heights of pellets and which on average are 0.2 cm thick, at the lower end of all the pins. The calculational model is based on Core 23B.

The pins used in reactivity worth measurements

These are the pins CPINA, MSTPINA, ALPINA and ALOPINA.

For all these pins the dimensions proposed for use in calculations are:

TOTAL LENGTH OF PIN ----- 29.5 cm
PIN RADIUS ----- 0.4685 cm

It is assumed that the pins rest on the bottom plate of the calandria, 0.11 cm from the bottom of the calandria, and reach to within 0.12 cm of the top of the calandria. If it is assumed that they have the same length as the fuel pins, 29.18 cm, there is a height difference of 0.32 cm, which is about 1% of the length of the pin and a small approximation compared with the other uncertainties.

3.1.3 Material Data

Atomic densities are given in units of atoms/barn.cm. The IRPhEP recommended atomic weights and Avogadro's Number have been used to calculate them. The atomic densities are given both in tables and in text form. The text form values for the reference cores can be found in the models set up in Appendix A whereas the text form values for the simplified models are given below the tables.

Atomic Densities of the Components in Assemblies 22 and 24.

In calculating the volumes and densities of core and can regions of plates, rounded corners have been made square and the material in the edge regions of cans has been assumed to fill the squared off rectangular regions enclosing the width of the plate. Weights of components are preserved. Because the edge regions of the canned plates are not well defined, or accurately treated, a standard width of 5.067cm has been adopted. The value given in the ZEBRA Database is sometimes slightly different from this.

If h denotes the height (or thickness) of the core region, and w its width, then the volume of the core region is taken to be:

$$V_{\text{core}} = h.w^2.$$

thus ignoring any curved corners.

If H denotes the plate height, and W its width, the volume of the plate is $H.W^2$ and the volume of the can region is taken to be:

$$V_{\text{can}} = (H.W^2 - h.w^2).$$

Irregular edge regions are being enlarged to fill the squared off volume, weights being preserved.

If the height (or thickness) of the core region isn't specified but the height (or thickness) of the plate, H , and the canning material thickness, t , are specified then the height of the core region is taken to be:

$$h = H - 2.t$$

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Table 3.M1 The Plutonium Metal Plate, PUVIII8.

The Pu241 and Am241 data relate to the reference date for the Cadenza cores of June 1981

Core region height 0.236 cm, width 4.671 cm, volume = 5.1491 cm³

	Atoms/barn.cm
Nuclide	
H	1.2764E-04
C	4.2260E-04
N	2.4215E-05
O	8.8450E-05
AL	2.2973E-05
SI	1.4158E-05
CR	3.5989E-06
MN	1.4902E-06
FE	1.6335E-05
NI	8.5688E-06
GA	2.0166E-03
U238	6.8782E-07
PU238	3.0461E-05
PU239	2.8920E-02
PU240	6.9095E-03
PU241	7.3960E-04
PU242	1.8699E-04
AM241	4.5718E-04
Total	3.9991E-02

Can region height 0.3274 cm, assumed width 5.067 cm, volume = 3.2567 cm³

	Atoms/barn.cm
Nuclide	
H	1.3760E-05
C	1.1393E-04
SI	3.6607E-04
P	1.3731E-05
CR	9.4011E-03
MN	8.5931E-04
FE	3.5542E-02
NI	4.1646E-03
CU	1.6613E-02
Total	6.7088E-02

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Table 3.M2 The Natural Uranium Oxide Plate, UO₂R₄.

Core region height 0.558 cm, width 4.851 cm, Volume = 13.1310 cm³

	Atoms/barn.cm
Nuclide	
H	3.1852E-05
C	1.1837E-05
O	4.6122E-02
AL	3.3995E-06
SI	2.3024E-05
MN	8.3479E-08
FE	1.3139E-06
NI	1.2503E-06
MO	3.3462E-07
U235	1.6585E-04
U238	2.2894E-02
Total	6.9254E-02

Can region height 0.6313 cm, assumed width 5.067 cm, Volume = 3.0773 cm³

	Atoms/barn.cm
Nuclide	
H	1.8834E-05
C	1.2695E-04
SI	6.3794E-04
P	3.4708E-04
S	3.5660E-05
CR	1.3673E-02
MN	8.4655E-04
FE	4.7796E-02
NI	8.3368E-03
Total	7.1819E-02

Table 3.M3 The Sodium Plate, NASTDL4.

Thickness of the sodium plate.

The thickness of the sodium plate has been reduced from its nominal value of 0.616 cm to 0.613694 cm to give a total core height of 89.32 cm for the 24 plate cells, equal to that actually measured. The sodium plate was chosen for adjustment because these components have a tendency to compress. It is the steel can region which has been compressed and so if it is wished to use a model with the same plate thickness (0.616 cm) as for the voided Core 24 it is the can region compositions which should be modified and the core region thickness left unchanged.

Core region height 0.541 cm, width 4.963 cm, Volume = 13.3256 cm³

	Atoms/barn.cm
Nuclide	
H	1.3900E-05
O	5.6492E-06
NA	2.3225E-02
CA	3.6083E-06
FE	1.6184E-07
Total	2.3248E-02

Can region height 0.613694 cm, assumed width 5.067 cm, Volume = 2.4307 cm³

	Atoms/barn.cm
Nuclide	
H	2.1631E-05
C	2.9290E-04
SI	6.0867E-04
P	3.2795E-05
S	3.3219E-05
CR	1.4759E-02
MN	1.3570E-03
FE	5.5054E-02
NI	7.0982E-03
NB	3.1147E-04
Total	7.9569E-02

Table 3.M4 Sodium Dummy Plates.

The plates STNAVR4 and STNAVS4 are rings and STNAV4 is “honeycomb” shaped.
For a ring shaped piece, with outer diameter 5.067 cm, inner diameter 4.6 cm and thickness 0.616 cm, the volume is 2.1841 cm³.

Note the circular outer and inner boundaries and the central void region of the rings.

For the plate STNAV4 of height 0.616 cm, and assuming smearing over a width of 5.067 cm, the volume is 15.8155 cm³.

	Atoms/barn.cm		
PLATENAME:	STNAVR4	STNAVS4	STNAV4
Volume (cm ³)	2.1841	2.1841	15.8155
Nuclide			
H	2.4073E-05	2.4073E-05	3.3245E-06
C	2.7547E-04	2.5251E-04	3.3477E-05
SI	7.5592E-04	7.4610E-04	1.2169E-04
P	4.5399E-05	1.7803E-05	4.9764E-06
S	1.2036E-05	1.7195E-05	2.5076E-06
CR	1.6594E-02	1.6248E-02	2.4643E-03
MN	1.1688E-03	1.5006E-03	1.9518E-04
FE	5.9245E-02	5.9881E-02	8.0717E-03
NI	9.9342E-03	9.4005E-03	1.2195E-03
NB	4.0746E-04	3.7393E-04	5.2657E-05
TOTAL	8.8462E-02	8.8462E-02	1.2169E-02

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Table 3.M5 The 40% Stainless Steel Plate, STSTF8.

The 40% void was achieved by cutting out sections of the plate. The plate is gate shaped , with a central cross-piece retained, but is assumed to have the shape of a square picture frame (with an inner square section void region).

PLATE height 0.317 cm, (the **CORE region is assumed to be a square void**, height 0.317 cm, width 3.925 cm). Plate width 5.067 cm, Volume of steel region = $0.317 \cdot (5.067^2 - 3.925^2) = 3.2552 \text{ cm}^3$

Nuclide	Atoms/barn.cm
H	1.8355E-05
C	8.7794E-05
AL	1.1862E-04
SI	7.9703E-04
P	4.0018E-05
S	1.4422E-05
TI	2.4806E-04
CR	1.5908E-02
MN	1.4972E-03
FE	5.5367E-02
NI	8.7976E-03
CU	5.0365E-05
NB	5.0000E-06
MO	8.0988E-05
Total	8.3030E-02

The uranium blanket and steel reflector regions.

Immediately above and below both the pin and plate geometry core cells there is a region of natural uranium metal pieces, about 30 cm in length. Next to the core there are 31 U8 plates followed by 10 U2 plates and 1 U3 block.

The cores are surrounded by radial blanket elements, each containing 20 U3 blocks, 152.45 cm in height. The centre of this region is closely aligned with the centre of the core region so that the upper and lower extremities of the uranium region are close to those of the axial blanket regions.

Table 3.D18 Blanket Region Natural Uranium Components, U8, U2 and U3

	Thickness (cm)	Width (cm)	Volume (cm ³)
U8	0.317	5.067	8.1388
U2	1.2723	5.067	32.6657
U3	7.6225	5.067	195.7038

	Atoms/barn.cm		
Plate	U8	U2	U3
Nuclide			
H	4.4048E-05	4.3899E-05	4.4574E-05
C	4.9283E-04	4.6047E-04	4.7140E-04
SI	2.1076E-04	1.9692E-04	2.0160E-04
FE	1.0599E-04	9.9032E-05	1.0138E-04
U235	3.3369E-04	3.3962E-04	3.4209E-04
U238	4.6021E-02	4.6785E-02	4.7156E-02
Total	4.7208E-02	4.7925E-02	4.8317E-02

Table 3.D19 Axial Reflector Mild Steel Block.

Above and below the uranium axial blanket regions there is a single mild steel block, MST3.

	Thickness (cm)	Width (cm)	Volume (cm ³)
MST3	7.60628	5.067	195.2874

Table 3.D20 Mild Steel Block, MST3.

	Atoms/barn.cm
Plate	MST3
Nuclide	
H	2.5700E-05
C	5.1066E-04
AL	1.3989E-04
TI	3.9416E-05
CR	2.7222E-05
MN	3.2634E-04
FE	8.3806E-02
NI	4.8234E-05
CU	4.4548E-05
MO	9.8355E-06
Total	8.4978E-02

The radial steel reflector region.

The radial blanket elements are surrounded by steel bars, MST9F10, 5.08 cm square and about 3 m long, extending axially beyond the region of interest in the core and radial blanket. These bars are not contained in sheaths.

The average density has been calculated based on both the actual square width of 5.08 cm (volume 25.8064 cm³ per 1 cm length) and the average element spacing of 5.4254 cm, (the volume being 29.435 cm³ per 1 cm length).

Table 3.M6 The Steel Bar MST9F10. Total length ~3 m

	Atoms/barn.cm	
	5.08 cm width	5.4254 width
Nuclide		
H	4.6306E-05	4.0597E-05
C	6.8972E-04	6.0468E-04
SI	3.1158E-04	2.7317E-04
P	4.2944E-05	3.7649E-05
S	3.7110E-05	3.2535E-05
MN	7.1275E-04	6.2488E-04
FE	8.1432E-02	7.1392E-02
Total	8.3272E-02	7.3006E-02

The Superlattice Grid Plates.

The superlattice grid plates have a width of 0.25 cm but are treated as being of width 0.2665 cm, so as to fill the width of the gaps between the groups of 5x5 elements. The density is reduced by the factor 0.25/0.2665 = 0.938. The plates are located, axially, between the planes 50.2 cm and 80.6 cm above and below the mid plane and are 30.4 cm high. The region between -50.2 cm and +50.2 cm, relative to the centre plane, is treated as void in Model A.

The composition of the superlattice grid plates is assumed to be the same as that of the mild steel sheath MSHTH, reduced by the factor 0.938.

	Atoms/barn.cm
Nuclide	
H	2.4856E-04
C	2.9201E-04
SI	4.3326E-05
P	1.1555E-05
S	4.3523E-05
MN	2.5798E-04
FE	7.3146E-02
Total	7.4043E-02

Table 3.M7 The Mild Steel Sheath.

The data for DSHEATH A (the majority component used) are assumed in the calculations.
(Note: The weight figures for the double sheath, DSHEATH A, are per single element and are per 1 cm length and corresponding to a single column of plates).

The area of steel, based on the dimensions of the sheath, inside width = 5.102 cm, outside width = 5.2544 cm is 1.57832 cm², a volume per 1 cm length of 1.57832 cm³. Based on these dimensions the atomic densities are as follows:

DSHEATH A

	Atoms/barn.cm
Nuclide	
H	7.5712E-05
C	2.3825E-04
AL	1.9798E-05
CR	3.6690E-06
MN	2.5697E-04
FE	7.7524E-02
NI	1.4302E-05
CU	2.2216E-05
Total	7.8155E-02

The alternative sheath used for some elements is the single sheath MSHTH

MSHTH

	Atoms/barn.cm
Nuclide	
H	2.6499E-04
C	3.1131E-04
SI	4.6190E-05
P	1.2319E-05
S	4.6400E-05
MN	2.7503E-04
FE	7.7981E-02
Total	7.8937E-02

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Compositions of the Pin Geometry Cells

Table 3.M8 Compositions of the Fuel.

(The Pu241 and Am241 data have been adjusted to June 1981, the reference date for the CADENZA cores)

The total pin length includes the end caps and spacers, the length of the fuel pellet column being 29.18 cm and the length of the mini-calandria 29.73 cm.

Atomic densities of the fuel pellet column

(Radius = 0.423 cm, Height = 29.18 cm, Volume = 16.4027 cm³)

	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
U234	1.3805E-06	1.3177E-06	1.2863E-06	1.4118E-06	1.1295E-06	1.1452E-06
U235	1.4114E-04	1.3457E-04	1.2997E-04	1.4266E-04	1.1465E-04	1.1526E-04
U236	7.9324E-07	7.4658E-07	7.3103E-07	7.9324E-07	6.3771E-07	6.3771E-07
U238	1.9379E-02	1.8472E-02	1.7843E-02	1.9584E-02	1.5739E-02	1.5824E-02
PU238	3.7786E-06	5.8915E-06	6.9094E-06	4.7348E-06	9.4851E-06	9.5005E-06
PU239	2.9689E-03	3.7341E-03	4.4708E-03	3.0189E-03	6.0438E-03	6.0112E-03
PU240	6.7253E-04	9.5200E-04	1.0602E-03	7.5441E-04	1.5103E-03	1.5285E-03
PU241	7.0350E-05	1.1199E-04	1.1598E-04	8.8443E-05	1.7707E-04	1.9723E-04
PU242	1.7488E-05	2.7984E-05	3.0047E-05	2.0961E-05	4.1953E-05	4.4380E-05
AM241	4.7854E-05	5.5789E-05	5.7784E-05	4.0742E-05	8.1559E-05	6.8035E-05
H	3.2784E-05	3.2784E-05	3.2784E-05	3.2784E-05	3.2784E-05	3.2784E-05
O	4.6606E-02	4.6993E-02	4.7434E-02	4.7314E-02	4.7299E-02	4.7482E-02
AL	1.1702E-05		1.9730E-05	1.8914E-05	9.5250E-06	1.4287E-05
SI		9.0199E-06	7.9741E-06	2.5099E-05	4.5753E-05	
CA	7.8782E-06			1.5940E-05	3.2062E-05	6.7514E-05
CR						4.9427E-06
FE	5.6537E-06		7.6916E-06	6.9027E-06	1.0321E-05	1.1505E-05
NI		5.4424E-06	1.0947E-05	1.4138E-05		2.1895E-06
Total	6.9967E-02	7.0537E-02	7.1230E-02	7.1085E-02	7.1149E-02	7.1415E-02

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Table 3.M9 Compositions of the Fuel Pin Cans and End Regions.

Notes: These weights are obtained from the average total steel weight in a pin, average weights for an end cap and a spacer disc, the estimated average number of spacers in a pin and the bonded compositions of the various steels.

Hydrogen has been assumed present at 5 ppm, based on a survey for steel components.
This figure has been used for all steels.

Atomic densities in atoms/barn.cm Volume 3.131685 cm³

Element	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
H	2.6710E-05	2.2895E-05	2.6710E-05	2.4802E-05	2.4802E-05	2.4802E-05
C	1.3288E-04	2.3695E-04	1.3609E-04	2.0172E-04	7.3646E-05	7.2045E-05
AL				6.4142E-06	6.4142E-06	4.2762E-06
SI	8.5585E-04	1.1571E-03	8.3531E-04	8.9693E-04	1.0476E-03	1.0544E-03
P	3.7870E-05	4.1596E-05	3.6008E-05	3.4145E-05	1.3658E-05	1.3658E-05
S	2.4585E-05	2.2786E-05	2.4585E-05	8.9942E-06	1.7389E-05	1.7989E-05
TI				2.8916E-05	2.8916E-05	2.1687E-05
CR	1.8218E-02	1.4981E-02	1.7856E-02	1.5910E-02	1.6102E-02	1.6284E-02
MN	1.5646E-03	1.5751E-03	1.5331E-03	1.1586E-03	9.8006E-04	9.8357E-04
FE	5.9675E-02	5.3171E-02	5.8512E-02	5.5753E-02	5.6794E-02	5.7354E-02
CO				4.2418E-06	4.2418E-06	3.2629E-06
NI	8.9153E-03	8.8137E-03	8.7515E-03	7.6341E-03	8.0503E-03	8.1453E-03
CU				6.0522E-06	6.0522E-06	4.5391E-06
NB		2.9391E-04				
MO				2.2047E-06	2.1446E-05	2.1246E-05
Total	8.9451E-02	8.0316E-02	8.7711E-02	8.1670E-02	8.3171E-02	8.4005E-02

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Table 3.M10 Atomic Densities of the UO₂ Pins

Note: The uranium used in UO₂PIND and UO₂PINE was obtained from two sources. The U²³⁵ content of one batch has been measured as 0.00722, 0.00717, 0.00724 and 0.00721 giving an average of 0.00721. The larger batch has U²³⁵ content determinations of 0.00705, 0.00695 and 0.00691, averaging 0.00697. The two batches were randomly mixed in making the pellets and an overall average U²³⁵ content of 0.0071 has been taken for these pins.

Atomic density of the fuel pins (Volume 16.4027 cm³)

Element	UO ₂ PINC	UO ₂ PIND	UO ₂ PINE
U ²³⁴	9.7268E-07	9.5699E-07	9.5699E-07
U ²³⁵	1.7084E-04	1.7073E-04	1.7098E-04
U ²³⁸	2.3588E-02	2.3573E-02	2.3607E-02
H	3.2784E-05	3.2784E-05	3.2784E-05
C	3.2095E-05		
O	4.7501E-02	4.7478E-02	4.7547E-02
AL	2.3812E-05	9.5250E-06	9.5250E-06
SI	4.0001E-05	1.3726E-05	1.3726E-05
CA	1.2825E-05	4.7635E-06	4.7635E-06
FE	1.1176E-06	2.3009E-06	2.3009E-06
Total	7.1400E-02	7.1281E-02	7.1386E-02

Atomic densities of the cans in the calculational model. (Volume = 3.131685 cm³)

Element	UO ₂ PINC	UO ₂ PIND	UO ₂ PINE
H	2.6710E-05	2.4802E-05	2.4802E-05
C	1.3288E-04	2.0493E-04	7.3646E-05
AL		5.7016E-06	5.7016E-06
SI	8.5585E-04	9.1748E-04	1.0544E-03
P	3.7870E-05	3.4766E-05	1.3658E-05
S	2.4585E-05	8.9942E-06	1.7989E-05
TI		2.6507E-05	2.6507E-05
CR	1.8255E-02	1.6284E-02	1.6195E-02
MN	1.5681E-03	1.1866E-03	9.8357E-04
FE	5.9792E-02	5.7041E-02	5.7100E-02
CO		3.9155E-06	3.9155E-06
NI	8.9349E-03	7.8144E-03	8.0995E-03
MO		2.0043E-06	2.1446E-05
AU		2.1373E-03	2.1373E-03
Total	8.9628E-02	8.5692E-02	8.5757E-02

Composition assumed for the calandria tubes and the top and bottom slab regions in the calculational models.

In the calculational model the compositions are simplified. The compositions of the calandria tubes and the upper and lower slab regions are taken to be the same for all the calandria and the variations in weight and composition of the calandria are assigned to the outer walls of the calandria. The masses are divided in the following way. 2 g of the fuel can weight is assigned to the end regions (a total of 16 x 2 g = 32 g), as is 30 g of the weight of the calandria, a total of 62 g assigned to the volume of 13.2055 cm³. 300 g is assigned to the calandria tubes, volume 36.7052 cm³. The trace elements in the fuel and the compositions of the cans vary between the different types of pin.

Table 3.M11 The Masses adopted for the Calandria Tubes and End Regions and the Corresponding Atomic Densities.
(Masses in g)

	Taken from Calandria.	In Tubes. <i>Volume</i> 36.7052 cm ³	To end plate regions	Fuel can contrib.	16 x fuel can contrib.	Total in end plate regions. <i>Volume</i> 13.2055 cm ³
SI	2	1.82	0.18	0.01	0.16	0.34
CR	58.7	53.2	5.5	0.37	5.92	11.42
MN	5	4.55	0.45	0.03	0.48	0.93
FE	228	206.83	21.17	1.4	22.4	43.57
NI	29.3	26.6	2.7	0.19	3.04	5.74
Total	323	293	30	2	32	62

	Tubes. Weight (g)	Percent by weight	Tubes Atoms/barn.cm	End plate. Weight (g)	Percent by weight	End plates Atoms/barn.cm
SI	1.82	0.621	1.0632E-03	0.340	0.548	5.5206E-04
CR	53.20	18.157	1.6787E-02	11.420	18.419	1.0016E-02
MN	4.55	1.553	1.3588E-03	0.930	1.500	7.7198E-04
FE	206.83	70.590	6.0762E-02	43.570	70.274	3.5578E-02
NI	26.60	9.078	7.4360E-03	5.740	9.258	4.4601E-03
Total	293.00	100.000	8.7407E-02	62.000	100.000	5.1378E-02

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Assumed atomic composition of calandria tubes (atoms/barn.cm)

SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02 NI 7.4360E-03

Assumed composition of calandria top and bottom end plate regions (atoms/barn.cm)

SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02 NI 4.4601E-03

Compositions of the mini-calandria.

Modified compositions of the mini-calandria outer walls in the calculational model

Table 3.M12 Atomic Densities of the Outer Mini-calandria Walls
(Assumed volume = 49.4853 cm³) (atoms/barn.cm)

Element	NACLI	NACLIIS	NACLIIS	NACLIIV	NACLV	VCLVI
H	3.9844E-05	3.8637E-05	3.9844E-05	3.7430E-05	3.8637E-05	3.8637E-05
C	2.8167E-04	6.5351E-04	1.5948E-04	3.5158E-04	2.6343E-04	2.4762E-04
SI	6.0229E-04	9.7623E-04	7.7474E-04	8.2197E-04	6.4389E-04	9.5110E-04
P	7.3471E-05	4.7540E-05	5.2334E-05	6.2274E-05	6.8560E-05	4.5654E-05
S	3.6808E-05	3.3014E-05	2.4551E-05	1.6431E-05	1.7190E-05	2.3793E-05
TI		2.4400E-04				
CR	1.4995E-02	1.4380E-02	1.4132E-02	1.3563E-02	1.3830E-02	1.3837E-02
MN	1.2214E-03	1.1060E-03	8.3089E-04	1.0026E-03	9.6934E-04	8.6191E-04
FE	4.8911E-02	4.7118E-02	5.0764E-02	4.7151E-02	4.9404E-02	4.8404E-02
CO		1.1151E-05				
NI	7.2440E-03	7.4526E-03	7.6658E-03	6.4549E-03	7.2532E-03	6.8530E-03
CU		1.0341E-05				
MO		3.4248E-06	2.4862E-05	8.8791E-06	8.8791E-06	2.4862E-05
Total	7.3405E-02	7.2074E-02	7.4469E-02	6.9470E-02	7.2497E-02	7.1288E-02

Contents of the sodium regions of the mini-calandria

Table 3.M13 Atomic Densities of the Sodium Region
(Assumed volume = 314.6100 cm³) (atoms/barn.cm)

Element	NACLI	NACLIIS	NACLIIS	NACLIIV	NACLV
H	5.5075E-06	1.1205E-05	7.5966E-06	7.5966E-06	7.5966E-06
O	6.4605E-06	1.0767E-06	3.5892E-06	3.5892E-06	3.5892E-06
NA	2.4129E-02	2.4379E-02	2.3888E-02	2.4037E-02	2.3829E-02
K			3.4270E-07	3.4270E-07	3.4270E-07
CA	1.1080E-06	9.5521E-08	6.6865E-07	6.6865E-07	6.6865E-07
FE	3.0847E-07				
Total	2.4142E-02	2.4391E-02	2.3900E-02	2.4049E-02	2.3841E-02

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Average compositions for the standard cells.

Table 3.D21A Plate Cell Volume Fractions.

Based on the overall average lattice pitch of 5.4254 cm and the height of the standard cell, 3.748082 cm, the cell volume is 110.32466 cm³.

The fractions of the standard (central region) cell occupied by the different materials are as follows.

Material	Composition	Basic Volume cm ³	Total Volume cm ³	Fraction
1	Plutonium core	5.1491	5.1491	0.046672
2	Plutonium clad	3.2567	3.2567	0.029519
3	UO ₂ core x 2	13.1310	26.2620	0.238044
4	UO ₂ clad x 2	3.0773	6.1546	0.055787
5	Na core x 3	13.3256	39.9768	0.362356
6	Na clad x 3	2.4307	7.2921	0.066097
7	40% steel plate	3.2552	3.2552	0.029506
8	Mild steel sheath	5.9157	5.9157	0.053621
Total				0.881600

Table 3.D21B Pin Cell Volume Fractions.

The height of the mini-calandria pin cell is 29.73 cm and the corresponding volume based on the overall average lattice pitch of 5.4254 cm is 875.10151 cm³.

The fractions of the standard cell occupied by the different components are as follows.

Material	Composition	Basic Volume cm ³	Total Volume cm ³	Fraction
1	U-Pu/O ₂ fuel x 16	16.4027	262.4432	0.299900
2	Fuel clad x 16	3.131685	50.1070	0.057259
3	Mini-calandria tube x 16		36.7052	0.041944
4	Coolant region		314.6100	0.359513
5	End plates		13.2055	0.015090
6	Mini-calandria walls		49.4853	0.056548
7	Mild steel sheath		46.92345	0.053621
Total				0.883874

Mini-calandria cell type 3A is considered, which has 16 identical type PUPINC fuel pins and the mini-calandria is NACL1.

The void regions are about 12% in both cases.

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Table 3.M14 Average Compositions of the Chosen Plate and Pin Cells
(atoms/barn.cm)

Material	Standard plate cell (Cells 1 and 2)	Uniform pin cell Cell Type 3A
H	0.0000261	0.0000197
C	0.0000677	0.0000365
N	0.0000011	-
O	0.0109852	0.0142278
NA	0.0084157	0.0086747
AL	0.0000064	0.0000070
SI	0.0001163	0.0001372
P	0.0000231	0.0000062
S	0.0000046	0.0000035
CA	0.0000013	0.0000004
TI	0.0000073	-
CR	0.0024855	0.0027258
MN	0.0002203	0.0002393
FE	0.0131461	0.0133609
NI	0.0013182	0.0012940
CU	0.0004931	0.0000012
GA	0.0000941	-
NB	0.0000207	-
MO	0.0000025	-
U234		0.0000004
U235	0.0000395	0.0000390
U236		0.0000002
U238	0.0054497	0.0053511
PU238	0.0000014	0.0000021
PU239	0.0013498	0.0013408
PU240	0.0003225	0.0003180
PU241	0.0000345	0.0000348
PU242	0.0000087	0.0000090
AM241	0.0000213	0.0000173

These values are very close to those obtained in the earlier analysis and reported in NEACRP-L-300.

Compositions for the Simplified Models.

Data have been derived for a set of simplified models and calculations have been made to compare these with the reference model, **Model A**. The models are illustrated in Figure 3.18.

Model B involves the homogenisation of the sheath over the space between the plates, or mini-calandria, and the 5.3721 cm square lattice cell boundary.

There is a gap between the sheath and the plates and also outside the sheath in the reference Model A. Homogenising the sheath over these inner and outer gaps (that is, over the area between the 5.067 cm square area of the plates and the 5.3721 cm square lattice area), but still representing the gaps between the 5x5 element superlattices and the superlattice grid plates, produces Model B.

Model C consists of a uniform lattice of square cells of size 5.4254 cm with homogenisation of the sheath over the space between the plates, or mini-calandria, and this larger square lattice cell boundary. The lattice is thus regular over the whole plan of the assembly.

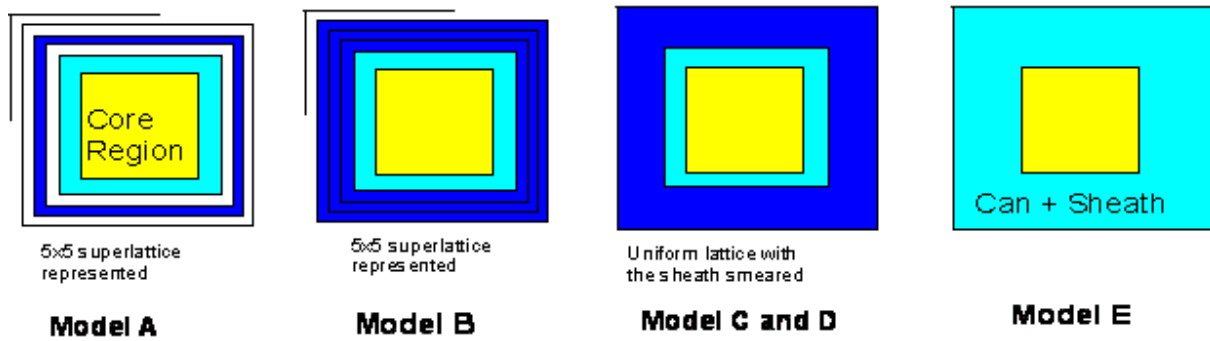
The sheath is homogenised over the space between the plates and the superlattice averaged lattice cell (that is, over the area between the 5.067 cm square area of the plates, or mini-calandria, and the 5.4254 cm square lattice cell area corresponding to the average cell spacing over the superlattices), thus also eliminating the gaps between the 5x5 element superlattices and slightly changing the positions of the elements. The superlattice grid plates are not taken into account in the compositions.

Model D has the core represented as in Model C but with the blanket and shield regions homogenised with the sheath over the lattice cell – a radial homogenisation of the blanket regions and shield regions to produce uniform compositions.

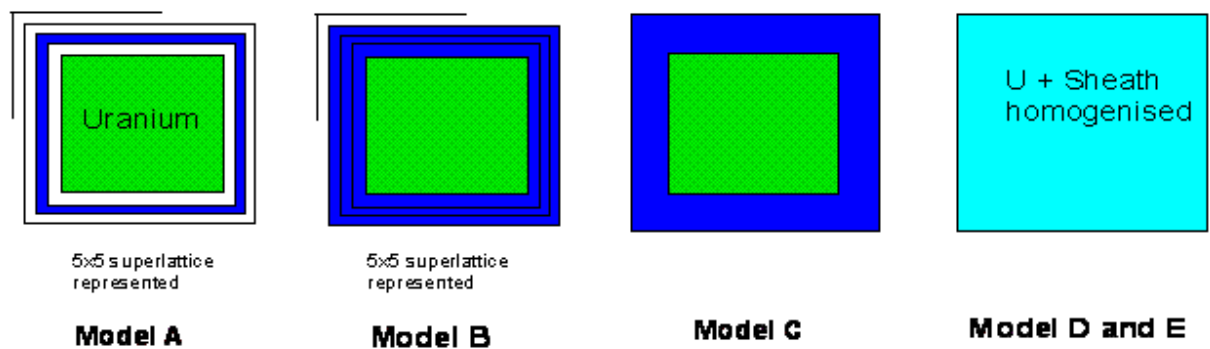
Model E is a further simplification of the core region cells of Models C and D. The plate cells are reduced to two radial regions, the core and an average of the edge region cans and the sheath (the MURAL cell model). The pin cells have the cans and the calandria tubes homogenised over the space between the fuel pins and the outer boundary of the tubes. The calandria walls are homogenised with the sheath material over the space between the inner dimension of the wall and the lattice cell boundary.

Models AS, BS, CS etc, where the S denotes a Single type of Core Element. The core elements of Assembly 24 use 3 different types of “dummy” replacement sodium plate. In Model S just one type is represented, the dominant type. The pin geometry assemblies 23 and 25 contain several types of pin geometry element and also an outer ring of plate geometry elements. In Model S there is only one type of core element represented, the dominant pin geometry element (which occupies the central region).

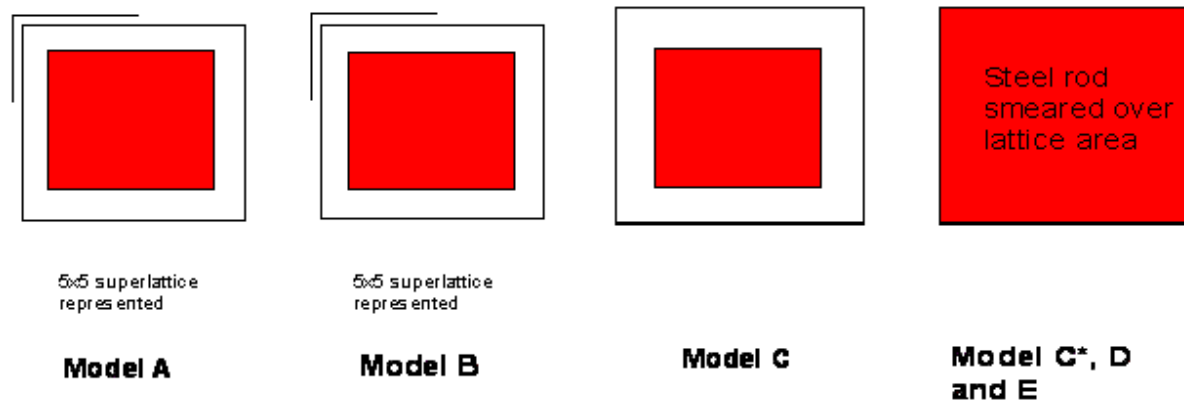
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CORE CELLS



BLANKET CELLS



REFLECTOR CELLS

Figure 3.18 Simplified Models of Cells

Compositions of the simplified models.

The simplified models are shown in Figure 3.18 and the corrections to be made to the reference k_{eff} values are discussed in Section 3.1.5.

Mild steel sheath smeared over the area between the plate edges and the lattice cell boundary.

Model B. The area of steel (or volume per 1 cm length) based on the dimensions of the sheath, inside width = 5.102 cm, outside width = 5.2544 cm is $(5.2544)^2 - (5.102)^2 = 1.57832 \text{ cm}^2$. The density is smeared over the space between the plate edges, 5.067 cm, and the cell boundary, 5.3721 cm, an area of $(5.3721)^2 - (5.067)^2 = 28.85946 - 25.67449 = 3.18497 \text{ cm}^2$ (this smearing reduces the density by a factor of 0.495553).

Model C. The density is smeared over the space between the plate edges, 5.067 cm, and the average pitch between elements of superlattices, 5.4254 cm, an area of $(5.4254)^2 - (5.067)^2 = 29.43497 - 25.67449 = 3.76048 \text{ cm}^2$ (this smearing reduces the density by a factor of 0.419712).

Figures are also given in the table for the atomic densities of the sheath smeared over the lattice area of $5.4254 \times 5.4254 = 29.4350$, a factor of 0.0536205 reduction relative to the densities for the area of 1.57832 cm^2 . These are the densities contributed by the sheath when the plate and sheath are smeared together over the lattice area of $(5.2544)^2$. Smearing a plate of width 5.067 cm over the lattice pitch of 5.4254 cm involves reducing the atomic densities by the factor 0.8722445.

Table 3.M15 Sheath Material Smeared over the area between the Plates, or Calandria, and the Lattice Cell Boundary, based on a Lattice Spacing of 5.3721 cm or 5.4254 cm
Smeared atomic densities (Atoms/barn.cm)

Nuclide	Sheath	Sheath smeared over lattice area to 5.3721 cm Model B	Sheath Smeared over lattice area to 5.4254 cm Model C	Smeared over a lattice area of 5.4254^2 cm^2
Area cm^2	1.57832	3.18497	3.76048	29.4350
Factor		0.495553	0.419712	0.0536205
H	7.5712E-05	3.7519E-05	3.1777E-05	4.0597E-06
C	2.3825E-04	1.1807E-04	9.9996E-05	1.2775E-05
AL	1.9798E-05	9.8110E-06	8.3095E-06	1.0616E-06
CR	3.6690E-06	1.8182E-06	1.5399E-06	1.9673E-07
MN	2.5697E-04	1.2734E-04	1.0785E-04	1.3779E-05
FE	7.7524E-02	3.8417E-02	3.2538E-02	4.1569E-03
NI	1.4302E-05	7.0874E-06	6.0027E-06	7.6688E-07
CU	2.2216E-05	1.1009E-05	9.3243E-06	1.1912E-06
Total	7.8155E-02	3.8730E-02	3.2803E-02	4.1907E-03

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The above tabular values are here repeated in text form for the convenience of users.

Atomic densities for the sheath smeared over the area between the plates (5.067 cm square) and the lattice boundary

(a) Model B, the lattice area (5.3721 cm square):

H	3.7519E-05	C	1.1807E-04	AL	9.8110E-06	CR	1.8182E-06
MN	1.2734E-04	FE	3.8417E-02	NI	7.0874E-06	CU	1.1009E-05

(b) Model C, the superlattice averaged lattice area, (5.4254 cm square):

H	3.1777E-05	C	9.9996E-05	AL	8.3095E-06	CR	1.5399E-06
MN	1.0785E-04	FE	3.2538E-02	NI	6.0027E-06	CU	9.3243E-06

Model D, the smearing of the blanket and shield regions, together with the sheath, over the superlattice average lattice cell area, 5.4254 cm square.

Smearing the uranium blanket regions.

These are homogenised with the sheath. The factors to be applied are 0.8722445 to the uranium atomic compositions and 0.0536205 to the sheath atomic compositions (relative to the sheath density for the area 1.57832 cm²).

Table 3.M16 Smeared Atomic Densities for the Natural Uranium Plate, U8, plus Sheath.
(Atoms/barn.cm)

Nuclide	Uranium plate	Reduced density of smeared uranium	Reduced smeared sheath density	Combined atomic densities
Factor		0.8722445	0.0536205	
H	4.4048E-05	3.8421E-05	4.0597E-06	4.2481E-05
C	4.9283E-04	4.2987E-04	1.2775E-05	4.4265E-04
AL			1.0616E-06	1.0616E-06
SI	2.1076E-04	1.8383E-04		1.8383E-04
CR			1.9673E-07	1.9673E-07
MN			1.3779E-05	1.3779E-05
FE	1.0599E-04	9.2449E-05	4.1569E-03	4.2493E-03
NI			7.6688E-07	7.6688E-07
CU			1.1912E-06	1.1912E-06
U235	3.3369E-04	2.9106E-04		2.9106E-04
U238	4.6021E-02	4.0142E-02		4.0142E-02
Total	4.7208E-02	4.1177E-02	4.1907E-03	4.5368E-02

The above tabular values are here repeated in text form:

Atomic densities for the natural uranium plate, U8, homogenised with the sheath :

H 4.2481E-05 C 4.4265E-04 AL 1.0616E-06 SI 1.8383E-04
CR 1.9673E-07 MN 1.3779E-05 FE 4.2493E-03 NI 7.6688E-07
CU 1.1912E-06
U235 2.9106E-04 U238 4.0142E-02

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Table 3.M17 Smeared Atomic Densities for the Natural Uranium Plate, U2, plus Sheath.
(Atoms/barn.cm)

Nuclide	Uranium plate	Reduced density of smeared uranium	Reduced smeared sheath density	Combined atomic densities
Factor		0.8722445	0.0536205	
H	4.3899E-05	3.8291E-05	4.0597E-06	4.2351E-05
C	4.6047E-04	4.0164E-04	1.2775E-05	4.1442E-04
AL			1.0616E-06	1.0616E-06
SI	1.9692E-04	1.7176E-04		1.7176E-04
CR			1.9673E-07	1.9673E-07
MN			1.3779E-05	1.3779E-05
FE	9.9032E-05	8.6380E-05	4.1569E-03	4.2433E-03
NI			7.6688E-07	7.6688E-07
CU			1.1912E-06	1.1912E-06
U235	3.3962E-04	2.9623E-04		2.9623E-04
U238	4.6785E-02	4.0808E-02		4.0808E-02
Total	4.7925E-02	4.1802E-02	4.1907E-03	4.5993E-02

The above tabular values are here repeated in text form:

Atomic densities for the natural uranium plate, U2, homogenised with the sheath:

H 4.2351E-05 C 4.1442E-04 AL 1.0616E-06 SI 1.7176E-04
CR 1.9673E-07 MN 1.3779E-05 FE 4.2433E-03 NI 7.6688E-07
CU 1.1912E-06
U235 2.9623E-04 U238 4.0808E-02

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Table 3.M18 Smeared Atomic Densities for the Natural Uranium Plate, U3, plus Sheath.
(Atoms/barn.cm)

Nuclide	Uranium plate	Reduced density of smeared uranium	Reduced smeared sheath density	Combined atomic densities
Factor		0.8722445	0.0536205	
H	4.4574E-05	3.8879E-05	4.0597E-06	4.2939E-05
C	4.7140E-04	4.1118E-04	1.2775E-05	4.2396E-04
AL			1.0616E-06	1.0616E-06
SI	2.0160E-04	1.7584E-04		1.7584E-04
CR			1.9673E-07	1.9673E-07
MN			1.3779E-05	1.3779E-05
FE	1.0138E-04	8.8428E-05	4.1569E-03	4.2453E-03
NI			7.6688E-07	7.6688E-07
CU			1.1912E-06	1.1912E-06
U235	3.4209E-04	2.9839E-04		2.9839E-04
U238	4.7156E-02	4.1132E-02		4.1132E-02
Total	4.8317E-02	4.2144E-02	4.1907E-03	4.6335E-02

The above tabular values are here repeated in text form:

Atomic densities for the natural uranium block, U3, homogenised with the sheath:

H 4.2939E-05 C 4.2396E-04 AL 1.0616E-06 SI 1.7584E-04
CR 1.9673E-07 MN 1.3779E-05 FE 4.2453E-03 NI 7.6688E-07
CU 1.1912E-06
U235 2.9839E-04 U238 4.1132E-02

Table 3.M19 Smeared Atomic Densities for the Mild Steel Axial Reflector Block, MST3, plus Sheath, averaged over the lattice spacing of 5.4254 cm.
Area (5.067)² cm² (Atoms/barn.cm)

Nuclide	Mild steel block	Smeared atomic densities	Smeared sheath atomic densities	Combined block and sheath atomic densities
Factor		0.8722445		
H	2.5700E-05	2.2417E-05	4.0597E-06	2.6476E-05
C	5.1066E-04	4.4542E-04	1.2775E-05	4.5820E-04
AL	1.3989E-04	1.2202E-04	1.0616E-06	1.2308E-04
TI	3.9416E-05	3.4380E-05		3.4380E-05
CR	2.7222E-05	2.3744E-05	1.9673E-07	2.3941E-05
MN	3.2634E-04	2.8465E-04	1.3779E-05	2.9843E-04
FE	8.3806E-02	7.3099E-02	4.1569E-03	7.7256E-02
NI	4.8234E-05	4.2072E-05	7.6688E-07	4.2839E-05
CU	4.4548E-05	3.8857E-05	1.1912E-06	4.0048E-05
MO	9.8355E-06	8.5790E-06		8.5790E-06
Total	8.4978E-02	7.4122E-02	4.1907E-03	7.8312E-02

The above tabular values are here repeated in text form:

Atomic densities for Axial Reflector MST3 mild steel block homogenised with the sheath:

H 2.6476E-05 C 4.5820E-04 AL 1.2308E-04 TI 3.4380E-05
CR 2.3941E-05 MN 2.9843E-04 FE 7.7256E-02 NI 4.2839E-05
CU 4.0048E-05 MO 8.5790E-06

Model E, Simplified Core Cells.

The plate geometry cells.

The canning of the plates is homogenised with the sheath material to form a cell with two square radial regions, the core region and the edge region (the MURAL model). The edge region of the plate is homogenised with the sheath and the upper and lower can regions are separately merged with the sheath. There are two ways of representing the cell. One is with just the edge region merged, producing three layers of two regions each. The other is to homogenise the upper and lower can regions with the sheath to produce a single upper and lower region above and below the two region core section.

The can of the Plutonium Metal Plate, PUVIII8.

Smearing the edge region canning material of the plate with the sheath.

Can end region height 0.236 cm, plate core width 4.671 cm, plate outer width 5.067 cm, can edge region area = 3.856248 cm². Smearing the edge region material with the wrapper material involves reducing the edge material density by the factor $3.856248/(3.856248+3.76048)$, a factor = 0.5062866, and the smeared sheath factor is therefore 0.4937133.

Table 3.M20 The Edge Region of the Plutonium Plate Combined with the Sheath and averaged over the space between the plate core and the lattice square of side 5.4254 cm. (Atoms/barn.cm)

Nuclide	Canning material	Reduced Atomic density	Sheath reduced atomic densities	Combined Atomic density
Area	3.856248			7.616728
Smearing Factor		0.5062866	0.4937133	
H	1.3760E-05	6.9665E-06	1.5689E-05	2.2655E-05
C	1.1393E-04	5.7681E-05	4.9370E-05	1.0705E-04
AL			4.1025E-06	4.1025E-06
SI	3.6607E-04	1.8534E-04		1.8534E-04
P	1.3731E-05	6.9518E-06		6.9518E-06
CR	9.4011E-03	4.7597E-03	7.6028E-07	4.7604E-03
MN	8.5931E-04	4.3506E-04	5.3249E-05	4.8831E-04
FE	3.5542E-02	1.7994E-02	1.6064E-02	3.4059E-02
NI	4.1646E-03	2.1085E-03	2.9636E-06	2.1114E-03
CU	1.6613E-02	8.4109E-03	4.6035E-06	8.4155E-03
Total	6.7088E-02	3.3966E-02	1.6195E-02	5.0161E-02

The above tabular values are here repeated in text form:

Atomic densities of the edge region of the Pu plate smeared with the sheath:

H	2.2655E-05	C	1.0705E-04	AL	4.1025E-06	SI	1.8534E-04
P	6.9518E-06	CR	4.7604E-03	MN	4.8831E-04	FE	3.4059E-02
NI	2.1114E-03	CU	8.4155E-03				

Radial smearing of the top and bottom can regions of the plutonium plate with the wrapper to give an equivalent one-dimensional plate.

The can atomic densities are multiplied by the factor 0.8722445 and the wrapper atomic densities by the factor 0.0536205 (relative to the wrapper densities for the area 1.57832 cm²).

Table 3.M21 Smeared Atomic Densities for the Upper and Lower Canning Region of the Plutonium Plate averaged with the sheath over the lattice square of side 5.4254 cm.
(Atoms/barn.cm)

Nuclide	Can Reduced Atomic density	Wrapper reduced atomic densities	Combined Atomic density
Smearing Factor	0.8722445	0.0536205	
H	1.2002E-05	4.0597E-06	1.6062E-05
C	9.9375E-05	1.2775E-05	1.1215E-04
AL		1.0616E-06	1.0616E-06
SI	3.1930E-04		3.1930E-04
P	1.1977E-05		1.1977E-05
CR	8.2001E-03	1.9673E-07	8.2003E-03
MN	7.4953E-04	1.3779E-05	7.6331E-04
FE	3.1001E-02	4.1569E-03	3.5158E-02
NI	3.6325E-03	7.6688E-07	3.6333E-03
CU	1.4491E-02	1.1912E-06	1.4492E-02
Total	5.8517E-02	4.1907E-03	6.2708E-02

The above tabular values are here repeated in text form:

Atomic densities of the can smeared with the sheath over the whole 5.4254 cm lattice area:

H 1.6062E-05 C 1.1215E-04 AL 1.0616E-06 SI 3.1930E-04
P 1.1977E-05 CR 8.2003E-03 MN 7.6331E-04 FE 3.5158E-02
NI 3.6333E-03 CU 1.4492E-02

Smearing the can region of the uranium oxide plate.

Smearing the edge region of the plate with the wrapper

The core region height is 0.558 cm, and the width is 4.851 cm. The overall width of the plate is 5.067 cm. The area of the edge region is therefore 2.14229 cm². Smearing this with the wrapper region involves a reduction in density by the factor $2.14229/(2.14229 + 3.76048) = 0.36293$. The factor for the smeared wrapper is 0.63707.

Table 3.M22 Smeared Atomic Densities. Smearing the UO₂ Plate Edge Region with the Sheath over the space between the plate core and the lattice square of side 5.4254 cm

(atomic densities in Atoms/barn.cm).

Nuclide	Canning material Atomic density	Can Reduced Atomic density	Sheath reduced atomic densities	Combined Atomic density
Volume	3.0773			
Factor		0.36293	0.63707	
H	1.8834E-05	6.8354E-06	2.0244E-05	2.7080E-05
C	1.2695E-04	4.6074E-05	6.3705E-05	1.0978E-04
AL			5.2937E-06	5.2937E-06
SI	6.3794E-04	2.3153E-04		2.3153E-04
P	3.4708E-04	1.2597E-04		1.2597E-04
S	3.5660E-05	1.2942E-05		1.2942E-05
CR	1.3673E-02	4.9623E-03	9.8104E-07	4.9633E-03
MN	8.4655E-04	3.0724E-04	6.8710E-05	3.7595E-04
FE	4.7796E-02	1.7347E-02	2.0728E-02	3.8075E-02
NI	8.3368E-03	3.0257E-03	3.8242E-06	3.0295E-03
CU			5.9403E-06	5.9403E-06
Total	7.1819E-02	2.6065E-02	2.0898E-02	4.6963E-02

The above tabular values are here repeated in text form:

Atomic densities of the edge region of the UO₂ plate smeared with the sheath:

H 2.7080E-05 C 1.0978E-04 AL 5.2937E-06 SI 2.3153E-04
P 1.2597E-04 S 1.2942E-05 CR 4.9633E-03 MN 3.7595E-04
FE 3.8075E-02 NI 3.0295E-03 CU 5.9403E-06

Smearing the top and bottom can regions of the UO₂ plate with the wrapper to give an equivalent one-dimensional plate.

The can atomic densities are multiplied by the factor 0.8722445 and the wrapper atomic densities by the factor 0.0536205 (relative to the densities for the area 1.57832 cm²).

Table 3.M23 Smeared Atomic Densities. Smearing the Upper and Lower Canning Region of the UO₂ plate with the Sheath over the lattice square of side 5.4254 cm.
(Atoms/barn.cm)

Nuclide	Canning material Atomic density	Can Reduced Atomic density	Sheath reduced atomic density	Combined Atomic density
Factor		0.8722445	0.0536205	
H	1.8834E-05	1.6428E-05	4.0597E-06	2.0488E-05
C	1.2695E-04	1.1073E-04	1.2775E-05	1.2351E-04
AL			1.0616E-06	1.0616E-06
SI	6.3794E-04	5.5644E-04		5.5644E-04
P	3.4708E-04	3.0274E-04		3.0274E-04
S	3.5660E-05	3.1104E-05		3.1104E-05
CR	1.3673E-02	1.1926E-02	1.9673E-07	1.1926E-02
MN	8.4655E-04	7.3840E-04	1.3779E-05	7.5218E-04
FE	4.7796E-02	4.1690E-02	4.1569E-03	4.5847E-02
NI	8.3368E-03	7.2717E-03	7.6688E-07	7.2725E-03
CU			1.1912E-06	1.1912E-06
Total	7.18E-02	6.2644E-02	4.1907E-03	6.7503E-02

The above tabular values are here repeated in text form:

Atomic densities of the can smeared with the sheath over the whole lattice area:

H	2.0448E-05	C	1.2351E-04	AL	1.0616E-06	SI	5.5644E-04
P	3.0274E-04	S	3.1104E-05	CR	1.1926E-02	MN	7.5218E-04
FE	4.5847E-02	NI	7.2725E-03	CU	1.1912E-06		

Smearing the canning of the sodium plate with the sheath

Smearing the edge region of the plate with the wrapper

Core region height 0.541 cm, width 4.963 cm. Edge region area $(5.067 \text{ cm})^2 - (4.963 \text{ cm})^2 = 1.04312 \text{ cm}^2$. Smearing with the wrapper involves a reduction in density by the factor $1.04312/(1.04312 + 3.76048) = 0.217154$. The (reduced density) wrapper densities are reduced by the factor 0.782846.

Table 3.M24 Smeared Atomic Densities. Smearing the Sodium Plate Edge Region with the Sheath over the space between the plate core and the lattice square of side 5.4254 cm.
(atomic densities in Atoms/barn.cm).

Nuclide	Canning material Atomic density	Can reduced Atomic density	Sheath reduced atomic densities	Combined Atomic density
Volume (cm ³)	2.4307			
Factor		0.217154	0.782846	
H	2.1631E-05	4.6973E-06	2.4877E-05	2.9574E-05
C	2.9290E-04	6.3604E-05	7.8282E-05	1.4189E-04
AL			6.5050E-06	6.5050E-06
SI	6.0867E-04	1.3218E-04		1.3218E-04
P	3.2795E-05	7.1216E-06		7.1216E-06
S	3.3219E-05	7.2136E-06		7.2136E-06
CR	1.4759E-02	3.2050E-03	1.2055E-06	3.2062E-03
MN	1.3570E-03	2.9468E-04	8.4433E-05	3.7911E-04
FE	5.5054E-02	1.1955E-02	2.5472E-02	3.7427E-02
NI	7.0982E-03	1.5414E-03	4.6992E-06	1.5461E-03
CU			7.2995E-06	7.2995E-06
NB	3.1147E-04	6.7637E-05		6.7637E-05
Total	7.9569E-02	1.7279E-02	2.5679E-02	4.2958E-02

The above tabular values are here repeated in text form:

Atomic densities for the sodium plate edge can region, smeared with the sheath:

H	2.9574E-05	C	1.4189E-04	AL	6.5050E-06	SI	1.3218E-04
P	7.1216E-06	S	7.2136E-06	CR	3.2062E-03	MN	3.7911E-04
FE	3.7427E-02	NI	1.5461E-03	CU	7.2995E-06	NB	6.7637E-05

Smearing the top and bottom can regions with the wrapper to give an equivalent one-dimensional plate.

The can atomic densities are multiplied by the factor 0.8722445 and the wrapper atomic densities by the factor 0.0536205 (relative to the densities for the area 1.57832 cm²).

Table 3.M25 Smeared Atomic Densities. Smearing the Upper and Lower Canning Region of the Sodium Plate with the Sheath over the lattice square of side 5.4254 cm.
(Atoms/barn.cm)

Nuclide	Canning material Atomic density	Reduced Atomic density	Sheath reduced atomic densities	Combined Atomic density
Factor		0.8722445	0.0536205	
H	1.9035E-05	1.8868E-05	4.0597E-06	2.2927E-05
C	1.2831E-04	2.5548E-04	1.2775E-05	2.6826E-04
AL	0.0		1.0616E-06	1.0616E-06
SI	6.4475E-04	5.3091E-04		5.3091E-04
P	3.5078E-04	2.8605E-05		2.8605E-05
S	3.6041E-05	2.8975E-05		2.8975E-05
CR	1.3819E-02	1.2873E-02	1.9673E-07	1.2874E-02
MN	8.5559E-04	1.1836E-03	1.3779E-05	1.1974E-03
FE	4.8306E-02	4.8021E-02	4.1569E-03	5.2177E-02
NI	8.4258E-03	6.1914E-03	7.6688E-07	6.1921E-03
CU	0.0		1.1912E-06	1.1912E-06
NB		2.7168E-04		2.7168E-04
Total	7.2585E-02	6.9404E-02	4.1907E-03	7.3594E-02

The above tabular values are here repeated in text form:

Atomic densities of the can smeared with the sheath over the whole lattice area:

H	2.2927E-05	C	2.6826E-04	AL	1.0616E-06	SI	5.3091E-04
P	2.8605E-05	S	2.8975E-05	CR	1.2874E-02	MN	1.1974E-03
FE	5.2177E-02	NI	6.1921E-03	CU	1.1912E-06	NB	2.7168E-04

Smearing the 40% steel plate with the wrapper to produce a uniform 1D plate.

In the MONK model the PLATE has height 0.317 cm, (CORE, assumed void, height 0.317 cm, width 3.925 cm) Plate width assumed to be 5.067 cm, Volume 3.2552 cm³. The area is thus 10.2688 cm².

The steel plate contains void regions but in the MURAL model it was smeared across the lattice area. The densities were thus reduced by the factor $10.2688 / (5.4254)^2 = 0.348864$

Table 3.M26 Smeared Atomic Densities. The 40%Steel Plate Smeared with the Sheath over the lattice square of side 5.4254 cm. (Atoms/barn.cm)

Nuclide	Atomic density	Reduced Atomic density	Sheath reduced atomic densities	Combined Atomic density Smeared over lattice cell	Smeared over the reduced area outside the central void
Area (cm ²)	10.2688		29.43497		14.02934
Factor		0.348864	0.0536205		2.0981
H	1.8355E-05	6.4034E-06	4.0597E-06	1.0463E-05	2.1952E-05
C	8.7794E-05	3.0628E-05	1.2775E-05	4.3403E-05	9.1064E-05
AL	1.1862E-04	4.1382E-05	1.0616E-06	4.2444E-05	8.9052E-05
SI	7.9703E-04	2.7806E-04		2.7806E-04	5.8340E-04
P	4.0018E-05	1.3961E-05		1.3961E-05	2.9292E-05
S	1.4422E-05	5.0313E-06		5.0313E-06	1.0556E-05
TI	2.4806E-04	8.6539E-05		8.6539E-05	1.8157E-04
CR	1.5908E-02	5.5497E-03	1.9673E-07	5.5499E-03	1.1644E-02
MN	1.4972E-03	5.2232E-04	1.3779E-05	5.3610E-04	1.1248E-03
FE	5.5367E-02	1.9316E-02	4.1569E-03	2.3472E-02	4.9247E-02
NI	8.7976E-03	3.0692E-03	7.6688E-07	3.0699E-03	6.4410E-03
CU	5.0365E-05	1.7571E-05	1.1912E-06	1.8762E-05	3.9365E-05
NB	0.000005	1.7443E-06		1.7443E-06	3.6597E-06
MO	8.0988E-05	2.8254E-05		2.8254E-05	5.9280E-05
Total	8.3030E-02	2.8966E-02	4.1907E-03	3.3157E-02	6.9567E-02

The above tabular values are here repeated in text form:

Atomic densities for the 40% steel plate, smearing with the sheath over the whole area of the lattice cell.

H 1.0463E-05 C 4.3403E-05 AL 4.2444E-05 SI 2.7806E-04
P 1.3961E-05 S 5.0313E-06 TI 8.6539E-05 CR 5.5499E-03
MN 5.3610E-04 FE 2.3472E-02 NI 3.0699E-03 CU 1.8762E-05
NB 1.7443E-06 MO 2.8254E-05

Smearing over the area between the central square void and the cell boundary.

H 2.1952E-05 C 9.1064E-05 AL 8.9052E-05 SI 5.8340E-04
P 2.9292E-05 S 1.0556E-05 TI 1.8157E-04 CR 1.1644E-02
MN 1.1248E-03 FE 4.9247E-02 NI 6.4410E-03 CU 3.9365E-05
NB 3.6597E-06 MO 5.9280E-05

Smearing the atomic densities of the sodium dummy plates over the plate area

The plates STNAVR4 and STNAVS4 are rings and STNAV4 is “honeycomb” shaped.
For a ring shaped piece, with outer diameter 5.067 cm, inner diameter 4.6 cm and thickness 0.616 cm, the area is 3.54567 and the volume is 2.1841 cm³.

Smearing the material over the lattice area of 5.067x5.067 reduces the atomic densities by the factor 3.54567/25.6745 = 0.138101:

Table 3.M27 Smeared Atomic Densities. Smearing the Sodium Dummy Plates over the Plate Area

(Atoms/barn.cm)

Nuclide	Atomic density	Smeared over plate area		Atomic density	Smeared over plate area
PLATENAME	STNAVR4	STNAVR4		STNAVS4	STNAVS4
Area (cm ²)	3.54567	25.6745		3.54567	25.6745
Factor		0.138101			0.138101
H	2.4073E-05	3.3245E-06		2.4073E-05	3.3245E-06
C	2.7547E-04	3.8043E-05		2.5251E-04	3.4872E-05
SI	7.5592E-04	1.0439E-04		7.4610E-04	1.0304E-04
P	4.5399E-05	6.2696E-06		1.7803E-05	2.4586E-06
S	1.2036E-05	1.6622E-06		1.7195E-05	2.3746E-06
CR	1.6594E-02	2.2916E-03		1.6248E-02	2.2439E-03
MN	1.1688E-03	1.6141E-04		1.5006E-03	2.0723E-04
FE	5.9245E-02	8.1818E-03		5.9881E-02	8.2696E-03
NI	9.9342E-03	1.3719E-03		9.4005E-03	1.2982E-03
NB	4.0746E-04	5.6271E-05		3.7393E-04	5.1640E-05
TOTAL	8.8462E-02	1.2217E-02		8.8462E-02	1.2217E-02

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For the plate STNAV4 of height 0.616 cm, and assuming smearing over a plate width of 5.067 cm, the area is 25.6745 cm²

Nuclide	Atomic density Smeared over plate area
PLATENAME:	STNAV4
Area (cm ²)	25.6745
H	3.3245E-06
C	3.3477E-05
SI	1.2169E-04
P	4.9764E-06
S	2.5076E-06
CR	2.4643E-03
MN	1.9518E-04
FE	8.0717E-03
NI	1.2195E-03
NB	5.2657E-05
TOTAL	1.2169E-02

Atomic densities of the dummy plates when smeared over the lattice area and combined with the sheath material.

The atomic densities averaged over the plate area of 25.6745 cm² are multiplied by the factor 0.8722445 and combined with the smeared sheath material.

Table 3.M28 The Reduced Atomic Densities of the Dummy Plates before combining with the Sheath, based on the area 5.4254² cm².
(Atoms/barn.cm)

Nuclide	Smeared sheath densities	Dummy plates smeared over the lattice area of 29.43497 cm. Plate densities reduced by the factor 0.8722445		
PLATE:		STNAVR4	STNAVS4	STNAV4
Area (cm ²)	29.43497	29.43497	29.43497	29.43497
H	4.0597E-06	2.8998E-06	2.8998E-06	2.8998E-06
C	1.2775E-05	3.3183E-05	3.0417E-05	2.9200E-05
AL	1.0616E-06			
SI		9.1054E-05	8.9876E-05	1.0614E-04
P		5.4686E-06	2.1445E-06	4.3406E-06
S		1.4498E-06	2.0712E-06	2.1872E-06
CR	1.9673E-07	1.9988E-03	1.9572E-03	2.1495E-03
MN	1.3779E-05	1.4079E-04	1.8076E-04	1.7024E-04
FE	4.1569E-03	7.1365E-03	7.2131E-03	7.0405E-03
NI	7.6688E-07	1.1966E-03	1.1323E-03	1.0637E-03
CU	1.1912E-06			
NB		4.9082E-05	4.5043E-05	4.5930E-05
TOTAL	4.1907E-03	1.0656E-02	1.0656E-02	1.0614E-02

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Table 3.M29 Atomic Densities of the Smeared Dummy Plates combined with the Sheath Material

Densities uniformly smeared over the lattice square of side 5.4254 cm.
(Atoms/barn.cm)

Nuclide	Dummy plates smeared over the lattice area of 29.43497 cm and combined with the sheath material		
PLATE:	STNAVR4	STNAVS4	STNAV4
Area (cm ²)	29.43497	29.43497	29.43497
H	6.9595E-06	6.9595E-06	6.9595E-06
C	4.5958E-05	4.3192E-05	4.1975E-05
AL	1.0616E-06	1.0616E-06	1.0616E-06
SI	9.1054E-05	8.9876E-05	1.0614E-04
P	5.4686E-06	2.1445E-06	4.3406E-06
S	1.4498E-06	2.0712E-06	2.1872E-06
CR	1.9990E-03	1.9574E-03	2.1497E-03
MN	1.5457E-04	1.9454E-04	1.8402E-04
FE	1.1293E-02	1.1370E-02	1.1197E-02
NI	1.1974E-03	1.1331E-03	1.0645E-03
CU	1.1912E-06	1.1912E-06	1.1912E-06
NB	4.9082E-05	4.5043E-05	4.5930E-05
TOTAL	1.4847E-02	1.4847E-02	1.4805E-02

The above tabular values are here repeated in text form:

Atomic densities for the plates smeared with the sheath material over the whole lattice cell area:

STNAVR4

H	6.9595E-06	C	4.5958E-05	AL	1.0616E-06	SI	9.1054E-05
P	5.4686E-06	S	1.4498E-06	CR	1.9990E-03	MN	1.5457E-04
FE	1.1293E-02	NI	1.1974E-03	CU	1.1912E-06	NB	4.9082E-05

STNAVS4

H	6.9595E-06	C	4.3192E-05	AL	1.0616E-06	SI	8.9876E-05
P	2.1445E-06	S	2.0712E-06	CR	1.9574E-03	MN	1.9454E-04
FE	1.1370E-02	NI	1.1331E-03	CU	1.1912E-06	NB	4.5043E-05

STNAV4

H	6.9595E-06	C	4.1975E-05	AL	1.0616E-06	SI	1.0614E-04
P	4.3406E-06	S	2.1872E-06	CR	2.1497E-03	MN	1.8402E-04
FE	1.1197E-02	NI	1.0645E-03	CU	1.1912E-06	NB	4.5930E-05

Model of the dummy plates with a central square void region

The dummy plates STNAVR4 and STNAVS4 are ring shaped, with a central circular void region. To model these in square geometry we can introduce a central square shaped void region, the square having side 4.6 cm (area 21.16 cm²). This is a fraction 0.718873 of the lattice area, the area occupied by the steel being $(5.4254)^2 - (4.6)^2 = 29.43497 - 21.16 = 8.27497 \text{ cm}^2$. The densities of the components have to be increased by the factor $29.43497 / 8.27497 = 3.55711$ when used with this model.

Table 3.M30 Atomic Densities of the Smeared Dummy Plates combined with the Sheath Material when there is a Central Square Hole of Side 4.6 cm.

(Atoms/barn.cm)

Nuclide	Dummy plates plus sheath smeared over the region between the central 4.6 cm square hole and the lattice boundary		
PLATE:	STNAVR4	STNAVS4	
Area (cm ²)	8.27497	8.27497	
H	2.4756E-05	2.4756E-05	
C	1.6348E-04	1.5364E-04	
AL	3.7762E-06	3.7762E-06	
SI	3.2389E-04	3.1970E-04	
P	1.9452E-05	7.6282E-06	
S	5.1571E-06	7.3675E-06	
CR	7.1107E-03	6.9627E-03	
MN	5.4982E-04	6.9200E-04	
FE	4.0172E-02	4.0444E-02	
NI	4.2592E-03	4.0304E-03	
CU	4.2372E-06	4.2372E-06	
NB	1.7459E-04	1.6022E-04	
TOTAL	5.2811E-02	5.2811E-02	

The above tabular values are here repeated in text form:

Atomic densities for the ring shaped dummy elements smeared over the area outside the central 4.6 cm square void region:

STNAVR4

H	2.4756E-05	C	1.6348E-04	AL	3.7762E-06	SI	3.2389E-04
P	1.9452E-05	S	5.1571E-06	CR	7.1107E-03	MN	5.4982E-04
FE	4.0172E-02	NI	4.2592E-03	CU	4.2372E-06	NB	1.7459E-04

STNAVS4

H	2.4756E-05	C	1.5364E-04	AL	3.7762E-06	SI	3.1970E-04
P	7.6282E-06	S	7.3675E-06	CR	6.9627E-03	MN	6.9200E-04
FE	4.0444E-02	NI	4.0304E-03	CU	4.2372E-06	NB	1.6022E-04

Simplified Models of the Pin Geometry Assemblies 23 and 25.

Various simplifications were made in the original analyses of these assemblies, made in the 1980s.

- The outer rings of plate geometry elements were replaced by pin geometry elements.
- The same pin array was used for all elements (the one which occupies the central area of the cores and contains the pin array adopted in most pin geometry elements). This uses pins having two different enrichments.
- Alternatively, instead of having a mixed pin array a uniform array of identical pins was used in the model.

Each of these simplifications involved a calculated correction to the experimental k-effective value, based on measurements of the relative worths of different elements. Details can be found in the ZTN/22 series of notes.

Further simplifications were to homogenise the element sheaths over the areas between the mini-calandria walls and the lattice area and to combine the sheath and mini-calandria walls to produce a single region as in Models C and E. This simplification is calculated here. The additional simplification calculated here is to combine the fuel pin can with the calandria tube and to eliminate the void regions.

An additional simplification to the pin cell calculations made in the original analyses (but not studied here) was to introduce the material of the minicalandria boxes and sheath into each pin cell calculation as an outer region surrounding each pin, and to then treat pin clusters. This was done to enable pin cluster collision probability calculations to be made in the MURAL cell code.

Homogenisation of the pin cell canning and calandria tube material

Table 3.D22 The Dimensions of the Pin Cell, Pellet Column, Canning and Calandria Tubes.
(dimensions in cm, and cm².)

	cm, cm ²
Fuel pellet column	
Fuel pellet column length	29.18
Fuel pellet radius	0.423
Fuel pellet area	0.562122
Void gap area ($\pi \times (0.4305^2 - 0.423^2)$)	0.0201101
Fuel can	
Fuel can inner radius	0.4305
Fuel can outer radius	0.4685
Pin can area ($\pi \times (0.4685^2 - 0.4305^2)$)	0.107323
Fuel can area fraction	0.4055318
Void gap area ($\pi \times (0.488^2 - 0.4685^2)$)	0.0585962
Calandria tubes	
Calandria tube inner radius	0.488
Calandria tube outer radius	0.513
Tube area ($\pi \times (0.513^2 - 0.488^2)$)	0.078618
Tube area fraction	0.2970679
Area of can + tube + void gaps	0.2646477

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Homogenising the can and tube over the area between the outer radius of the fuel pin and the outer radius of the tube involves combining 0.4055318 times the can material densities with 0.2970679 times the tube material densities.

Table 3.M31 Atomic Densities of the Tubes and the Scaled Atomic Densities.
(Atoms/barn.cm)

Nuclide	At. density	At. density x 0.2970679
SI	1.0632E-03	3.1584E-04
CR	1.6787E-02	4.9869E-03
MN	1.3588E-03	4.0366E-04
FE	6.0762E-02	1.8050E-02
NI	7.4360E-03	2.2090E-03
Total	8.7407E-02	2.5966E-02

Table 3.M32 Atomic Densities of the Cans
(Atoms/barn.cm)

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
H	2.6710E-05	2.2895E-05	2.6710E-05	2.4802E-05	2.4802E-05	2.4802E-05
C	1.3288E-04	2.3695E-04	1.3609E-04	2.0172E-04	7.3646E-05	7.2045E-05
AL				6.4142E-06	6.4142E-06	4.2762E-06
SI	8.5585E-04	1.1571E-03	8.3531E-04	8.9693E-04	1.0476E-03	1.0544E-03
P	3.7870E-05	4.1596E-05	3.6008E-05	3.4145E-05	1.3658E-05	1.3658E-05
S	2.4585E-05	2.2786E-05	2.4585E-05	8.9942E-06	1.7389E-05	1.7989E-05
TI				2.8916E-05	2.8916E-05	2.1687E-05
CR	1.8218E-02	1.4981E-02	1.7856E-02	1.5910E-02	1.6102E-02	1.6284E-02
MN	1.5646E-03	1.5751E-03	1.5331E-03	1.1586E-03	9.8006E-04	9.8357E-04
FE	5.9675E-02	5.3171E-02	5.8512E-02	5.5753E-02	5.6794E-02	5.7354E-02
CO				4.2418E-06	4.2418E-06	3.2629E-06
NI	8.9153E-03	8.8137E-03	8.7515E-03	7.6341E-03	8.0503E-03	8.1453E-03
CU				6.0522E-06	6.0522E-06	4.5391E-06
NB		2.9391E-04				
MO				2.2047E-06	2.1446E-05	2.1246E-05
Total	8.9451E-02	8.0316E-02	8.7711E-02	8.1670E-02	8.3171E-02	8.4005E-02

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Table 3.M33 Scaled Atomic Densities of the Cans (x 0.4055318)
(Atoms/barn.cm)

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
H	1.0832E-05	9.2847E-06	1.0832E-05	1.0058E-05	1.0058E-05	1.0058E-05
C	5.3887E-05	9.6091E-05	5.5189E-05	8.1804E-05	2.9866E-05	2.9217E-05
AL				2.6012E-06	2.6012E-06	1.7341E-06
SI	3.4707E-04	4.6924E-04	3.3874E-04	3.6373E-04	4.2484E-04	4.2759E-04
P	1.5357E-05	1.6869E-05	1.4602E-05	1.3847E-05	5.5388E-06	5.5388E-06
S	9.9700E-06	9.2404E-06	9.9700E-06	3.6474E-06	7.0518E-06	7.2951E-06
TI				1.1726E-05	1.1726E-05	8.7948E-06
CR	7.3880E-03	6.0753E-03	7.2412E-03	6.4520E-03	6.5299E-03	6.6037E-03
MN	6.3450E-04	6.3875E-04	6.2172E-04	4.6985E-04	3.9745E-04	3.9887E-04
FE	2.4200E-02	2.1563E-02	2.3728E-02	2.2610E-02	2.3032E-02	2.3259E-02
CO				1.7202E-06	1.7202E-06	1.3232E-06
NI	3.6154E-03	3.5742E-03	3.5490E-03	3.0959E-03	3.2647E-03	3.3032E-03
CU				2.4544E-06	2.4544E-06	1.8407E-06
NB		1.1919E-04				
MO				8.9408E-07	8.6970E-06	8.6159E-06
Total	3.6275E-02	3.2571E-02	3.5570E-02	3.3120E-02	3.3728E-02	3.4067E-02

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Table 3.M34 Combined Can Plus Tube Homogenised Atomic Number Densities
(Atoms/barn.cm)

Nuclide	PUPINA	PUPINB	PUPINC	PUPIND	PUPINE	PUPINF
H	1.0832E-05	9.2847E-06	1.0832E-05	1.0058E-05	1.0058E-05	1.0058E-05
C	5.3887E-05	9.6091E-05	5.5189E-05	8.1804E-05	2.9866E-05	2.9217E-05
AL				2.6012E-06	2.6012E-06	1.7341E-06
SI	6.6291E-04	7.8508E-04	6.5458E-04	6.7957E-04	7.4068E-04	7.4343E-04
P	1.5357E-05	1.6869E-05	1.4602E-05	1.3847E-05	5.5388E-06	5.5388E-06
S	9.9700E-06	9.2404E-06	9.9700E-06	3.6474E-06	7.0518E-06	7.2951E-06
TI				1.1726E-05	1.1726E-05	8.7948E-06
CR	1.2375E-02	1.1062E-02	1.2228E-02	1.1439E-02	1.1517E-02	1.1591E-02
MN	1.0382E-03	1.0424E-03	1.0254E-03	8.7351E-04	8.0111E-04	8.0253E-04
FE	4.2250E-02	3.9613E-02	4.1778E-02	4.0660E-02	4.1082E-02	4.1309E-02
CO				1.7202E-06	1.7202E-06	1.3232E-06
NI	5.8244E-03	5.7832E-03	5.7580E-03	5.3049E-03	5.4737E-03	5.5122E-03
CU				2.4544E-06	2.4544E-06	1.8407E-06
NB		1.1919E-04				
MO				8.9408E-07	8.6970E-06	8.6159E-06
Total	6.2241E-02	5.8537E-02	6.1536E-02	5.9086E-02	5.9694E-02	6.0033E-02

The above tabular values are here repeated in text form:

PUPINA

H 1.0832E-05 C 5.3887E-05 SI 6.6291E-04 P 1.5357E-05
S 9.9700E-06 CR 1.2375E-02 MN 1.0382E-03 FE 4.2250E-02
NI 5.8244E-03

PUPINB

H 9.2847E-06 C 9.6091E-05 SI 7.8508E-04 P 1.6869E-05
S 9.2404E-06 CR 1.1062E-02 MN 1.0424E-03 FE 3.9613E-02
NI 5.7832E-03 NB 1.1919E-04

PUPINC

H 1.0832E-05 C 5.5189E-05 SI 6.5458E-04 P 1.4602E-05
S 9.9700E-06 CR 1.2228E-02 MN 1.0254E-03 FE 4.1778E-02
NI 5.7580E-03

PUPIND

H 1.0058E-05 C 8.1804E-05 AL 2.6012E-06 SI 6.7957E-04
P 1.3847E-05 S 3.6474E-06 TI 1.1726E-05 CR 1.1439E-02
MN 8.7351E-04 FE 4.0660E-02 CO 1.7202E-06 NI 5.3049E-03
CU 2.4544E-06 MO 8.9408E-07

PUPINE

H 1.0058E-05 C 2.9866E-05 AL 2.6012E-06 SI 7.4068E-04
P 5.5388E-06 S 7.0518E-06 TI 1.1726E-05 CR 1.1517E-02
MN 8.0111E-04 FE 4.1082E-02 CO 1.7202E-06 NI 5.4737E-03
CU 2.4544E-06 MO 8.6970E-06

PUPINF

H 1.0058E-05 C 2.9217E-05 AL 1.7341E-06 SI 7.4343E-04
P 5.5388E-06 S 7.2951E-06 TI 8.7948E-06 CR 1.1591E-02
MN 8.0253E-04 FE 4.1309E-02 CO 1.3232E-06 NI 5.5122E-03
CU 1.8407E-06 MO 8.6159E-06

Homogenisation of the calandria walls and the sheath.

Table 3.D23 Dimensions of the Calandria Walls

Calandria walls	(cm, cm ²)
Inner width of the calandria (cm)	4.9
Outer width of the calandria (cm)	5.067
Area of calandria outer walls (5.067 sq. – 4.9 sq.) (cm ²)	1.66449
Outer width of lattice cell (averaged over the supercell) (cm)	5.4254
Area of the homogenised sheath (5.4254 sq. – 5.067 sq.) (cm ²)	3.76048
Total area of region (5.4254 sq. – 4.9 sq.) (cm ²)	5.42497
Calandria wall fraction	0.30682
Homogenised sheath fraction	0.69318

Table 3.M35 Atomic Density Contributed by the Smeared Sheath
(Atoms/barn.cm)

Nuclide	Sheath Smeared over lattice area to 5.4254 cm square	Sheath at density to be Smeared with the calandria wall x0.69318
Area cm ²	3.76048	5.42497
H	3.1777E-05	2.2027E-05
C	9.9996E-05	6.9315E-05
AL	8.3095E-06	5.7600E-06
CR	1.5399E-06	1.0674E-06
MN	1.0785E-04	7.4759E-05
FE	3.2538E-02	2.2555E-02
NI	6.0027E-06	4.1610E-06
CU	9.3243E-06	6.4634E-06
Total	3.2803E-02	2.2738E-02

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Table 3.M36 Atomic Densities of the Calandria Walls
(Atoms/barn.cm)

Nuclide	NACLI	NACLIIS	NACLIH	NACLIV	NACLV	VCLVI
H	3.9844E-05	3.8637E-05	3.9844E-05	3.7430E-05	3.8637E-05	3.8637E-05
C	2.8167E-04	6.5351E-04	1.5948E-04	3.5158E-04	2.6343E-04	2.4762E-04
SI	6.0229E-04	9.7623E-04	7.7474E-04	8.2197E-04	6.4389E-04	9.5110E-04
P	7.3471E-05	4.7540E-05	5.2334E-05	6.2274E-05	6.8560E-05	4.5654E-05
S	3.6808E-05	3.3014E-05	2.4551E-05	1.6431E-05	1.7190E-05	2.3793E-05
TI		2.4400E-04				
CR	1.4995E-02	1.4380E-02	1.4132E-02	1.3563E-02	1.3830E-02	1.3837E-02
MN	1.2214E-03	1.1060E-03	8.3089E-04	1.0026E-03	9.6934E-04	8.6191E-04
FE	4.8911E-02	4.7118E-02	5.0764E-02	4.7151E-02	4.9404E-02	4.8404E-02
CO		1.1151E-05				
NI	7.2440E-03	7.4526E-03	7.6658E-03	6.4549E-03	7.2532E-03	6.8530E-03
CU		1.0341E-05				
MO		3.4248E-06	2.4862E-05	8.8791E-06	8.8791E-06	2.4862E-05
Total	7.3405E-02	7.2074E-02	7.4469E-02	6.9470E-02	7.2497E-02	7.1288E-02

Table 3.M37 Atomic Densities of the Walls Scaled by the Factor 0.30682
(Atoms/barn.cm)

Element	NACLI	NACLIIS	NACLIH	NACLIV	NACLV	VCLVI
H	1.2225E-05	1.1855E-05	1.2225E-05	1.1484E-05	1.1855E-05	1.1855E-05
C	8.6422E-05	2.0051E-04	4.8932E-05	1.0787E-04	8.0826E-05	7.5975E-05
AL						
SI	1.8479E-04	2.9953E-04	2.3771E-04	2.5220E-04	1.9756E-04	2.9182E-04
P	2.2542E-05	1.4586E-05	1.6057E-05	1.9107E-05	2.1036E-05	1.4008E-05
S	1.1293E-05	1.0129E-05	7.5327E-06	5.0414E-06	5.2742E-06	7.3002E-06
TI		7.4864E-05				
CR	4.6008E-03	4.4121E-03	4.3360E-03	4.1614E-03	4.2433E-03	4.2455E-03
MN	3.7475E-04	3.3934E-04	2.5493E-04	3.0762E-04	2.9741E-04	2.6445E-04
FE	1.5007E-02	1.4457E-02	1.5575E-02	1.4467E-02	1.5158E-02	1.4851E-02
CO		3.4213E-06				
NI	2.2226E-03	2.2866E-03	2.3520E-03	1.9805E-03	2.2254E-03	2.1026E-03
CU		3.1728E-06				
MO		1.0508E-06	7.6282E-06	2.7243E-06	2.7243E-06	7.6282E-06
Total	2.2522E-02	2.2114E-02	2.2849E-02	2.1315E-02	2.2244E-02	2.1873E-02

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Table 3.M38 Atomic Density of the Calandria Walls and Sheath Combined
(Atoms/barn.cm)

Element	NACLI	NACLIIS	NACLIIS	NACLIV	NACLIV	VCLVI
H	3.4252E-05	3.3882E-05	3.4252E-05	3.3511E-05	3.3882E-05	3.3882E-05
C	1.5574E-04	2.6983E-04	1.1825E-04	1.7719E-04	1.5014E-04	1.4529E-04
AL	5.7600E-06	5.7600E-06	5.7600E-06	5.7600E-06	5.7600E-06	5.7600E-06
SI	1.8479E-04	2.9953E-04	2.3771E-04	2.5220E-04	1.9756E-04	2.9182E-04
P	2.2542E-05	1.4586E-05	1.6057E-05	1.9107E-05	2.1036E-05	1.4008E-05
S	1.1293E-05	1.0129E-05	7.5327E-06	5.0414E-06	5.2742E-06	7.3002E-06
TI		7.4864E-05				
CR	4.6018E-03	4.4131E-03	4.3370E-03	4.1625E-03	4.2444E-03	4.2465E-03
MN	4.4951E-04	4.1410E-04	3.2969E-04	3.8238E-04	3.7217E-04	3.3921E-04
FE	3.7562E-02	3.7011E-02	3.8130E-02	3.7022E-02	3.7713E-02	3.7406E-02
CO		3.4213E-06				
NI	2.2268E-03	2.2908E-03	2.3562E-03	1.9847E-03	2.2296E-03	2.1068E-03
CU	6.4634E-06	9.6362E-06	6.4634E-06	6.4634E-06	6.4634E-06	6.4634E-06
MO		1.0508E-06	7.6282E-06	2.7243E-06	2.7243E-06	7.6282E-06
Total	4.5261E-02	4.4852E-02	4.5587E-02	4.4053E-02	4.4982E-02	4.4611E-02

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The above tabular values are here repeated in text form:

**Compositions of the combined calandria walls and sheath, homogenised over the region
between the inner surface of the calandria wall (4.9cm square) and the lattice cell
boundary (5.4254 cm square)**

NACLI

H	3.4252E-05	C	1.5574E-04	AL	5.7600E-06	SI	1.8479E-04
P	2.2542E-05	S	1.1293E-05	CR	4.6018E-03	MN	4.4951E-04
FE	3.7562E-02	NI	2.2268E-03	CU	6.4634E-06		

NACLIIS

H	3.3882E-05	C	2.6983E-04	AL	5.7600E-06	SI	2.9953E-04
P	1.4586E-05	S	1.0129E-05	TI	7.4864E-05	CR	4.4131E-03
MN	4.1410E-04	FE	3.7011E-02	CO	3.4213E-06	NI	2.2908E-03
CU	9.6362E-06	MO	1.0508E-06				

NACLIH

H	3.4252E-05	C	1.1825E-04	AL	5.7600E-06	SI	2.3771E-04
P	1.6057E-05	S	7.5327E-06	CR	4.3370E-03	MN	3.2969E-04
FE	3.8130E-02	NI	2.3562E-03	CU	6.4634E-06	MO	7.6282E-06

NACLIV

H	3.3511E-05	C	1.7719E-04	AL	5.7600E-06	SI	2.5220E-04
P	1.9107E-05	S	5.0414E-06	CR	4.1625E-03	MN	3.8238E-04
FE	3.7022E-02	NI	1.9847E-03	CU	6.4634E-06	MO	2.7243E-06

NACLV

H	3.3882E-05	C	1.5014E-04	AL	5.7600E-06	SI	1.9756E-04
P	2.1036E-05	S	5.2742E-06	CR	4.2444E-03	MN	3.7217E-04
FE	3.7713E-02	NI	2.2296E-03	CU	6.4634E-06	MO	2.7243E-06

VCLVI

H	3.3882E-05	C	1.4529E-04	AL	5.7600E-06	SI	2.9182E-04
P	1.4008E-05	S	7.3002E-06	CR	4.2465E-03	MN	3.3921E-04
FE	3.7406E-02	NI	2.1068E-03	CU	6.4634E-06	MO	7.6282E-06

Atomic densities for the UO₂ fuel pin canning plus the tube in the calculational model which combines them over the area between the UO₂ pin and the tube outer boundary.

Table 3.M39 Atomic Densities for the UO₂ Fuel Pin Canning Plus the Tube
(Atoms/barn.cm)

Nuclide	UO ₂ PINC can	Scaled	Scaled tube	Combined can and tube
factor		x 0.4055318		
H	2.6710E-05	1.0832E-05		1.0832E-05
C	1.3288E-04	5.3887E-05		5.3887E-05
SI	8.5585E-04	3.4707E-04	3.1584E-04	6.6291E-04
P	3.7870E-05	1.5357E-05		1.5357E-05
S	2.4585E-05	9.9700E-06		9.9700E-06
CR	1.8255E-02	7.4030E-03	4.9869E-03	1.2390E-02
MN	1.5681E-03	6.3591E-04	4.0366E-04	1.0396E-03
FE	5.9792E-02	2.4248E-02	1.8050E-02	4.2298E-02
NI	8.9349E-03	3.6234E-03	2.2090E-03	5.8324E-03
Total	8.9628E-02	3.6347E-02	2.5966E-02	6.2313E-02

The above tabular values are here repeated in text form:

Atomic densities for the combined UO₂ fuel pin can and tube

H 1.0832E-05 C 5.3887E-05 SI 6.6291E-04 P 1.5357E-05
S 9.9700E-06 CR 1.2390E-02 MN 1.0396E-03 FE 4.2298E-02
NI 5.8324E-03

3.1.4 Temperature data.

The reference temperature is 300K.

3.1.5 Experimental and Benchmark Model keff Parameters

The values given in this section are for the Reference Model, Model A.

The k_{eff} values of the 4 critical systems, and the associated uncertainties are given in the following Table 3.2.

Table 3.2 K_{eff} values and Uncertainties

	Core 22	Core 23	Core 24	Core 25
	Plate geometry Sodium present	Pin geometry Sodium present	Plate geometry Sodium voided	Pin geometry Sodium voided
k-values of Reference Models	1.00217 ± 0.00077	1.00162 ± 0.00127	1.00228 ± 0.00077	1.00132 ± 0.00127

In the comparisons with calculation these have been reduced to 4 places of decimals.

The pin geometry cores with plate geometry zones at the centre are to be calculated as critical assemblies, but it is the differences between the values calculated for these cores and for the pin geometry cores which are to be compared with measurement.

For the version of Core 23 with the 45 element plate zone at the centre
the difference in k_{eff} relative to Core 23 is:

$(+12.75 \pm 3.1) \times 10^{-4} \text{ dk/k}$, implying a k_{eff} value for the core of **1.00290 ± 0.00131**

For the version of Core 25 with the 69 element plate zone at the centre
the difference in k_{eff} relative to Core 25 is:

$(+0.49 \pm 4.1) \times 10^{-4} \text{ dk/k}$, implying a k_{eff} value for the core of **1.00137 ± 0.00133**

In addition to the k_{eff} values the differences between the values of k_{eff} for the different cores are to be derived. The uncertainties associated with these differences are as follows.

Table 3.3 Uncertainties affecting the Comparison of k_{eff} values for Pin versus Plate Geometry Cores

Assembly	22	23	24	25
Type	Na-Flooded Plate	Na-Flooded Pin	Na-Voided Plate	Na-Voided Pin
Total relative uncertainty	± 0.00131		± 0.00130	

Table 3.4 Uncertainties affecting the Comparison of k_{eff} values for Sodium Filled versus Sodium Voided Cores

Assembly	22	24	23	25
Type	Na-Flooded Plate	Na-Voided Plate	Na-Flooded Pin	Na-Voided Pin
Total relative uncertainty	± 0.00036		± 0.00088	

Table 3. 5 Uncertainties affecting the Comparison of k_{eff} values for the central plate zones in the pin geometry cores, Assembly 23 and 25

Assembly	23	23+Central plate zone	25	25+Central plate zone
Type	Na-Flooded	Na-Voided	Na-Flooded	Na-Voided
Total relative uncertainty	± 0.00031		± 0.00041	

Results obtained using Monte Carlo methods for simplified models.

Several ways in which the representation of the cores can be simplified have been explored, these being illustrated in Figure 3.1, 3.2 and 3.18. Calculations have been made using different ways to represent the element sheaths and to treat the superlattice spacings and grid plates (Models B and C).

There is a gap between the sheath and the plates and also between the sheath and the lattice boundary in the most detailed model, Model A. Homogenising the sheath over these inner and outer gaps (that is, over the area between the 5.067 cm square area of the plates and the 5.3721 cm square lattice area), and still representing the gaps between the 5x5 element superlattices and the lattice grid plates, produces Model B.

In Model C a uniform lattice of 5.4254 cm square lattice cells is adopted over the whole reactor and the sheath is homogenised over the space between the plates and the cell boundary (that is, over the area between the 5.067 cm square area of the plates and the 5.4254 cm square lattice cell area corresponding to the average spacing over the superlattices). This also eliminates the gaps between the 5x5 element superlattices and slightly changes the positions of the elements.

In Model CS a further simplification is made that there is just one type of core element. Model CS is the same as Model C for Assembly 22 because this core has only one type of element. In Assembly 24, the sodium plates of Assembly 22 are replaced by so-called “dummy” plates containing approximately the same quantity of steel and having about the same thickness as the sodium plates. There is a slight difference in thickness because the sodium plates are measured to be compressed by the weight of the stack of plates above and this difference is taken into account in the models. Three different “dummy” plates were used but the simplified Model CS uses just one type of “dummy” plate.

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In the case of the simplified MCNP models CS of the Cadenza pin geometry cores, Assemblies 23 and 25 a further approximation has been made. There is an outer ring of plate geometry elements in these cores and these have been replaced in the simplified models by pin geometry elements. In Zebra 23 the effect of replacing 44 plate elements in the outer radial ring (out of the total in the ring of 49 plate elements) by pin elements was measured to be a reduction in reactivity of 0.7×10^{-4} dk. In Zebra 25 the reactivity effect of replacing 66 of the 69 plate elements by pin geometry elements was measured to be a reduction in reactivity of 2.1×10^{-4} dk. These reactivity changes are small compared with the uncertainty in the measured reactivities of these cores and so it is considered acceptable to make this approximation. Furthermore the cores have been approximated as containing just the one type of pin geometry element, the dominant one, type C, containing the pins of type A and E.

Calculations have been made using the MCNP Monte Carlo code (Los Alamos National Laboratory, X-5 Monte Carlo Team) to estimate the effects of these different approximations.

Table 3.6A Comparison of MCNP/JEFF-3.1 k-eff values Calculated using Different Models

	Assembly 22	Assembly 23	Assembly 24	Assembly 25
Reference Model A	1.00614 ± 0.00015 1.00619 ± 0.00014	1.00836 ± 0.00016 1.00826 ± 0.00016	1.00482 ± 0.00015	1.00687 ± 0.00015
Model B	1.00639 ± 0.00016	1.00831 ± 0.00014	1.00526 ± 0.00016	1.00723 ± 0.00014
B - A	+0.0002 ± 0.0002	0.0000 ± 0.0002	+0.0004 ± 0.0002	+0.0004 ± 0.0002
Model C	1.00594 ± 0.00015	1.00849 ± 0.00014	1.00495 ± 0.00015	1.00722 ± 0.00015
C - A	-0.0002 ± 0.0002	+0.0002 ± 0.0002	+0.0001 ± 0.0002	+0.0004 ± 0.0002
Model CS		1.00818 ± 0.00015	1.00499 ± 0.00016	1.00668 ± 0.00015
CS - A		-0.0002 ± 0.0002	+0.0002 ± 0.0002	-0.0002 ± 0.0002

The quoted standard deviations are the ones calculated by MCNP from the variation about the mean for individual stages of the calculation. However, other factors can affect the accuracy of results, such as the initial fission source distribution, the number of settling stages and the number of histories per stage. Calculations made for the pin geometry Assemblies 23 and 25 have shown some convergence problems, in particular for the sodium voided Assembly 25, and so the number of settling stages has been increased from 100 to 200 for Assembly 25. There is also the question of how accurately the modelling is being reproduced in the code, representing the arrays of components within cells, cells within elements, forming groups of elements and then arrays of these groups.

The results looks to be consistent. The differences between the MCNP/JEFF-3.1 calculations for models A and B, and between models A and CS range up to 0.0004 ± 0.0002 .

It is concluded that Models A, B, C and CS are equally valid as representations of the assemblies and the same measured value of k-effective can be used for all of these models of the assemblies.

Models D and E. Calculations have also been made using the MONK Monte Carlo code (SercoAssurance, Winfrith, UK) for modified versions of Model C in which the blanket and shield (or reflector) regions are homogenised with the sheath or neighbouring void regions to produce radially homogeneous blanket and shield regions (Model D). Simplifications to the core cells have also been explored in Model E. In the case of the plate cells the sheath has been homogenised with the neighbouring plate canning material so as to reduce to two radial regions the representation of the plates in a lattice cell. The pin cells have been simplified by combining the cans and calandria tubes and combining calandria walls and sheath (eliminating void gaps).

Table 3.6B Comparison of MONK/JEF-2.2 k-effective values Calculated using Different Models

	Assembly 22	Assembly 23	Assembly 24	Assembly 25
Reference Model A	1.0005 ± 0.0001	1.0038 ± 0.0001	1.0000 ± 0.0001	1.0032 ± 0.0001
Model D	1.0013 ± 0.0003	1.0058 ± 0.0002	1.0009 ± 0.0003	1.0046 ± 0.0002
D - A	0.0008 ± 0.0003	0.0020 ± 0.0003	0.0016 ± 0.0003	0.0021 ± 0.0003
Model E	1.0027 ± 0.0002	1.0059 ± 0.0002	1.0023 ± 0.0002	1.0049 ± 0.0002
E - A	0.0022 ± 0.0002	0.0021 ± 0.0003	0.0023 ± 0.0003	0.0017 ± 0.0003

If Model D or E is used it is recommended that the measured value of k-effective be increased by 0.0015 and the uncertainty be increased by ± 0.0010.

3.2 Benchmark-Model Specifications for Buckling and Extrapolation-Length Measurements

Not measured

3.3 Benchmark-Model Specifications for Spectral Characteristics Measurements

3.3.1 Description of the Calculational Methodology and Model

Central Reaction Rate Ratios in Assembly 22.

These are to be calculated using the criticality model of Assembly 22. There are two types of measurement, the cell averaged reaction rate ratio in the central region of the core and the measurement on the mid-plane of a half element at the centre of the reactor.

The measured cell averaged value is to be compared with the ratios of the calculated components of the neutron balance for the central cell (or a central group of cells) of the reactor divided by the cell averaged atomic density of the material. This can be calculated using either Monte Carlo or a whole reactor calculation made using homogenised cell averaged cross-sections derived in the usual way from cell calculations.

For the calculation of the fission chamber measurements the half-element at the centre of the core should be modelled and the fission rates calculated in the flux at the central surface of the half element. Alternatively, supplementary cell calculations could be made relating the reaction rate at the boundary of the cell plus the average rate through the cell (not the cell averaged rate, which is the rate weighted with the atomic density of the material) to the cell averaged value. A method which has been used is to combine the value calculated for the upper surface of the sodium plate (or within the sodium plate) with the cell flux averaged value, because half of the flux incident on the foil comes from above and originates from the edge regions of all the plates in a cell.

3.3.2 Dimensions

Any of the models described in Section 3.1 as suitable for making criticality calculations for Assembly 22 would also be suitable for calculating the central spectral indices.

3.3.3 Material Data

See Section 3.1.

3.3.4 Temperature Data

Records of the temperature at which the measurements were performed are not available. For the purposes of the calculations, the models and temperatures used for the criticality calculations can be adopted.

3.3.5 Experimental and Benchmark Reaction Rate Ratios

The measured values which are to be compared with calculation are those given in Table 2.12, reproduced on the next page.

Table 3.8 Recommended Reaction Rate Ratio Measurements in the Central Region of Assembly
22

Reaction rate ratio	Measured by AEEW team	Total uncertainty in Recommended Benchmark Values
F28/F25 (Cell Average)	0.03634	±1.3%
F25/F49 (Cell Average)	0.959	±1.6%
C28/F49 (Cell Average)	0.1266	±1.1%
F28/F25 (Chamber)	0.03483	±4.3%
F25/F49 (Chamber)	0.960	±1.6%
F40/F49 (Chamber)	0.2594	±4.6
F41/F49 (Chamber)	1.217	±4.0%

It should also be noted that intercomparison measurements have shown significant differences between the measurements made by different groups and they could all be affected by unidentified systematic uncertainties associated with the techniques used by the group.

Table 3.9 Possible systematic uncertainties associated with the Zebra techniques

Reaction rate ratio	Uncertainty
F28/F25 (Cell Average)	± 3%
F25/F49 (Cell Average)	± 1%
C28/F49 (Cell Average)	± 3%
F28/F25 (Chamber)	± 3%
F25/F49 (Chamber)	± 1%

3.4 Benchmark-Model Specifications for Reactivity Effects Measurements

3.4.1 Description of the Calculational Methodology and Model

The types of measurement considered here are the element replacement measurements and the modified cell measurements (including the sodium voiding measurements). Depending on the size of the change it can be calculated either by direct calculation of the k_{eff} values for the modified system, relative to the unperturbed critical assembly, or using perturbation theory methods. It is the whole element, or group of 9 elements, or group of cells, which must be calculated and not simply a perturbation theory calculation for the addition or replacement of the single material component. This is so that the effects of the changes in spectra on the cross-sections of neighbouring materials (such as changes in resonance shielding) are taken into account. Also, it should be noted that a correction has already been applied to the measured value for any change in core height resulting from the replacement of a component in the cells. This requires that atomic densities must be used which are consistent with the dimensions remaining unaltered.

The reactivity changes can be considered relative to a standard, such as the change in plutonium enrichment, or in absolute terms, when the $\pm 5\%$ systematic uncertainty in the absolute reactivity scale must be applied.

Both standard components (as described in Section 3.1) and special components (as described in Section 3.4.2 and 3.4.3) are involved in the measurements. These should be used together with the criticality models described in Section 3.1.

3.4.2 Dimensions

Any of the XYZ geometry models described in Section 3.1 as suitable for making criticality calculations would also be suitable as the unperturbed core to which the perturbation is to be applied.

3.4.3 Material Data

The standard core materials are described in Section 3.1.

Components used in Reactivity Worth Experiments and in Non-Standard Elements.

Alternative plutonium plates (*Corrected for Pu-241 decay*)

The plutonium plates used in the cells D (PUIX8) and E (PUX8) are compared here with the plate used in the standard element cells C (PUVIII8).

The can thickness of all plates is 0.0457 cm. All plates are taken to have the same thickness as the standard PUVIII8 plate, 0.3274 cm and the same core thickness of 0.2360 cm

Core region thickness 0.236 cm, width 4.671 cm, volume = 5.1491 cm³

Plate thickness 0.3274 cm, assumed width 5.067 cm, volume of canning = 3.2567 cm³.

Table 3.M40 Atomic Densities for the Alternative Core Region Plutonium Plates

CORE REGION (atoms/barn.cm)

Plate	PUVIII8	PUIX8	PUX8
H	1.2764E-04	1.5085E-04	1.0443E-04
C	4.2260E-04	2.8043E-04	2.9406E-04
N	2.4215E-05	9.1849E-06	1.0020E-05
O	8.8450E-05	5.7017E-05	4.5322E-05
AL	2.2973E-05	2.2973E-05	2.1673E-05
SI	1.4158E-05	2.8317E-05	1.5824E-05
CR	3.5989E-06	6.0731E-06	4.2737E-06
MN	1.4902E-06	1.7031E-06	1.0644E-06
FE	1.6335E-05	1.2984E-05	1.4869E-05
NI	8.5688E-06	2.6703E-05	1.6141E-05
GA	2.0166E-03	2.1106E-03	2.2328E-03
U238	6.8782E-07	5.2569E-06	1.4248E-06
PU238	3.0461E-05	3.5374E-05	3.3899E-05
PU239	2.8919E-02	2.8880E-02	2.8991E-02
PU240	6.9095E-03	6.9197E-03	6.8842E-03
PU241	7.2648E-04	7.3353E-04	7.3004E-04
PU242	1.8698E-04	1.7974E-04	1.8457E-04
AM241	4.7029E-04	4.6228E-04	4.3486E-04
Total	3.9990E-02	3.9922E-02	4.0021E-02

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CAN REGION Atomic Densities (atoms/barn.cm)

	PUVIII8	PUIX8	PUX8
H	1.3760E-05	1.3760E-05	1.3576E-05
C	1.1393E-04	1.1303E-04	1.2040E-04
SI	3.6607E-04	3.6500E-04	5.1983E-04
P	1.3731E-05	1.3414E-05	2.6680E-05
S	0.0000E+00	0.0000E+00	1.5459E-05
TI	0.0000E+00	0.0000E+00	5.7544E-06
CR	9.4011E-03	9.3780E-03	9.9599E-03
MN	8.5931E-04	8.5733E-04	8.5240E-04
FE	3.5542E-02	3.5455E-02	3.3817E-02
NI	4.1646E-03	4.1542E-03	4.8344E-03
CU	1.6613E-02	1.6613E-02	1.6855E-02
Total	6.7088E-02	6.6962E-02	6.7020E-02

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Table 3.M41 Atomic Densities for the Half-thickness Plutonium Plate, PUJ16

Values corrected for Pu241 decay to June 1981 (Pu-241 half-life = 14.35 years, $\lambda = 0.0483$), Factor = 0.605.

Core region: core height 0.115 cm, width 4.76 cm, core volume = 2.6056cm³

	Atoms/barn.cm
Nuclide	
AL	4.0431E-03
PU238	7.7672E-06
PU239	3.1183E-02
PU240	2.7112E-03
PU241	1.5720E-04
PU242	1.5277E-05
AM241	1.0839E-04
Total	3.8226E-02

Can region: plate height 0.155 cm, width assumed in model 5.067 cm, can thickness = 0.02 cm, can volume = 1.3739 cm³.

	Atoms/barn.cm
Nuclide	
C	1.4597E-04
SI	9.4733E-04
P	2.8303E-05
S	2.0501E-05
TI	2.7738E-04
CR	1.5341E-02
MN	1.0085E-03
FE	5.4969E-02
NI	7.9277E-03
Total	8.0666E-02

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Table 3.M42 Atomic Densities for the Mixed Oxide Plate used in the Plutonium Enrichment and Element Replacement Measurements, PUIV4.

(Corrected for Pu241 decay)

Core region volume = 13.4708 cm³

Nuclide	Atoms/barn. cm
C	6.2529E-05
O	4.3173E-02
AL	2.7835E-05
SI	2.6741E-05
FE	1.3448E-05
NI	1.2797E-05
U234	7.6405E-07
U235	1.1640E-04
U238	1.6054E-02
NP237	1.8859E-07
PU239	4.8080E-03
PU240	5.3746E-04
PU241	3.2762E-05
PU242	4.8018E-06
AM241	4.4331E-05
Total	6.4915E-02
Core height	0.55312 cm
Core width	4.953 cm

Can region dimensions: Plate width assumed in model = 5.067 cm, can volume = 2.64764 cm³

Nuclide	Atoms/barn. cm
H	1.9408E-05
C	1.6248E-04
SI	5.6978E-04
P	2.5202E-05
S	2.4341E-05
CR	1.3437E-02
MN	1.0586E-03
FE	4.8552E-02
NI	6.6436E-03
NB	2.7307E-04
Total	7.0765E-02
Plate height	0.6278 cm
Can thickness	0.03734 cm

(The ZEBRA Database value of the TOTAL PLATE WIDTH is slightly less ----- 5.0620 cm)

Table 3.M43 Atomic Densities for the Plutonium Plate PUII8

(Corrected for Pu-241 decay)

Core region: thickness = 0.2159 cm, width = 4.671 cm, Volume = 4.71056 cm³

Nuclide	Atoms/barn.cm
H	1.5221E-04
C	1.0431E-04
AL	4.6434E-05
SI	4.4609E-05
FE	2.2434E-05
NI	2.1347E-05
GA	2.3470E-03
NP237	1.2404E-05
PU239	3.6094E-02
PU240	1.8693E-03
PU241	6.1607E-05
AM241	8.5037E-05
Total	4.0861E-02

Can region: plate thickness = 0.3175 ±0.0005 cm, plate width = 5.067 cm

Can thickness = 0.0508 cm, can volume = 3.44109 cm³

Nuclide	Atoms/barn.cm
H	1.4064E-05
C	1.6451E-04
SI	3.4173E-04
P	1.8227E-05
S	1.7604E-05
CR	9.8481E-03
MN	4.8299E-04
FE	3.6019E-02
NI	4.4298E-03
Additional material	
CU	1.6166E-02
Overall total	6.7502E-02

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Table 3.M43B Atomic Densities for the Uranium Oxide Plate UO₂R4 a component in the Mixed Oxide Plate Element C22±04A used in the Element Replacement Measurements.

This plate contains silver-copper braze material, which can have a significant effect on reactivity. However there are only 11 of these plates in a C22±04A element (one per cell, CC22-06A).

CORE

Material	Atoms/barn.cm
Volume	13.0425 (cm ³)
H	2.4503E-05
C	3.0842E-05
O	4.5733E-02
SI	1.3190E-05
FE	6.6332E-06
U234	1.1871E-06
U235	1.6462E-04
U238	2.2694E-02
Total	6.8668E-02
Core thickness	0.55424 cm
Core width	4.851 cm

CAN

Material	Atoms/barn.cm
Volume	3.0785 (cm ³)
H	1.7335E-05
C	1.4546E-04
SI	6.0964E-04
P	2.2563E-05
S	2.1792E-05
CR	1.2365E-02
MN	9.7951E-04
FE	4.3411E-02
NI	6.0134E-03
CU	8.1603E-04
AG	1.2368E-03
TOTAL	6.5639E-02
Can thickness	0.03683 cm
Plate thickness	0.6279 cm
Plate width	5.067 cm

TOTAL VOLUME ----- 16.1210 (cm³)

Table 3.M44 Stainless Steel Plates STSTBR8 (bright) and STSTD8 (dull) used in the Reactivity Worth Measurements

	STSTBR8	STSTD8
Volume	8.14395 cm ³	8.30826 cm ³
Nuclide	Atoms/barn.cm	Atoms/barn.cm
H	2.3265E-05	2.3115E-05
C	7.8091E-04	7.7587E-04
AL	1.7381E-04	1.7269E-04
SI	1.3358E-03	1.3272E-03
TI	2.9384E-04	2.9195E-04
CR	1.6325E-02	1.6220E-02
MN	9.3901E-04	9.3295E-04
FE	5.8278E-02	5.7902E-02
NI	7.7510E-03	7.7009E-03
CU	7.3801E-05	7.3324E-05
MO	9.7764E-05	9.7133E-05
Total	8.6072E-02	8.5517E-02
Plate width	5.067 cm	5.067 cm
Plate thickness	0.3172 cm	0.3274 cm

Table 3.M45 GII8 Graphite Plate used in the Reactivity Worth Measurements

Nuclide	Atoms/barn.cm
Volume	8.15807 cm ³
H	2.0286E-05
C	8.5101E-02
S	1.2751E-06
FE	1.8306E-06
TOTAL	8.5125E-02
Plate width	5.067 cm
Plate thickness	0.31775 cm

Table 3.M46 AL₂O₃ Aluminium Oxide Plate used in the Reactivity Worth Measurements

Nuclide	Atoms/barn.cm
Volume	16.21858 cm ³
H	5.1483E-05
B10	4.5063E-06
B11	1.6599E-05
O	6.6386E-02
AL	4.4240E-02
TOTAL	1.1070E-01
Plate width	5.067 cm
Plate thickness	0.6317 cm

Table 3.M47 ALG8 Aluminium Plate used in the Reactivity Worth Measurements

Nuclide	Atoms/barn.cm
Volume	8.1311 cm ³
AL	5.9345E-02
SI	5.8135E-06
MN	1.7122E-06
FE	8.3580E-05
CU	1.0248E-06
Total	5.9437E-02
Plate width	5.067 cm
Plate thickness	0.3167 cm

STSTSR4

This plate corresponds approximately, in weight and dimensions, to a sodium "dummy" plate (weight 17.60 g). It replaces a UO₂ plate in the reactivity perturbation measurements. In the absence of data it is suggested that the "dummy" plate STNAV4 be used as a replacement for it in calculations.

The pins used in the reactivity worth measurements

The total length of the pins is 29.5 cm.
For all pins the recommended radius is 0.4685 cm:

Table 3.M48 MSTPINA The Mild Steel Pin

Note: The hydrogen content assumes that it was present as 5 ppm of the steel and as 4 mg/cm² in the MkII blacking.

Nuclide	Atoms/barn.cm
Volume	20.3419 cm ³
H	3.4660E-05
C	6.1620E-04
SI	8.4327E-05
P	2.4851E-05
S	6.9234E-05
MN	6.8975E-04
FE	8.5876E-02
Total	8.7395E-02

The compositions given in the ZEBRA Database do not include trace impurities for the following components.

Two "6 inch" pins were used, giving a total length of 29.5 cm. To indicate that the weights refer to the two pins a number 2 is placed in front of the component identifier.

Table 3.M49 The Pins, 2ALPINA, 2ALOPINA and 2CPINA

2ALPINA

	Weight	Atoms/barn.cm
AL	55.34 g	6.0719E-02

2ALOPINA

	Weight	Atoms/barn.cm
O	35.88 g	6.6391E-02
AL	40.32 g	4.4239E-02
Total	76.20 g	1.1063E-01

2CPINA

	Weight	Atoms/barn.cm
C	35.04 g	8.6365E-02

3.4.4 Temperature data.

The temperature was not specified. The temperature of the criticality model is 300K and this should be used for the reactivity worth measurements.

3.4.5 Experimental and Benchmark Model Reactivity Worth Measurements

The measured values to be calculated are tabulated in Section 1.4.7 and are as follows:

Element replacements: Section 1.4.7.2, Tables 1.17 to 1.20.

Plutonium addition measurements: Section 1.4.7.3, Table 1.21.

Changes in cell heterogeneity: Section 1.4.7.4, Table 1.22.

Cell component replacement measurements: Section 1.4.7.5, Tables 1.23 to 1.29.

Sodium voiding reactivity measurements: Section 1.4.7.6, Tables 1.31 and 1.32.

3.5 Benchmark-Model Specifications for Reactivity Coefficient Measurements

Not considered as benchmarks.

3.6 Benchmark-Model Specifications for Kinetics Measurements

Not considered as a benchmark.

3.7 Benchmark-Model Specifications for Reaction Rate Distribution Measurements

3.7.1 Description of the Calculational Methodology and Model

The criticality model must be modified to take into account a possible asymmetry introduced by the asymmetrical loadings of the control rods, with an absorber section being at the top ends of the rods and the regulating rod being partly inserted.

3.7.2 Dimensions of the Zebra Control Rods

In addition to the data for the critical core models given in Section 3.1.2 the control rod dimensions and compositions are required, unless some other method is used to allow for the axial tilt.

The materials used in the control rods were chosen to match the core and blanket regions of the neighbouring elements but with a boron absorber section above the upper blanket region. The blanket regions consist of natural uranium plates. The 9 control rods occupy the places of single elements. The control rods were loaded so that when raised the centre line of the core section coincided with the centre line of the core section of the standard core elements. When lowered, the centre line of the boron absorber section took that position. In the experiments requiring a representation of the rods all of the rods can be treated as in the withdrawn position excepting for the fine regulating rod FR9.

The control rods comprise a square tube moving within an outer square tube. The inner tube is loaded with plates. All plates are assumed to be 4.318 cm square (an area of 18.6451 cm²). The control rod outer tube has an assumed outer dimension of 5.2544 cm square, the same as the standard elements. Details of the dimensions and components of the rods are given in Section 1.1 but the components and dimensions are repeated here for convenience.

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Table 3.D24 Control Rod Components and Dimensions

Control Rod Plate Identifiers (All plates are 4.318 cm square)

Identifier	Type of Plate	Thickness (cm)
PUXIVC8	Pu metal Mk.XIV	0.3207
U02C4R4	U02 (4 radiused corners)	0.6279
NASTMC4	Sodium	0.616
STSTCF8	Stainless steel	0.3180
UC8	Natural uranium	0.3167
ALCG8	45% aluminium	0.3167
B10C2	B10	1.27

Control rod sheath

Identifier	Type of sheath
CRSHEATH	Single element rod

Control Rod Cells

Core region		Boron absorber region cell patterns		
		Cell CB22-02A	Cell CB22-03A	Cell CB22-04A
NASTMC4		ALCG8	3 x ALCG8	10 x ALCG8
U02C4R4		B10C2	B10C2	B10C2
PUXIVC8		2 x ALCG8	5 x ALCG8	19 x ALCG8
U02C4R4		B10C2	B10C2	B10C2
STSTCF8		2 x ALCG8	5 x ALCG8	10 x ALCG8
NASTMC4		B10C2	B10C2	
U02C4R4		ALCG8	3 x ALCG8	
PUXIVC8		B10C2		
U02C4R4		2 x ALCG8		
NASTMC4		B10C2		
		2 x ALCG8		
		B10C2		
		ALCG8		
Cell height		Cell height		
5.319 cm		11.104 cm	8.877 cm	14.891 cm

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Control Elements

Region	Element Type C22-02B Rods 1, 2, 3, 4, 5, 6	Element Type C22- 02C Rods 5+6	Element Type C22-02D Rod 9	Height (cm)
Top blanket	23 x UC8	23 x UC8	22 x UC8	See note (a),
Absorber	8 x CB22-02A	10 x CB22-03A	6 x CB22-04A	See note (b)
Middle blanket	95 x UC8	95 x UC8	94 x UC8	See note (c)
Core	17xCC22-04A	17xCC22-04A	17xCC22-04A	90.42
Lower blanket	178 x UC8	178 x UC8	178 x UC8	56.37

Notes:

(a) 23 UC8 plates have a height of 7.28 cm and 22 a height of 6.97 cm.

(b) Absorber section lengths are:

C22-02B 88.83 cm

C22-02C 88.77 cm

C22-02D 89.35 cm

(c) The Height of the Upper Axial Blanket regions are:

Rods 1 to 8 30.09 cm

Rod 9 29.77 cm

Note: The heights of the UC8 regions differ from those given in ZTN22-1 and ZTN22-11, the thickness of the plates used here being the ZEBRA Database value of 0.3167 cm (and not the value 0.3176 used in ZTN22-1 and ZTN22-11). The height of the core section also differs by 0.03 cm per cell. There are also small differences in the heights of the absorber sections which have been kept consistent with the adopted plate thicknesses.

3.7.3 Compositions of the Zebra Control Rods

Table 3.M50 Control Rod Plate PUXIVC8
PLATE CORE COMPOSITION
(Corrected for Pu241 decay)

Nuclide	Atomic density Atoms/barn.cm
H	1.7728E-04
C	2.2315E-04
N	1.2757E-05
O	6.7010E-05
AL	2.6490E-05
SI	1.9086E-05
TI	3.7321E-06
CR	6.8731E-06
FE	9.5989E-06
NI	1.5223E-05
CU	2.8120E-06
ZN	2.7327E-06
GA	2.4398E-03
U238	9.0075E-06
NP237	7.5379E-07
PU238	4.2786E-05
PU239	3.1238E-02
PU240	6.9151E-03
PU241	7.8299E-04
PU242	2.0965E-04
AM241	3.1848E-04
Total	4.2524E-02
Volume, cm ³	3.37021

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PU PLATE CAN COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	1.1449E-05
C	1.1529E-04
SI	2.5475E-04
P	2.6079E-05
S	1.2234E-05
CR	8.0982E-03
MN	6.5536E-04
FE	2.8779E-02
NI	3.9746E-03
Cu	1.5254E-02
Total	5.7182E-02
Volume, cm ³	2.60927

Table 3.M51 Control Rod Plate UO2C4R4

PLATE CORE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	2.3728E-05
C	3.0136E-05
SI	1.2888E-05
FE	6.4814E-06
O	4.5094E-02
U234	1.1599E-06
U235	1.6225E-04
U238	2.2363E-02
Total	6.7694E-02
Volume, cm ³	9.3168

PLATE CAN COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	1.6246E-05
C	1.3633E-04
SI	5.7406E-04
P	2.1146E-05
S	2.0424E-05
CR	1.1579E-02
MN	9.1710E-04
FE	4.0652E-02
NI	5.6316E-03
CU	9.1180E-04
AG	1.3545E-03
Total	6.1815E-02
Volume, cm ³	2.3905

Table 3.M52 Control Rod Plate UC8

PLATE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
C	4.9248E-04
SI	2.1061E-04
FE	1.0592E-04
U235	3.3280E-04
U238	4.5875E-02
Total	4.7017E-02
Volume, cm ³	5.9049

Table 3.M53 Control Rod Plate STSTCF8 ("Reduced density" steel plate)

PLATE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
Volume (cm ³)	5.9291
H	7.0823E-06
C	3.3875E-05
AL	4.5770E-05
SI	3.0753E-04
P	1.5441E-05
S	5.5647E-06
TI	9.5714E-05
CR	6.1381E-03
MN	5.7769E-04
FE	2.1363E-02
NI	3.3946E-03
CU	1.9433E-05
NB	1.9293E-06
MO	3.1249E-05
Total	3.2037E-02

Table 3.M54 Control Rod Plate NASTMC4

PLATE CORE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	1.2233E-05
O	5.3944E-06
NA	2.2032E-02
CA	3.3840E-06
FE	1.1039E-07
Total	2.2053E-02
Volume, cm ³	9.7684

CAN COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	2.2640E-05
C	2.2777E-04
SI	8.3286E-04
P	3.3857E-05
S	1.7061E-05
CR	1.6869E-02
MN	1.3347E-03
FE	5.5256E-02
NI	8.3452E-03
NB	3.6038E-04
Total	8.3300E-02
Volume, cm ³	1.7170

Control Rod Absorber Regions

The absorber regions are made up from aluminium plates, ALCG8 and the boron plates, B10C2.

Table 3.M55 Control Rod Plate ALCG8
PLATE CORE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
AL	2.6702E-02
SI	4.8295E-05
MN	4.1768E-06
FE	3.2378E-05
CU	3.6110E-06
Total	2.6791E-02
Volume cm ³	5.9049

Table 3.M56 Control Rod Plate B10C2
PLATE CORE COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
H	2.2737E-04
B10	4.9962E-02
B11	3.9855E-03
C	7.3388E-04
O	7.5688E-04
AL	8.7111E-05
SI	1.5693E-04
K	6.0115E-05
CR	4.5203E-05
FE	7.3663E-05
NI	7.5095E-05
CU	3.6987E-05
Total	5.6200E-02
Volume cm ³	21.5479

PLATE CAN COMPOSITION

Nuclide	Atomic density
	Atoms/barn.cm
NI	1.7836E-01
Volume cm ³	2.1314

The Control Rod Sheath. (The combined inner and outer tubes)

Table 3.M57 Control Rod Sheath CRSHEATH

Nuclide	At density	At density	At density
Assumed Outer Width (cm)	5.2544	5.3721	5.4254
H	9.9986E-05	8.7743E-05	8.2535E-05
C	2.7968E-04	2.4543E-04	2.3086E-04
SI	9.5685E-05	8.3969E-05	7.8984E-05
P	2.1691E-05	1.9035E-05	1.7905E-05
S	2.0949E-05	1.8384E-05	1.7293E-05
MN	2.6904E-04	2.3610E-04	2.2208E-04
FE	4.4294E-02	3.8871E-02	3.6563E-02
Total	4.5081E-02	3.9561E-02	3.7213E-02
Area (cm ²)	8.9636	10.2143	10.8589

All plates are assumed to be 4.318 cm square and the control rod sheath has an assumed outer dimension of 5.2544 cm square, the same as the standard elements. The area occupied by the sheath material is then 8.9636 cm².

In addition, atomic number densities are given for smearing over the lattice area of 5.3721 cm square (an area occupied by the sheath material of 10.2143 cm²) and the average core lattice area (including the superlattice grid) of 5.4254 cm square (an area of 10.8589 cm²).

3.7.4 Temperature Data.

The temperatures were not specified. The temperature of the criticality models is 300K and this should be used for the reaction rate distribution measurements.

3.7.5 Experimental and Benchmark Reaction Rate Distribution Measurements

The Multi-chamber Scan Measurements of Pu239 Fission Rates

Results are given in Section 1.7.2C Figures 1.25A to E, for the measurement in Core 22B (normalised to the central value of 10,000) and in Figures 1.26A to E for the differences between the measurements in Core 24 and Core 22A, which have similar levels of control rod insertion. Account should be taken of the control rod insertion and of the boron absorber sections in the top sections of the control rods. The rod insertions are given below Figures 1.25 A and 1.26 A. Essentially it is only CR9 which is partly inserted, the other rods being in the withdrawn positions.

The control rod insertions corresponding to the Assembly 22 scan results given in Figures 1.25A to E are:

CR7 119.443 cm, CR8 119.738 cm, CR9 92.612 cm

For the differences between the Assembly 24 and Assembly 22 scans the rod insertions are:

Assembly 22A, (215 element core loading)

CR7 119.441 cm, CR8 119.751 cm, CR9 71.204 cm

Assembly 24 (222 element core loading)

CR7 119.443 cm, CR8 119.739 cm, CR9 66.331 cm

3.8 Benchmark-Model Specifications for Power Distribution Measurements

Not measured

3.9 Benchmark-Model Specifications for Isotopic Measurements

Not measured

3.10 Miscellaneous

No other types of measurement included.

4. RESULTS OF SAMPLE CALCULATIONS

Calculations of k_{eff} and central reaction rate ratios have been made using the MONK continuous energy Monte Carlo code and the nuclear data libraries, JEF-2.2, JENDL-3.2 and ENDF/B-VI version 4 and the MCNP Monte Carlo code with the libraries JEFF-3.1 and JENDL-3.3. Two different versions of the JEF-2.2 library have been used in MONK, the Dice library version and the Bingo library version. These differ in the unresolved resonance region treatment of Pu239. (The first version of the Pu239 unresolved resonance region data is the standard version as generally distributed and the second is a corrected version used primarily in France.) All the libraries used were derived for a temperature of 300K or thereabouts.

The numbers of histories involved in the MONK Monte Carlo calculations giving an accuracy of $\pm 2.10^{-4}$ are 20 million, and for the accuracy of $\pm 1.10^{-4}$ are about 60 million. The MCNP calculations have a typical standard deviation of $\pm 1.6 \times 10^{-4}$ and are made for 20 million histories.

Comparisons are also made with the Zebra Assembly MZA which had a very similar core to Assembly 22 but a more realistic axial and radial blanket than the natural uranium blanket of the Cadenza Assemblies. The MZA blanket included sodium and steel.

4.1 Results of Calculations of the Critical or Subcritical Configurations.

4.1.1 k_{eff} Values for the CADENZA Cores Calculated for the Reference Model (Model A)

Table 4.1A. MONK/Dice-JEF-2.2 k-effective Results

Core	C (Dice-JEF-2.2)	E	(C-E)/E% (MONK/JEF-2.2)
Assembly 22B	1.0005 ± 0.0001	1.0022 ± 0.0008	$(-0.17 \pm 0.08)\%$
Assembly 23	1.0038 ± 0.0001	1.0016 ± 0.0013	$(+0.22 \pm 0.13)\%$
Assembly 24	1.0000 ± 0.0001	1.0023 ± 0.0008	$(-0.23 \pm 0.08)\%$
Assembly 25	1.0032 ± 0.0001	1.0013 ± 0.0013	$(+0.19 \pm 0.13)\%$
Core 23 with the central plate zone of 45 plate elements.	1.0042 ± 0.0002	1.0029 ± 0.0013	$(+0.13 \pm 0.13)\%$
Assembly 25 with the central zone of 69 plate elements.	1.0015 ± 0.0002	1.0014 ± 0.0013	$(+0.01 \pm 0.13)\%$
MZA	1.0121 ± 0.00015	1.0097 ± 0.0016	$(+0.24 \pm 0.16)\%$

Table 4.1B. Calculations using the Bingo-JEF-2.2 Library in MONK

This version of the JEF-2.2 Library includes the corrected Pu239 unresolved resonance region data.

Core	C (MONK/Bingo-JEF-2.2)	E	(C-E)/E% (MONK/JEF-2.2)
Assembly 22B	0.9931 ± 0.0001	1.0022 ± 0.0008	$(-0.91 \pm 0.08)\%$
Assembly 23	0.9959 ± 0.0001	1.0016 ± 0.0013	$(-0.57 \pm 0.13)\%$
Assembly 24	0.9938 ± 0.0002	1.0023 ± 0.0008	$(-0.85 \pm 0.08)\%$
Assembly 25	0.9965 ± 0.0002	1.0013 ± 0.0013	$(-0.48 \pm 0.13)\%$

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Table 4.1C MONK9A/Dice-JENDL-3.2 k-effective Results

Core	C (JENDL-3.2)	E	(C-E)/E% (JENDL-3.2)
Assembly 22B	0.9956 ± 0.0001	1.0022 ± 0.0008	(-0.66 ± 0.08)%
Assembly 23	0.9984 ± 0.00011	1.0016 ± 0.0013	(-0.32 ± 0.13)%
Assembly 24	0.9950 ± 0.00015	1.0023 ± 0.0008	(-0.73 ± 0.08)%
Assembly 25	0.9981 ± 0.00015	1.0013 ± 0.0013	(-0.32 ± 0.13)%
Assembly 23 with the central zone of 45 plate elements.	0.9985 ± 0.0002	1.0029 ± 0.0013	(-0.44 ± 0.13)% (MONK8B)
Assembly 25 with the central zone of 69 plate elements.	0.9965 ± 0.0002	1.0014 ± 0.0013	(-0.49 ± 0.13)% (MONK8B)
MZA	1.0076 ± 0.00015	1.0097 ± 0.0016	(-0.21 ± 0.16)%

Table 4.1D MONK/ENDF/B-VI-v4 k-effective Results

Core	C (ENDF/B-VI-v4)	E	(C-E)/E% (ENDF/B-VI-v4)
Assembly 22	1.0083 ± 0.0001	1.0022 ± 0.0008	(+0.61 ± 0.08)%
Assembly 23	1.0107 ± 0.0001	1.0016 ± 0.0013	(+0.91 ± 0.13)%
Assembly 24	1.0095 ± 0.0001	1.0023 ± 0.0008	(+0.72 ± 0.08)%
Assembly 25	1.0115 ± 0.0001	1.0013 ± 0.0013	(+1.02 ± 0.13)%
Assembly 23 with the central zone of 45 plate elements.	1.0107 ± 0.0002	1.0029 ± 0.0013	(+0.78 ± 0.13)%
Assembly 25 with the central zone of 69 plate elements.	1.0100 ± 0.0002	1.0014 ± 0.0013	(+0.87 ± 0.13)%
MZA	1.0165 ± 0.00015	1.0097 ± 0.0016	(+0.68 ± 0.16)%

Table 4.2 KENO5a+CONSYST+ABBN-93 k-effective Results
(Results provided by Anatoli Tsiboulia and Mikhail Semenov)

Core	C	E	(C-E)/E%
Assembly 22	0.99968 ± 0.00014	1.0022 ± 0.0008	(-0.25 ± 0.08)%
Assembly 23	1.00181 ± 0.00012	1.0016 ± 0.0013	(+0.02 ± 0.13)%
Assembly 24	1.00015 ± 0.00014	1.0023 ± 0.0008	(-0.21 ± 0.08)%

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Table 4.3A MCNP/JENDL-3.3 k-effective Results

Core	C (JENDL-3.3)	E	(C-E)% (JENDL-3.3)
Assembly 22B	0.99656 ± 0.00015	1.0022 ± 0.0008	(-0.56 ± 0.08)%
Assembly 23	0.99902 ± 0.00015	1.0016 ± 0.0013	(-0.26 ± 0.13)%
Assembly 24	0.99507 ± 0.00016	1.0023 ± 0.0008	(-0.72 ± 0.08)%
Assembly 25	0.99788 ± 0.00014	1.0013 ± 0.0013	(-0.34 ± 0.13)%
Assembly 23 with the central zone of 45 plate elements.	0.99972 ± 0.00016	1.0029 ± 0.0013	(-0.32 ± 0.13)%
Assembly 25 with the central zone of 69 plate elements.	0.99647 ± 0.00014	1.0014 ± 0.0013	(-0.49 ± 0.13)%
MZA	1.00948 ± 0.00015	1.0097 ± 0.0016	(-0.02 ± 0.16)%

Table 4.3B MCNP/JEFF-3.1 k-effective Results

Core	C (JEFF-3.1)	E	(C-E)% (JEFF-3.1)
Assembly 22B	1.00614 ± 0.00015	1.0022 ± 0.0008	(0.39 ± 0.08)%
Assembly 23	1.00831 ± 0.00015	1.0016 ± 0.0013	(0.67 ± 0.13)%
Assembly 24	1.00482 ± 0.00015	1.0023 ± 0.0008	(0.25 ± 0.08)%
Assembly 25	1.00687 ± 0.00015	1.0013 ± 0.0013	(0.56 ± 0.13)%
Assembly 23 with the central zone of 45 plate elements.	1.00845 ± 0.00016	1.0029 ± 0.0013	(0.56 ± 0.13)%
Assembly 25 with the central zone of 69 plate elements.	1.00570 ± 0.00016	1.0014 ± 0.0013	(0.43 ± 0.13)%
MZA	1.01418 ± 0.00015	1.0097 ± 0.0016	(+0.45 ± 0.16)%

4.1.2 Differences Between the Values of (C-E) for k-effective for the Different Assemblies; the Pin-Plate Discrepancy and the Reactivity Change resulting from Sodium Voiding.

Notes of explanation.

The differences between the k-effective discrepancies, $\Delta(C-E)$, resulting from the change from pin to plate geometry are derived by taking the differences between the value of (C-E) for Core 23 and the value of (C-E) for Core 22, and similarly for Core 25 minus Core 24. These are the pin/plate discrepancies.

Similarly, the differences, $\Delta(C-E)$, between the value of (C-E) for Core 22 and the value of (C-E) for Core 24, and between Core 23 and Core 25, are the discrepancies in the calculation of the reactivity effect of sodium voiding.

Table 4.4A MONK/Dice JEF-2.2 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	39 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	42 ± 13
Plate flooded - voided	± 2	± 4	6 ± 5
Pin flooded - voided	± 2	± 9	3 ± 9
Difference: Assembly 23 with plate zone – Assembly 23	± 3	± 3	-7 ± 4
Assembly 25 with central plate zone – Assembly 25	± 3	± 4	-11 ± 5
MZA –Zebra 22 (C-E)	± 2	± 18	41 ± 18

Table 4.4B MONK/Bingo JEF-2.2 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	34 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	37 ± 13
Plate flooded - voided	± 2	± 4	6 ± 5
Pin flooded - voided	± 2	± 9	9 ± 9

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Table 4.4C MONK9A/JENDL-3.2 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	34 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	41 ± 13
Plate flooded - voided	± 2	± 4	7 ± 5
Pin flooded - voided	± 2	± 9	0 ± 9
Difference: Assembly 23 with plate zone – Assembly 23 (MONK8b)	± 3	± 3	-6 ± 4
Assembly 25 with central plate zone – Assembly 25 (MONK8B)	± 3	± 4	-6 ± 5
MZA-Zebra 22 (C-E)	± 2	± 18	45 ± 18

Table 4.4D MONK/ENDF/B-VI-v4 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	30 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	30 ± 13
Plate flooded - voided	± 2	± 4	-11 ± 5
Pin flooded - voided	± 2	± 9	-11 ± 9
Difference: Assembly 23 with plate zone – Assembly 23	± 3	± 3	-10 ± 4
Assembly 25 with central plate zone – Assembly 25	± 3	± 4	-16 ± 5
MZA-Zebra 22 (C-E)	± 2	± 18	7 ± 18

Table 4.5 KENO5a+CONSYST+ABBN-93 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	27 ± 13
Pin – Plate C/E (voided cores)		± 13	
Plate flooded - voided	± 2	± 4	-3.7 ± 5
Pin flooded - voided		± 9	

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Table 4.6A MCNP/JENDL-3.3 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	30 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	38 ± 13
Plate flooded - voided	± 2	± 4	-16 ± 5
Pin flooded - voided	± 2	± 9	-8 ± 9
Assembly 23 with plate zone – Assembly 23	± 3	± 3	-6 ± 4
Assembly 25 with central plate zone – Assembly 25	± 3	± 4	-15 ± 5
MZA-Zebra 22 (C-E)	± 2	± 18	54 ± 18

Table 4.6B MCNP/JEFF-3.1 Results for $\Delta(C-E)$ ($\times 10^{-4}$)

Cores compared	Uncertainty in ΔC	Uncertainty in ΔE	$\Delta(C-E)$ ($\times 10^{-4}$)
Pin – Plate C/E (flooded cores)	± 2	± 13	28 ± 13
Pin – Plate C/E (voided cores)	± 2	± 13	31 ± 13
Plate flooded - voided	± 2	± 4	-15 ± 5
Pin flooded - voided	± 2	± 9	-11 ± 9
Assembly 23 with plate zone – Assembly 23	± 3	± 3	-11 ± 4
Assembly 25 with central plate zone – Assembly 25	± 3	± 4	-13 ± 5
MZA-Zebra 22 (C-E)	± 2	± 18	6 ± 18

4.1.3 Comments on the Results of the Monte Carlo k-effective Calculations.

The results of the calculations made using the six datasets, JEF-2.2, JENDL-3.2, ENDF/B-VI-Version 4, ABBN-93, JENDL-3.3 and JEFF-3.1 are very consistent in the discrepancies they show for the difference between the plate geometry and pin geometry cores. The pin-plate discrepancy is in the range 24 to 42×10^{-4} dk/k for all the data libraries, JEF-2.2, JENDL-3.2, ENDF/B-VI-V4, ABBN-93, JENDL-3.3 and JEFF-3.1, the standard deviation of the measured difference being $\pm 13 \times 10^{-4}$ dk/k. (The lower figure of 24×10^{-4} is within two standard deviations of the measurement uncertainty.) These values compare with the discrepancy of 52×10^{-4} calculated by ANL, in the 1980s, using Monte Carlo methods and to the value of 48×10^{-4} calculated in the UK, at that time, using approximate 3D cell models. Using more recent datasets has reduced the discrepancy, but not eliminated it. Concerning the difference between the “flooded” and “sodium voided” cores, it is known that aspects of the sodium data in JEF-2.2 are unsatisfactory, in particular in the higher energy range.

The differences between the (C-E) values for the similar Zebra assemblies, MZA and Zebra 22, also deserve comment. These show a wide variation, ranging from agreement for MONK/ENDF-BVI-v4 and MCNP/JEFF-3.1 to discrepancies of about $(40 \pm 18) \times 10^{-4}$ for MONK/JEF-2.2 and MONK/JENDL-3.2 and $(54 \pm 18) \times 10^{-4}$ for MCNP/JENDL-3.3.

Although the systematic pin-plate discrepancies are now smaller they do appear to be real, and not within the uncertainties of measurement, nor of assembly composition and core height. Nuclear data uncertainties for the materials which are present in different proportions in the plate and pin geometry cores (for example, oxygen and copper) could contribute to the remaining difference. An error in modelling the cores might also be an explanation, although there is consistency between the present models and those used in the early 1980s for average cell compositions, and between the MONK, KENO and MCNP representations of the models. The differences between the (C-E) values for MZA and Zebra2 could be related to the differences in the nuclear data for blanket materials, Zebra 22 having a natural uranium blanket and MZA a simulation of a more realistic fast reactor blanket, including sodium diluent.

4.2 Results of Bucklings and Extrapolation Lengths Calculations

Not a benchmark

4.3 Results of Spectral Characteristics Calculations

Central Spectral Indices Measured in Assembly 22 Calculated using the Reference Model (Model A)

Table 4.8 Cell Averaged Reaction Rate Ratio Calculations using MONK/JEF-2.2

Reaction rate ratio	Calculated (MONK/JEF-2.2)	Measured	(C-E)/E%
F28/F25	0.03455 (± 0.57%)	0.03634 (± 1.3%)	-4.9% (± 1.4%)
F25/F49	0.9655 (± 0.56%)	0.959 (± 1.6%)	+0.7% (± 1.7%)
C28/F49	0.1236 (± 0.17%)	0.1266 (± 1.1%)	-2.4% (± 1.1%)
	Cell average calculation	Chamber measurement	
F28/F25 (Chamber)	0.03455 (± 0.57%)	0.03483 (± 4.3%)	(-0.8%) *
F25/F49 (Chamber)	0.9655 (± 0.56%)	0.960 (± 1.6%)	(+0.6%) *
F40/F49 (Chamber)	0.2887 (± 0.4%)	0.2594 (± 4.6%)	
F41/F49 (Chamber)	1.217 (± 0.5%)	1.217 (± 4.0%)	(0.0%) *

* Chamber measurement compared with a cell average calculation

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Table 4.9 Cell Averaged Reaction Rate Ratio Calculations using MONK/JENDL-3.2

Reaction rate ratio	Calculated (MONK/JENDL-3.2)	Measured	(C-E)/E%
F28/F25	0.03495 (± 1.2%)	0.03634 (± 1.3%)	-3.8% (± 1.8%)
F25/F49	0.974 (± 1.1%)	0.959 (± 1.6%)	+1.6% (± 1.9%)
C28/F49	0.1235 (± 0.34%)	0.1266 (± 1.1%)	-2.4% (± 1.2%)
	Cell average calculation	Chamber measurement	
F28/F25 (Chamber)	0.03495 (± 1.2%)	0.03483 (± 4.3%)	(+0.3%) *
F25/F49 (Chamber)	0.974 (± 1.1%)	0.960 (± 1.6%)	(+1.4%) *
F40/F49 (Chamber)	0.2908 (± 0.75%)	0.2594 (± 4.6%)	(+12.1%) *
F41/F49 (Chamber)	1.324 (± 1.0%)	1.217 (± 4.0%)	(+8.8%) *

* Chamber measurement compared with a cell average calculation

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Table 4.10 Cell Averaged Reaction Rate Ratio Calculations using MONK/ ENDF/B-VI-v4

Reaction rate ratio	Calculated (MONK/ENDF/B-VI- v4)	Measured	(C-E)/E%
F28/F25	0.03481 (± 0.7%)	0.03634 (± 1.3%)	-4.2% (± 1.5%)
F25/F49	0.969 (± 0.7%)	0.959 (± 1.6%)	+1.0% (± 1.7%)
C28/F49	0.1229 (± 0.2%)	0.1266 (± 1.1%)	-3.0% (± 1.1%)
	Cell average calculation	Chamber measurement	
F28/F25 (Chamber)	0.03481 (± 0.7%)	0.03483 (± 4.3%)	(-0.1%) *
F25/F49 (Chamber)	0.969 (± 0.7%)	0.960 (± 1.6%)	(+0.9%) *
F40/F49 (Chamber)	0.3020 (± 0.4%)	0.2594 (± 4.6%)	(+16.4%) *
F41/F49 (Chamber)	1.284 (± 0.6%)	1.217 (± 4.0%)	(5.5%) *

* Chamber measurement compared with a cell average calculation

All three datasets underestimate the cell averaged fission ratio measurement, F28/F25, by about 4% ± 1.5%, and the value of C28/F49 by about 2.5% ± 1%. Note, however, the estimates of possible systematic uncertainties in the ZEBRA techniques of ±3% in F28/F25, ±1% in F25/F49 and ±3% in C28/F49. These are based on the comparisons with measurements made by the staff of other laboratories.

4.4 Results of Reactivity Effects Calculations

Presented here are the original calculations made by the ZEBRA team, in the early 1980s, to compare with the measurements, as described in ZTN22-13, together with MONK-JEF-2.2 Monte Carlo calculations of the reactivity effects of element replacements.

The calculations made by the Zebra team began with the preparation of cell averaged 37 energy group macroscopic and microscopic cross-sections for all the cells, using the collision probability cell code MURAL in the single buckling search option, with the 2000-group adjusted cross-section set, FGL5. These cross-sections were then used in XYZ geometry TIGAR diffusion theory calculations and associated perturbation theory edits.

These calculations used the standard ZEBRA route, that is, one-dimensional slab geometry was used for the cells with the compositions smeared radially over the area of the average element pitch. (These calculations were made before the approximate 3D cell representation was developed and used in the later calculations of k_{eff} . This approximate 3D cell treatment is the method now incorporated in the ECCO cell code of the ERANOS system of codes.) Plutonium metal and UO_2 regions were separated axially from their cans and other diluent regions. The plate region thicknesses used differ slightly from those recommended in Section 3.1.2 in that the thickness of the sodium plates and their dummies are the same and are those from the ZEBRA Databank (i.e. 0.616 cm instead of the reduced thickness of 0.613694 cm adopted here for the compressed sodium plate). It is considered that these changes in cell lengths will give rise to negligible differences in calculated parameters for the cells and the XYZ models. (When calculating using the reduced height of the core with the sodium plates present the macroscopic cross-sections were multiplied by a factor of 1.00186 to correspond to reducing the height from 89.486 cm to the average measured core height of 89.32 cm.)

Similar slab geometry MURAL calculations were made for the plate cells containing the mixed-oxide plates, which were used in the enrichment perturbation experiments. The factor applied to correct for the difference between the height obtained from the plate thickness in the ZEBRA Database which gives the standard core height of 89.32 cm, was 0.99797,

For the pin cells, the cylindrical version of MURAL was used. Three regions were represented for the uniform pin cells, the first consisting of the oxide pellets, the second containing the steel of the pin can plus the minicalandria tube, and the third being one-sixteenth of the steel from the remainder of the minicalandria and the sheath and (where present) one-sixteenth of the sodium from the minicalandria. The radii of the regions were 4.230mm, 5.131mm and 7.6524mm respectively. For the minicalandria containing two pin types, a special version of MURAL prepared for such cells was used. In this version, separate sub-cells represent each of the two pins and contained the appropriate oxide pellets, the steel of the pin tube and the minicalandria tube, and one sixteenth of the remainder of the minicalandria plus the sheath. The coupling between the two pin cells was represented by input values for the probability of a neutron leaving one subcell type and entering another subcell or one of the same type. Macroscopic and microscopic cross-sections were produced as for the plate cells. No height correction factors were required for the macroscopic cross-sections as the minicalandria height in ZEBRA Database corresponded to one-third of the core height in the diffusion-theory calculations used for the pin cores.

Corrections were made to the diffusion coefficients to allow for the effects of neutron streaming in the dilute regions of the flooded and voided plate and pin cells. The factors were those obtained for the same plate and pin cells in the analysis of the heterogeneous BIZET assemblies (BTN-103). The corrections were greater for the voided cells than for the sodium flooded cells.

The blanket and reflector zones consist of uranium metal or steel pieces and were treated as homogeneous for the purposes of the reactivity perturbation studies. Cell-average macroscopic and

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microscopic cross-sections were prepared from the 37-group FD5 data in this case. Studies of methods of cross-section preparation for such reflector zones had shown this to be more suitable than using MURAL/FGL5 in the critical buckling search or k-effective options.

Deterministic Element Replacement Calculations made by the Zebra Team

First Order Perturbation Theory (FOP) calculations were made in XYZ geometry. Exact/FOP corrections were applied to the 9 element FOP results in Core 22, based on RZ geometry calculations. The factors for the absorption, fission, scatter, radial leakage and axial leakage terms were 0.986, 0.994, 0.907, 1.005 and 1.004 respectively for the introduction of 9 C22+03A pin elements and 0.988, 0.988, 0.919, 0.900 and 1.001 respectively for the introduction of 9 C22+04A mixed oxide plate elements. Because the resulting percentage changes to the total FOP calculated worths were small, it was considered that the corresponding corrections for the single element replacements were negligible compared with the experimental uncertainties and so the Exact values were not derived for these.

Table 4.11 FOP and Exact Perturbation Calculations for Element Replacements in Core 22 and Comparison with Experiment (from ZTN22-13) (Units 10^{-4} dk/k)

Position	Element Introduced	No. of Elements	Type of Calc.	Calc. (C)	Experiment (E)	C-E
50,45	C22+03A (Pins)	9	FOP	-11.85	-18.16 $\pm$ 0.27	+6.3 $\pm$ 0.3
		1	Exact	-11.50	-18.16 $\pm$ 0.27	+6.7 $\pm$ 0.3
			FOP	-1.374	-2.10 $\pm$ 0.05	+0.73 $\pm$ 0.05
50,42	C22+03A (Pins)	9	FOP	-8.82	-14.43 $\pm$ 0.21	+5.6 $\pm$ 0.2
		1	Exact	8.52	-14.43 $\pm$ 0.21	+5.9 $\pm$ 0.2
			FOP	1.021	-1.52 $\pm$ 0.04	+0.50 $\pm$ 0.04
50,42	C22+03C (Pins)	9	FOP	-4.26	-9.48 $\pm$ 0.21	+5.2 $\pm$ 0.2
50,39	C22+03A (Pins)	9	FOP	-2.305	-5.36 $\pm$ 0.10	+3.1 $\pm$ 0.1
		1	Exact	-2.09	-5.36 $\pm$ 0.10	+3.3 $\pm$ 0.1
			FOP	-0.266	-0.575 $\pm$ 0.03	+0.31 $\pm$ 0.03
50,45	C22+04A (Oxide Plates)	9	FOP	-30.04	-35.02 $\pm$ 0.51	+5.0 $\pm$ 0.5
		1	Exact	-29.36	-35.02 $\pm$ 0.51	+5.6 $\pm$ 0.5
			FOP	-3.444	-4.10 $\pm$ 0.06	+0.66 $\pm$ 0.06
50,42	C22+04A (Oxide Plates)	9	FOP	-24.25	-27.55 $\pm$ 0.40	+3.3 $\pm$ 0.4
		1	Exact	-23.75	-27.55 $\pm$ 0.40	+3.8 $\pm$ 0.4
			FOP	-2.774	-3.09 $\pm$ 0.05	+0.32 $\pm$ 0.05
50,39	C22+04A (Oxide Plates)	9	FOP	-11.44	-13.31 $\pm$ 0.20	+1.87 $\pm$ 0.20
		1	Exact	11.34	-13.31 $\pm$ 0.20	+1.97 $\pm$ 0.20
			FOP	1.291	-1.51 $\pm$ 0.03	+0.22 $\pm$ 0.03

Note: In each case, the elements replaced C22+01C standard plate elements.

Table 4.12 FOP Calculations for Element Replacements in Core 24 and Comparison with Experiment (from ZTN22-13) (Units 10^{-4} dk/k)

Position	Element Introduced	No. of Elements	Calc. (C)	Experiment (E)	C-E
50,45	C24+30A (Pins)	9	-11.65	-17.45 $\pm$ 0.27	5.8 $\pm$ 0.3
		1	-1.344	-2.13 $\pm$ 0.05	0.79 $\pm$ 0.05
50,42	C24+30A (Pins)	9	-8.99	-13.90 $\pm$ 0.21	4.9 $\pm$ 0.2
		1	-1.038	-1.68 $\pm$ 0.04	0.64 $\pm$ 0.04
50,39	C24+30A (Pins)	9	-3.054	-6.13 $\pm$ 0.10	3.08 $\pm$ 0.10
		1	-0.354	-0.715 $\pm$ 0.02	0.36 $\pm$ 0.02
50,45	C24+40A (Oxide Plates)	9	-28.57	-31.90 $\pm$ 0.45	3.3 $\pm$ 0.5
		1	-3.263	-3.71 $\pm$ 0.06	0.45 $\pm$ 0.06
50,42	C24+40A (Oxide Plates)	9	-23.73	-26.29 $\pm$ 0.38	2.6 $\pm$ 0.4
		1	-2.709	-3.04 $\pm$ 0.05	0.33 $\pm$ 0.05
50,39	C24+40A (Oxide Plates)	9	-12.60	-13.98 $\pm$ 0.20	1.4 $\pm$ 0.2
		1	-1.432	-1.567 $\pm$ 0.03	0.13 $\pm$ 0.03

Note: In each case, the elements replaced C22+01CY standard plate elements.

The experimental uncertainties in these tables are the random contributions from the rod profile and reproducibility and drifts during the measurements. The systematic uncertainties due to the plutonium contents of the fuel ((0.08 to 0.04) $\times 10^{-4}$ dk/k per element for the pin element replacements and (0.10 to 0.06) $\times 10^{-4}$ dk/k per element for the oxide plate element replacements) and the reactivity scale uncertainty of $\pm 5\%$ are not included.

Plutonium Enrichment Changes

The calculated values were obtained using FOP and XYZ diffusion theory, increased by 0.5% to correct for the use of FOP (based on comparisons of FOP and Exact results in XY geometry). The plate core results have been increased by a further 0.3% to allow for the presence of the end cells.

Table 4.13 Comparison of Calculated and Experimental Enrichment Worths
(uncertainty in the measured values $\sim \pm 1.5\%$, excluding the systematic uncertainty of $\pm 5\%$)

Core	Lattice Position	Calculated Worth (C)	Experimental Worth (E)	(C-E)/E%
22	50,45	19.77	19.45	+1.6 %
	50,42	16.46	16.40	+0.4 %
	50,39/51	18.09	17.49	+3.4 %
23	50,45	15.69	16.09	-0.25 %
	50,42	13.01	13.32	-0.23 %
	50,39/51	14.49	14.58	-0.6 %
24	50,45	17.21	17.25	-0.3 %
	50,42	14.82	14.79	+0.2 %
	50,39	9.20	9.13	+0.8 %
25	50,45	13.92	14.13	-1.5 %
	50,42	11.90	12.09	-1.6 %
	50,39/51	14.58	14.66	-0.5%

The agreement between measurement and calculation gives confidence in the reactivity scale.

The experimental uncertainties (excluding the systematic contribution from the absolute reactivity scale calibration of 5%) arise from the control rod profile, the inverse-kinetics measurements, the plutonium contents, and the rod interaction corrections and are $\sim \pm 1.5\%$.

Addition of Material Components to Cells

Calculations were made for Core 22 and Core 23 using both FOP and Exact Perturbation Theory. The analysis was made using only FOP for Core 24 and Core 25.

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Table 4.14 Comparison of Measured and Calculated values of the Effects of Changes in the Plate Loading of Cells in Cores 22 and 24. (Units 10^{-4} dk/k)

Perturbation	Position	Core Section	Core 22			Core 24	
			FOP	Exact	Expt. (± 0.04)	FOP	Expt. (± 0.02)
ALF2→AL8	50,45	C	-0.329	-0.330	-0.35	-0.312	-0.39
		T+B	-0.116	-0.116	-0.10	-0.155	-0.21
	50,42	C	-0.209	-0.207	-0.19		
		T+B	-0.018	-0.015	+0.02		
		All				-0.281	-0.35
	50,39/5 ₁	All	+0.419	+0.454	+0.58	+0.230	+0.255
ALF2→STSTBR8	50,45	C	-1.032	-1.026	-1.09	-0.961	-1.06
		T+B	-0.665	-0.654	-0.70	-0.743	-0.84
	50,42	All	-1.147	-1.130	-1.19	-1.250	-1.39
	50,39/5 ₁	All	+0.084	+0.122	+0.20	-0.454	-0.48
ALF2→AL2034	50,45	C	-0.730	-0.725	-0.67	-0.755	-0.79
		T+B	-0.237	-0.224	-0.18	-0.440	-0.415
	50,42	C	-0.441	-0.424	-0.410.		
		T+B	+0.003	+0.027	+0.07		
		All				-0.736	-0.69
		All	1.166	1.349	1.25	0.447	+0.495
ALF2→GII8		C	-0.484	-0.470	-0.34	-0.579	-0.51
		T+B	-0.167	-0.144	0.02	-0.504	-0.33
		C	-0.279	-0.255	-0.140		
		T+B	+0.011	+0.039	0.15		
		All				-0.676	-0.46
		All	0.809	0.981	1.08	0.000	+0.24

Table 4.15 Comparison of Measured and Calculated Effects of Changes in the Pin Loading of Cells in Cores 23 and 25. (Units 10^{-4} dk/k)

Perturbation	Position	Core 23			Core 25	
		FOP	Exact	Expt	FOP	Expt.
MT→ALPINA	50-45 C	-0.308	-0.303	-0.34 ±0.02	-0.310	-0.329 ±0.013
	T+B	+0.028	+0.025	+0.03 ±0.02	+0.010	+0.013 ±0.013
	50-39 All	+0.342	+0.354	+0.36 ±0.02	+0.325	+0.362 ±0.014
MT→MSTPINA	50-45 C	-0.685	-0.677	-0.77 ±0.02	-0.665	-0.747 ±0.015
	T+B	-0.283	-0.284	+0.27 ±0.02	-0.326	-0.385 ±0.014
	50-39/51 All	+0.322	+0.357	+0.37 ±0.02	+0.160	+0.178 ±0.013
MT→CPINA	50-45 C	-0.310	-0.276	-0.21 ±0.02	-0.432	-0.338 ±0.013
	T+B	+0.163	+0.193	+0.25 ±0.02	-0.035	+0.055 ±0.013
	50-39/51 All	+1.215	+1.286	+1.32 ±0.02	+0.832	+0.942 ±0.016
ALPINA→ALOPINA	50-45 C	-0.184	-0.169	-0.17 ±0.02		
	T+B	+0.087	+0.102	+0.08 ±0.02		
	50-39 All	+0.366	+0.428	+0.32 ±0.02		

MT denotes an empty position being filled.

Sodium Voiding and Flooding

Cell calculations were made for the two configurations and the two sets of cell averaged macroscopic cross-sections were then used in two whole reactor perturbation theory calculations. The difference between the two cases was calculated simply by removing (or adding) the sodium from the cell. The cell height and the weight of steel were not changed. First order perturbation theory calculations were made to which corrections were applied based on a limited set of calculations of the differences between exact and first order perturbation theory.

A fit was made to the values of (C-E) to obtain scaling factors to be applied to the three perturbation theory components of the change in reactivity, the central term (absorption plus fission plus moderation) the radial leakage and the axial leakage. (Note, the fission term arises because of the change in spectrum and resonance shielding.)

Table 4.16 Comparison of Calculation and Experiment for the Small-Zone Sodium Worths in the Plate and Pin Geometry Cores (From ZTN22-13) (Units 10^{-6} dk/k)

Core	Lattice Position	Axial Extent	FOP Calculated Worth	Corrected Calculated Worth	Measured Worth	(C-E)
22	50,45	M	362.0	376	403 $\pm$ 11	-27 $\pm$ 11
		T+B	-143.3	-98	-84 $\pm$ 12	-6 $\pm$ 12
	50,42	M	149.4	175	180 $\pm$ 9	-5 $\pm$ 9
		T+B	-301.0	-247	-236 $\pm$ 12	-11 $\pm$ 12
	50,39	M	-282.1	-233	-235 $\pm$ 9	+2 $\pm$ 9
		T+B	-600.6	-529	-506 $\pm$ 13	-23 $\pm$ 13
24	50,45	M	-361.8	-354	-340 $\pm$ 9	-14 $\pm$ 9
23	50,45	M	+323.2	+344	+347 $\pm$ 6	-3 $\pm$ 6
		T+B	-279.5	-219	-211 $\pm$ 5	-8 $\pm$ 5
	50,42	M	+133.9	+167	+163 $\pm$ 5	+4 $\pm$ 5
		T+B	-387.8	-319	-321 $\pm$ 6	+2 $\pm$ 6
	50,39	M	-220.0	-163	-197 $\pm$ 5	+34 $\pm$ 5
		T+B	-553.4	-472	-498 $\pm$ 7	+26 $\pm$ 7
25	50,45	M	-356.4	-344	-323 $\pm$ 6	-21 $\pm$ 6
		T+B	-13.8	-30	+80 $\pm$ 6	-110 $\pm$ 6
	50,39	M	+55.9	+106	+108 $\pm$ 5	-2 $\pm$ 5

The Assembly 22 and 23 values are for sodium voiding and the Assembly 24 and 25 values are for sodium flooding.

The components of the FOP calculated values have been scaled using factors found in a comparison of first order and exact perturbation theory values of the components.

Each measurement occupied 9 elements in a 3 x 3 square, the region voided (or flooded) being either the middle 8 cells (M) or the top 8 plus bottom 8 cells (T+B). The Core 22 measurements were sodium voiding; the Core 24, sodium flooding.

The experimental uncertainties quoted are from the reactivity profile of FR9, reproducibility and drifts and the height-change correction. The further systematic error of $\pm 5\%$ from the experimental reactivity scale is not included.

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Table 4.17. MONK JEF-2.2 calculations of the reactivity changes resulting from element replacements (Groups of Pin versus Plate elements, etc).

Cores with replacement elements, Pin versus Plate, MOX elements, etc	MONK9A-JEF-2.2 Calculated value	Measured value	C-E
Reference Core 22	1.0004 ± 0.0001		
Core 22 with 9 Central PinA elements	0.9989 ± 0.0001		
Worth of 9 PinA vs plate elements	-0.0015 ± 0.00014	-0.00182 ± 0.000027	0.0003 ± 0.00014
Second run	0.9991± 0.0001		
	-0.0013± 0.00014	-0.00182 ± 0.000027	0.0005 ± 0.00014
Core 22 with 9 PinA elements at mid core radius	0.9991 ± 0.0001		
Worth of 9 Mid PinA vs plate elements	-0.0013 ± 0.00014	-0.00144 ± 0.000021	0.0001± 0.00014
Core 22 with 9 Edge region PinA elements	1.0001± 0.0001		
Worth of 9 OffC PinA vs plate elements	-0.0003 ± 0.00014	-0.00054 ± 0.0000	0.0002 ± 0.00014
Core 22 with 9 Central MOX plate elements	0.9978 ± 0.0001		
Worth of 9 MOX plate elements	-0.0026 ± 0.00014	-0.00350 ± 0.00003	0.0009 ± 0.00014
Core 22 mid-radius 9 MOX elements	0.9984 ± 0.0001		
Worth of 9 Mid MOX vs metal elements	-0.0020 ± 0.00014	-0.00276 ± 0.00004	0.0008 ± 0.00014
Core 22 with 9 Edge region MOX elements	0.9996 ± 0.0001		
Worth of 9 Edge Region MOX vs plate elements	-0.0008 ± 0.00014	-0.00133 ± 0.0000	0.0005± 0.00014
Core 22 with Pu enriched plate element	1.0023 ± 0.0001		
	0.0019 ± 0.00014	0.001945 ± 0.00003	0.0000 ± 0.00014
Core 22 with 2 edge Pu enriched element	1.0023 ± 0.0001		
	0.0019 ± 0.00014	0.00175 ± 0.00003	0.0001 ± 0.00014
Reference Flooded Pin Core, Core 23	1.0038 ± 0.0001	1.0016 ± 0.0013	
Z23 with 25 plate elements	1.00625 ± 0.0001		
Reactivity difference of 25 plate/pin	+ 0.00245± 0.00014	+ 0.00315	-0.0007 ± 0.00014
Z23 with 45 plate elements Run 1	1.0072 ± 0.0002		
Reactivity difference of 45 plate/pin R1	+0.0034 ± 0.00022	+ 0.00493	-0.0015 ± 0.00022
Z23 with 45 plate elements Run 2	1.0074 ± 0.0001		
Reactivity difference of 45 plate/pin R2	+0.0036	+ 0.00493	-0.0013± 0.00014

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Table 4.17. continued

Reference Core24 Full height, X dummy	0.9997 ± 0.0001		
Core 24 with 9 Central MOX elements	0.9972 ± 0.0001		
Worth of 9 MOX elements	-0.0025 ± 0.00014	-0.00319 ± 0.00005	0.0007 ± 0.00014
Core 24 with 9 Mid Radius MOX els.	0.9976 ± 0.0001		
Worth of 9 Mid MOX elements	-0.0021 ± 0.00014	-0.00263 ± 0.00004	0.0005 ± 0.00014
Core 24 with 9 Edge MOX elements	0.9986 ± 0.0001		
Worth of 9 Edge MOX vs plate elements	-0.0011 ± 0.00014	-0.00140 ± 0.00002	0.0003 ± 0.00014
Core 24 with 9 Central PinA elements	0.9984 ± 0.00015		
Worth of 9 Central PinA elements	-0.0013 ± 0.00018	-0.001724 ± 0.0000	0.0004 ± 0.00018
Core 24 with 9 Mid Radius PinA els.	0.9986 ± 0.0001		
Worth of 9 Mid PinA elements	-0.0011 ± 0.00014	-0.00139 ± 0.0000	0.0003 ± 0.00014
Core 24 with 9 Edge PinA elements	0.9991 ± 0.0001		
Worth of 9 Edge PinA vs plate elements	-0.0006 ± 0.00014	-0.00061 ± 0.0000	0.0000 ± 0.00014
Core 24 with Pu enriched element	1.0013 ± 0.0001		
Worth of Pu enrichment	0.0016 ± 0.00014	0.00173 ± 0.00003	-0.00013 ± 0.00014
Core25 with 9 plate-pin replacements	1.0043 ± 0.0001		
Worth of 9 plate vs pins	0.0011 ± 0.00014	0.00178 ± 0.0000	-0.0007 ± 0.00014

The effects of the plutonium enrichment of elements are well predicted but the reactivity effects of the replacement of plate elements by pin elements are not well predicted and the discrepancies are in the sense of the discrepancies between the keffective values of the plate versus pin geometry cores.

4.5 Results of Reactivity Coefficient Calculations

Not a benchmark.

4.6 Results of Kinetics Parameter Calculations

Not a benchmark.

4.7 Results of Reaction-Rate Distribution Calculations

Not analysed.

4.8 Results of Power Distribution Calculations

Not a benchmark.

4.9 Results of Isotopic Calculations

Not a benchmark.

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ZTN22-5	Material Worth Measurements in Core 24 – the Cadenza Voided Plate Core	S E Johnson and J M Stevenson
ZTN22-6	Material Worth Measurements in Zebra 23 and 25 – the Cadenza Pin Cores	S E Johnson and J M Stevenson
ZTN22-7	First Calculated Studies for the CADENZA Assemblies	S E Johnson
ZTN22-8	Cell Heterogeneity and Sample Worth Measurement at the Centre of ZEBRA 22	J M Stevenson and S E Johnson
ZTN22-9	Reaction Rate Ratio Measurements in the Fissile Region of ZEBRA Assembly 22A	B L H Burbridge, M F Murphy and Miss P A Smart
ZTN22-10	Summary of Further K-Value Related Data for the CADENZA Assemblies	B L H Burbridge, A D Knipe and J M Stevenson
ZTN22-11	Description of CADENZA Plate Assemblies 22 and 24	Miss P A Smart
ZTN22-13	First Analysis of the CADENZA Assemblies	J M Stevenson
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APPENDIX A. INPUT DATA USED IN THE CALCULATIONS

A.1 MONK MONTE CARLO MODELS OF THE ASSEMBLIES.

MONK9a is a hyperfine group Monte Carlo code (Serco-Assurance, Winfrith, UK).

K-effective values, and central reaction rate ratios (in the case of ZEBRA assembly 22) were calculated using MONK9a. Calculations were made using the nuclear data sets based on JEF-2.2, JENDL-3.2 and ENDFB-VI-v3. The input data listings for the Model A cases are given first, followed by the modifications to treat the simplified models.

Note: The data used in these models differs slightly from the data specified in Sections 1 to 3. The width of the UO₂ plate has been taken to be 4.857 cm (instead of the value of 4.851 cm given in Section 1, this latter value being the current Zebra Database value) and the atomic densities for both the core region and the canning are correspondingly different.

The data for the UO₂ pins are also slightly different. The values from the Zebra Database are the ones given in Section 1 to 3 whereas the values used in these MONK models are the values from the original NEACRP benchmark models.

The gap between the groups of 5x5 elements has been taken to be 0.2667 instead of the value 0.2665 cm given in the text. This difference is a consequence of the different values in use for the average lattice spacing, 5.42544 and the value 5.4254 cm given in the text.

MONK9A Continuous Energy Monte Carlo Code Models.

A1.1. Assembly 22B. The sodium filled plate geometry core. Model A.

*** MONK9A Input Listing for Assembly 22B Model A,**

- * Case with Grid Plates included
- * Assembly 22 is the Plate Geometry Version of the Cadenza cores.
- * Full height model
- * Reactor structure: elements arranged on a square grid
- * The 269 Core Elements contain Core Cells and an Axial Region Cell,
* enclosed in a mild steel sheath and reflected in the midplane.
- * The standard plates have a width of 5.067 cm.
- * The Element sheath has an inner width 5.102 cm, outer width 5.2544 cm.
- * The elements occupy a lattice area of 5.3721 cm square.
- * Groups of 5x5 elements form the superlattice
* with a space between them
- * The 332 Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
- * The radial shielding elements consist of the Steel bar MST9F10
* which is about 3 00 cm high.
- * These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (pitch 5.4254 cm)
- * Elements are grouped in square arrays containing 5x5 = 25 elements
* and the Assembly is built from these.
- * A more regular array can be achieved by adding an extra ring of
* elements to make the radius 95.9 cm
- * There is a gap between these groups of elements of 0.2667 cm
- * There are 9 types of 5x5 arrays, plus rotations (or reflections)
* of some of these.
- * Core Element structure:
 - * The element consists of combinations of the following cells:
 - * Core Cell PART 1, Core Cell PART 2, is an inversion of PART 1,
 - * Core Cell PART 3, which is the same as PART 1
 - * but with the 40%Steel plate omitted,
 - * and the Upper Axial Region Cell, PART4.
 - * This is reflected in the mid-plane.
- * Structure of Core Cell 1, PART 1, 7 plates. Cell height 3.748082 cm.
- * Enclosed in mild steel sheath.
- * Outer area of all plates is 5.067 cm x 5.067 cm
- * From the top down:

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*      Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
*      UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
*      Sodium (0.613694 cm thick,)
*      Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671cm x 4.671 cm)
*      40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
*      UO2 (0.6313 cm thick)
*      Sodium (0.613694 cm thick)
* Structure of Core Cell 2 PART 2. The inverse of PART 1
* Structure of Core Cell PART 3. PART 1 without the 40%Steel plate.
*      Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
*      Cell height From the top:
*      MST3 Block (7.60628 cm thick)
*      U3 Block (7.6225 cm thick,)
*      U2 region (10 plates, total thickness 12.723 cm )
*      U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
*      Height of the reflected half height element
*      MST3 Block (7.60628 cm thick)
*      U3 Block composition (height above mid-plane to match the core
*      element blanket height of 74.83248 cm)
*****
* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium plate core
* material 6 - Sodium plate clad
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Mild steel sheath
* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
* material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
* material 15 - Plutonium metal plate core at reactor core centre
* material 16 - UO2 plate core at reactor core centre
* material 17 - Grid plate material
*

```

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BEGIN MATERIAL SPECIFICATION

NUMBER DENSITY

MATERIAL 1

```

U238  6.8782E-07  PU238  3.0461E-05  PU239  2.8920E-02
PU240  6.9095E-03  PU241  7.3960E-04  PU242  1.8699E-04
AM241  4.5718E-04
H1  1.2764E-04  C  4.2260E-04  N  2.4215E-05  O16  8.8450E-05
AL  2.2973E-05  SI  1.4158E-05  CR  3.5989E-06  MN  1.4902E-06
FE  1.6335E-05  NI  8.5688E-06  GA  2.0166E-03

```

MATERIAL 2

```

H1  1.3760E-05  C  1.1393E-04  SI  3.6607E-04  P  1.3731E-05
CR  9.4011E-03  MN  8.5931E-04  FE  3.5542E-02  NI  4.1646E-03
CU  1.6613E-02

```

MATERIAL 3

```

H1  3.1773E-05  C  1.1808E-05  O16  4.6008E-02  AL  3.3911E-06
SI  2.2967E-05  MN  8.3273E-08  FE  1.3107E-06  NI  1.2472E-06
MO  3.3379E-07  U235  1.6544E-04  U238  2.2837E-02

```

MATERIAL 4

```

H1  1.9035E-05  C  1.2831E-04  SI  6.4475E-04  P  3.5078E-04
S  3.6041E-05  CR  1.3819E-02  MN  8.5559E-04  FE  4.8306E-02
NI  8.4258E-03

```

MATERIAL 5

```

H1  1.3900E-05  O16  5.6492E-06  NA  2.3225E-02  CA  3.6083E-06
FE  1.6184E-07

```

MATERIAL 6

```

H1  2.1631E-05  C  2.9290E-04  SI  6.0867E-04  P  3.2795E-05
S  3.3219E-05  CR  1.4759E-02  MN  1.3570E-03  FE  5.5054E-02
NI  7.0982E-03  NB  3.1147E-04

```

MATERIAL 7

```

H1  1.8355E-05  C  8.7794E-05  AL  1.1862E-04  SI  7.9703E-04
P  4.0018E-05  S  1.4422E-05  TI  2.4806E-04  CR  1.5908E-02
MN  1.4972E-03  FE  5.5367E-02  NI  8.7976E-03  CU  5.0365E-05

```

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NB 4.9781E-06 MO 8.0988E-05
MATERIAL 8
H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04
U235 3.3369E-04 U238 4.6021E-02
MATERIAL 9
H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05
U235 3.3962E-04 U238 4.6785E-02
MATERIAL 10
H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04
U235 3.4209E-04 U238 4.7156E-02
MATERIAL 11
H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05
CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05
CU 4.4548E-05 MO 9.8355E-06
MATERIAL 12
H1 7.5712E-05 C 2.3825E-04 AL 1.9798E-05 CR 3.6690E-06
MN 2.5697E-04 FE 7.7524E-02 NI 1.4302E-05 CU 2.2216E-05
MATERIAL 13
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
MATERIAL 14
H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02
MATERIAL 15
U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02
PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04
AM241 4.5718E-04
H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05
AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06
FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03
MATERIAL 16
H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06
SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06
MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02
MATERIAL 17
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
END
*
*****
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.5335 -2.5185 0.0 5.067 5.067 0.3274
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.3274
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.3274
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558
BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.6313
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.6313
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313
*
* Plate 3, the sodium plate
PART 3 NEST
BOX M5 -2.4815 -2.4815 0.036347 4.963 4.963 0.541
BOX M6 -2.5335 -2.5335 0.0 5.067 5.067 0.613694
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.613694
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.613694
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.613694
*
* Plate 4, the 40% steel plate
PART 4 NEST
BOX M0 -1.9625 -1.9625 0.0 3.925 3.925 0.317
BOX M7 -2.5335 -2.5335 0.0 5.067 5.067 0.317
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.317
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.317
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.317
*

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*****
* Core Cell 1
PART 5 ARRAY
1 1 14 3 2 4 1 3 2 3 3 2 3 1 4 2 3
* Core Cell 2
PART 6 ARRAY
1 1 6 3 2 3 1 2 3
*
* Core Cell 3
PART 7 ARRAY
1 1 6 3 2 1 3 2 3
*
*****
* Axial blanket U8 section
PART 8 NEST
BOX M8 -2.5335 -2.5335 0.0 5.067 5.067 9.827
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 9.827
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 9.827
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 9.827
*
* Axial blanket U2 section
PART 9 NEST
BOX M9 -2.5335 -2.5335 0.0 5.067 5.067 12.723
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 12.723
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 12.723
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 12.723
*
* Axial blanket U3 section
PART 10 NEST
BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 7.6225
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 7.6225
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 7.6225
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 7.6225
*
* Axial reflector MST3 section
PART 11 NEST
BOX M11 -2.5335 -2.5335 0.0 5.067 5.067 7.60628
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 7.60628
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 7.60628
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 7.60628
*
*****
* Radial blanket U3 section (over core height)
PART 12 NEST
BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 149.664968
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 149.664968
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 149.664968
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 149.664968
*
* Steel reflector bars (over assembly height)
PART 13 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 164.877528
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 164.877528
*
*****
* The Core Element (full height)
PART 14 ARRAY
1 1 21 11 10 9 8 6 (5)*11 7 8 9 10 11
*
*The Radial Blanket element (full height)
PART 15 ARRAY
1 1 3 11 12 11
*
*****
* Groups of 5x5 elements surrounded by the superlattice gap
* Core group
PART 16 ARRAY
5 5 1 (14)*25
*
PART 17 OVERLAP
BOX P16 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M17 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M17 -13.5635 -13.5635 132.63876 27.127 27.127 30.4

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BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127 164.877528
*
* Core bottom left corner group
PART 18 ARRAY
5  5  1  (15)*3  (14)*2   15  (14)*4   15  (14)*14
*
PART 19 OVERLAP
BOX      P18     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core bottom right group
PART 20 ARRAY
5  5  1  (14)*2  (15)*3  (14)*3  (15)*2  (14)*4  15  (14)*10
*
PART 21 OVERLAP
BOX      P20     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core top left corner group
PART 22 ARRAY
5  5  1  (14)*10  15  (14)*4  (15)*2  (14)*3  (15)*3  (14)*2
*
PART 23 OVERLAP
BOX      P22     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core top right group
PART 24 ARRAY
5  5  1  (14)*14  15  (14)*4  15  (14)*2  (15)*3
*
PART 25 OVERLAP
BOX      P24     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core bottom group
PART 26 ARRAY
5  5  1  (15)*21  (14)*3   15
*
PART 27 OVERLAP
BOX      P26     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core top group
PART 28 ARRAY
5  5  1      15  (14)*3  (15)*21
*
PART 29 OVERLAP
BOX      P28     -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core left group
PART 30 ARRAY
5  5  1  (15)*9  14  (15)*4  14  (15)*4  14  (15)*5
*
PART 31 OVERLAP
BOX      P30     -13.43025 -13.43025   0.0 26.8605 26.8605 164.877528
BOX      M17     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M17     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Core right group
PART 32 ARRAY

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5  5  1  (15)*5  14  (15)*4  14  (15)*4  14  (15)*9
*
PART 33 OVERLAP
BOX    P32  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
*
*****
* Blanket element group
PART 34 ARRAY
5  5  1  (15)*25
*
PART 35 OVERLAP
BOX    P34  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
*
*****
* top and bottom groups have Y=3
* Shield bottom group
PART 36 ARRAY
5  3  1  (13)*10  (15)*5
*
PART 37 OVERLAP
BOX    P36  -13.43025 -8.05815  0.0 26.8605 16.1163 164.877528
BOX    M17  -13.5635  -8.1914  1.83876 27.127 16.3828 30.4
BOX    M17  -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX    M0   -13.5635  -8.1914  0.0 27.127 16.3828 164.877528
*
* Shield top group
PART 38 ARRAY
5  3  1  (15)*5  (13)*10
*
PART 39 OVERLAP
BOX    P38  -13.43025 -8.05815  0.0 26.8605 16.1163 164.877528
BOX    M17  -13.5635  -8.1914  1.83876 27.127 16.3828 30.4
BOX    M17  -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX    M0   -13.5635  -8.1914  0.0 27.127 16.3828 164.877528
*
*****
* Shield left group
PART 40 ARRAY
5  5  1  (13)*4 15  (13)*4 15  (13)*4 15  (13)*4 15  (13)*4 15
*
PART 41 OVERLAP
BOX    P40  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
*
* Shield right group
PART 42 ARRAY
5  5  1  15  (13)*4 15  (13)*4 15  (13)*4 15  (13)*4 15  (13)*4
*
PART 43 OVERLAP
BOX    P42  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
*
*Shield corner sections
* Bottom left group
PART 44 ARRAY
5  5  1  (13)*9 15  (13)*3  (15)*2  (13)*2  (15)*3 13  (15)*4
*
PART 45 OVERLAP
BOX    P44  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
*

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* Bottom right group
PART 46 ARRAY
5 5 1 (13)*5 15 (13)*4 (15)*2 (13)*3 (15)*3 (13)*2 (15)*4 13
*
PART 47 OVERLAP
BOX P46 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M17 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M17 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* Top left group
PART 48 ARRAY
5 5 1 13 (15)*4 (13)*2 (15)*3 (13)*3 (15)*2 (13)*4 15 (13)*5
*
PART 49 OVERLAP
BOX P48 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M17 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M17 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* top right group
PART 50 ARRAY
5 5 1 (15)*4 13 (15)*3 (13)*2 (15)*2 (13)*3 15 (13)*9
*
PART 51 OVERLAP
BOX P50 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M17 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M17 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
*****
*
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 52 ARRAY
5 3 1 (13)*13 (15)*2
PART 53 OVERLAP
BOX P52 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M17 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M17 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre is Part 37
* Right side
PART 54 ARRAY
5 3 1 (13)*10 (15)*2 (13)*3
PART 55 OVERLAP
BOX P54 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M17 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M17 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* combine these arrays to form the row 1 array
PART 56 ARRAY
3 1 1 53 37 55
*
*****
*
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 57 ARRAY
5 3 1 (13)*3 (15)*2 (13)*10
PART 58 OVERLAP
BOX P57 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M17 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M17 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre is Part 39
* Right side
PART 59 ARRAY
5 3 1 (15)*2 (13)*13
PART 60 OVERLAP
BOX P59 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M17 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4

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BOX      M17  -13.5635  -8.1914   132.63876  27.127  16.3828  30.4
BOX      M0   -13.5635  -8.1914    0.0  27.127  16.3828  164.877528
* combine these arrays to form the row 7 array
PART 61 ARRAY
3  1  1  58  39  60
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays
* Left hand array
PART 62 ARRAY
3  5  1  (13)*11  15  (13)*2  15
PART 63 OVERLAP
BOX      P62  -8.05815  -13.43025  0.0  16.1163  26.8605  164.877528
BOX      M17  -8.1914  -13.5635   1.83876  16.3828  27.127  30.4
BOX      M17  -8.1914  -13.5635   132.63876  16.3828  27.127  30.4
BOX      M0   -8.1914  -13.5635    0.0  16.3828  27.127  164.877528
* right hand array
PART 64 ARRAY
3  5  1  (13)*9  15  (13)*2  15  (13)*2
PART 65 OVERLAP
BOX      P64  -8.05815  -13.43025  0.0  16.1163  26.8605  164.877528
BOX      M17  -8.1914  -13.5635   1.83876  16.3828  27.127  30.4
BOX      M17  -8.1914  -13.5635   132.63876  16.3828  27.127  30.4
BOX      M0   -8.1914  -13.5635    0.0  16.3828  27.127  164.877528
* Form the row 3 array
PART 66 ARRAY
7  1  1  63  35  19  17  21  35  65
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 67 ARRAY
3  5  1  (13)*2  15  (13)*2  15  (13)*9
PART 68 OVERLAP
BOX      P67  -8.05815  -13.43025  0.0  16.1163  26.8605  164.877528
BOX      M17  -8.1914  -13.5635   1.83876  16.3828  27.127  30.4
BOX      M17  -8.1914  -13.5635   132.63876  16.3828  27.127  30.4
BOX      M0   -8.1914  -13.5635    0.0  16.3828  27.127  164.877528
*
* right hand shield array
PART 69 ARRAY
3  5  1  15  (13)*2  15  (13)*11
PART 70 OVERLAP
BOX      P69  -8.05815  -13.43025  0.0  16.1163  26.8605  164.877528
BOX      M17  -8.1914  -13.5635   1.83876  16.3828  27.127  30.4
BOX      M17  -8.1914  -13.5635   132.63876  16.3828  27.127  30.4
BOX      M0   -8.1914  -13.5635    0.0  16.3828  27.127  164.877528
* Form the row 5 array
PART 71 ARRAY
7  1  1  68  35  23  17  25  35  70
*
*****
* Arrays of the Superlattice groups
* Row 2
PART 72 ARRAY
5  1  1  45  35  27  35  47
*
* Row 6
PART 73 ARRAY
5  1  1  49  35  29  35  51
*
* Insert special element at the core centre
*
* Plate 74, the Pu metal plate at the core centre
PART 74 NEST
BOX      M15  -2.3355  -2.3355  0.0457  4.671  4.671  0.236
BOX      M2   -2.5335  -2.5185  0.0      5.067  5.067  0.3274
BOX      M0   -2.5510  -2.5510  0.0      5.102  5.102  0.3274
BOX      M12  -2.6272  -2.6272  0.0      5.2544  5.2544  0.3274
BOX      M0   -2.68605 -2.68605  0.0      5.3721  5.3721  0.3274
*
* Plate 75, the UO2 plate
PART 75 NEST

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BOX      M16  -2.4285  -2.4285  0.03665 4.857  4.857  0.558
BOX      M4   -2.5335  -2.5335  0.0      5.067  5.067  0.6313
BOX      M0   -2.5510  -2.5510  0.0      5.102  5.102  0.6313
BOX      M12  -2.6272  -2.6272  0.0      5.2544 5.2544 0.6313
BOX      M0   -2.68605 -2.68605 0.0      5.3721 5.3721 0.6313
*
* Special cell at the core centre
*
PART 76 ARRAY
1 1 7 3 75 4 74 3 75 3
* Special element at core centre
*
* Neighbouring cell at the core centre
*
PART 77 ARRAY
1 1 7 3 75 3 74 4 75 3
* Special element at core centre
*
* The Core Element (half height) (bottom cell 2 reflected at Z=0)
PART 78 ARRAY
1 1 26 11 10 9 8 6 (5)*3 (76 77)*5 (5)*3
7 8 9 10 11
*
* Group of elements including the special element at the centre
* Groups of 5x5 elements surrounded by the superlattice gap
* Core group including the special element
*
PART 79 ARRAY
5 5 1 (78)*25
*
PART 80 OVERLAP
BOX      P79  -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX      M17  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX      M17  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Middle line, Row 4
PART 81 ARRAY
7 1 1 41 31 17 80 17 33 43
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 82 CLUSTER
BOX      P61  -40.6905  67.8175  0.0 81.381 16.3828 164.877528
BOX      P73  -67.8175  40.6905  0.0 135.635 27.127 164.877528
BOX      P71  -84.2003  13.5635  0.0 168.4006 27.127 164.877528
BOX      P81  -94.9445  -13.5635  0.0 189.889 27.127 164.877528
BOX      P66  -84.2003  -40.6905  0.0 168.4006 27.127 164.877528
BOX      P72  -67.8175  -67.8175  0.0 135.635 27.127 164.877528
BOX      P56  -40.6905  -84.2003  0.0 81.381 16.3828 164.877528
ZROD     M14   0.0      0.0      0.0 96.6 168.0
*
*****
* Albedo for free boundaries at side top and bottom
*
ALBEDO 0.0 0.0 0.0
END
*
*****
*
BEGIN CONTROL DATA
STAGES -50 2400 5000 STDV 0.0001
END
*
*****
*
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 1
END
*
*****
*
BEGIN ACTION TALLIES
NONORM
END

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A1.2. Assembly 24. The voided plate geometry core. Model A

* MONK9A Input Listing for Assembly 24B,
* Assembly 24 is the Voided Plate Geometry Version of the Cadenza cores.
* Symmetry about the mid-plane
* Reactor structure: elements arranged on a square grid
* The 269 Core Elements contain Core Cells and an Axial Region Cell,
* enclosed in a mild steel sheath and reflected in the midplane.
* The standard plates have a width of 5.067 cm.
* The Element sheath has an inner width 5.102 cm, outer width 5.2544 cm.
* The elements occupy a lattice area of 5.3721 cm square.
* Groups of 5x5 elements form the superlattice
* with a space between them
* The 332 Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
* The radial shielding elements consist of the Steel bar MST9F10
* which is about 3 00 cm high.
* These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (pitch 5.4254 cm)
* Elements are grouped in square arrays containing 5x5 = 25 elements
* and the Assembly is built from these.
* A more regular array can be achieved by adding an extra ring of
* elements to make the radius 95.9 cm
* There is a gap between these groups of elements of 0.2667 cm
* There are 9 types of 5x5 arrays, plus rotations (or reflections)
* of some of these.
* Core Element structure:
* The element consists of combinations of the following cells:
* Core Cell PART 1, Core Cell PART 2, is an inversion of PART 1,
* Core Cell PART 3, which is the same as PART 1
* but with the 40%Steel plate omitted,
* and the Upper Axial Region Cell, PART4.
* This is reflected in the mid-plane.
* Structure of Core Cell 1, PART 1, 7 plates. Cell height 3.748082 cm.
* Enclosed in mild steel sheath.
* Outer area of all plates is 5.067 cm x 5.067 cm
* From the top down:
* Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
* UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
* Sodium (0.613694 cm thick,)
* Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671cm x 4.671 cm)
* 40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
* UO2 (0.6313 cm thick)
* Sodium (0.613694 cm thick)
* Structure of Core Cell 2 PART 2. The inverse of PART 1
* Structure of Core Cell PART 3. PART 1 without the 40%Steel plate.
* Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
* Cell height From the top:
* MST3 Block (7.60628 cm thick)
* U3 Block (7.6225 cm thick,)
* U2 region (10 plates, total thickness 12.723 cm)
* U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
* Height of the reflected half height element
* MST3 Block (7.60628 cm thick)
* U3 Block composition (height above mid-plane to match the core
* element blanket height of 74.83248 cm)

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium plate core
* material 6 - Sodium plate clad
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Mild steel sheath

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* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
 * material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
 * material 15 - Sodium dummy plate type STNAVR4 (ring)
 * material 16 - Sodium dummy plate type STNAVS4 (ring)
 * material 17 - Sodium dummy plate type STNAV4 (uniform)
 * material 18 - Grid plate material

 COLUMNS 1 132
 BEGIN MATERIAL SPECIFICATION
 NUMBER DENSITY
 MATERIAL 1
 U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02
 PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04
 AM241 4.5718E-04
 H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05
 AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06
 FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03
 MATERIAL 2
 H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05
 CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03
 CU 1.6613E-02
 MATERIAL 3
 H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06
 SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06
 MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02
 MATERIAL 4
 H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04
 S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02
 NI 8.4258E-03
 MATERIAL 5
 H1 1.3900E-05 O16 5.6492E-06 NA 2.3225E-02 CA 3.6083E-06
 FE 1.6184E-07
 MATERIAL 6
 H1 2.1631E-05 C 2.9290E-04 SI 6.0867E-04 P 3.2795E-05
 S 3.3219E-05 CR 1.4759E-02 MN 1.3570E-03 FE 5.5054E-02
 NI 7.0982E-03 NB 3.1147E-04
 MATERIAL 7
 H1 1.8355E-05 C 8.7794E-05 AL 1.1862E-04 SI 7.9703E-04
 P 4.0018E-05 S 1.4422E-05 TI 2.4806E-04 CR 1.5908E-02
 MN 1.4972E-03 FE 5.5367E-02 NI 8.7976E-03 CU 5.0365E-05
 NB 4.9781E-06 MO 8.0988E-05
 MATERIAL 8
 H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04
 U235 3.3369E-04 U238 4.6021E-02
 MATERIAL 9
 H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05
 U235 3.3962E-04 U238 4.6785E-02
 MATERIAL 10
 H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04
 U235 3.4209E-04 U238 4.7156E-02
 MATERIAL 11
 H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05
 CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05
 CU 4.4548E-05 MO 9.8355E-06
 MATERIAL 12
 H1 7.5712E-05 C 2.3825E-04 AL 1.9798E-05 CR 3.6690E-06
 MN 2.5697E-04 FE 7.7524E-02 NI 1.4302E-05 CU 2.2216E-05
 MATERIAL 13
 H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
 S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
 MATERIAL 14
 H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
 S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02
 * sodium dummy plates
 MATERIAL 15
 H1 2.4073E-05 C 2.7547E-04 SI 7.5592E-04 P 4.5399E-05
 S 1.2036E-05 CR 1.6594E-02 MN 1.1688E-03 FE 5.9245E-02
 NI 9.9342E-03 NB 4.0746E-04
 MATERIAL 16
 H1 2.4073E-05 C 2.5251E-04 SI 7.4610E-04 P 1.7803E-05
 S 1.7195E-05 CR 1.6248E-02 MN 1.5006E-03 FE 5.9881E-02
 NI 9.4005E-03 NB 3.7393E-04
 MATERIAL 17
 H1 3.3245E-06 C 3.3477E-05 SI 1.2169E-04 P 4.9764E-06

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S 2.5076E-06 CR 2.4643E-03 MN 1.9518E-04 FE 8.0717E-03
NI 1.2195E-03 NB 5.2657E-05
MATERIAL 18
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
END
*
*****
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.5335 -2.5185 0.0 5.067 5.067 0.3274
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.3274
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.3274
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558
BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.6313
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.6313
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313
*
* Plate 3, the sodium dummy plate type STNAVR4 (ring shape)
PART 3 NEST
ZROD M0 0.0 0.0 0.0 2.3 0.616
ZROD M15 0.0 0.0 0.0 2.5335 0.616
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.616
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.616
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.616
*
* Plate 4, the 40% steel plate
PART 4 NEST
BOX M0 -1.9625 -1.9625 0.0 3.925 3.925 0.317
BOX M7 -2.5335 -2.5335 0.0 5.067 5.067 0.317
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.317
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.317
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.317
*
*****
* Alternative dummy plates
* Plate 5, the sodium dummy plate type STNAVS4 (ring shape)
PART 5 NEST
ZROD M0 0.0 0.0 0.0 2.3 0.616
ZROD M16 0.0 0.0 0.0 2.5335 0.616
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.616
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.616
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.616
* Plate 6, the sodium dummy plate type STNAV4 (uniform)
PART 6 NEST
BOX M17 -2.5335 -2.5335 0.0 5.067 5.067 0.616
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.616
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.616
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.616
*
*****
* Core cells for the type X element
* Core Cell 1 (element type X)
PART 7 ARRAY
1 1 7 3 2 4 1 3 2 3
* Core Cell 2 (element type X)
PART 8 ARRAY
1 1 7 3 2 3 1 4 2 3
*
* Core Cell 3 (element type X)
PART 9 ARRAY
1 1 6 3 2 1 3 2 3
*
* Core cells for the type Y element
* Core Cell 1 (element type Y)
PART 10 ARRAY

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1 1 7 5 2 4 1 5 2 5
* Core Cell 2 (element type Y)
PART 11 ARRAY
1 1 7 5 2 5 1 4 2 5
*
* Core Cell 3 (element type Y)
PART 12 ARRAY
1 1 6 5 2 1 5 2 5
*
* Core cells for the type Z element
* Core Cell 1 (element type Z)
PART 13 ARRAY
1 1 7 6 2 4 1 6 2 6
* Core Cell 2 (element type Z)
PART 14 ARRAY
1 1 7 6 2 6 1 4 2 6
*
* Core Cell 3 (element type Z)
PART 15 ARRAY
1 1 6 6 2 1 6 2 6
*
*
*****
* Axial blanket U8 section
PART 16 NEST
BOX M8 -2.5335 -2.5335 0.0 5.067 5.067 9.827
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 9.827
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 9.827
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 9.827
*
* Axial blanket U2 section
PART 17 NEST
BOX M9 -2.5335 -2.5335 0.0 5.067 5.067 12.723
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 12.723
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 12.723
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 12.723
*
* Axial blanket U3 section
PART 18 NEST
BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 7.6225
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 7.6225
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 7.6225
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 7.6225
*
* Axial reflector MST3 section
PART 19 NEST
BOX M11 -2.5335 -2.5335 0.0 5.067 5.067 7.60628
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 7.60628
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 7.60628
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 7.60628
*
*****
* Radial blanket U3 section (over half core height)
PART 20 NEST
BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 74.83248
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 74.83248
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 74.83248
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 74.83248
*
* Axial reflector MST3 section above the radial reflector
PART 21 NEST
BOX M11 -2.5335 -2.5335 0.0 5.067 5.067 7.6893
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 7.6893
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 7.6893
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 7.6893
*
* Steel reflector bars (over half core height)
PART 22 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 82.52178
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 82.52178
*
*****
*
* The Core Element X (half height) (bottom cell 2 reflected at Z=0)

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PART 23 ARRAY
1 1 16 (8 7)*5      8  9 16 17 18 19
*
* The Core Element Y (half height)(bottom cell 2 reflected at Z=0)
PART 24 ARRAY
1 1 16 (11 10)*5    11 12 16 17 18 19
*
* The Core Element Z (half height)(bottom cell 2 reflected at Z=0)
PART 25 ARRAY
1 1 16 (14 13)*5    14 15 16 17 18 19
*
*The Radial Blanket element (half height)(Cell 8 reflected at Z = 0)
PART 26 ARRAY
1 1 2 20 21
*
*****
* Groups of 5x5 elements surrounded by the superlattice gap
* Core centre group (Row 4 centre)
PART 27 ARRAY
5 5 1 (23)*25
*
PART 28 OVERLAP
BOX   P27 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*
* Core bottom left corner group (Row 3 left)
PART 29 ARRAY
5 5 1 (26)*3 (25)*2 26 (25)*2 (24)*2 26 25 (24)*3 25 (24)*4
25 (24)*3 23
*
PART 30 OVERLAP
BOX   P29 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*
* Core bottom centre group (Row 3 centre)
PART 31 ARRAY
5 5 1 (24)*15 (23)*10
*
PART 32 OVERLAP
BOX   P31 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*
* Core bottom right group (Row 3 right)
PART 33 ARRAY
5 5 1 (25)*2 (26)*3 (24)*2 (25)*2 26 (24)*3 25 26 (24)*4 25
23 (24)*4
*
PART 34 OVERLAP
BOX   P33 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*
* Core left centre group (Row 4 left)
PART 35 ARRAY
5 5 1 (24)*3 (23)*2 (24)*3 (23)*2 (24)*3 (23)*2 (24)*3 (23)*2
(24)*3 (23)*2
*
PART 36 OVERLAP
BOX   P35 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*
* Core right centre group (Row 4 right)
PART 37 ARRAY
5 5 1 23 (24)*4 23 (24)*4 23 (24)*4 23 (24)*4 23 (24)*4
*
PART 38 OVERLAP
BOX   P37 -13.43025 -13.43025  0.0 26.8605 26.8605 82.52178
BOX   M18 -13.5635 -13.5635  50.2      27.127 27.127 30.4
BOX   M0  -13.5635 -13.5635  0.0 27.127 27.127 82.52178
*

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* Core top left corner group (Row 5 left)
PART 39 ARRAY
5 5 1 25 (24)*3 23 25 (24)*3 23 26 25 (24)*3 26 (25)*2 (24)*2
(26)*3 (25)*2
*
PART 40 OVERLAP
BOX P39 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Core top centre group (Row 5 centre)
PART 41 ARRAY
5 5 1 (23)*2 24 (23)*2 24 (23)*2 (24)*2 23 (24)*2
(24)*2 23 (24)*2 (24)*5
*
PART 42 OVERLAP
BOX P41 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Core top right group (Row 5 right)
PART 43 ARRAY
5 5 1 23 (24)*3 25 (24)*4 25 (24)*3 25 26 (24)*2 (25)*2 26
(25)*2 (26)*3
*
PART 44 OVERLAP
BOX P43 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 2 three groups containing core elements
*left group
PART 45 ARRAY
5 5 1 (26)*24 25
*
PART 46 OVERLAP
BOX P45 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Centre group
PART 47 ARRAY
5 5 1 (26)*20 (25)*5
*
PART 48 OVERLAP
BOX P47 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Right group (Also the row 3 right hand blanket group)
PART 49 ARRAY
5 5 1 (26)*20 25 (26)*4
*
PART 50 OVERLAP
BOX P49 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 5 blanket group (Core left group) Also the Row 6 left-hand group
PART 51 ARRAY
5 5 1 (26)*4 25 (26)*20
*
PART 52 OVERLAP
BOX P51 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 5 centre group
PART 53 ARRAY
5 5 1 (25)*5 (26)*20
*
PART 54 OVERLAP
BOX P53 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4

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BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127  82.52178
*
* Row 5 right hand group group
PART 55 ARRAY
5  5  1  25      (26)*24
*
PART 56 OVERLAP
BOX      P55     -13.43025 -13.43025   0.0 26.8605 26.8605 82.52178
BOX      M18     -13.5635  -13.5635   50.2          27.127  27.127  30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127  82.52178
*
* Row 4 left hand blanket group
PART 57 ARRAY
5  5  1  (26)*4  25 (26)*4  25 (26)*4  25 (26)*4  25 (26)*4  25
*
PART 58 OVERLAP
BOX      P57     -13.43025 -13.43025   0.0 26.8605 26.8605 82.52178
BOX      M18     -13.5635  -13.5635   50.2          27.127  27.127  30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127  82.52178
*
* Row 4 right hand blanket group
PART 59 ARRAY
5  5  1  25 (26)*4  25 (26)*4  25 (26)*4  25 (26)*4  25 (26)*4
*
PART 60 OVERLAP
BOX      P59     -13.43025 -13.43025   0.0 26.8605 26.8605 82.52178
BOX      M18     -13.5635  -13.5635   50.2          27.127  27.127  30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127  82.52178
*
*****
* Blanket element group
PART 61 ARRAY
5  5  1  (26)*25
*
PART 62 OVERLAP
BOX      P61     -13.43025 -13.43025   0.0 26.8605 26.8605 82.52178
BOX      M18     -13.5635  -13.5635   50.2          27.127  27.127  30.4
BOX      M0      -13.5635  -13.5635   0.0 27.127  27.127  82.52178
*****
*
* top and bottom groups have Y=3
*
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 63 ARRAY
5  3  1  (22)*13 (26)*2
PART 64 OVERLAP
BOX      P63     -13.43025 -8.05815   0.0 26.8605 16.1163 82.52178
BOX      M18     -13.5635  -8.1914   50.2 27.127  16.3828  30.4
BOX      M0      -13.5635  -8.1914   0.0 27.127  16.3828  82.52178
*
* Row 1 Shield centre bottom group
PART 65 ARRAY
5  3  1  (22)*10 (26)*5
*
PART 66 OVERLAP
BOX      P65     -13.43025 -8.05815   0.0 26.8605 16.1163 82.52178
BOX      M18     -13.5635  -8.1914   50.2 27.127  16.3828  30.4
BOX      M0      -13.5635  -8.1914   0.0 27.127  16.3828  82.52178
*
* Row 1 Right side
PART 67 ARRAY
5  3  1  (22)*10 (26)*2 (22)*3
PART 68 OVERLAP
BOX      P67     -13.43025 -8.05815   0.0 26.8605 16.1163 82.52178
BOX      M18     -13.5635  -8.1914   50.2 27.127  16.3828  30.4
BOX      M0      -13.5635  -8.1914   0.0 27.127  16.3828  82.52178
* combine these arrays to form the row 1 array
PART 69 ARRAY
3  1  1  64  66  68
*
*****
*

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* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Row 7 Left side
PART 70 ARRAY
5 3 1 (22)*3 (26)*2 (22)*10
PART 71 OVERLAP
BOX P70 -13.43025 -8.05815 0.0 26.8605 16.1163 82.52178
BOX M18 -13.5635 -8.1914 50.2 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 82.52178
*
* Row 7 Shield centre group
PART 72 ARRAY
5 3 1 (26)*5 (22)*10
*
PART 73 OVERLAP
BOX P72 -13.43025 -8.05815 0.0 26.8605 16.1163 82.52178
BOX M18 -13.5635 -8.1914 50.2 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 82.52178

* Right side
PART 74 ARRAY
5 3 1 (26)*2 (22)*13
PART 75 OVERLAP
BOX P74 -13.43025 -8.05815 0.0 26.8605 16.1163 82.52178
BOX M18 -13.5635 -8.1914 50.2 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 82.52178
* combine these arrays to form the row 7 array
PART 76 ARRAY
3 1 1 71 73 75
*
*****
*
*Row 2 Shield corner sections
* Bottom left group
PART 77 ARRAY
5 5 1 (22)*9 26 (22)*3 (26)*2 (22)*2 (26)*3 22 (26)*4
*
PART 78 OVERLAP
BOX P77 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 2 Bottom right group
PART 79 ARRAY
5 5 1 (22)*5 26 (22)*4 (26)*2 (22)*3 (26)*3 (22)*2 (26)*4 22
*
PART 80 OVERLAP
BOX P79 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* combine the arrays to form the row 2 array
PART 81 ARRAY
5 1 1 78 46 48 50 80
*
*****
*
* Row 6 Top left group
PART 82 ARRAY
5 5 1 22 (26)*4 (22)*2 (26)*3 (22)*3 (26)*2 (22)*4 26 (22)*5
*
PART 83 OVERLAP
BOX P82 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 6 top right group
PART 84 ARRAY
5 5 1 (26)*4 22 (26)*3 (22)*2 (26)*2 (22)*3 26 (22)*9
*
PART 85 OVERLAP
BOX P84 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178

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*
* combine the arrays to form the row 6 array
PART 86 ARRAY
5 1 1 83 52 54 56 85
*
*****
*
* Row 3, 7 groups, the two end groups being 3x5 arrays
* Left hand array
PART 87 ARRAY
3 5 1 (22)*11 26 (22)*2 26
PART 88 OVERLAP
BOX P87 -8.05815 -13.43025 0.0 16.1163 26.8605 82.52178
BOX M18 -8.1914 -13.5635 50.2 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 82.52178
* right hand array
PART 89 ARRAY
3 5 1 (22)*9 26 (22)*2 26 (22)*2
PART 90 OVERLAP
BOX P89 -8.05815 -13.43025 0.0 16.1163 26.8605 82.52178
BOX M18 -8.1914 -13.5635 50.2 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 82.52178
* Form the row 3 array
PART 91 ARRAY
7 1 1 88 62 30 32 34 50 90
*
*****
*
* Row 5, 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 92 ARRAY
3 5 1 (22)*2 26 (22)*2 26 (22)*9
PART 93 OVERLAP
BOX P92 -8.05815 -13.43025 0.0 16.1163 26.8605 82.52178
BOX M18 -8.1914 -13.5635 50.2 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 82.52178
*
* right hand shield array
PART 94 ARRAY
3 5 1 26 (22)*2 26 (22)*11
PART 95 OVERLAP
BOX P94 -8.05815 -13.43025 0.0 16.1163 26.8605 82.52178
BOX M18 -8.1914 -13.5635 50.2 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 82.52178
*
* Form the row 5 array
PART 96 ARRAY
7 1 1 93 52 40 42 44 62 95
*
*****
*
* Row 4 Shield left group
*
PART 97 ARRAY
5 5 1 (22)*4 26 (22)*4 26 (22)*4 26 (22)*4 26 (22)*4 26
*
PART 98 OVERLAP
BOX P97 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
* Row 4 Shield right group
PART 99 ARRAY
5 5 1 26 (22)*4 26 (22)*4 26 (22)*4 26 (22)*4 26 (22)*4
*
PART 100 OVERLAP
BOX P99 -13.43025 -13.43025 0.0 26.8605 26.8605 82.52178
BOX M18 -13.5635 -13.5635 50.2 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 82.52178
*
PART 101 ARRAY
7 1 1 98 58 36 28 38 60 100

```

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*****
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 102 CLUSTER
BOX P76 -40.6905 67.8175 0.0 81.381 16.3828 82.52178
BOX P86 -67.8175 40.6905 0.0 135.635 27.127 82.52178
BOX P96 -84.2003 13.5635 0.0 168.4006 27.127 82.52178
BOX P101 -94.9445 -13.5635 0.0 189.889 27.127 82.52178
BOX P91 -84.2003 -40.6905 0.0 168.4006 27.127 82.52178
BOX P81 -67.8175 -67.8175 0.0 135.635 27.127 82.52178
BOX P69 -40.6905 -84.2003 0.0 81.381 16.3828 82.52178
ZROD M14 0.0 0.0 0.0 96.6 84.0
*
*****
* Albedo for free boundaries at side and top and reflection at bottom
*
ALBEDO 0.0 0.0 1.0
END
*
*****
BEGIN CONTROL DATA
STAGES -50 3000 5000 STDV 0.0001
END
*
*****
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 1
END
*****

```

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A1.3. Assembly 23. The sodium filled pin geometry core. Model A.

*** MONK9A Input Listing for Assembly 23, Model A.**

* Assembly 23 is the Pin Geometry Version of the Cadenza cores.
* it also includes an outer ring of plate geometry elements
* Reactor structure: elements arranged on a square grid
* The Pin Elements in the core contain 3 minicalandria and an Axial
* Region Cell, enclosed in a mild steel sheath.
* The plate elements contain 24 cells, the plates having width 5.067 cm.
* The Element sheath has an inner width 5.102 cm, outer width 5.2544 cm.
* The elements occupy a lattice area of 5.3721 cm square.
* Groups of 5x5 elements form the superlattice
* with a space between them
* The Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
* The radial shielding elements consist of the Steel bar MST9F10
* which is about 300 cm high.
* These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (pitch 5.4254 cm)
* Elements are grouped in square arrays containing 5x5 = 25 elements
* plus edge groups with 3x5 elements. The Assembly is built from these.
* There is a gap between these groups of elements of 0.2667 cm
* Core Plate Geometry Element structure:
* The plate element consists of combinations of the following:
* Core Cell PART 1, Core Cell PART 2, an inversion of PART 1,
* Core Cell PART 3, which is the same as PART 1
* but with the 40%Steel plate omitted, and the inversion of
* this cell which forms PART 4
* the Axial Region Cell is PART5.
* Structure of Core Plate Cell 1, PART 1, 7 plates.
* Cell height 3.748082 cm. Enclosed in mild steel sheath.
* Outer area of all plates is 5.067 cm x 5.067 cm
* From the top down:
* Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
* UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
* Sodium (0.613694 cm thick,)
* Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671cm x 4.671 cm)
* 40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
* UO2 (0.6313 cm thick)
* Sodium (0.613694 cm thick)
* Structure of Core Plate Cell 2 PART 2. The inverse of PART 1
* Structure of Core Plate Cell PART 3. PART 1 without 40%Steel plate.
* Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
* Cell height From the top:
* MST3 Block (7.60628 cm thick)
* U3 Block (7.6225 cm thick,)
* U2 region (10 plates, total thickness 12.723 cm)
* U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
* Height of the reflected half height element
* MST3 Block (7.60628 cm thick)
* U3 Block composition (height above mid-plane to match the core
* element blanket height of 74.83248 cm)

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium plate core
* material 6 - Sodium plate clad
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Mild steel sheath
* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
* material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
* material 15 - Pin fuel A
* material 16 - Pin fuel B
* material 17 - Pin fuel C

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* material 18 - Pin fuel D
* material 19 - Pin fuel E
* material 20 - Pin fuel F
* material 21 - Pin fuel UPINC
* material 22 - Pin can A
* material 23 - Pin can B
* material 24 - Pin can C
* material 25 - Pin can D
* material 26 - Pin can E
* material 27 - Pin can F
* material 28 - Pin can UPINC
* material 29 - Tube
* material 30 - Calandria end regions
* material 31 - Calandria Walls Type NACLI
* material 32 - Calandria Walls Type NACLIIS
* material 33 - Calandria Walls Type NACLIIS
* material 34 - Calandria Walls Type NACLIV
* material 35 - Calandria Walls Type NACLIV
* material 36 - Calandria Sodium Type NACLI
* material 37 - Calandria Sodium Type NACLIIS
* material 38 - Calandria Sodium Type NACLIIS
* material 39 - Calandria Sodium Type NACLIV
* material 40 - Calandria Sodium Type NACLIV
* material 41 - Superlattice grid
*****
COLUMNS 1 132
BEGIN MATERIAL SPECIFICATION
NUMBER DENSITY
MATERIAL 1
U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02
PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04
AM241 4.5718E-04
H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05
AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06
FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03
MATERIAL 2
H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05
CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03
CU 1.6613E-02
MATERIAL 3
H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06
SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06
MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02
MATERIAL 4
H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04
S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02
NI 8.4258E-03
MATERIAL 5
H1 1.3900E-05 O16 5.6492E-06 NA 2.3225E-02 CA 3.6083E-06
FE 1.6184E-07
MATERIAL 6
H1 2.1631E-05 C 2.9290E-04 SI 6.0867E-04 P 3.2795E-05
S 3.3219E-05 CR 1.4759E-02 MN 1.3570E-03 FE 5.5054E-02
NI 7.0982E-03 NB 3.1147E-04
MATERIAL 7
H1 1.8355E-05 C 8.7794E-05 AL 1.1862E-04 SI 7.9703E-04
P 4.0018E-05 S 1.4422E-05 TI 2.4806E-04 CR 1.5908E-02
MN 1.4972E-03 FE 5.5367E-02 NI 8.7976E-03 CU 5.0365E-05
NB 4.9781E-06 MO 8.0988E-05
MATERIAL 8
H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04
U235 3.3369E-04 U238 4.6021E-02
MATERIAL 9
H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05
U235 3.3962E-04 U238 4.6785E-02
MATERIAL 10
H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04
U235 3.4209E-04 U238 4.7156E-02
MATERIAL 11
H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05
CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05
CU 4.4548E-05 MO 9.8355E-06
MATERIAL 12
H1 7.5712E-05 C 2.3825E-04 AL 1.9798E-05 CR 3.6690E-06

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MN 2.5697E-04 FE 7.7524E-02 NI 1.4302E-05 CU 2.2216E-05
MATERIAL 13
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
MATERIAL 14
H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02

* Pin fuel A, B, C, D, E, F and U
MATERIAL 15
U234 1.3805E-06 U235 1.4114E-04 U236 7.9324E-07 U238 1.9379E-02
PU238 3.7786E-06 PU239 2.9689E-03 PU240 6.7253E-04 PU241 7.0350E-05
PU242 1.7488E-05 AM241 4.7854E-05
H1 3.2784E-05 O16 4.6606E-02 AL 1.1702E-05 CA 7.8782E-06 FE 5.6537E-06
MATERIAL 16
U234 1.3177E-06 U235 1.3457E-04 U236 7.4658E-07 U238 1.8472E-02
PU238 5.8915E-06 PU239 3.7341E-03 PU240 9.5200E-04 PU241 1.1199E-04
PU242 2.7984E-05 AM241 5.5789E-05
H1 3.2784E-05 O16 4.6993E-02 SI 9.0199E-06 NI 5.4424E-06
MATERIAL 17
U234 1.2863E-06 U235 1.2997E-04 U236 7.3103E-07 U238 1.7843E-02
PU238 6.9094E-06 PU239 4.4708E-03 PU240 1.0602E-03 PU241 1.1598E-04
PU242 3.0047E-05 AM241 5.7784E-05
H1 3.2784E-05 O16 4.7434E-02 AL 1.9730E-05 SI 7.9741E-06
FE 7.6916E-06 NI 1.0947E-05
MATERIAL 18
U234 1.4118E-06 U235 1.4266E-04 U236 7.9324E-07 U238 1.9584E-02
PU238 4.7348E-06 PU239 3.0189E-03 PU240 7.5441E-04 PU241 8.8443E-05
PU242 2.0961E-05 AM241 4.0742E-05
H1 3.2784E-05 O16 4.7314E-02 AL 1.8914E-05 SI 2.5099E-05
CA 1.5940E-05 FE 6.9027E-06 NI 1.4138E-05
MATERIAL 19
U234 1.1295E-06 U235 1.1465E-04 U236 6.3771E-07 U238 1.5739E-02
PU238 9.4851E-06 PU239 6.0438E-03 PU240 1.5103E-03 PU241 1.7707E-04
PU242 4.1953E-05 AM241 8.1559E-05
H1 3.2784E-05 O16 4.7299E-02 AL 9.5250E-06 SI 4.5753E-05
CA 3.2062E-05 FE 1.0321E-05
MATERIAL 20
U234 1.1452E-06 U235 1.1526E-04 U236 6.3771E-07 U238 1.5824E-02
PU238 9.5005E-06 PU239 6.0112E-03 PU240 1.5285E-03 PU241 1.9723E-04
PU242 4.4380E-05 AM241 6.8035E-05
H1 3.2784E-05 O16 4.7482E-02 AL 1.4287E-05 CA 6.7514E-05
CR 4.9427E-06 FE 1.1505E-05 NI 2.1895E-06
* UO2 fuel pin
MATERIAL 21
U235 1.7604E-04 U238 2.3580E-02
H1 3.2784E-05 C 3.2095E-05 O16 4.7501E-02 AL 2.3812E-05
SI 4.0001E-05 CA 1.2825E-05 FE 1.1176E-06

* Fuel pin cans
MATERIAL 22
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05 S 2.4585E-05
CR 1.8218E-02 MN 1.5646E-03 FE 5.9675E-02 NI 8.9153E-03
MATERIAL 23
H1 2.2895E-05 C 2.3695E-04 SI 1.1571E-03 P 4.1596E-05 S 2.2786E-05
CR 1.4981E-02 MN 1.5751E-03 FE 5.3171E-02 NI 8.8137E-03
NB 2.9391E-04
MATERIAL 24
H1 2.6710E-05 C 1.3609E-04 SI 8.3531E-04 P 3.6008E-05 S 2.4585E-05
CR 1.7856E-02 MN 1.5331E-03 FE 5.8512E-02 NI 8.7515E-03
MATERIAL 25
H1 2.4802E-05 C 2.0172E-04 AL 6.4142E-06 SI 8.9693E-04 P 3.4145E-05
S 8.9942E-06 TI 2.8916E-05 CR 1.5910E-02 MN 1.1586E-03 FE 5.5753E-02
CO 4.2418E-06 NI 7.6341E-03 CU 6.0522E-06 MO 2.2047E-06
MATERIAL 26
H1 2.4802E-05 C 7.3646E-05 AL 6.4142E-06 SI 1.0476E-03 P 1.3658E-05
S 1.7389E-05 TI 2.8916E-05 CR 1.6102E-02 MN 9.8006E-04 FE 5.6794E-02
CO 4.2418E-06 NI 8.0503E-03 CU 6.0522E-06 MO 2.1446E-05
MATERIAL 27
H1 2.4802E-05 C 7.2045E-05 AL 4.2762E-06 SI 1.0544E-03 P 1.3658E-05
S 1.7989E-05 TI 2.1687E-05 CR 1.6284E-02 MN 9.8357E-04 FE 5.7354E-02
CO 3.2629E-06 NI 8.1453E-03 CU 4.5391E-06 MO 2.1246E-05
MATERIAL 28
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05

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S 2.4585E-05 CR 1.8255E-02 MN 1.5681E-03 FE 5.9792E-02
NI 8.9349E-03

* Composition of calandria tubes
MATERIAL 29
SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02
NI 7.4360E-03
* Composition of Calandria end plate regions
MATERIAL 30
SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02
NI 4.4601E-03
* Compositions of Calandria outer walls
MATERIAL 31
H1 3.9844E-05 C 2.8167E-04 SI 6.0229E-04 P 7.3471E-05 S 3.6808E-05
CR 1.4995E-02 MN 1.2214E-03 FE 4.8911E-02 NI 7.2440E-03
MATERIAL 32
H1 3.8637E-05 C 6.5351E-04 SI 9.7623E-04 P 4.7540E-05 S 3.3014E-05
TI 2.4400E-04 CR 1.4380E-02 MN 1.1060E-03 FE 4.7118E-02 CO 1.1151E-05
NI 7.4526E-03 CU 1.0341E-05 MO 3.4248E-06
MATERIAL 33
H1 3.9844E-05 C 1.5948E-04 SI 7.7474E-04 P 5.2334E-05 S 2.4551E-05
CR 1.4132E-02 MN 8.3089E-04 FE 5.0764E-02 NI 7.6658E-03 MO 2.4862E-05
MATERIAL 34
H1 3.7430E-05 C 3.5158E-04 SI 8.2197E-04 P 6.2274E-05 S 1.6431E-05
CR 1.3563E-02 MN 1.0026E-03 FE 4.7151E-02 NI 6.4549E-03 MO 8.8791E-06
MATERIAL 35
H1 3.8637E-05 C 2.4762E-04 SI 9.5110E-04 P 4.5654E-05 S 2.3793E-05
CR 1.3837E-02 MN 8.6191E-04 FE 4.8404E-02 NI 6.8530E-03 MO 2.4862E-05

* Sodium compositions
MATERIAL 36
H1 5.5075E-06 O16 6.4605E-06 NA 2.4129E-02 CA 1.1080E-06 FE 3.0847E-07
MATERIAL 37
H1 1.1205E-05 O16 1.0767E-06 NA 2.4379E-02 CA 9.5521E-08
MATERIAL 38
H1 7.5966E-06 O16 3.5892E-06 NA 2.3888E-02 K 3.4270E-07 CA 6.6865E-07
MATERIAL 39
H1 7.5966E-06 O16 3.5892E-06 NA 2.4037E-02 K 3.4270E-07 CA 6.6865E-07
MATERIAL 40
H1 7.5966E-06 O16 3.5892E-06 NA 2.3829E-02 K 3.4270E-07 CA 6.6865E-07
* Superlattice grid
MATERIAL 41
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
END

*
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.5335 -2.5335 0.0 5.067 5.067 0.3274
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.3274
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.3274
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558
BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.6313
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.6313
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313
*
* Plate 3, the sodium plate
PART 3 NEST
BOX M5 -2.4815 -2.4815 0.036347 4.963 4.963 0.541
BOX M6 -2.5335 -2.5335 0.0 5.067 5.067 0.613694
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.613694
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.613694
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.613694
*
* Plate 4, the 40% steel plate

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PART 4 NEST
BOX      M0  -1.9625 -1.9625 0.0      3.925  3.925  0.317
BOX      M7  -2.5335 -2.5335 0.0      5.067  5.067  0.317
BOX      M0  -2.5510 -2.5510 0.0      5.102  5.102  0.317
BOX      M12 -2.6272 -2.6272 0.0      5.2544 5.2544 0.317
BOX      M0  -2.68605 -2.68605 0.0    5.3721 5.3721 0.317
*
* Core Cell 1
PART 5 ARRAY
1 1 7 3 2 4 1 3 2 3
* Core Cell 2, the reflection of cell 1
PART 6 ARRAY
1 1 7 3 2 3 1 4 2 3
*
* Core Cell 3 This is Cell 1 minus Plate 4
PART 7 ARRAY
1 1 6 3 2 1 3 2 3
*Core Cell 4 the reflection of cell 3, Cell 2 minus Plate 4
PART 8 ARRAY
1 1 6 3 2 3 1 2 3
*
*****
* Axial blanket U8 section
PART 9 NEST
BOX      M8      -2.5335 -2.5335 0.0      5.067  5.067  9.827
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  9.827
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 9.827
BOX      M0     -2.68605 -2.68605 0.0      0.0    5.3721 5.3721 9.827
*
* Axial blanket U2 section
PART 10 NEST
BOX      M9      -2.5335 -2.5335 0.0      5.067  5.067  12.723
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  12.723
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 12.723
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 12.723
*
* Axial blanket U3 section
PART 11 NEST
BOX      M10     -2.5335 -2.5335 0.0      5.067  5.067  7.6225
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.6225
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.6225
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.6225
*
* Axial reflector MST3 section
PART 12 NEST
BOX      M11     -2.5335 -2.5335 0.0      5.067  5.067  7.60628
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.60628
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.60628
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.60628
*
*****
* Radial blanket U3 section (over half core height)
PART 13 NEST
BOX      M10     -2.5335 -2.5335 0.0      5.067  5.067  74.83248
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  74.83248
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 74.83248
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 74.83248
*
*****
* A whole height model.
* The axial height of the pin cell core is slightly less than
* that of the plate cell core, 89.19 cm compared with 89.32 cm.
* (0.13 cm = 2 * 0.065 cm)
* The axial shielding material is extended in the model
* to cover this distance
* Axial steel reflector section extended 0.065 cm in length
PART 14 NEST
BOX      M11     -2.5335 -2.5335 0.0      5.067  5.067  7.67128
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.67128
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.67128
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.67128
*
*****
* The Core Element (full height)

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PART 15 ARRAY

1 1 32 12 11 10 9 8 (5 6)*11 7 9 10 11 12

*

*The Radial Blanket element

PART 16 ARRAY

1 1 4 12 13 13 12

*

* Specification of the pin cells, A to F and U/C

* Pin cell A

PART 17 NEST

ZROD M15	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M22	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell B

PART 18 NEST

ZROD M16	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M23	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell C

PART 19 NEST

ZROD M17	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M24	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell D

PART 20 NEST

ZROD M18	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M25	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell E

PART 21 NEST

ZROD M19	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M26	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell F

PART 22 NEST

ZROD M20	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M27	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell U/C

PART 23 NEST

ZROD M21	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M28	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Mini-calandria

*

Mini calandria 3A,

* 16 PUPINC in NACLI

* Pin C in square of sodium

PART 24 NEST

ZROD P19	0.0	0.0	0.0	0.513	29.18
BOX M36	-0.595	-0.595	0.0 1.19	1.19	29.18

* array of pins in sodium

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PART 25 ARRAY
4 4 1 (24)*16
* mini-calandria in the element sheath (M12)
PART 26 NEST
BOX P25 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3B,
* 11 PUPINB and 5 PUPINF in NACL I
* Pin B in square of sodium
PART 27 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 28 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 29 ARRAY
4 4 1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27
* mini-calandria in the element sheath (M12)
PART 30 NEST
BOX P29 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3H,
* 11 PUPINB and 5 PUPINF in NACL V
* Pin B in square of NACL V sodium
PART 31 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 32 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 33 ARRAY
4 4 1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31
* mini-calandria in the element sheath (M12)
PART 34 NEST
BOX P33 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M40 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M35 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3L,
* 11 PUPINB and 5 PUPINF in NACL IV
* Pin B in square of NACL IV sodium
PART 35 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35

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* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPINA and 8 PUPINE in NACLIII
* Pin A in square of NACLIII sodium
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin E in square of sodium
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in square of NACLIII sodium
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPIND and 8 PUPINF in NACLIIS
* Pin D in square of NACLIIS sodium
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 48 47 48 47
* mini-calandria in the element sheath (M12)
PART 50 NEST

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BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M37 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 12 PUPINE and 4 UO2PINC in NACLIV
* Pin E in square of NACLIV sodium
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)
PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* form the elements 3A to 3L
* Element 3A
PART 55 ARRAY
1 1 11 14 11 10 9 (26)*3 9 10 11 14
* Element 3B
PART 56 ARRAY
1 1 11 14 11 10 9 (30)*3 9 10 11 14
* Element 3C
PART 57 ARRAY
1 1 11 14 11 10 9 (42)*3 9 10 11 14
* Element 3D
PART 58 ARRAY
1 1 11 14 11 10 9 (46)*3 9 10 11 14
* Element 3E
PART 59 ARRAY
1 1 11 14 11 10 9 (50)*3 9 10 11 14
* Element 3H
PART 60 ARRAY
1 1 11 14 11 10 9 (34)*3 9 10 11 14
* Element 3J
PART 61 ARRAY
1 1 11 14 11 10 9 (54)*3 9 10 11 14
* Element 3L
PART 62 ARRAY
1 1 11 14 11 10 9 (38)*3 9 10 11 14
*
*****
* Steel reflector bars
PART 63 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 164.877528
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 164.877528
*
*****
* assemble the arrays of elements
*
* Groups of 5x5 elements surrounded by the superlattice gap
* With groups of 5x3 in rows 1 and 7 and 3x5 in rows 3 and 5
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side

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PART 64 ARRAY
5 3 1 (63)*13 (16)*2
PART 65 OVERLAP
BOX P64 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre
PART 66 ARRAY
5 3 1 (63)* 10 (16)*5
PART 67 OVERLAP
BOX P66 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Right side
PART 68 ARRAY
5 3 1 (63)*10 (16)*2 (63)*3
PART 69 OVERLAP
BOX P68 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* combine these arrays to form the row 1 array
PART 70 ARRAY
3 1 1 65 67 69
*
*****
* A 5x5 array of blanket elements
PART 71 ARRAY
5 5 1 (16)*25
*
PART 72 OVERLAP
BOX P71 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
*****
* Row 2. 5 arrays of 5x5 elements, two being PART 72
* Left hand array
PART 73 ARRAY
5 5 1 (63)*9 16 (63)*3 (16)*2 (63)*2 (16)*3 63 (16)*4
*
PART 74 OVERLAP
BOX P73 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Middle array
PART 75 ARRAY
5 5 1 (16)*20 (15)*5
*
PART 76 OVERLAP
BOX P75 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Right hand array
PART 77 ARRAY
5 5 1 (63)*5 16 (63)*4 (16)*2 (63)*3 (16)*3 (63)*2 (16)*4 63
*
PART 78 OVERLAP
BOX P77 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* Form row 2 array
PART 79 ARRAY
5 1 1 74 72 76 72 78
*
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays

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```

* Left hand array
PART 80 ARRAY
3 5 1 (63)*11 16 (63)*2 16
PART 81 OVERLAP
BOX P80 -8.05815 -13.43025 0.0 16.1163 26.8605 164.877528
BOX M41 -8.1914 -13.5635 1.83876 16.3828 27.127 30.4
BOX M41 -8.1914 -13.5635 132.63876 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 164.877528
* Core lower left hand array
PART 82 ARRAY
5 5 1 (16)*3 (15)*2 16 (15)*2 (60)*2 16 15 55 58 60
15 (58)*2 57 59 15 (58)*2 57 59
*
PART 83 OVERLAP
BOX P82 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Core lower middle array
PART 84 ARRAY
5 5 1 (62)*5 (56)*10 (57)*10
*
PART 85 OVERLAP
BOX P84 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Core lower right hand array
PART 86 ARRAY
5 5 1 (15)*2 (16)*3 (60)*2 (15)*2 16 60 58 55 15 16
59 57 58 59 15 59 57 58 59 15
*
PART 87 OVERLAP
BOX P86 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* right hand array
PART 88 ARRAY
3 5 1 (63)*9 16 (63)*2 16 (63)*2
PART 89 OVERLAP
BOX P88 -8.05815 -13.43025 0.0 16.1163 26.8605 164.877528
BOX M41 -8.1914 -13.5635 1.83876 16.3828 27.127 30.4
BOX M41 -8.1914 -13.5635 132.63876 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 164.877528
* Form the row 3 array
PART 90 ARRAY
7 1 1 81 72 83 85 87 72 89
*
*****
* Row 4 (the middle row) 7 groups of 5x5 elements
* Left hand shield group
PART 91 ARRAY
5 5 1 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16
*
PART 92 OVERLAP
BOX P91 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Left hand blanket group
PART 93 ARRAY
5 5 1 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15
*
PART 94 OVERLAP
BOX P93 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Left hand core group
PART 95 ARRAY
5 5 1 55 61 58 (59)*2 55 (58)*2 (59)*2 56 (59)*4
55 58 55 (59)*2 55 61 55 (59)*2

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*
PART 96 OVERLAP
BOX    P95  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Centre core group
PART 97 ARRAY
5  5  1  (57)*25
*
PART 98 OVERLAP
BOX    P97  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Right hand core group
PART 99 ARRAY
5  5  1  (59)*2 58 61 55 (59)*2 (58)*2 55 (59)*4 56
(59)*2 55 58 55 (59)*2 55 61 55
*
PART 100 OVERLAP
BOX    P99  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Right hand blanket group
PART 101 ARRAY
5  5  1  15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4
*
PART 102 OVERLAP
BOX    P101 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Right hand shield group
PART 103 ARRAY
5  5  1  16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4
*
PART 104 OVERLAP
BOX    P103 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Form the row 4 array
PART 105 ARRAY
7  1  1  92 94 96 98 100 102 104
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 106 ARRAY
3  5  1  (63)*2 16 (63)*2 16 (63)*9
PART 107 OVERLAP
BOX    P106 -8.05815 -13.43025  0.0 16.1163 26.8605 164.877528
BOX    M41  -8.1914  -13.5635  1.83876 16.3828 27.127 30.4
BOX    M41  -8.1914  -13.5635  132.63876 16.3828 27.127 30.4
BOX    M0   -8.1914  -13.5635  0.0 16.3828 27.127 164.877528
* Core upper left hand array
PART 108 ARRAY
5  5  1  15 (58)*2 57 59 15 56 58 57 59 16 15 55 58 58
16 (15)*2 (60)*2 (16)*3 (15)*2
*
PART 109 OVERLAP
BOX    P108 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635  -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635  -13.5635  0.0 27.127 27.127 164.877528
* Core upper middle array
PART 110 ARRAY
5  5  1  (57)*10 (56)*10 (62)*5
*
PART 111 OVERLAP

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BOX      P110  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
* Core upper right hand array
PART 112 ARRAY
5  5  1  59  57  58  58  15  59  57  58  56  15  58  58  55  15
16 (60)*2 (15)*2 16 (15)*2 (16)*3
*
PART 113 OVERLAP
BOX      P112  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* right hand shield array
PART 114 ARRAY
3  5  1  16 (63)*2 16 (63)*2 (63)*9
PART 115 OVERLAP
BOX      P114  -8.05815  -13.43025  0.0      16.1163 26.8605 164.877528
BOX      M41  -8.1914  -13.5635   1.83876 16.3828 27.127 30.4
BOX      M41  -8.1914  -13.5635  132.63876 16.3828 27.127 30.4
BOX      M0   -8.1914  -13.5635   0.0 16.3828 27.127 164.877528
* Form the row 5 array
PART 116 ARRAY
7  1  1  107 72 109 111 113 72 115
*
*****
* Row 6 arrays 5 groups of 5x5, one being PART 72
*
* Left hand array
PART 117 ARRAY
5  5  1  63 (16)*4 (63)*2 (16)*3 (63)*3 (16)*2 (63)*4 16 (63)*5
*
PART 118 OVERLAP
BOX      P117  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
* Middle array
PART 119 ARRAY
5  5  1  (15)*5 (16)*20
*
PART 120 OVERLAP
BOX      P119  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
*
* Right middle array
PART 121 ARRAY
5  5  1  15 (16)*24
*
PART 122 OVERLAP
BOX      P121  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Right hand array
PART 123 ARRAY
5  5  1  (16)*4 63 (16)*3 (63)*2 (16)*2 (63)*3 16 (63)*9
*
PART 124 OVERLAP
BOX      P123  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Form row 6 array
PART 125 ARRAY
5  1  1  118 72 120 122 124
*

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*****
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 126 ARRAY
5 3 1 (63)*3 (16)*2 (63)*10
PART 127 OVERLAP
BOX P126 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre
PART 128 ARRAY
5 3 1 (16)*5 (63)* 10
PART 129 OVERLAP
BOX P128 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Right side
PART 130 ARRAY
5 3 1 (16)*2 (63)*13
PART 131 OVERLAP
BOX P130 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* combine these arrays to form the row 7 array
PART 132 ARRAY
3 1 1 127 129 131
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 133 CLUSTER
BOX P132 -40.6905 67.8175 0.0 81.381 16.3828 164.877528
BOX P125 -67.8175 40.6905 0.0 135.635 27.127 164.877528
BOX P116 -84.2003 13.5635 0.0 168.4006 27.127 164.877528
BOX P105 -94.9445 -13.5635 0.0 189.889 27.127 164.877528
BOX P90 -84.2003 -40.6905 0.0 168.4006 27.127 164.877528
BOX P79 -67.8175 -67.8175 0.0 135.635 27.127 164.877528
BOX P70 -40.6905 -84.2003 0.0 81.381 16.3828 164.877528
ZROD M14 0.0 0.0 -1.56 96.6 168.0
*
*****
* Albedo for free boundaries at side and top and bottom
*
ALBEDO 0.0 0.0 0.0
END
*
*****
BEGIN CONTROL DATA
STAGES -50 3000 3000 STDV 0.0001
END
*
*****
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 15
END

```

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A1.4. Assembly 25. The sodium voided pin geometry core, Model A.

*** MONK9A Input Listing for Assembly 25, Model A**

* Assembly 25 is the sodium voided Pin Geometry Version of the Cadenza cores.
* it also includes an extra outer ring of plate geometry elements
* Reactor structure: elements arranged on a square grid
* The Pin Elements in the core contain 3 minicalandria and an Axial
* Region Cell, enclosed in a mild steel sheath.
* The plate elements contain 24 cells, the plates having width 5.067 cm.
* The Element sheath has an inner width 5.102 cm, outer width 5.2544 cm.
* The elements occupy a lattice area of 5.3721 cm square.
* Groups of 5x5 elements form the superlattice (mean pitch 5.4254)
* with a space between them
* The Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
* The radial shielding elements consist of the Steel bar MST9F10
* which is about 300 cm high.
* These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (mean pitch 5.4254 cm)
* Elements are grouped in square arrays containing 5x5 = 25 elements
* plus edge groups with 3x5 elements. The Assembly is built from these.
* There is a gap between these groups of elements of 0.2667 cm
* Core Plate Geometry Element structure:
* The plate element consists of combinations of the following:
* Core Cell PART 1, Core Cell PART 2, an inversion of PART 1,
* Core Cell PART 3, which is the same as PART 1
* but with the 40%Steel plate omitted, and the inversion of
* this cell which forms PART 4
* the Axial Region Cell is PART5.
* Structure of Core Plate Cell 1, PART 1, 7 plates.
* Cell height 3.748082 cm. Enclosed in mild steel sheath.
* Outer area of all plates is 5.067 cm x 5.067 cm
* From the top down:
* Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
* UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
* Sodium (0.613694 cm thick,)
* Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671cm x 4.671 cm)
* 40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
* UO2 (0.6313 cm thick)
* Sodium (0.613694 cm thick)
* Structure of Core Plate Cell 2 PART 2. The inverse of PART 1
* Structure of Core Plate Cell PART 3. PART 1 without 40%Steel plate.
* Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
* Cell height From the top:
* MST3 Block (7.60628 cm thick)
* U3 Block (7.6225 cm thick,)
* U2 region (10 plates, total thickness 12.723 cm)
* U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
* Height of the reflected half height element
* MST3 Block (7.60628 cm thick)
* U3 Block composition (height above mid-plane to match the core
* element blanket height of 74.83248 cm)

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium dummy, type Y (STNAVS4 ring)
* material 6 - Sodium dummy type Z (STNAV4 uniform, eggbox)
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Smeared Mild steel sheath
* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
* material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
* material 15 - Pin fuel A
* material 16 - Pin fuel B
* material 17 - Pin fuel C

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* material 18 - Pin fuel D
* material 19 - Pin fuel E
* material 20 - Pin fuel F
* material 21 - Pin fuel UPINC
* material 22 - Pin can A
* material 23 - Pin can B
* material 24 - Pin can C
* material 25 - Pin can D
* material 26 - Pin can E
* material 27 - Pin can F
* material 28 - Pin can UPINC
* material 29 - Tube
* material 30 - Calandria end regions
* material 31 - Calandria Walls Type NACLI
* material 32 - Calandria Walls Type NACLIIS
* material 33 - Calandria Walls Type NACLIIS
* material 34 - Calandria Walls Type NACLIV
* material 35 - Calandria Walls Type NACLIV
* material 36 - Grid material
*****
COLUMNS 1 132
BEGIN MATERIAL SPECIFICATION
NUMBER DENSITY
MATERIAL 1
U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02
PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04
AM241 4.5718E-04
H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05
AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06
FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03
MATERIAL 2
H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05
CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03
CU 1.6613E-02
MATERIAL 3
H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06
SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06
MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02
MATERIAL 4
H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04
S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02
NI 8.4258E-03
MATERIAL 5
H1 2.4073E-05 C 2.5251E-04 SI 7.4610E-04 P 1.7803E-05
S 1.7195E-05 CR 1.6248E-02 MN 1.5006E-03 FE 5.9881E-02
NI 9.4005E-03 NB 3.7393E-04
MATERIAL 6
H1 3.3245E-06 C 3.3477E-05 SI 1.2169E-04 P 4.9764E-06
S 2.5076E-06 CR 2.4643E-03 MN 1.9518E-04 FE 8.0717E-03
NI 1.2195E-03 NB 5.2657E-05
MATERIAL 7
H1 1.8355E-05 C 8.7794E-05 AL 1.1862E-04 SI 7.9703E-04
P 4.0018E-05 S 1.4422E-05 TI 2.4806E-04 CR 1.5908E-02
MN 1.4972E-03 FE 5.5367E-02 NI 8.7976E-03 CU 5.0365E-05
NB 4.9781E-06 MO 8.0988E-05
MATERIAL 8
H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04
U235 3.3369E-04 U238 4.6021E-02
MATERIAL 9
H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05
U235 3.3962E-04 U238 4.6785E-02
MATERIAL 10
H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04
U235 3.4209E-04 U238 4.7156E-02
MATERIAL 11
H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05
CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05
CU 4.4548E-05 MO 9.8355E-06
MATERIAL 12
H1 3.7519E-05 C 1.1807E-04 AL 9.8110E-06 CR 1.8182E-06
MN 1.2734E-04 FE 3.8417E-02 NI 7.0874E-06 CU 1.1009E-05
MATERIAL 13
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02

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MATERIAL 14
H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02

* Pin fuel A, B, C, D, E, F and U

MATERIAL 15
U234 1.3805E-06 U235 1.4114E-04 U236 7.9324E-07 U238 1.9379E-02
PU238 3.7786E-06 PU239 2.9689E-03 PU240 6.7253E-04 PU241 7.0350E-05
PU242 1.7488E-05 AM241 4.7854E-05
H1 3.2784E-05 O16 4.6606E-02 AL 1.1702E-05 CA 7.8782E-06 FE 5.6537E-06

MATERIAL 16
U234 1.3177E-06 U235 1.3457E-04 U236 7.4658E-07 U238 1.8472E-02
PU238 5.8915E-06 PU239 3.7341E-03 PU240 9.5200E-04 PU241 1.1199E-04
PU242 2.7984E-05 AM241 5.5789E-05
H1 3.2784E-05 O16 4.6993E-02 SI 9.0199E-06 NI 5.4424E-06

MATERIAL 17
U234 1.2863E-06 U235 1.2997E-04 U236 7.3103E-07 U238 1.7843E-02
PU238 6.9094E-06 PU239 4.4708E-03 PU240 1.0602E-03 PU241 1.1598E-04
PU242 3.0047E-05 AM241 5.7784E-05
H1 3.2784E-05 O16 4.7434E-02 AL 1.9730E-05 SI 7.9741E-06
FE 7.6916E-06 NI 1.0947E-05

MATERIAL 18
U234 1.4118E-06 U235 1.4266E-04 U236 7.9324E-07 U238 1.9584E-02
PU238 4.7348E-06 PU239 3.0189E-03 PU240 7.5441E-04 PU241 8.8443E-05
PU242 2.0961E-05 AM241 4.0742E-05
H1 3.2784E-05 O16 4.7314E-02 AL 1.8914E-05 SI 2.5099E-05
CA 1.5940E-05 FE 6.9027E-06 NI 1.4138E-05

MATERIAL 19
U234 1.1295E-06 U235 1.1465E-04 U236 6.3771E-07 U238 1.5739E-02
PU238 9.4851E-06 PU239 6.0438E-03 PU240 1.5103E-03 PU241 1.7707E-04
PU242 4.1953E-05 AM241 8.1559E-05
H1 3.2784E-05 O16 4.7299E-02 AL 9.5250E-06 SI 4.5753E-05
CA 3.2062E-05 FE 1.0321E-05

MATERIAL 20
U234 1.1452E-06 U235 1.1526E-04 U236 6.3771E-07 U238 1.5824E-02
PU238 9.5005E-06 PU239 6.0112E-03 PU240 1.5285E-03 PU241 1.9723E-04
PU242 4.4380E-05 AM241 6.8035E-05
H1 3.2784E-05 O16 4.7482E-02 AL 1.4287E-05 CA 6.7514E-05
CR 4.9427E-06 FE 1.1505E-05 NI 2.1895E-06
* UO2 fuel pin

MATERIAL 21
U235 1.7604E-04 U238 2.3580E-02
H1 3.2784E-05 C 3.2095E-05 O16 4.7501E-02 AL 2.3812E-05
SI 4.0001E-05 CA 1.2825E-05 FE 1.1176E-06

* Fuel pin cans

MATERIAL 22
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05 S 2.4585E-05
CR 1.8218E-02 MN 1.5646E-03 FE 5.9675E-02 NI 8.9153E-03

MATERIAL 23
H1 2.2895E-05 C 2.3695E-04 SI 1.1571E-03 P 4.1596E-05 S 2.2786E-05
CR 1.4981E-02 MN 1.5751E-03 FE 5.3171E-02 NI 8.8137E-03
NB 2.9391E-04

MATERIAL 24
H1 2.6710E-05 C 1.3609E-04 SI 8.3531E-04 P 3.6008E-05 S 2.4585E-05
CR 1.7856E-02 MN 1.5331E-03 FE 5.8512E-02 NI 8.7515E-03

MATERIAL 25
H1 2.4802E-05 C 2.0172E-04 AL 6.4142E-06 SI 8.9693E-04 P 3.4145E-05
S 8.9942E-06 TI 2.8916E-05 CR 1.5910E-02 MN 1.1586E-03 FE 5.5753E-02
CO 4.2418E-06 NI 7.6341E-03 CU 6.0522E-06 MO 2.2047E-06

MATERIAL 26
H1 2.4802E-05 C 7.3646E-05 AL 6.4142E-06 SI 1.0476E-03 P 1.3658E-05
S 1.7389E-05 TI 2.8916E-05 CR 1.6102E-02 MN 9.8006E-04 FE 5.6794E-02
CO 4.2418E-06 NI 8.0503E-03 CU 6.0522E-06 MO 2.1446E-05

MATERIAL 27
H1 2.4802E-05 C 7.2045E-05 AL 4.2762E-06 SI 1.0544E-03 P 1.3658E-05
S 1.7989E-05 TI 2.1687E-05 CR 1.6284E-02 MN 9.8357E-04 FE 5.7354E-02
CO 3.2629E-06 NI 8.1453E-03 CU 4.5391E-06 MO 2.1246E-05

MATERIAL 28
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05
S 2.4585E-05 CR 1.8255E-02 MN 1.5681E-03 FE 5.9792E-02
NI 8.9349E-03

* Composition of calandria tubes

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MATERIAL 29
SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02
NI 7.4360E-03
* Composition of Calandria end plate regions
MATERIAL 30
SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02
NI 4.4601E-03
* Compositions of Calandria outer walls
MATERIAL 31
H1 3.9844E-05 C 2.8167E-04 SI 6.0229E-04 P 7.3471E-05 S 3.6808E-05
CR 1.4995E-02 MN 1.2214E-03 FE 4.8911E-02 NI 7.2440E-03
MATERIAL 32
H1 3.8637E-05 C 6.5351E-04 SI 9.7623E-04 P 4.7540E-05 S 3.3014E-05
TI 2.4400E-04 CR 1.4380E-02 MN 1.1060E-03 FE 4.7118E-02 CO 1.1151E-05
NI 7.4526E-03 CU 1.0341E-05 MO 3.4248E-06
MATERIAL 33
H1 3.9844E-05 C 1.5948E-04 SI 7.7474E-04 P 5.2334E-05 S 2.4551E-05
CR 1.4132E-02 MN 8.3089E-04 FE 5.0764E-02 NI 7.6658E-03 MO 2.4862E-05
MATERIAL 34
H1 3.7430E-05 C 3.5158E-04 SI 8.2197E-04 P 6.2274E-05 S 1.6431E-05
CR 1.3563E-02 MN 1.0026E-03 FE 4.7151E-02 NI 6.4549E-03 MO 8.8791E-06
MATERIAL 35
H1 3.8637E-05 C 2.4762E-04 SI 9.5110E-04 P 4.5654E-05 S 2.3793E-05
CR 1.3837E-02 MN 8.6191E-04 FE 4.8404E-02 NI 6.8530E-03 MO 2.4862E-05
MATERIAL 36
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
END
*****
*
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.5335 -2.5335 0.0 5.067 5.067 0.3274
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558
BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313
*
* Plate 3, the sodium dummy plate type Z, STNAV4 (uniform)
PART 3 NEST
BOX M6 -2.5335 -2.5335 0.0 5.067 5.067 0.616
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.616
*
* Plate 4, the 40% steel plate
PART 4 NEST
BOX M0 -1.9625 -1.9625 0.0 3.925 3.925 0.317
BOX M7 -2.5335 -2.5335 0.0 5.067 5.067 0.317
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.317
*
* Core Cell 1Z
PART 5 ARRAY
1 1 7 3 2 4 1 3 2 3
* Core Cell 2Z, the reflection of cell 1
PART 6 ARRAY
1 1 7 3 2 3 1 4 2 3
*
* Core Cell 3Z This is Cell 1 minus Plate 4
PART 7 ARRAY
1 1 6 3 2 1 3 2 3
*Core Cell 4Z the reflection of cell 3, Cell 2 minus Plate 4
PART 8 ARRAY
1 1 6 3 2 3 1 2 3
*
*****
* Axial blanket U8 section
PART 9 NEST
BOX M8 -2.5335 -2.5335 0.0 5.067 5.067 9.827
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 9.827

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*
* Axial blanket U2 section
PART 10 NEST
BOX   M9      -2.5335 -2.5335 0.0      5.067  5.067  12.723
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 12.723
*
* Axial blanket U3 section
PART 11 NEST
BOX   M10      -2.5335 -2.5335 0.0      5.067  5.067  7.6225
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 7.6225
*
* Axial reflector MST3 section
PART 12 NEST
BOX   M11      -2.5335 -2.5335 0.0      5.067  5.067  7.60628
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 7.60628
*
*****
* Radial blanket U3 section (over half core height)
* (height to match the core elements)
PART 13 NEST
BOX   M10      -2.5335 -2.5335 0.0      5.067  5.067  76.225
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 76.225
*
*****
* A whole height model.
* The axial height of the pin cell elements is slightly less than
* that of the plate cell elements, 89.19 cm compared with 89.486 cm.
* (0.296 cm = 2 * 0.148 cm)
*
* The axial shielding material in the minicalandria elements
* is extended in the model to cover this distance
* Axial steel reflector section extended 0.148 cm in length
PART 14 NEST
BOX   M11      -2.5335 -2.5335 0.0      5.067  5.067  7.75428
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 7.75428
*
*****
* The Core Element type Z (full height)
PART 15 ARRAY
1  1  32  12  11  10  9  8  (5  6)*11  7  9  10  11  12
*
*****
* Axial steel reflector section above the radial blanket reduced
* in length to match the core elements
PART 16 NEST
BOX   M11      -2.5335 -2.5335 0.0      5.067  5.067  6.29678
BOX   M12     -2.68605 -2.68605      0.0    5.3721 5.3721 6.29678
*
*****
* Specification of the pin cells, A to F and U/C
* Pin cell A
PART 17 NEST
ZROD  M15      0.0      0.0      0.0      0.423  29.18
ZROD  M0        0.0      0.0      0.0      0.4305 29.18
ZROD  M22       0.0      0.0      0.0      0.4685 29.18
ZROD  M0        0.0      0.0      0.0      0.488  29.18
ZROD  M29       0.0      0.0      0.0      0.513  29.18
*
* Pin cell B
PART 18 NEST
ZROD  M16      0.0      0.0      0.0      0.423  29.18
ZROD  M0        0.0      0.0      0.0      0.4305 29.18
ZROD  M23       0.0      0.0      0.0      0.4685 29.18
ZROD  M0        0.0      0.0      0.0      0.488  29.18
ZROD  M29       0.0      0.0      0.0      0.513  29.18
*
* Pin cell C
PART 19 NEST
ZROD  M17      0.0      0.0      0.0      0.423  29.18
ZROD  M0        0.0      0.0      0.0      0.4305 29.18
ZROD  M24       0.0      0.0      0.0      0.4685 29.18
ZROD  M0        0.0      0.0      0.0      0.488  29.18
ZROD  M29       0.0      0.0      0.0      0.513  29.18

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*
* Pin cell D
PART 20 NEST
ZROD M18 0.0 0.0 0.0 0.423 29.18
ZROD M0 0.0 0.0 0.0 0.4305 29.18
ZROD M25 0.0 0.0 0.0 0.4685 29.18
ZROD M0 0.0 0.0 0.0 0.488 29.18
ZROD M29 0.0 0.0 0.0 0.513 29.18
*
* Pin cell E
PART 21 NEST
ZROD M19 0.0 0.0 0.0 0.423 29.18
ZROD M0 0.0 0.0 0.0 0.4305 29.18
ZROD M26 0.0 0.0 0.0 0.4685 29.18
ZROD M0 0.0 0.0 0.0 0.488 29.18
ZROD M29 0.0 0.0 0.0 0.513 29.18
*
* Pin cell F
PART 22 NEST
ZROD M20 0.0 0.0 0.0 0.423 29.18
ZROD M0 0.0 0.0 0.0 0.4305 29.18
ZROD M27 0.0 0.0 0.0 0.4685 29.18
ZROD M0 0.0 0.0 0.0 0.488 29.18
ZROD M29 0.0 0.0 0.0 0.513 29.18
*
* Pin cell U/C
PART 23 NEST
ZROD M21 0.0 0.0 0.0 0.423 29.18
ZROD M0 0.0 0.0 0.0 0.4305 29.18
ZROD M28 0.0 0.0 0.0 0.4685 29.18
ZROD M0 0.0 0.0 0.0 0.488 29.18
ZROD M29 0.0 0.0 0.0 0.513 29.18
*
*****
* Mini-calandria
*
* 16 PUPINC in void square
* Pin C in square of void
PART 24 NEST
ZROD P19 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in calandria inner region
PART 25 ARRAY
4 4 1 (24)*16
* mini-calandria in the element sheath (M12)
PART 26 NEST
BOX P25 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3B,
* 11 PUPINB and 5 PUPINF in void
* Pin B in square void region
PART 27 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 28 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in void inner calandria region
PART 29 ARRAY
4 4 1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27
* mini-calandria in the element sheath (M12)
PART 30 NEST
BOX P29 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*

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*****
*
* Mini calandria 3H,
* 11 PUPINB and 5 PUPINF
* Pin B in square
PART 31 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square
PART 32 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 33 ARRAY
4 4 1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31
* mini-calandria in the element sheath (M12)
PART 34 NEST
BOX P33 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M35 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3L,
* 11 PUPINB and 5 PUPINF
* Pin B in void square
PART 35 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35
* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3C,
* 8 PUPINA and 8 PUPINE
* Pin A in void square
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin E in void square
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3D,
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in void square
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square

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PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPIND and 8 PUPINF
* Pin D in void square
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 48 47 48 47
* mini-calandria in the element sheath (M12)
PART 50 NEST
BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 12 PUPINE and 4 UO2PINC
* Pin E in void square
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)
PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* form the pin fuelled elements 3A to 3L
* Element 3A
PART 55 ARRAY
1 1 11 14 11 10 9 (26)*3 9 10 11 14
* Element 3B
PART 56 ARRAY
1 1 11 14 11 10 9 (30)*3 9 10 11 14
* Element 3C
PART 57 ARRAY
1 1 11 14 11 10 9 (42)*3 9 10 11 14
* Element 3D
PART 58 ARRAY
1 1 11 14 11 10 9 (46)*3 9 10 11 14
* Element 3E
PART 59 ARRAY

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1 1 11 14 11 10 9 (50)*3 9 10 11 14
* Element 3H
PART 60 ARRAY
1 1 11 14 11 10 9 (34)*3 9 10 11 14
* Element 3J
PART 61 ARRAY
1 1 11 14 11 10 9 (54)*3 9 10 11 14
* Element 3L
PART 62 ARRAY
1 1 11 14 11 10 9 (38)*3 9 10 11 14
*
*****
* Steel reflector bars
* (height adjusted to match the height of the core plate elements)
PART 63 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 165.04356
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 165.04356
*
*
*The Radial Blanket element
PART 64 ARRAY
1 1 4 16 13 13 16
*
*****
* Plate 3Y, the sodium dummy plate type Y, STNAVS4 (ring)
PART 65 NEST
ZROD M0 0.0 0.0 0.0 2.3 0.616
ZROD M5 0.0 0.0 0.0 2.5335 0.616
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.616
*
*
* Core Cell 1Y
PART 66 ARRAY
1 1 7 65 2 4 1 65 2 65
* Core Cell 2Y, the reflection of cell 1
PART 67 ARRAY
1 1 7 65 2 65 1 4 2 65
*
* Core Cell 3Y This is Cell 1Y minus Plate 4
PART 68 ARRAY
1 1 6 65 2 1 65 2 65
*Core Cell 4Y the reflection of cell 3Y, Cell 2Y minus Plate 4
PART 69 ARRAY
1 1 6 65 2 65 1 2 65
*
* The Core Element type Y (full height)
PART 70 ARRAY
1 1 32 12 11 10 9 69 (66 67)*11 68 9 10 11 12
*
*
*****
* assemble the arrays of elements
*
* Groups of 5x5 elements surrounded by the superlattice gap
* With groups of 5x3 in rows 1 and 7 and 3x5 in rows 3 and 5
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 71 ARRAY
5 3 1 (63)*13 (64)*2
PART 72 OVERLAP
BOX P71 -13.43025 -8.05815 0.0 26.8605 16.1163 165.04356
BOX M36 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M36 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 165.04356
* Centre
PART 73 ARRAY
5 3 1 (63)*10 (64)*5
PART 74 OVERLAP
BOX P73 -13.43025 -8.05815 0.0 26.8605 16.1163 165.04356
BOX M36 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M36 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4

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```

BOX      M0      -13.5635  -8.1914    0.0  27.127  16.3828  165.04356
* Right side
PART 75 ARRAY
5  3  1  (63)*10 (64)*2 (63)*3
PART 76 OVERLAP
BOX      P75     -13.43025 -8.05815  0.0  26.8605 16.1163 165.04356
BOX      M36     -13.5635  -8.1914   1.83876 27.127 16.3828 30.4
BOX      M36     -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX      M0      -13.5635  -8.1914    0.0  27.127 16.3828 165.04356
* combine these arrays to form the row 1 array
PART 77 ARRAY
3  1  1  72  74  76
*
*****
*
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 78 ARRAY
5  3  1  (63)*3 (64)*2 (63)*10
PART 79 OVERLAP
BOX      P78     -13.43025 -8.05815  0.0  26.8605 16.1163 165.04356
BOX      M36     -13.5635  -8.1914   1.83876 27.127 16.3828 30.4
BOX      M36     -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX      M0      -13.5635  -8.1914    0.0  27.127 16.3828 165.04356
* Centre
PART 80 ARRAY
5  3  1  (64)*5 (63)*10
PART 81 OVERLAP
BOX      P80     -13.43025 -8.05815  0.0  26.8605 16.1163 165.04356
BOX      M36     -13.5635  -8.1914   1.83876 27.127 16.3828 30.4
BOX      M36     -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX      M0      -13.5635  -8.1914    0.0  27.127 16.3828 165.04356
* Right side
PART 82 ARRAY
5  3  1  (64)*2 (63)*13
PART 83 OVERLAP
BOX      P82     -13.43025 -8.05815  0.0  26.8605 16.1163 165.04356
BOX      M36     -13.5635  -8.1914   1.83876 27.127 16.3828 30.4
BOX      M36     -13.5635  -8.1914  132.63876 27.127 16.3828 30.4
BOX      M0      -13.5635  -8.1914    0.0  27.127 16.3828 165.04356
* combine these arrays to form the row 7 array
PART 84 ARRAY
3  1  1  79  81  83
*
*****
* Row 2. 5 arrays of 5x5 elements
* Left hand array
PART 85 ARRAY
5  5  1  (63)*9 64 (63)*3 (64)*2 (63)*2 (64)*3 63 (64)*4
*
PART 86 OVERLAP
BOX      P85     -13.43025 -13.43025  0.0  26.8605 26.8605 165.04356
BOX      M36     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M36     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635    0.0  27.127 27.127 165.04356
*
* Middle left blanket elements plus Z (15)
PART 87 ARRAY
5  5  1  (64)*24 15
*
PART 88 OVERLAP
BOX      P87     -13.43025 -13.43025  0.0  26.8605 26.8605 165.04356
BOX      M36     -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M36     -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0      -13.5635  -13.5635    0.0  27.127 27.127 165.04356
*
* Middle array blanket elements plus five Z
PART 89 ARRAY
5  5  1  (64)*20 (15)*5
*
PART 90 OVERLAP
BOX      P89     -13.43025 -13.43025  0.0  26.8605 26.8605 165.04356

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BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Middle right blanket elements plus one Z
PART 91 ARRAY
5  5  1  (64)*20 15 (64)*4
*
PART 92 OVERLAP
BOX      P91  -13.43025 -13.43025   0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
*
* Right hand array
PART 93 ARRAY
5  5  1  (63)*5 64 (63)*4 (64)*2 (63)*3 (64)*3 (63)*2 (64)*4 63
*
PART 94 OVERLAP
BOX      P93  -13.43025 -13.43025   0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Form row 2 array
PART 95 ARRAY
5  1  1  86 88 90 92 94
*
*****
*
* Row 6 arrays 5 groups of 5x5,
*
* Left hand array
PART 96 ARRAY
5  5  1  63 (64)*4 (63)*2 (64)*3 (63)*3 (64)*2 (63)*4 64 (63)*5
*
PART 97 OVERLAP
BOX      P96  -13.43025 -13.43025   0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Middle left array (one Z element, 15)
PART 98 ARRAY
5  5  1  (64)*4 15 (64)*20
*
PART 99 OVERLAP
BOX      P98  -13.43025 -13.43025   0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Middle array (five Z elements)
PART 100 ARRAY
5  5  1  (15)*5 (64)*20
*
PART 101 OVERLAP
BOX      P100 -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Middle right array (one Z element)
PART 102 ARRAY
5  5  1  15 (64)*24
*
PART 103 OVERLAP
BOX      P102 -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* Right hand array

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PART 104 ARRAY
5 5 1 (64)*4 63 (64)*3 (63)*2 (64)*2 (63)*3 64 (63)*9
*
PART 105 OVERLAP
BOX P104 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Form row 6 array
PART 106 ARRAY
5 1 1 97 99 101 103 105
*
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays of shield
* elements plus two blanket elements
* and the intermediate groups contain blanket elements plus one or two
* core plate elements (Y or Z)
* Left hand array
PART 107 ARRAY
3 5 1 (63)*11 64 (63)*2 64
PART 108 OVERLAP
BOX P107 -8.05815 -13.43025 0.0 16.1163 26.8605 165.04356
BOX M36 -8.1914 -13.5635 1.83876 16.3828 27.127 30.4
BOX M36 -8.1914 -13.5635 132.63876 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 165.04356
*
* left hand blanket array plus one Y element
PART 109 ARRAY
5 5 1 (64)*24 70
PART 110 OVERLAP
BOX P109 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower left hand array (additional Y and Z elements
* compared with the flooded core)
PART 111 ARRAY
5 5 1 (64)*2 70 (15)*2 64 15 70 (60)*2 (70)*2 55 58 60
15 (58)*2 57 59 15 (58)*2 57 59
*
PART 112 OVERLAP
BOX P111 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower middle array
PART 113 ARRAY
5 5 1 (62)*5 (56)*10 (57)*10
*
PART 114 OVERLAP
BOX P113 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower right hand array
PART 115 ARRAY
5 5 1 (15)*2 70 (64)*2 (60)*2 70 15 64 60 58 55 (70)*2
59 57 58 59 15 59 57 58 59 70
*
PART 116 OVERLAP
BOX P115 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* right hand blanket array plus one Y and one Z element
PART 117 ARRAY
5 5 1 (64)*15 15 (64)*4 70 (64)*4
PART 118 OVERLAP
BOX P117 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356

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BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
*   right hand array
PART 119 ARRAY
3 5 1 (63)*9 64 (63)*2 64 (63)*2
PART 120 OVERLAP
BOX      P119  -8.05815  -13.43025  0.0          16.1163 26.8605 165.04356
BOX      M36  -8.1914  -13.5635   1.83876  16.3828 27.127  30.4
BOX      M36  -8.1914  -13.5635  132.63876  16.3828 27.127  30.4
BOX      M0   -8.1914  -13.5635   0.0 16.3828 27.127 165.04356
* Form the row 3 array
PART 121 ARRAY
7 1 1 108 110 112 114 116 118 120
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
*   Left hand shield array
PART 122 ARRAY
3 5 1 (63)*2 64 (63)*2 64 (63)*9
PART 123 OVERLAP
BOX      P122  -8.05815  -13.43025  0.0          16.1163 26.8605 165.04356
BOX      M36  -8.1914  -13.5635   1.83876  16.3828 27.127  30.4
BOX      M36  -8.1914  -13.5635  132.63876  16.3828 27.127  30.4
BOX      M0   -8.1914  -13.5635   0.0 16.3828 27.127 165.04356
*
* left hand blanket array plus one Y and one Z element
PART 124 ARRAY
5 5 1 (64)*4 70 (64)*4 15 (64)*15
PART 125 OVERLAP
BOX      P124  -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
*   Core upper left hand array
PART 126 ARRAY
5 5 1 15 (58)*2 57 59 15 56 58 57 59 (70)*2 55 58 58
64 15 70 (60)*2 (64)*2 70 (15)*2
*
PART 127 OVERLAP
BOX      P126  -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
*   Core upper middle array
PART 128 ARRAY
5 5 1 (57)*10 (56)*10 (62)*5
*
PART 129 OVERLAP
BOX      P128  -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
*   Core upper right hand array
PART 130 ARRAY
5 5 1 59 57 58 58 15 59 57 58 56 15 58 58 55 (70)*2
(60)*2 70 15 64 (15)*2 70 (64)*2
*
PART 131 OVERLAP
BOX      P130  -13.43025          -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M36  -13.5635  -13.5635   1.83876  27.127  27.127  30.4
BOX      M36  -13.5635  -13.5635  132.63876  27.127  27.127  30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127  27.127 165.04356
*
* right hand blanket array plus one Y element
PART 132 ARRAY
5 5 1 70 (64)*24

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PART 133 OVERLAP
BOX   P132  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*
* right hand shield array
PART 134 ARRAY
3 5 1 64 (63)*2 64 (63)*11
PART 135 OVERLAP
BOX   P134  -8.05815     -13.43025  0.0      16.1163 26.8605 165.04356
BOX   M36   -8.1914     -13.5635   1.83876 16.3828 27.127 30.4
BOX   M36   -8.1914     -13.5635   132.63876 16.3828 27.127 30.4
BOX   M0    -8.1914     -13.5635    0.0 16.3828 27.127 165.04356

* Form the row 5 array
PART 136 ARRAY
7 1 1 123 125 127 129 131 133 135
*
*****
*
* Row 4 (the middle row) 7 groups of 5x5 elements
* Left hand shield group
PART 137 ARRAY
5 5 1 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64
*
PART 138 OVERLAP
BOX   P137  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*
* Left hand centre blanket group
PART 139 ARRAY
5 5 1 (64)*4 70 (64)*4 15 (64)*4 15 (64)*4 15 (64)*4 70
*
PART 140 OVERLAP
BOX   P139  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*
* Left hand centre core group
PART 141 ARRAY
5 5 1 55 61 58 (59)*2 55 (58)*2 (59)*2 56 (59)*4
55 58 55 (59)*2 55 61 55 (59)*2
*
PART 142 OVERLAP
BOX   P141  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*
* Centre core group
PART 143 ARRAY
5 5 1 (57)*25
*
PART 144 OVERLAP
BOX   P143  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*
* Right hand centre core group
PART 145 ARRAY
5 5 1 (59)*2 58 61 55 (59)*2 (58)*2 55 (59)*4 56
(59)*2 55 58 55 (59)*2 55 61 55
*
PART 146 OVERLAP
BOX   P145  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX   M36   -13.5635     -13.5635   1.83876 27.127 27.127 30.4
BOX   M36   -13.5635     -13.5635   132.63876 27.127 27.127 30.4
BOX   M0    -13.5635     -13.5635    0.0 27.127 27.127 165.04356
*

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* Right hand central row blanket group (two Y and three Z)
PART 147 ARRAY
5 5 1 70 (64)*4 15 (64)*4 15 (64)*4 15 (64)*4 70 (64)*4
*
PART 148 OVERLAP
BOX P147 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Right hand shield group
PART 149 ARRAY
5 5 1 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4
*
PART 150 OVERLAP
BOX P149 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M36 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M36 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Form the row 4 array
PART 151 ARRAY
7 1 1 138 140 142 144 146 148 150
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 152 CLUSTER
BOX P84 -40.6905 67.8175 0.0 81.381 16.3828 165.04356
BOX P106 -67.8175 40.6905 0.0 135.635 27.127 165.04356
BOX P136 -84.2003 13.5635 0.0 168.4006 27.127 165.04356
BOX P151 -94.9445 -13.5635 0.0 189.889 27.127 165.04356
BOX P121 -84.2003 -40.6905 0.0 168.4006 27.127 165.04356
BOX P95 -67.8175 -67.8175 0.0 135.635 27.127 165.04356
BOX P77 -40.6905 -84.2003 0.0 81.381 16.3828 165.04356
ZROD M14 0.0 0.0 -1.56 96.6 168.0
*
*****
* Albedo for free boundaries at side and top and bottom
*
ALBEDO 0.0 0.0 0.0
END
*
*****
BEGIN CONTROL DATA
STAGES -50 3000 2000 STDV 0.0001
END
*
*****
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 15
END

```

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A1.5. Assembly 23 with the central region of plate elements. Model A

*** MONK9A Input Listing for Assembly 23 with the central plate region.**

* Assembly 23 is the Pin Geometry Version of the Cadenza cores.
* it also includes an outer ring of plate geometry elements
* Reactor structure: elements arranged on a square grid
* The Pin Elements in the core contain 3 minicalandria and an Axial
* Region Cell, enclosed in a mild steel sheath.
* The plate elements contain 24 cells, the plates having width 5.067 cm.
* The Element sheath has an inner width 5.102 cm, outer width 5.2544 cm.
* The elements occupy a lattice area of 5.3721 cm square.
* Groups of 5x5 elements form the superlattice
* with a space between them
* The Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
* The radial shielding elements consist of the Steel bar MST9F10
* which is about 300 cm high.
* These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (pitch 5.4254 cm)
* Elements are grouped in square arrays containing 5x5 = 25 elements
* plus edge groups with 3x5 elements. The Assembly is built from these.
* There is a gap between these groups of elements of 0.2667 cm
* Core Plate Geometry Element structure:
* The plate element consists of combinations of the following:
* Core Cell PART 1, Core Cell PART 2, an inversion of PART 1,
* Core Cell PART 3, which is the same as PART 1
* but with the 40%Steel plate omitted, and the inversion of
* this cell which forms PART 4
* the Axial Region Cell is PART5.
* Structure of Core Plate Cell 1, PART 1, 7 plates.
* Cell height 3.748082 cm. Enclosed in mild steel sheath.
* Outer area of all plates is 5.067 cm x 5.067 cm
* From the top down:
* Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
* UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
* Sodium (0.613694 cm thick,)
* Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671 cm x 4.671 cm)
* 40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
* UO2 (0.6313 cm thick)
* Sodium (0.613694 cm thick)
* Structure of Core Plate Cell 2 PART 2. The inverse of PART 1
* Structure of Core Plate Cell PART 3. PART 1 without 40%Steel plate.
* Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
* Cell height From the top:
* MST3 Block (7.60628 cm thick)
* U3 Block (7.6225 cm thick,)
* U2 region (10 plates, total thickness 12.723 cm)
* U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
* Height of the reflected half height element
* MST3 Block (7.60628 cm thick)
* U3 Block composition (height above mid-plane to match the core
* element blanket height of 74.83248 cm)

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium plate core
* material 6 - Sodium plate clad
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Mild steel sheath
* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
* material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
* material 15 - Pin fuel A
* material 16 - Pin fuel B
* material 17 - Pin fuel C

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* material 18 - Pin fuel D
* material 19 - Pin fuel E
* material 20 - Pin fuel F
* material 21 - Pin fuel UPINC
* material 22 - Pin can A
* material 23 - Pin can B
* material 24 - Pin can C
* material 25 - Pin can D
* material 26 - Pin can E
* material 27 - Pin can F
* material 28 - Pin can UPINC
* material 29 - Tube
* material 30 - Calandria end regions
* material 31 - Calandria Walls Type NACLI
* material 32 - Calandria Walls Type NACLIIS
* material 33 - Calandria Walls Type NACLIIS
* material 34 - Calandria Walls Type NACLIV
* material 35 - Calandria Walls Type NACLIV
* material 36 - Calandria Sodium Type NACLI
* material 37 - Calandria Sodium Type NACLIIS
* material 38 - Calandria Sodium Type NACLIIS
* material 39 - Calandria Sodium Type NACLIV
* material 40 - Calandria Sodium Type NACLIV
* material 41 - Superlattice grid

COLUMNS 1 132

BEGIN MATERIAL SPECIFICATION

NUMBER DENSITY

MATERIAL 1

U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02

PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04

AM241 4.5718E-04

H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05

AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06

FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03

MATERIAL 2

H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05

CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03

CU 1.6613E-02

MATERIAL 3

H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06

SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06

MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02

MATERIAL 4

H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04

S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02

NI 8.4258E-03

MATERIAL 5

H1 1.3900E-05 O16 5.6492E-06 NA 2.3225E-02 CA 3.6083E-06

FE 1.6184E-07

MATERIAL 6

H1 2.1631E-05 C 2.9290E-04 SI 6.0867E-04 P 3.2795E-05

S 3.3219E-05 CR 1.4759E-02 MN 1.3570E-03 FE 5.5054E-02

NI 7.0982E-03 NB 3.1147E-04

MATERIAL 7

H1 1.8355E-05 C 8.7794E-05 AL 1.1862E-04 SI 7.9703E-04

P 4.0018E-05 S 1.4422E-05 TI 2.4806E-04 CR 1.5908E-02

MN 1.4972E-03 FE 5.5367E-02 NI 8.7976E-03 CU 5.0365E-05

NB 4.9781E-06 MO 8.0988E-05

MATERIAL 8

H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04

U235 3.3369E-04 U238 4.6021E-02

MATERIAL 9

H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05

U235 3.3962E-04 U238 4.6785E-02

MATERIAL 10

H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04

U235 3.4209E-04 U238 4.7156E-02

MATERIAL 11

H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05

CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05

CU 4.4548E-05 MO 9.8355E-06

MATERIAL 12

H1 7.5712E-05 C 2.3825E-04 AL 1.9798E-05 CR 3.6690E-06

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MN 2.5697E-04 FE 7.7524E-02 NI 1.4302E-05 CU 2.2216E-05
MATERIAL 13
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
MATERIAL 14
H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02

* Pin fuel A, B, C, D, E, F and U
MATERIAL 15
U234 1.3805E-06 U235 1.4114E-04 U236 7.9324E-07 U238 1.9379E-02
PU238 3.7786E-06 PU239 2.9689E-03 PU240 6.7253E-04 PU241 7.0350E-05
PU242 1.7488E-05 AM241 4.7854E-05
H1 3.2784E-05 O16 4.6606E-02 AL 1.1702E-05 CA 7.8782E-06 FE 5.6537E-06
MATERIAL 16
U234 1.3177E-06 U235 1.3457E-04 U236 7.4658E-07 U238 1.8472E-02
PU238 5.8915E-06 PU239 3.7341E-03 PU240 9.5200E-04 PU241 1.1199E-04
PU242 2.7984E-05 AM241 5.5789E-05
H1 3.2784E-05 O16 4.6993E-02 SI 9.0199E-06 NI 5.4424E-06
MATERIAL 17
U234 1.2863E-06 U235 1.2997E-04 U236 7.3103E-07 U238 1.7843E-02
PU238 6.9094E-06 PU239 4.4708E-03 PU240 1.0602E-03 PU241 1.1598E-04
PU242 3.0047E-05 AM241 5.7784E-05
H1 3.2784E-05 O16 4.7434E-02 AL 1.9730E-05 SI 7.9741E-06
FE 7.6916E-06 NI 1.0947E-05
MATERIAL 18
U234 1.4118E-06 U235 1.4266E-04 U236 7.9324E-07 U238 1.9584E-02
PU238 4.7348E-06 PU239 3.0189E-03 PU240 7.5441E-04 PU241 8.8443E-05
PU242 2.0961E-05 AM241 4.0742E-05
H1 3.2784E-05 O16 4.7314E-02 AL 1.8914E-05 SI 2.5099E-05
CA 1.5940E-05 FE 6.9027E-06 NI 1.4138E-05
MATERIAL 19
U234 1.1295E-06 U235 1.1465E-04 U236 6.3771E-07 U238 1.5739E-02
PU238 9.4851E-06 PU239 6.0438E-03 PU240 1.5103E-03 PU241 1.7707E-04
PU242 4.1953E-05 AM241 8.1559E-05
H1 3.2784E-05 O16 4.7299E-02 AL 9.5250E-06 SI 4.5753E-05
CA 3.2062E-05 FE 1.0321E-05
MATERIAL 20
U234 1.1452E-06 U235 1.1526E-04 U236 6.3771E-07 U238 1.5824E-02
PU238 9.5005E-06 PU239 6.0112E-03 PU240 1.5285E-03 PU241 1.9723E-04
PU242 4.4380E-05 AM241 6.8035E-05
H1 3.2784E-05 O16 4.7482E-02 AL 1.4287E-05 CA 6.7514E-05
CR 4.9427E-06 FE 1.1505E-05 NI 2.1895E-06
* UO2 fuel pin
MATERIAL 21
U235 1.7604E-04 U238 2.3580E-02
H1 3.2784E-05 C 3.2095E-05 O16 4.7501E-02 AL 2.3812E-05
SI 4.0001E-05 CA 1.2825E-05 FE 1.1176E-06

* Fuel pin cans
MATERIAL 22
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05 S 2.4585E-05
CR 1.8218E-02 MN 1.5646E-03 FE 5.9675E-02 NI 8.9153E-03
MATERIAL 23
H1 2.2895E-05 C 2.3695E-04 SI 1.1571E-03 P 4.1596E-05 S 2.2786E-05
CR 1.4981E-02 MN 1.5751E-03 FE 5.3171E-02 NI 8.8137E-03
NB 2.9391E-04
MATERIAL 24
H1 2.6710E-05 C 1.3609E-04 SI 8.3531E-04 P 3.6008E-05 S 2.4585E-05
CR 1.7856E-02 MN 1.5331E-03 FE 5.8512E-02 NI 8.7515E-03
MATERIAL 25
H1 2.4802E-05 C 2.0172E-04 AL 6.4142E-06 SI 8.9693E-04 P 3.4145E-05
S 8.9942E-06 TI 2.8916E-05 CR 1.5910E-02 MN 1.1586E-03 FE 5.5753E-02
CO 4.2418E-06 NI 7.6341E-03 CU 6.0522E-06 MO 2.2047E-06
MATERIAL 26
H1 2.4802E-05 C 7.3646E-05 AL 6.4142E-06 SI 1.0476E-03 P 1.3658E-05
S 1.7389E-05 TI 2.8916E-05 CR 1.6102E-02 MN 9.8006E-04 FE 5.6794E-02
CO 4.2418E-06 NI 8.0503E-03 CU 6.0522E-06 MO 2.1446E-05
MATERIAL 27
H1 2.4802E-05 C 7.2045E-05 AL 4.2762E-06 SI 1.0544E-03 P 1.3658E-05
S 1.7989E-05 TI 2.1687E-05 CR 1.6284E-02 MN 9.8357E-04 FE 5.7354E-02
CO 3.2629E-06 NI 8.1453E-03 CU 4.5391E-06 MO 2.1246E-05
MATERIAL 28
H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05

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S 2.4585E-05 CR 1.8255E-02 MN 1.5681E-03 FE 5.9792E-02
NI 8.9349E-03
*****
* Composition of calandria tubes
MATERIAL 29
SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02
NI 7.4360E-03
* Composition of Calandria end plate regions
MATERIAL 30
SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02
NI 4.4601E-03
* Compositions of Calandria outer walls
MATERIAL 31
H1 3.9844E-05 C 2.8167E-04 SI 6.0229E-04 P 7.3471E-05 S 3.6808E-05
CR 1.4995E-02 MN 1.2214E-03 FE 4.8911E-02 NI 7.2440E-03
MATERIAL 32
H1 3.8637E-05 C 6.5351E-04 SI 9.7623E-04 P 4.7540E-05 S 3.3014E-05
TI 2.4400E-04 CR 1.4380E-02 MN 1.1060E-03 FE 4.7118E-02 CO 1.1151E-05
NI 7.4526E-03 CU 1.0341E-05 MO 3.4248E-06
MATERIAL 33
H1 3.9844E-05 C 1.5948E-04 SI 7.7474E-04 P 5.2334E-05 S 2.4551E-05
CR 1.4132E-02 MN 8.3089E-04 FE 5.0764E-02 NI 7.6658E-03 MO 2.4862E-05
MATERIAL 34
H1 3.7430E-05 C 3.5158E-04 SI 8.2197E-04 P 6.2274E-05 S 1.6431E-05
CR 1.3563E-02 MN 1.0026E-03 FE 4.7151E-02 NI 6.4549E-03 MO 8.8791E-06
MATERIAL 35
H1 3.8637E-05 C 2.4762E-04 SI 9.5110E-04 P 4.5654E-05 S 2.3793E-05
CR 1.3837E-02 MN 8.6191E-04 FE 4.8404E-02 NI 6.8530E-03 MO 2.4862E-05
*****
* Sodium compositions
MATERIAL 36
H1 5.5075E-06 O16 6.4605E-06 NA 2.4129E-02 CA 1.1080E-06 FE 3.0847E-07
MATERIAL 37
H1 1.1205E-05 O16 1.0767E-06 NA 2.4379E-02 CA 9.5521E-08
MATERIAL 38
H1 7.5966E-06 O16 3.5892E-06 NA 2.3888E-02 K 3.4270E-07 CA 6.6865E-07
MATERIAL 39
H1 7.5966E-06 O16 3.5892E-06 NA 2.4037E-02 K 3.4270E-07 CA 6.6865E-07
MATERIAL 40
H1 7.5966E-06 O16 3.5892E-06 NA 2.3829E-02 K 3.4270E-07 CA 6.6865E-07
* Superlattice grid
MATERIAL 41
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
END
*****
*
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.5335 -2.5335 0.0 5.067 5.067 0.3274
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.3274
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.3274
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558
BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.6313
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.6313
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313
*
* Plate 3, the sodium plate
PART 3 NEST
BOX M5 -2.4815 -2.4815 0.036347 4.963 4.963 0.541
BOX M6 -2.5335 -2.5335 0.0 5.067 5.067 0.613694
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 0.613694
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 0.613694
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 0.613694
*
* Plate 4, the 40% steel plate

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PART 4 NEST
BOX      M0  -1.9625 -1.9625 0.0      3.925  3.925  0.317
BOX      M7  -2.5335 -2.5335 0.0      5.067  5.067  0.317
BOX      M0  -2.5510 -2.5510 0.0      5.102  5.102  0.317
BOX      M12 -2.6272 -2.6272 0.0      5.2544 5.2544 0.317
BOX      M0  -2.68605 -2.68605 0.0     5.3721 5.3721 0.317
*
* Core Cell 1
PART 5 ARRAY
1 1 7 3 2 4 1 3 2 3
* Core Cell 2, the reflection of cell 1
PART 6 ARRAY
1 1 7 3 2 3 1 4 2 3
*
* Core Cell 3 This is Cell 1 minus Plate 4
PART 7 ARRAY
1 1 6 3 2 1 3 2 3
*Core Cell 4 the reflection of cell 3, Cell 2 minus Plate 4
PART 8 ARRAY
1 1 6 3 2 3 1 2 3
*
*****
* Axial blanket U8 section
PART 9 NEST
BOX      M8      -2.5335 -2.5335 0.0      5.067  5.067  9.827
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  9.827
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 9.827
BOX      M0     -2.68605 -2.68605 0.0      0.0    5.3721 5.3721 9.827
*
* Axial blanket U2 section
PART 10 NEST
BOX      M9      -2.5335 -2.5335 0.0      5.067  5.067  12.723
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  12.723
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 12.723
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 12.723
*
* Axial blanket U3 section
PART 11 NEST
BOX      M10     -2.5335 -2.5335 0.0      5.067  5.067  7.6225
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.6225
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.6225
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.6225
*
* Axial reflector MST3 section
PART 12 NEST
BOX      M11     -2.5335 -2.5335 0.0      5.067  5.067  7.60628
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.60628
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.60628
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.60628
*
*****
* Radial blanket U3 section (over half core height)
PART 13 NEST
BOX      M10     -2.5335 -2.5335 0.0      5.067  5.067  74.83248
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  74.83248
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 74.83248
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 74.83248
*
*****
* A whole height model.
* The axial height of the pin cell core is slightly less than
* that of the plate cell core, 89.19 cm compared with 89.32 cm.
* (0.13 cm = 2 * 0.065 cm)
* The axial shielding material is extended in the model
* to cover this distance
* Axial steel reflector section extended 0.065 cm in length
PART 14 NEST
BOX      M11     -2.5335 -2.5335 0.0      5.067  5.067  7.67128
BOX      M0      -2.5510 -2.5510 0.0      5.102  5.102  7.67128
BOX      M12     -2.6272 -2.6272 0.0      5.2544 5.2544 7.67128
BOX      M0     -2.68605 -2.68605 0.0      5.3721 5.3721 7.67128
*
*****
* The Core Element (full height)

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PART 15 ARRAY

1 1 32 12 11 10 9 8 (5 6)*11 7 9 10 11 12

*

*The Radial Blanket element

PART 16 ARRAY

1 1 4 12 13 13 12

*

* Specification of the pin cells, A to F and U/C

* Pin cell A

PART 17 NEST

ZROD M15	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M22	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell B

PART 18 NEST

ZROD M16	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M23	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell C

PART 19 NEST

ZROD M17	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M24	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell D

PART 20 NEST

ZROD M18	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M25	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell E

PART 21 NEST

ZROD M19	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M26	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell F

PART 22 NEST

ZROD M20	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M27	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Pin cell U/C

PART 23 NEST

ZROD M21	0.0	0.0	0.0	0.423	29.18
ZROD M0	0.0	0.0	0.0	0.4305	29.18
ZROD M28	0.0	0.0	0.0	0.4685	29.18
ZROD M0	0.0	0.0	0.0	0.488	29.18
ZROD M29	0.0	0.0	0.0	0.513	29.18

*

* Mini-calandria

*

Mini calandria 3A,

* 16 PUPINC in NACLI

* Pin C in square of sodium

PART 24 NEST

ZROD P19	0.0	0.0	0.0	0.513	29.18
BOX M36	-0.595	-0.595	0.0 1.19	1.19	29.18

* array of pins in sodium

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PART 25 ARRAY
4 4 1 (24)*16
* mini-calandria in the element sheath (M12)
PART 26 NEST
BOX P25 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3B,
* 11 PUPINB and 5 PUPINF in NACL I
* Pin B in square of sodium
PART 27 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 28 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 29 ARRAY
4 4 1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27
* mini-calandria in the element sheath (M12)
PART 30 NEST
BOX P29 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3H,
* 11 PUPINB and 5 PUPINF in NACL V
* Pin B in square of NACL V sodium
PART 31 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 32 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 33 ARRAY
4 4 1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31
* mini-calandria in the element sheath (M12)
PART 34 NEST
BOX P33 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M40 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M35 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3L,
* 11 PUPINB and 5 PUPINF in NACL IV
* Pin B in square of NACL IV sodium
PART 35 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35

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* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPINA and 8 PUPINE in NACLIII
* Pin A in square of NACLIII sodium
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin E in square of sodium
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in square of NACLIII sodium
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 8 PUPIND and 8 PUPINF in NACLIIS
* Pin D in square of NACLIIS sodium
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 48 47 48 47
* mini-calandria in the element sheath (M12)
PART 50 NEST

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BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M37 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* Mini calandria 3J,
* 12 PUPINE and 4 UO2PINC in NACLIV
* Pin E in square of NACLIV sodium
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)
PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* form the elements 3A to 3L
* Element 3A
PART 55 ARRAY
1 1 11 14 11 10 9 (26)*3 9 10 11 14
* Element 3B
PART 56 ARRAY
1 1 11 14 11 10 9 (30)*3 9 10 11 14
* Element 3C
PART 57 ARRAY
1 1 11 14 11 10 9 (42)*3 9 10 11 14
* Element 3D
PART 58 ARRAY
1 1 11 14 11 10 9 (46)*3 9 10 11 14
* Element 3E
PART 59 ARRAY
1 1 11 14 11 10 9 (50)*3 9 10 11 14
* Element 3H
PART 60 ARRAY
1 1 11 14 11 10 9 (34)*3 9 10 11 14
* Element 3J
PART 61 ARRAY
1 1 11 14 11 10 9 (54)*3 9 10 11 14
* Element 3L
PART 62 ARRAY
1 1 11 14 11 10 9 (38)*3 9 10 11 14
*
*****
* Steel reflector bars
PART 63 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 164.877528
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 164.877528
*
*****
* assemble the arrays of elements
*
* Groups of 5x5 elements surrounded by the superlattice gap
* With groups of 5x3 in rows 1 and 7 and 3x5 in rows 3 and 5
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side

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PART 64 ARRAY
5 3 1 (63)*13 (16)*2
PART 65 OVERLAP
BOX P64 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre
PART 66 ARRAY
5 3 1 (63)* 10 (16)*5
PART 67 OVERLAP
BOX P66 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Right side
PART 68 ARRAY
5 3 1 (63)*10 (16)*2 (63)*3
PART 69 OVERLAP
BOX P68 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* combine these arrays to form the row 1 array
PART 70 ARRAY
3 1 1 65 67 69
*
*****
* A 5x5 array of blanket elements
PART 71 ARRAY
5 5 1 (16)*25
*
PART 72 OVERLAP
BOX P71 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
*****
* Row 2. 5 arrays of 5x5 elements, two being PART 72
* Left hand array
PART 73 ARRAY
5 5 1 (63)*9 16 (63)*3 (16)*2 (63)*2 (16)*3 63 (16)*4
*
PART 74 OVERLAP
BOX P73 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Middle array
PART 75 ARRAY
5 5 1 (16)*20 (15)*5
*
PART 76 OVERLAP
BOX P75 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Right hand array
PART 77 ARRAY
5 5 1 (63)*5 16 (63)*4 (16)*2 (63)*3 (16)*3 (63)*2 (16)*4 63
*
PART 78 OVERLAP
BOX P77 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* Form row 2 array
PART 79 ARRAY
5 1 1 74 72 76 72 78
*
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays

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* Left hand array
PART 80 ARRAY
3 5 1 (63)*11 16 (63)*2 16
PART 81 OVERLAP
BOX P80 -8.05815 -13.43025 0.0 16.1163 26.8605 164.877528
BOX M41 -8.1914 -13.5635 1.83876 16.3828 27.127 30.4
BOX M41 -8.1914 -13.5635 132.63876 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 164.877528
* Core lower left hand array
PART 82 ARRAY
5 5 1 (16)*3 (15)*2 16 (15)*2 (60)*2 16 15 55 58 60
15 (58)*2 57 59 15 (58)*2 57 59
*
PART 83 OVERLAP
BOX P82 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Core lower middle array
PART 84 ARRAY
5 5 1 (62)*5 (56)*10 (57)*5 (15)*5
*
PART 85 OVERLAP
BOX P84 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Core lower right hand array
PART 86 ARRAY
5 5 1 (15)*2 (16)*3 (60)*2 (15)*2 16 60 58 55 15 16
59 57 58 59 15 59 57 58 59 15
*
PART 87 OVERLAP
BOX P86 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
*
* right hand array
PART 88 ARRAY
3 5 1 (63)*9 16 (63)*2 16 (63)*2
PART 89 OVERLAP
BOX P88 -8.05815 -13.43025 0.0 16.1163 26.8605 164.877528
BOX M41 -8.1914 -13.5635 1.83876 16.3828 27.127 30.4
BOX M41 -8.1914 -13.5635 132.63876 16.3828 27.127 30.4
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 164.877528
* Form the row 3 array
PART 90 ARRAY
7 1 1 81 72 83 85 87 72 89
*
*****
* Row 4 (the middle row) 7 groups of 5x5 elements
* Left hand shield group
PART 91 ARRAY
5 5 1 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16
*
PART 92 OVERLAP
BOX P91 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Left hand blanket group
PART 93 ARRAY
5 5 1 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15
*
PART 94 OVERLAP
BOX P93 -13.43025 -13.43025 0.0 26.8605 26.8605 164.877528
BOX M41 -13.5635 -13.5635 1.83876 27.127 27.127 30.4
BOX M41 -13.5635 -13.5635 132.63876 27.127 27.127 30.4
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 164.877528
* Left hand core group
PART 95 ARRAY
5 5 1 55 61 58 59 15 55 (58)*2 59 15 56 (59)*3 15
55 58 55 59 15 55 61 55 59 15

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*
PART 96 OVERLAP
BOX    P95  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Centre core group of plate elements
PART 97 ARRAY
5  5  1  (15)*25
*
PART 98 OVERLAP
BOX    P97  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Right hand core group
PART 99 ARRAY
5  5  1  15 59  58 61  55 15 59 (58)*2 55 15 (59)*3 56
15 59 55 58 55 15 59 55 61 55
*
PART 100 OVERLAP
BOX    P99  -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Right hand blanket group
PART 101 ARRAY
5  5  1  15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4
*
PART 102 OVERLAP
BOX    P101 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Right hand shield group
PART 103 ARRAY
5  5  1  16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4
*
PART 104 OVERLAP
BOX    P103 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Form the row 4 array
PART 105 ARRAY
7  1  1  92 94 96 98 100 102 104
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 106 ARRAY
3  5  1  (63)*2 16 (63)*2 16 (63)*9
PART 107 OVERLAP
BOX    P106 -8.05815 -13.43025  0.0 16.1163 26.8605 164.877528
BOX    M41  -8.1914 -13.5635  1.83876 16.3828 27.127 30.4
BOX    M41  -8.1914 -13.5635  132.63876 16.3828 27.127 30.4
BOX    M0   -8.1914 -13.5635  0.0 16.3828 27.127 164.877528
* Core upper left hand array
PART 108 ARRAY
5  5  1  15 (58)*2 57 59 15 56 58 57 59 16 15 55 58 58
16 (15)*2 (60)*2 (16)*3 (15)*2
*
PART 109 OVERLAP
BOX    P108 -13.43025 -13.43025  0.0 26.8605 26.8605 164.877528
BOX    M41  -13.5635 -13.5635  1.83876 27.127 27.127 30.4
BOX    M41  -13.5635 -13.5635  132.63876 27.127 27.127 30.4
BOX    M0   -13.5635 -13.5635  0.0 27.127 27.127 164.877528
* Core upper middle array
PART 110 ARRAY
5  5  1  (15)*5 (57)*5 (56)*10 (62)*5
*
PART 111 OVERLAP

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BOX      P110  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
* Core upper right hand array
PART 112 ARRAY
5  5  1  59  57  58  58  15  59  57  58  56  15  58  58  55  15
16 (60)*2 (15)*2 16 (15)*2 (16)*3
*
PART 113 OVERLAP
BOX      P112  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* right hand shield array
PART 114 ARRAY
3  5  1  16 (63)*2 16 (63)*2 (63)*9
PART 115 OVERLAP
BOX      P114  -8.05815  -13.43025  0.0      16.1163 26.8605 164.877528
BOX      M41  -8.1914  -13.5635   1.83876 16.3828 27.127 30.4
BOX      M41  -8.1914  -13.5635  132.63876 16.3828 27.127 30.4
BOX      M0   -8.1914  -13.5635   0.0 16.3828 27.127 164.877528
* Form the row 5 array
PART 116 ARRAY
7  1  1  107 72 109 111 113 72 115
*
*****
* Row 6 arrays 5 groups of 5x5, one being PART 72
*
* Left hand array
PART 117 ARRAY
5  5  1  63 (16)*4 (63)*2 (16)*3 (63)*3 (16)*2 (63)*4 16 (63)*5
*
PART 118 OVERLAP
BOX      P117  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
* Middle array
PART 119 ARRAY
5  5  1  (15)*5 (16)*20
*
PART 120 OVERLAP
BOX      P119  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
*
* Right middle array
PART 121 ARRAY
5  5  1  15 (16)*24
*
PART 122 OVERLAP
BOX      P121  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Right hand array
PART 123 ARRAY
5  5  1  (16)*4 63 (16)*3 (63)*2 (16)*2 (63)*3 16 (63)*9
*
PART 124 OVERLAP
BOX      P123  -13.43025      -13.43025  0.0 26.8605 26.8605 164.877528
BOX      M41  -13.5635  -13.5635   1.83876 27.127 27.127 30.4
BOX      M41  -13.5635  -13.5635  132.63876 27.127 27.127 30.4
BOX      M0   -13.5635  -13.5635   0.0 27.127 27.127 164.877528
*
* Form row 6 array
PART 125 ARRAY
5  1  1  118 72 120 122 124
*

```

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```

*****
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 126 ARRAY
5 3 1 (63)*3 (16)*2 (63)*10
PART 127 OVERLAP
BOX P126 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Centre
PART 128 ARRAY
5 3 1 (16)*5 (63)* 10
PART 129 OVERLAP
BOX P128 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* Right side
PART 130 ARRAY
5 3 1 (16)*2 (63)*13
PART 131 OVERLAP
BOX P130 -13.43025 -8.05815 0.0 26.8605 16.1163 164.877528
BOX M41 -13.5635 -8.1914 1.83876 27.127 16.3828 30.4
BOX M41 -13.5635 -8.1914 132.63876 27.127 16.3828 30.4
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 164.877528
* combine these arrays to form the row 7 array
PART 132 ARRAY
3 1 1 127 129 131
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 133 CLUSTER
BOX P132 -40.6905 67.8175 0.0 81.381 16.3828 164.877528
BOX P125 -67.8175 40.6905 0.0 135.635 27.127 164.877528
BOX P116 -84.2003 13.5635 0.0 168.4006 27.127 164.877528
BOX P105 -94.9445 -13.5635 0.0 189.889 27.127 164.877528
BOX P90 -84.2003 -40.6905 0.0 168.4006 27.127 164.877528
BOX P79 -67.8175 -67.8175 0.0 135.635 27.127 164.877528
BOX P70 -40.6905 -84.2003 0.0 81.381 16.3828 164.877528
ZROD M14 0.0 0.0 -1.56 96.6 168.0
*
*****
* Albedo for free boundaries at side and top and bottom
*
ALBEDO 0.0 0.0 0.0
END
*
*****
BEGIN CONTROL DATA
STAGES -50 3000 3000 STDV 0.0001
END
*
*****
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 15
END

```

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A1.6. Assembly 25 with the central region of 69 plate elements. Model A representation but without the grid plates.

*** MONK9A Input Listing for Assembly 23 with the central plate region.**

* There are 45 plate elements at the core centre
* and those at the core boundary have been replaced by pin elements.
* There are also fewer core elements
*

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal clad
* material 3 - UO2 plate core
* material 4 - UO2 plate clad
* material 5 - Sodium dummy, type Y (STNAVS4 ring)
* material 6 - Sodium dummy type Z (STNAV4 uniform, honeycomb)
* material 7 - 40%Steel
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Mild steel sheath
* material 13 - Steel bar MST9F10 at actual density (width 5.08 cm)
* material 14 - Steel bar averaged over the mean spacing of 5.4254 cm
* material 15 - Pin fuel A
* material 16 - Pin fuel B
* material 17 - Pin fuel C
* material 18 - Pin fuel D
* material 19 - Pin fuel E
* material 20 - Pin fuel F
* material 21 - Pin fuel UPINC
* material 22 - Pin can A
* material 23 - Pin can B
* material 24 - Pin can C
* material 25 - Pin can D
* material 26 - Pin can E
* material 27 - Pin can F
* material 28 - Pin can UPINC
* material 29 - Tube
* material 30 - Calandria end regions
* material 31 - Calandria Walls Type NACLI
* material 32 - Calandria Walls Type NACLIIS
* material 33 - Calandria Walls Type NACLIIS
* material 34 - Calandria Walls Type NACLIV
* material 35 - Calandria Walls Type NACLV
*

COLUMNS 1 132
BEGIN MATERIAL SPECIFICATION
NUMBER DENSITY
MATERIAL 1
U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02
PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04
AM241 4.5718E-04
H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05
AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06
FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03
MATERIAL 2
H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05
CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03
CU 1.6613E-02
MATERIAL 3
H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06
SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06
MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02
MATERIAL 4
H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04
S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02
NI 8.4258E-03
MATERIAL 5
H1 2.4073E-05 C 2.5251E-04 SI 7.4610E-04 P 1.7803E-05
S 1.7195E-05 CR 1.6248E-02 MN 1.5006E-03 FE 5.9881E-02
NI 9.4005E-03 NB 3.7393E-04
MATERIAL 6

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```

H1 3.3245E-06 C 3.3477E-05 SI 1.2169E-04 P 4.9764E-06
S 2.5076E-06 CR 2.4643E-03 MN 1.9518E-04 FE 8.0717E-03
NI 1.2195E-03 NB 5.2657E-05
MATERIAL 7
H1 1.8355E-05 C 8.7794E-05 AL 1.1862E-04 SI 7.9703E-04
P 4.0018E-05 S 1.4422E-05 TI 2.4806E-04 CR 1.5908E-02
MN 1.4972E-03 FE 5.5367E-02 NI 8.7976E-03 CU 5.0365E-05
NB 4.9781E-06 MO 8.0988E-05
MATERIAL 8
H1 4.4048E-05 C 4.9283E-04 SI 2.1076E-04 FE 1.0599E-04
U235 3.3369E-04 U238 4.6021E-02
MATERIAL 9
H1 4.3899E-05 C 4.6047E-04 SI 1.9692E-04 FE 9.9032E-05
U235 3.3962E-04 U238 4.6785E-02
MATERIAL 10
H1 4.4574E-05 C 4.7140E-04 SI 2.0160E-04 FE 1.0138E-04
U235 3.4209E-04 U238 4.7156E-02
MATERIAL 11
H1 2.5700E-05 C 5.1066E-04 AL 1.3989E-04 TI 3.9416E-05
CR 2.7222E-05 MN 3.2634E-04 FE 8.3806E-02 NI 4.8234E-05
CU 4.4548E-05 MO 9.8355E-06
MATERIAL 12
H1 7.5712E-05 C 2.3825E-04 AL 1.9798E-05 CR 3.6690E-06
MN 2.5697E-04 FE 7.7524E-02 NI 1.4302E-05 CU 2.2216E-05
MATERIAL 13
H1 4.6306E-05 C 6.8972E-04 SI 3.1158E-04 P 4.2944E-05
S 3.7110E-05 MN 7.1275E-04 FE 8.1432E-02
MATERIAL 14
H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05
S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02
*****
* Pin fuel A, B, C, D, E, F and U
MATERIAL 15
U234 1.3805E-06 U235 1.4114E-04 U236 7.9324E-07 U238 1.9379E-02
PU238 3.7786E-06 PU239 2.9689E-03 PU240 6.7253E-04 PU241 7.0350E-05
PU242 1.7488E-05 AM241 4.7854E-05
H1 3.2784E-05 O16 4.6606E-02 AL 1.1702E-05 CA 7.8782E-06 FE 5.6537E-06
MATERIAL 16
U234 1.3177E-06 U235 1.3457E-04 U236 7.4658E-07 U238 1.8472E-02
PU238 5.8915E-06 PU239 3.7341E-03 PU240 9.5200E-04 PU241 1.1199E-04
PU242 2.7984E-05 AM241 5.5789E-05
H1 3.2784E-05 O16 4.6993E-02 SI 9.0199E-06 NI 5.4424E-06
MATERIAL 17
U234 1.2863E-06 U235 1.2997E-04 U236 7.3103E-07 U238 1.7843E-02
PU238 6.9094E-06 PU239 4.4708E-03 PU240 1.0602E-03 PU241 1.1598E-04
PU242 3.0047E-05 AM241 5.7784E-05
H1 3.2784E-05 O16 4.7434E-02 AL 1.9730E-05 SI 7.9741E-06
FE 7.6916E-06 NI 1.0947E-05
MATERIAL 18
U234 1.4118E-06 U235 1.4266E-04 U236 7.9324E-07 U238 1.9584E-02
PU238 4.7348E-06 PU239 3.0189E-03 PU240 7.5441E-04 PU241 8.8443E-05
PU242 2.0961E-05 AM241 4.0742E-05
H1 3.2784E-05 O16 4.7314E-02 AL 1.8914E-05 SI 2.5099E-05
CA 1.5940E-05 FE 6.9027E-06 NI 1.4138E-05
MATERIAL 19
U234 1.1295E-06 U235 1.1465E-04 U236 6.3771E-07 U238 1.5739E-02
PU238 9.4851E-06 PU239 6.0438E-03 PU240 1.5103E-03 PU241 1.7707E-04
PU242 4.1953E-05 AM241 8.1559E-05
H1 3.2784E-05 O16 4.7299E-02 AL 9.5250E-06 SI 4.5753E-05
CA 3.2062E-05 FE 1.0321E-05
MATERIAL 20
U234 1.1452E-06 U235 1.1526E-04 U236 6.3771E-07 U238 1.5824E-02
PU238 9.5005E-06 PU239 6.0112E-03 PU240 1.5285E-03 PU241 1.9723E-04
PU242 4.4380E-05 AM241 6.8035E-05
H1 3.2784E-05 O16 4.7482E-02 AL 1.4287E-05 CA 6.7514E-05
CR 4.9427E-06 FE 1.1505E-05 NI 2.1895E-06
* UO2 fuel pin
MATERIAL 21
U235 1.7604E-04 U238 2.3580E-02
H1 3.2784E-05 C 3.2095E-05 O16 4.7501E-02 AL 2.3812E-05
SI 4.0001E-05 CA 1.2825E-05 FE 1.1176E-06
*****
* Fuel pin cans
MATERIAL 22

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H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05 S 2.4585E-05
 CR 1.8218E-02 MN 1.5646E-03 FE 5.9675E-02 NI 8.9153E-03

MATERIAL 23

H1 2.2895E-05 C 2.3695E-04 SI 1.1571E-03 P 4.1596E-05 S 2.2786E-05
 CR 1.4981E-02 MN 1.5751E-03 FE 5.3171E-02 NI 8.8137E-03

NB 2.9391E-04

MATERIAL 24

H1 2.6710E-05 C 1.3609E-04 SI 8.3531E-04 P 3.6008E-05 S 2.4585E-05
 CR 1.7856E-02 MN 1.5331E-03 FE 5.8512E-02 NI 8.7515E-03

MATERIAL 25

H1 2.4802E-05 C 2.0172E-04 AL 6.4142E-06 SI 8.9693E-04 P 3.4145E-05
 S 8.9942E-06 TI 2.8916E-05 CR 1.5910E-02 MN 1.1586E-03 FE 5.5753E-02
 CO 4.2418E-06 NI 7.6341E-03 CU 6.0522E-06 MO 2.2047E-06

MATERIAL 26

H1 2.4802E-05 C 7.3646E-05 AL 6.4142E-06 SI 1.0476E-03 P 1.3658E-05
 S 1.7389E-05 TI 2.8916E-05 CR 1.6102E-02 MN 9.8006E-04 FE 5.6794E-02
 CO 4.2418E-06 NI 8.0503E-03 CU 6.0522E-06 MO 2.1446E-05

MATERIAL 27

H1 2.4802E-05 C 7.2045E-05 AL 4.2762E-06 SI 1.0544E-03 P 1.3658E-05
 S 1.7989E-05 TI 2.1687E-05 CR 1.6284E-02 MN 9.8357E-04 FE 5.7354E-02
 CO 3.2629E-06 NI 8.1453E-03 CU 4.5391E-06 MO 2.1246E-05

MATERIAL 28

H1 2.6710E-05 C 1.3288E-04 SI 8.5585E-04 P 3.7870E-05
 S 2.4585E-05 CR 1.8255E-02 MN 1.5681E-03 FE 5.9792E-02
 NI 8.9349E-03

* Composition of calandria tubes

MATERIAL 29

SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02
 NI 7.4360E-03

* Composition of Calandria end plate regions

MATERIAL 30

SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02
 NI 4.4601E-03

* Compositions of Calandria outer walls

MATERIAL 31

H1 3.9844E-05 C 2.8167E-04 SI 6.0229E-04 P 7.3471E-05 S 3.6808E-05
 CR 1.4995E-02 MN 1.2214E-03 FE 4.8911E-02 NI 7.2440E-03

MATERIAL 32

TI 3.8637E-05 C 6.5351E-04 SI 9.7623E-04 P 4.7540E-05 S 3.3014E-05
 TI 2.4400E-04 CR 1.4380E-02 MN 1.1060E-03 FE 4.7118E-02 CO 1.1151E-05
 NI 7.4526E-03 CU 1.0341E-05 MO 3.4248E-06

MATERIAL 33

H1 3.9844E-05 C 1.5948E-04 SI 7.7474E-04 P 5.2334E-05 S 2.4551E-05
 CR 1.4132E-02 MN 8.3089E-04 FE 5.0764E-02 NI 7.6658E-03 MO 2.4862E-05

MATERIAL 34

H1 3.7430E-05 C 3.5158E-04 SI 8.2197E-04 P 6.2274E-05 S 1.6431E-05
 CR 1.3563E-02 MN 1.0026E-03 FE 4.7151E-02 NI 6.4549E-03 MO 8.8791E-06

MATERIAL 35

H1 3.8637E-05 C 2.4762E-04 SI 9.5110E-04 P 4.5654E-05 S 2.3793E-05
 CR 1.3837E-02 MN 8.6191E-04 FE 4.8404E-02 NI 6.8530E-03 MO 2.4862E-05

END

*

BEGIN MATERIAL GEOMETRY

*

* Plate 1, the Pu metal plate

PART 1 NEST

BOX	M1	-2.3355	-2.3355	0.0457	4.671	4.671	0.236
BOX	M2	-2.5335	-2.5335	0.0	5.067	5.067	0.3274
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	0.3274
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	0.3274
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	0.3274

*

* Plate 2, the UO2 plate

PART 2 NEST

BOX	M3	-2.4285	-2.4285	0.03665	4.857	4.857	0.558
BOX	M4	-2.5335	-2.5335	0.0	5.067	5.067	0.6313
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	0.6313
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	0.6313
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	0.6313

*

* Plate 3, the sodium dummy plate type Z, STNAV4 (uniform)

PART 3 NEST

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BOX	M6	-2.5335	-2.5335	0.0	5.067	5.067	0.616
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	0.616
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	0.616
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	0.616
*							
* Plate 4, the 40% steel plate							
PART 4 NEST							
BOX	M0	-1.9625	-1.9625	0.0	3.925	3.925	0.317
BOX	M7	-2.5335	-2.5335	0.0	5.067	5.067	0.317
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	0.317
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	0.317
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	0.317
*							
* Core Cell 1Z							
PART 5 ARRAY							
1 1 7 3 2 4 1 3 2 3							
* Core Cell 2Z, the reflection of cell 1							
PART 6 ARRAY							
1 1 7 3 2 3 1 4 2 3							
*							
* Core Cell 3Z This is Cell 1 minus Plate 4							
PART 7 ARRAY							
1 1 6 3 2 1 3 2 3							
*Core Cell 4Z the reflection of cell 3, Cell 2 minus Plate 4							
PART 8 ARRAY							
1 1 6 3 2 3 1 2 3							
*							

* Axial blanket U8 section							
PART 9 NEST							
BOX	M8	-2.5335	-2.5335	0.0	5.067	5.067	9.827
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	9.827
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	9.827
BOX	M0	-2.68605	-2.68605	0.0	0.0	5.3721	5.3721 9.827
*							
* Axial blanket U2 section							
PART 10 NEST							
BOX	M9	-2.5335	-2.5335	0.0	5.067	5.067	12.723
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	12.723
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	12.723
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	12.723
*							
* Axial blanket U3 section							
PART 11 NEST							
BOX	M10	-2.5335	-2.5335	0.0	5.067	5.067	7.6225
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	7.6225
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	7.6225
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	7.6225
*							
* Axial reflector MST3 section							
PART 12 NEST							
BOX	M11	-2.5335	-2.5335	0.0	5.067	5.067	7.60628
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	7.60628
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	7.60628
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	7.60628
*							

* Radial blanket U3 section (over half core height)							
* (height to match the core elements)							
PART 13 NEST							
BOX	M10	-2.5335	-2.5335	0.0	5.067	5.067	76.225
BOX	M0	-2.5510	-2.5510	0.0	5.102	5.102	76.225
BOX	M12	-2.6272	-2.6272	0.0	5.2544	5.2544	76.225
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	76.225
*							

* A whole height model.							
* The axial height of the pin cell elements is slightly less than							
* that of the plate cell elements, 89.19 cm compared with 89.486 cm.							
* (0.296 cm = 2 * 0.148 cm)							
*							
* The axial shielding material in the minicalandria elements							
* is extended in the model to cover this distance							
* Axial steel reflector section extended 0.148 cm in length							

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PART 14 NEST
BOX   M11   -2.5335 -2.5335 0.0    5.067  5.067  7.75428
BOX   M0    -2.5510 -2.5510 0.0    5.102  5.102  7.75428
BOX   M12   -2.6272 -2.6272 0.0    5.2544 5.2544 7.75428
BOX   M0    -2.68605 -2.68605 0.0    5.3721 5.3721 7.75428
*
*****
* The Core Element type Z (full height)
PART 15 ARRAY
1  1  32  12  11  10  9  8  (5  6)*11  7  9  10  11  12
*
*****
* Axial steel reflector section above the radial blanket reduced
* in length to match the core elements
PART 16 NEST
BOX   M11   -2.5335 -2.5335 0.0    5.067  5.067  6.29678
BOX   M0    -2.5510 -2.5510 0.0    5.102  5.102  6.29678
BOX   M12   -2.6272 -2.6272 0.0    5.2544 5.2544 6.29678
BOX   M0    -2.68605 -2.68605 0.0    5.3721 5.3721 6.29678
*
*****
* Specification of the pin cells, A to F and U/C
* Pin cell A
PART 17 NEST
ZROD  M15    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M22    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell B
PART 18 NEST
ZROD  M16    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M23    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell C
PART 19 NEST
ZROD  M17    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M24    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell D
PART 20 NEST
ZROD  M18    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M25    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell E
PART 21 NEST
ZROD  M19    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M26    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell F
PART 22 NEST
ZROD  M20    0.0    0.0    0.0    0.423  29.18
ZROD  M0     0.0    0.0    0.0    0.4305 29.18
ZROD  M27    0.0    0.0    0.0    0.4685 29.18
ZROD  M0     0.0    0.0    0.0    0.488  29.18
ZROD  M29    0.0    0.0    0.0    0.513  29.18
*
* Pin cell U/C
PART 23 NEST
ZROD  M21    0.0    0.0    0.0    0.423  29.18

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ZROD  M0      0.0      0.0      0.0      0.4305  29.18
ZROD  M28     0.0      0.0      0.0      0.4685  29.18
ZROD  M0      0.0      0.0      0.0      0.488   29.18
ZROD  M29     0.0      0.0      0.0      0.513   29.18
*
*****
* Mini-calandria
*
* Mini calandria 3A,
* 16 PUPINC in void square
* Pin C in square of void
PART 24  NEST
ZROD  P19     0.0      0.0      0.0      0.513   29.18
BOX   M0    -0.595 -0.595  0.0    1.19    1.19    29.18
* array of pins in calandria inner region
PART 25  ARRAY
4  4  1 (24)*16
* mini-calandria in the element sheath (M12)
PART 26  NEST
BOX   P25    -2.38  -2.38  0.44  4.76  4.76  29.18
BOX   M0     -2.45  -2.45  0.44  4.9   4.9   29.18
BOX   M30    -2.45  -2.45  0.0   4.9   4.9   29.73
BOX   M31    -2.5335 -2.5335  0.0   5.067  5.067  29.73
BOX   M0     -2.5510 -2.5510  0.0   5.102  5.102  29.73
BOX   M12    -2.6272 -2.6272  0.0   5.2544 5.2544 29.73
BOX   M0     -2.68605 -2.68605 0.0   5.3721 5.3721 29.73
*
*****
* Mini calandria 3B,
* 11 PUPINB and 5 PUPINF in void
* Pin B in square void region
PART 27  NEST
ZROD  P18     0.0      0.0      0.0      0.513   29.18
BOX   M0    -0.595 -0.595  0.0    1.19    1.19    29.18
* Pin F in square of sodium
PART 28  NEST
ZROD  P22     0.0      0.0      0.0      0.513   29.18
BOX   M0    -0.595 -0.595  0.0    1.19    1.19    29.18
* array of pins in void inner calandria region
PART 29  ARRAY
4  4  1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27
* mini-calandria in the element sheath (M12)
PART 30  NEST
BOX   P29    -2.38  -2.38  0.44  4.76  4.76  29.18
BOX   M0     -2.45  -2.45  0.44  4.9   4.9   29.18
BOX   M30    -2.45  -2.45  0.0   4.9   4.9   29.73
BOX   M31    -2.5335 -2.5335  0.0   5.067  5.067  29.73
BOX   M0     -2.5510 -2.5510  0.0   5.102  5.102  29.73
BOX   M12    -2.6272 -2.6272  0.0   5.2544 5.2544 29.73
BOX   M0     -2.68605 -2.68605 0.0   5.3721 5.3721 29.73
*
*****
* Mini calandria 3H,
* 11 PUPINB and 5 PUPINF
* Pin B in square
PART 31  NEST
ZROD  P18     0.0      0.0      0.0      0.513   29.18
BOX   M0    -0.595 -0.595  0.0    1.19    1.19    29.18
* Pin F in square
PART 32  NEST
ZROD  P22     0.0      0.0      0.0      0.513   29.18
BOX   M0    -0.595 -0.595  0.0    1.19    1.19    29.18
* array of pins
PART 33  ARRAY
4  4  1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31
* mini-calandria in the element sheath (M12)
PART 34  NEST
BOX   P33    -2.38  -2.38  0.44  4.76  4.76  29.18
BOX   M0     -2.45  -2.45  0.44  4.9   4.9   29.18
BOX   M30    -2.45  -2.45  0.0   4.9   4.9   29.73
BOX   M35    -2.5335 -2.5335  0.0   5.067  5.067  29.73
BOX   M0     -2.5510 -2.5510  0.0   5.102  5.102  29.73
BOX   M12    -2.6272 -2.6272  0.0   5.2544 5.2544 29.73
BOX   M0     -2.68605 -2.68605 0.0   5.3721 5.3721 29.73
*

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*****
*
* Mini calandria 3L,
* 11 PUPINB and 5 PUPINF
* Pin B in void square
PART 35 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35
* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* Mini calandria 3C,
* 8 PUPINA and 8 PUPINE
* Pin A in void square
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin E in void square
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* Mini calandria 3D,
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in void square
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square
PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* Mini calandria 3E,

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* 8 PUPIND and 8 PUPINF
* Pin D in void square
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 47 48 47
* mini-calandria in the element sheath (M12)
PART 50 NEST
BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 12 PUPINE and 4 UO2PINC
* Pin E in void square
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in void square
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M0 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)
PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M0 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M0 -2.5510 -2.5510 0.0 5.102 5.102 29.73
BOX M12 -2.6272 -2.6272 0.0 5.2544 5.2544 29.73
BOX M0 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
* form the pin fuelled elements 3A to 3L
* Element 3A
PART 55 ARRAY
1 1 11 14 11 10 9 (26)*3 9 10 11 14
* Element 3B
PART 56 ARRAY
1 1 11 14 11 10 9 (30)*3 9 10 11 14
* Element 3C
PART 57 ARRAY
1 1 11 14 11 10 9 (42)*3 9 10 11 14
* Element 3D
PART 58 ARRAY
1 1 11 14 11 10 9 (46)*3 9 10 11 14
* Element 3E
PART 59 ARRAY
1 1 11 14 11 10 9 (50)*3 9 10 11 14
* Element 3H
PART 60 ARRAY
1 1 11 14 11 10 9 (34)*3 9 10 11 14
* Element 3J
PART 61 ARRAY
1 1 11 14 11 10 9 (54)*3 9 10 11 14
* Element 3L
PART 62 ARRAY
1 1 11 14 11 10 9 (38)*3 9 10 11 14
*
*****

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* Steel reflector bars
* (height adjusted to match the height of the core plate elements)
PART 63 NEST
BOX    M13    -2.54    -2.54    0.0    5.08    5.08    165.04356
BOX    M0     -2.68605  -2.68605    0.0    5.3721  5.3721  165.04356
*
*
*The Radial Blanket element
PART 64 ARRAY
1  1   4  16  13   13  16
*
*****
*
* Plate 3Y, the sodium dummy plate type Y, STNAVS4 (ring)
PART 65 NEST
ZROD   M0      0.0      0.0      0.0      2.3      0.616
ZROD   M5      0.0      0.0      0.0      2.5335  0.616
BOX    M0     -2.5510  -2.5510    0.0      5.102    5.102    0.616
BOX    M12     -2.6272  -2.6272    0.0      5.2544  5.2544    0.616
BOX    M0     -2.68605  -2.68605    0.0      5.3721  5.3721    0.616
*
*
* Core Cell 1Y
PART 66 ARRAY
1  1   7  65  2   4   1  65  2   65
* Core Cell 2Y, the reflection of cell 1
PART 67 ARRAY
1  1   7  65  2   65  1   4   2   65
*
* Core Cell 3Y This is Cell 1Y minus Plate 4
PART 68 ARRAY
1  1   6  65  2   1   65  2   65
*Core Cell 4Y the reflection of cell 3Y, Cell 2Y minus Plate 4
PART 69 ARRAY
1  1   6  65  2   65  1   2   65
*
* The Core Element type Y (full height)
PART 70 ARRAY
1  1  32  12  11  10  9  69  (66 67)*11  68  9  10  11  12
*
*****
* assemble the arrays of elements
*
* Groups of 5x5 elements surrounded by the superlattice gap
* With groups of 5x3 in rows 1 and 7 and 3x5 in rows 3 and 5
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 71 ARRAY
5  3  1  (63)*13 (64)*2
PART 72 NEST
BOX    P71    -13.43025  -8.05815    0.0    26.8605  16.1163  165.04356
BOX    M0     -13.5635   -8.1914     0.0    27.127   16.3828  165.04356
* Centre
PART 73 ARRAY
5  3  1  (63)*10 (64)*5
PART 74 NEST
BOX    P73    -13.43025  -8.05815    0.0    26.8605  16.1163  165.04356
BOX    M0     -13.5635   -8.1914     0.0    27.127   16.3828  165.04356
* Right side
PART 75 ARRAY
5  3  1  (63)*10 (64)*2 (63)*3
PART 76 NEST
BOX    P75    -13.43025  -8.05815    0.0    26.8605  16.1163  165.04356
BOX    M0     -13.5635   -8.1914     0.0    27.127   16.3828  165.04356
* combine these arrays to form the row 1 array
PART 77 ARRAY
3  1  1  72  74  76
*
*****
*
* Row 7, the top set of groups of size 5x3 (5 along the x axis)

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* 3 arrays
* Left side
PART 78 ARRAY
5 3 1 (63)*3 (64)*2 (63)*10
PART 79 NEST
BOX P78 -13.43025 -8.05815 0.0 26.8605 16.1163 165.04356
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 165.04356
* Centre
PART 80 ARRAY
5 3 1 (64)*5 (63)*10
PART 81 NEST
BOX P80 -13.43025 -8.05815 0.0 26.8605 16.1163 165.04356
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 165.04356
* Right side
PART 82 ARRAY
5 3 1 (64)*2 (63)*13
PART 83 NEST
BOX P82 -13.43025 -8.05815 0.0 26.8605 16.1163 165.04356
BOX M0 -13.5635 -8.1914 0.0 27.127 16.3828 165.04356
* combine these arrays to form the row 7 array
PART 84 ARRAY
3 1 1 79 81 83
*
*****
* Row 2. 5 arrays of 5x5 elements
* Left hand array
PART 85 ARRAY
5 5 1 (63)*9 64 (63)*3 (64)*2 (63)*2 (64)*3 63 (64)*4
*
PART 86 NEST
BOX P85 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Middle left blanket elements
PART 87 ARRAY
5 5 1 (64)*25
*
PART 88 NEST
BOX P87 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
*
* Middle array blanket elements plus five 3C3
PART 89 ARRAY
5 5 1 (64)*20 (57)*5
*
PART 90 NEST
BOX P89 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Middle right blanket elements plus one (301)
PART 91 ARRAY
5 5 1 (64)*20 59 (64)*4
*
PART 92 NEST
BOX P91 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
*
* Right hand array
PART 93 ARRAY
5 5 1 (63)*5 64 (63)*4 (64)*2 (63)*3 (64)*3 (63)*2 (64)*4 63
*
PART 94 NEST
BOX P93 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Form row 2 array
PART 95 ARRAY
5 1 1 86 88 90 92 94
*
*****
*
* Row 6 arrays 5 groups of 5x5,

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*
* Left hand array
PART 96 ARRAY
5 5 1 63 (64)*4 (63)*2 (64)*3 (63)*3 (64)*2 (63)*4 64 (63)*5
*
PART 97 NEST
BOX P96 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Middle left array (one 387 element, 56)
PART 98 ARRAY
5 5 1 (64)*4 56 (64)*20
*
PART 99 NEST
BOX P98 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Middle array (4 3C3 and one 387 element)
PART 100 ARRAY
5 5 1 (57)*4 56 (64)*20
*
PART 101 NEST
BOX P100 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Middle right array
PART 102 ARRAY
5 5 1 (64)*25
*
PART 103 NEST
BOX P102 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Right hand array
PART 104 ARRAY
5 5 1 (64)*4 63 (64)*3 (63)*2 (64)*2 (63)*3 64 (63)*9
*
PART 105 NEST
BOX P104 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Form row 6 array
PART 106 ARRAY
5 1 1 97 99 101 103 105
*
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays of shield
* elements plus two blanket elements
*
* Left hand array
PART 107 ARRAY
3 5 1 (63)*11 64 (63)*2 64
PART 108 NEST
BOX P107 -8.05815 -13.43025 0.0 16.1163 26.8605 165.04356
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 165.04356
*
* left hand blanket array
PART 109 ARRAY
5 5 1 (64)*25
PART 110 NEST
BOX P109 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower left hand array (additional Y and Z elements
* compared with the flooded core)
PART 111 ARRAY
5 5 1 (64)*2 59 (57)*2 64 57 59 (60)*2 (57)*2 55 58 60
57 (58)*2 57 59 57 (58)*2 57 70
*
PART 112 NEST
BOX P111 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower middle array

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PART 113 ARRAY
5 5 1 (62)*5 (56)*10 15 70 (15)*3 15 70 (15)*3
*
PART 114 NEST
BOX P113 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core lower right hand array
PART 115 ARRAY
5 5 1 (57)*2 58 (64)*2 (60)*2 58 57 64 60 58 55 (57)*2
59 57 58 59 57 15 57 58 59 57
*
PART 116 NEST
BOX P115 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* right hand blanket array
PART 117 ARRAY
5 5 1 (64)*25
PART 118 NEST
BOX P117 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* right hand array
PART 119 ARRAY
3 5 1 (63)*9 64 (63)*2 64 (63)*2
PART 120 NEST
BOX P119 -8.05815 -13.43025 0.0 16.1163 26.8605 165.04356
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 165.04356
* Form the row 3 array
PART 121 ARRAY
7 1 1 108 110 112 114 116 118 120
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 122 ARRAY
3 5 1 (63)*2 64 (63)*2 64 (63)*9
PART 123 NEST
BOX P122 -8.05815 -13.43025 0.0 16.1163 26.8605 165.04356
BOX M0 -8.1914 -13.5635 0.0 16.3828 27.127 165.04356
*
* left hand blanket array
PART 124 ARRAY
5 5 1 (64)*25
PART 125 NEST
BOX P124 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core upper left hand array
PART 126 ARRAY
5 5 1 57 (58)*2 57 15 57 56 58 57 59 (57)*2 55 58 58
64 57 58 (60)*2 (64)*2 58 (57)*2
*
PART 127 NEST
BOX P126 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core upper middle array
PART 128 ARRAY
5 5 1 (15)*3 70 15 (15)*3 70 15 (56)*10 (62)*5
*
PART 129 NEST
BOX P128 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Core upper right hand array
PART 130 ARRAY
5 5 1 15 57 58 58 57 59 57 58 56 57
58 58 55 (59)*2 (60)*2 58 57 64 (57)*3 (64)*2
*
PART 131 NEST

```

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```

BOX      P130  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* right hand blanket array
PART 132 ARRAY
5 5 1 (64)*25
PART 133 NEST
BOX      P132  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* right hand shield array
PART 134 ARRAY
3 5 1 64 (63)*2 64 (63)*11
PART 135 NEST
BOX      P134  -8.05815  -13.43025  0.0      16.1163 26.8605 165.04356
BOX      M0    -8.1914  -13.5635   0.0 16.3828 27.127 165.04356
* Form the row 5 array
PART 136 ARRAY
7 1 1 123 125 127 129 131 133 135
*
*****
*
* Row 4 (the middle row) 7 groups of 5x5 elements
* Left hand shield group
PART 137 ARRAY
5 5 1 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64
*
PART 138 NEST
BOX      P137  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Left hand centre blanket group
PART 139 ARRAY
5 5 1 (64)*4 57 (64)*4 57 (64)*4 57 (64)*4 57 (64)*4 57
*
PART 140 NEST
BOX      P139  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Left hand centre core group
PART 141 ARRAY
5 5 1 55 61 58 (15)*2 55 (58)*2 (70)*2 56 (59)*2 (70)*2
55 58 55 (15)*2 55 61 55 (15)*2
*
PART 142 NEST
BOX      P141  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Centre core group
PART 143 ARRAY
5 5 1 (70)*4 15 (70)*10 15 (70)*9
*
PART 144 NEST
BOX      P143  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Right hand centre core group
PART 145 ARRAY
5 5 1 70 15 58 61 55 (15)*2 (58)*2 55 70 15 (59)*2 56
(15)*2 55 58 55 (15)*2 55 61 55
*
PART 146 NEST
BOX      P145  -13.43025      -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Right hand central row blanket group
PART 147 ARRAY
5 5 1 57 (64)*4 57 (64)*4 57 (64)*4 57 (64)*4 57 (64)*4
*
PART 148 NEST
BOX      P147  -13.43025  -13.43025  0.0 26.8605 26.8605 165.04356
BOX      M0    -13.5635  -13.5635   0.0 27.127 27.127 165.04356
*
* Right hand shield group

```

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```

PART 149 ARRAY
5 5 1 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4 64 (63)*4
*
PART 150 NEST
BOX P149 -13.43025 -13.43025 0.0 26.8605 26.8605 165.04356
BOX M0 -13.5635 -13.5635 0.0 27.127 27.127 165.04356
*
* Form the row 4 array
PART 151 ARRAY
7 1 1 138 140 142 144 146 148 150
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 152 CLUSTER
BOX P84 -40.6905 67.8175 0.0 81.381 16.3828 165.04356
BOX P106 -67.8175 40.6905 0.0 135.635 27.127 165.04356
BOX P136 -84.2003 13.5635 0.0 168.4006 27.127 165.04356
BOX P151 -94.9445 -13.5635 0.0 189.889 27.127 165.04356
BOX P121 -84.2003 -40.6905 0.0 168.4006 27.127 165.04356
BOX P95 -67.8175 -67.8175 0.0 135.635 27.127 165.04356
BOX P77 -40.6905 -84.2003 0.0 81.381 16.3828 165.04356
ZROD M14 0.0 0.0 -1.56 96.6 168.0
*
*****
* Albedo for free boundaries at side and top and bottom
*
ALBEDO 0.0 0.0 0.0
END
*
*****
BEGIN CONTROL DATA
STAGES -50 2000 2000 STDV 0.0001
END
*
*****
BEGIN SOURCE GEOMETRY
ZONEMAT
ALL / MATERIAL 1
END

```

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A1.7.Simplified MONK Models

* MONK8B Input Listing for Assembly 22B, Model B

* Simplified treatment of the sheath and neighbouring void regions

* Modified material 12

MATERIAL 12

H1 3.7519E-05 C 1.1807E-04 AL 9.8110E-06 CR 1.8182E-06

MN 1.2734E-04 FE 3.8417E-02 NI 7.0874E-06 CU 1.1009E-05 *

BEGIN MATERIAL GEOMETRY

*

* Plate 1, the Pu metal plate

PART 1 NEST

BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236

BOX M2 -2.5335 -2.5185 0.0 5.067 5.067 0.3274

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.3274

*

* Plate 2, the UO2 plate

PART 2 NEST

BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558

BOX M4 -2.5335 -2.5335 0.0 5.067 5.067 0.6313

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.6313

*

* Plate 3, the sodium plate

PART 3 NEST

BOX M5 -2.4815 -2.4815 0.036347 4.963 4.963 0.541

BOX M6 -2.5335 -2.5335 0.0 5.067 5.067 0.613694

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.613694

*

* Plate 4, the 40% steel plate

PART 4 NEST

BOX M0 -1.9625 -1.9625 0.0 3.925 3.925 0.317

BOX M7 -2.5335 -2.5335 0.0 5.067 5.067 0.317

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 0.317

*

* Core Cell 1

PART 5 ARRAY

1 1 7 3 2 4 1 3 2 3

* Core Cell 2

PART 6 ARRAY

1 1 7 3 2 3 1 4 2 3

*

* Core Cell 3

PART 7 ARRAY

1 1 6 3 2 1 3 2 3

*

* Axial blanket U8 section

PART 8 NEST

BOX M8 -2.5335 -2.5335 0.0 5.067 5.067 9.827

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 9.827

*

* Axial blanket U2 section

PART 9 NEST

BOX M9 -2.5335 -2.5335 0.0 5.067 5.067 12.723

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 12.723

*

* Axial blanket U3 section

PART 10 NEST

BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 7.6225

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 7.6225

*

* Axial reflector MST3 section

PART 11 NEST

BOX M11 -2.5335 -2.5335 0.0 5.067 5.067 7.60628

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 7.60628

*

* Radial blanket U3 section (over half core height)

PART 12 NEST

BOX M10 -2.5335 -2.5335 0.0 5.067 5.067 74.83248

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 74.83248

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*

* Steel reflector bars (over half core height)

PART 13 NEST

BOX	M13	-2.54	-2.54	0.0	5.08	5.08	82.438764
BOX	M0	-2.68605	-2.68605	0.0	5.3721	5.3721	82.438764

*

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*** MONK9A Input Listing for Assembly 22B Model C,**

* The lattice pitch is changed to 5.4254 cm and the sheath homogenised
* Material 12 is changed

MATERIAL 12

H1 3.1777E-05 C 9.9996E-05 AL 8.3095E-06 CR 1.5399E-06
MN 1.0785E-04 FE 3.2538E-02 NI 6.0027E-06 CU 9.3243E-06

*

BEGIN MATERIAL GEOMETRY

*

* Plate 1, the Pu metal plate

PART 1 NEST

BOX	M1	-2.3355	-2.3355	0.0457	4.671	4.671	0.236
BOX	M2	-2.5335	-2.5185	0.0	5.067	5.067	0.3274
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	0.3274

*

* Plate 2, the UO2 plate

PART 2 NEST

BOX	M3	-2.4285	-2.4285	0.03665	4.857	4.857	0.558
BOX	M4	-2.5335	-2.5335	0.0	5.067	5.067	0.6313
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	0.6313

*

* Plate 3, the sodium plate

PART 3 NEST

BOX	M5	-2.4815	-2.4815	0.036347	4.963	4.963	0.541
BOX	M6	-2.5335	-2.5335	0.0	5.067	5.067	0.613694
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	0.613694

*

* Plate 4, the 40% steel plate

PART 4 NEST

BOX	M0	-1.9625	-1.9625	0.0	3.925	3.925	0.317
BOX	M7	-2.5335	-2.5335	0.0	5.067	5.067	0.317
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	0.317

*

* Core Cell 1

PART 5 ARRAY

1 1 7 3 2 4 1 3 2 3

* Core Cell 2

PART 6 ARRAY

1 1 7 3 2 3 1 4 2 3

*

* Core Cell 3

PART 7 ARRAY

1 1 6 3 2 1 3 2 3

*

* Axial blanket U8 section

PART 8 NEST

BOX	M8	-2.5335	-2.5335	0.0	5.067	5.067	9.827
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	9.827

*

* Axial blanket U2 section

PART 9 NEST

BOX	M9	-2.5335	-2.5335	0.0	5.067	5.067	12.723
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	12.723

*

* Axial blanket U3 section

PART 10 NEST

BOX	M10	-2.5335	-2.5335	0.0	5.067	5.067	7.6225
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	7.6225

*

* Axial reflector MST3 section

PART 11 NEST

BOX	M11	-2.5335	-2.5335	0.0	5.067	5.067	7.60628
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	7.60628

*

* Radial blanket U3 section (over half core height)

PART 12 NEST

BOX	M10	-2.5335	-2.5335	0.0	5.067	5.067	74.83248
BOX	M12	-2.7127	-2.7127	0.0	5.4254	5.4254	74.83248

*

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```

* Steel reflector bars (over half core height)
PART 13 NEST
BOX   M13   -2.54  -2.54  0.0    5.08   5.08   82.438764
BOX   M0    -2.7127 -2.7127 0.0    5.4254 5.4254 82.438764
*
*****
*
* The Core Element (half height) (bottom cell 2 reflected at Z=0)
PART 14 ARRAY
1 1 16 (6 5)*5 6 7 8 9 10 11
*
*The Radial Blanket element (half height) (Cell 8 reflected at Z = 0)
PART 15 ARRAY
1 1 2 12 11
*
*****
* Insert special element at the core centre
*
* Plate 16, the Pu metal plate at the core centre
PART 16 NEST
BOX   M15   -2.3355 -2.3355 0.0457 4.671  4.671  0.236
BOX   M2    -2.5335 -2.5185 0.0    5.067  5.067  0.3274
BOX   M12   -2.7127 -2.7127 0.0    5.4254 5.4254 0.3274
*
* Plate 17, the UO2 plate
PART 17 NEST
BOX   M16   -2.4285 -2.4285 0.03665 4.857  4.857  0.558
BOX   M4    -2.5335 -2.5335 0.0    5.067  5.067  0.6313
BOX   M12   -2.7127 -2.7127 0.0    5.4254 5.4254 0.6313
*
*****
* Special cell at the core centre
*
PART 18 ARRAY
1 1 7 3 17 4 16 3 17 3
* Special element at core centre
*
* Neighbouring cell at the core centre
*
PART 19 ARRAY
1 1 7 3 17 3 16 4 17 3
*
* The Special Core Element (half height) (bottom cell 2 reflected at Z=0)
PART 20 ARRAY
1 1 16 (19 18)*2 (6 5)*3 6 7 8 9 10 11
*
*****
* Groups of 5x5 elements forming a superlattice group
* Core group
PART 21 ARRAY
5 5 1 (14)*25
*
* Core bottom left corner group
PART 22 ARRAY
5 5 1 (15)*3 (14)*2 15 (14)*4 15 (14)*14
*
* Core bottom right group
PART 23 ARRAY
5 5 1 (14)*2 (15)*3 (14)*3 (15)*2 (14)*4 15 (14)*10
*
* Core top left corner group
PART 24 ARRAY
5 5 1 (14)*10 15 (14)*4 (15)*2 (14)*3 (15)*3 (14)*2
*
* Core top right group
PART 25 ARRAY
5 5 1 (14)*14 15 (14)*4 15 (14)*2 (15)*3
*
* Core bottom group
PART 26 ARRAY
5 5 1 (15)*21 (14)*3 15
*
* Core top group
PART 27 ARRAY

```

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```

5 5 1 15 (14)*3 (15)*21
*
* Core left group
PART 28 ARRAY
5 5 1 (15)*9 14 (15)*4 14 (15)*4 14 (15)*5
*
* Core right group
PART 29 ARRAY
5 5 1 (15)*5 14 (15)*4 14 (15)*4 14 (15)*9
*
*****
* Blanket element group
PART 30 ARRAY
5 5 1 (15)*25
*
*****
* top and bottom groups have Y=3
* Shield bottom group
PART 31 ARRAY
5 3 1 (13)*10 (15)*5
*
* Shield top group
PART 32 ARRAY
5 3 1 (15)*5 (13)*10
*
*****
* Shield left group
PART 33 ARRAY
5 5 1 (13)*4 15 (13)*4 15 (13)*4 15 (13)*4 15 (13)*4 15
*
* Shield right group
PART 34 ARRAY
5 5 1 15 (13)*4 15 (13)*4 15 (13)*4 15 (13)*4 15 (13)*4
*
*Shield corner sections
* Bottom left group
PART 35 ARRAY
5 5 1 (13)*9 15 (13)*3 (15)*2 (13)*2 (15)*3 13 (15)*4
*
* Bottom right group
PART 36 ARRAY
5 5 1 (13)*5 15 (13)*4 (15)*2 (13)*3 (15)*3 (13)*2 (15)*4 13
*
* Top left group
PART 37 ARRAY
5 5 1 13 (15)*4 (13)*2 (15)*3 (13)*3 (15)*2 (13)*4 15 (13)*5
*
* top right group
PART 38 ARRAY
5 5 1 (15)*4 13 (15)*3 (13)*2 (15)*2 (13)*3 15 (13)*9
*
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 39 ARRAY
5 3 1 (13)*13 (15)*2
*
* Centre is Part 31
* Right side
PART 40 ARRAY
5 3 1 (13)*10 (15)*2 (13)*3
*
* combine these arrays to form the row 1 array
PART 41 ARRAY
3 1 1 39 31 40
*
*****
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays

```

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```

* Left side
PART 42 ARRAY
5 3 1 (13)*3 (15)*2 (13)*10
*
* Centre is Part 32
* Right side
PART 43 ARRAY
5 3 1 (15)*2 (13)*13
*
* combine these arrays to form the row 7 array
PART 44 ARRAY
3 1 1 42 32 43
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays
* Left hand array
PART 45 ARRAY
3 5 1 (13)*11 15 (13)*2 15
*
* right hand array
PART 46 ARRAY
3 5 1 (13)*9 15 (13)*2 15 (13)*2
*
* Form the row 3 array
PART 47 ARRAY
7 1 1 45 30 22 21 23 30 46
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5
* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 48 ARRAY
3 5 1 (13)*2 15 (13)*2 15 (13)*9
*
* right hand shield array
PART 49 ARRAY
3 5 1 15 (13)*2 15 (13)*11
*
* Form the row 5 array
PART 50 ARRAY
7 1 1 48 30 24 21 25 30 49
*
*****
* Arrays of the Superlattice groups
* Row 2
PART 51 ARRAY
5 1 1 35 30 26 30 36
*
* Row 6
PART 52 ARRAY
5 1 1 37 30 27 30 38
*
* Group of elements including the special element at the centre
* Groups of 5x5 elements surrounded by the superlattice gap
* Core group including the special element
*
PART 53 ARRAY
5 5 1 (20)*25
*
* Middle line, Row 4
PART 54 ARRAY
7 1 1 33 28 21 53 21 29 34
*
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 55 CLUSTER
BOX P44 -40.6905 67.8175 0.0 81.381 16.2762 82.438764
BOX P52 -67.8175 40.6905 0.0 135.635 27.127 82.438764
BOX P50 -84.0937 13.5635 0.0 168.1874 27.127 82.438764
BOX P54 -94.9445 -13.5635 0.0 189.889 27.127 82.438764
BOX P47 -84.0937 -40.6905 0.0 168.1874 27.127 82.438764
BOX P51 -67.8175 -67.8175 0.0 135.635 27.127 82.438764

```

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BOX	P41	-40.6905	-84.0937	0.0	81.381	16.2762	82.438764
ZROD	M14	0.0	0.0	0.0	96.6	84.0	
*							

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*** MONK9A Input Listing for Assembly 22B, Model D**

* As model C with the blanket and shield regions homogenised

* Materials 8, 9, 10, 11 and 12 revised

* material 8 - U8 natural uranium region

* material 9 - U2 natural uranium region

* material 10 - U3 natural uranium block

* material 11 - MST3 Steel block

* material 12 - Mild steel sheath averaged over the superlattice space

*

MATERIAL 8

H1 4.2481E-05 C 4.4265E-04 AL 1.0616E-06 SI 1.8383E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2493E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9106E-04 U238 4.0142E-02

MATERIAL 9

H1 4.2351E-05 C 4.1442E-04 AL 1.0616E-06 SI 1.7176E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2433E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9623E-04 U238 4.0808E-02

MATERIAL 10

H1 4.2939E-05 C 4.2396E-04 AL 1.0616E-06 SI 1.7584E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2453E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9839E-04 U238 4.1132E-02

MATERIAL 11

H1 2.6476E-05 C 4.5820E-04 AL 1.2308E-04 TI 3.4380E-05

CR 2.3941E-05 MN 2.9843E-04 FE 7.7256E-02 NI 4.2839E-05

CU 4.0048E-05 MO 8.5790E-06

MATERIAL 12

H1 3.1777E-05 C 9.9996E-05 AL 8.3095E-06 CR 1.5399E-06

MN 1.0785E-04 FE 3.2538E-02 NI 6.0027E-06 CU 9.3243E-06

*

BEGIN MATERIAL GEOMETRY

*

* Axial blanket U8 section

PART 8 NEST

BOX M8 -2.7127 -2.7127 0.0 5.4254 5.4254 9.827

*

* Axial blanket U2 section

PART 9 NEST

BOX M9 -2.7127 -2.7127 0.0 5.4254 5.4254 12.723

*

* Axial blanket U3 section

PART 10 NEST

BOX M10 -2.7127 -2.7127 0.0 5.4254 5.4254 7.6225

*

* Axial reflector MST3 section

PART 11 NEST

BOX M11 -2.7127 -2.7127 0.0 5.4254 5.4254 7.60628

*

* Radial blanket U3 section (over half core height)

PART 12 NEST

BOX M10 -2.7127 -2.7127 0.0 5.4254 5.4254 74.83248

*

* Steel reflector bars (over half core height)

PART 13 NEST

BOX M14 -2.7127 -2.7127 0.0 5.4254 5.4254 82.438764

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*** MONK8B Input Listing for Assembly 22B, Model E homogenisation**

* As Model D but with the canning and sheath material homogenised

* Revised materials 2, 4, 6, 7 New materials 12, 13 and 14

*

* material 1 - Plutonium metal plate core
* material 2 - Plutonium metal plate can
* material 3 - UO2 plate core
* material 4 - UO2 plate can
* material 5 - Sodium plate core
* material 6 - Sodium plate can
* material 7 - 40%Steel region
* material 8 - U8 natural uranium region
* material 9 - U2 natural uranium region
* material 10 - U3 natural uranium block
* material 11 - MST3 Steel block
* material 12 - Plutonium plate edge region
* material 13 - UO2 plate edge region
* material 14 - Sodium plate edge region
* material 15 - Plutonium metal plate core at reactor core centre
* material 16 - UO2 plate core at reactor core centre
* material 17 - Steel bar averaged over the mean spacing of 5.4254 cm

COLUMNS 1 132

BEGIN MATERIAL SPECIFICATION

NUMBER DENSITY

MATERIAL 1

U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02

PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04

AM241 4.5718E-04

H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05

AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06

FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03

MATERIAL 2

H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05

CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03

CU 1.6613E-02

MATERIAL 3

H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06

SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06

MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02

MATERIAL 4

H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04

S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02

NI 8.4258E-03

MATERIAL 5

H1 1.3900E-05 O16 5.6492E-06 NA 2.3225E-02 CA 3.6083E-06

FE 1.6184E-07

MATERIAL 6

H1 2.1631E-05 C 2.9290E-04 SI 6.0867E-04 P 3.2795E-05

S 3.3219E-05 CR 1.4759E-02 MN 1.3570E-03 FE 5.5054E-02

NI 7.0982E-03 NB 3.1147E-04

MATERIAL 7

H1 2.1952E-05 C 9.1064E-05 AL 8.9052E-05 SI 5.8340E-04

P 2.9292E-05 S 1.0556E-05 TI 1.8157E-04 CR 1.1644E-02

MN 1.1248E-03 FE 4.9247E-02 NI 6.4410E-03 CU 3.9365E-05

NB 3.6597E-06 MO 5.9280E-05

MATERIAL 8

H1 4.2481E-05 C 4.4265E-04 AL 1.0616E-06 SI 1.8383E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2493E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9106E-04 U238 4.0142E-02

MATERIAL 9

H1 4.2351E-05 C 4.1442E-04 AL 1.0616E-06 SI 1.7176E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2433E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9623E-04 U238 4.0808E-02

MATERIAL 10

H1 4.2939E-05 C 4.2396E-04 AL 1.0616E-06 SI 1.7584E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2453E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9839E-04 U238 4.1132E-02

MATERIAL 11

H1 2.6476E-05 C 4.5820E-04 AL 1.2308E-04 TI 3.4380E-05

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CR  2.3941E-05  MN  2.9843E-04  FE  7.7256E-02  NI  4.2839E-05
CU  4.0048E-05  MO  8.5790E-06
MATERIAL 12
H1  2.2655E-05  C   1.0705E-04  AL  4.1025E-06  SI  1.8534E-04
P   6.9518E-06  CR  4.7604E-03  MN  4.8831E-04  FE  3.4059E-02
NI  2.1114E-03  CU  8.4155E-03
MATERIAL 13
H1  2.7234E-05  C   1.1009E-04  AL  5.3465E-06  SI  2.2990E-04
P   1.2508E-04  S   1.2851E-05  CR  4.9286E-03  MN  3.7448E-04
FE  3.8160E-02  NI  3.0083E-03  CU  5.9995E-06
MATERIAL 14
H1  2.9574E-05  C   1.4189E-04  AL  6.5050E-06  SI  1.3218E-04
P   7.1216E-06  S   7.2136E-06  CR  3.2062E-03  MN  3.7911E-04
FE  3.7427E-02  NI  1.5461E-03  CU  7.2995E-06  NB  6.7637E-05
MATERIAL 15
U238  6.8782E-07  PU238  3.0461E-05  PU239  2.8920E-02
PU240  6.9095E-03  PU241  7.3960E-04  PU242  1.8699E-04
AM241  4.5718E-04
H1  1.2764E-04  C   4.2260E-04  N   2.4215E-05  O16  8.8450E-05
AL  2.2973E-05  SI  1.4158E-05  CR  3.5989E-06  MN  1.4902E-06
FE  1.6335E-05  NI  8.5688E-06  GA  2.0166E-03
MATERIAL 16
H1  3.1773E-05  C   1.1808E-05  O16  4.6008E-02  AL  3.3911E-06
SI  2.2967E-05  MN  8.3273E-08  FE  1.3107E-06  NI  1.2472E-06
MO  3.3379E-07  U235  1.6544E-04  U238  2.2837E-02
MATERIAL 17
H1  4.0597E-05  C   6.0468E-04  SI  2.7317E-04  P   3.7649E-05
S   3.2535E-05  MN  6.2488E-04  FE  7.1392E-02
END
*
*****
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX  M1  -2.3355  -2.3355  0.0457  4.671  4.671  0.236
BOX  M2  -2.3355  -2.3355  0.0      4.671  4.671  0.3274
BOX  M12 -2.7127  -2.7127  0.0      5.4254  5.4254  0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX  M3  -2.4285  -2.4285  0.03665  4.857  4.857  0.558
BOX  M4  -2.4285  -2.4285  0.0      4.857  4.857  0.6313
BOX  M13 -2.7127  -2.7127  0.0      5.4254  5.4254  0.6313
*
* Plate 3, the sodium plate
PART 3 NEST
BOX  M5  -2.4815  -2.4815  0.036347  4.963  4.963  0.541
BOX  M6  -2.4815  -2.4815  0.0      4.963  4.963  0.613694
BOX  M14 -2.7127  -2.7127  0.0      5.4254  5.4254  0.613694
*
* Plate 4, the 40% steel plate
PART 4 NEST
BOX  M0  -1.9625  -1.9625  0.0      3.925  3.925  0.317
BOX  M7  -2.7127  -2.7127  0.0      5.4254  5.4254  0.317
*
*****
*
*****
* Insert special element at the core centre
*
* Plate 16, the Pu metal plate at the core centre
PART 16 NEST
BOX  M15 -2.3355  -2.3355  0.0457  4.671  4.671  0.236
BOX  M2  -2.3355  -2.3355  0.0      4.671  4.671  0.3274
BOX  M12 -2.7127  -2.7127  0.0      5.4254  5.4254  0.3274
*
* Plate 17, the UO2 plate
PART 17 NEST
BOX  M16 -2.4285  -2.4285  0.03665  4.857  4.857  0.558
BOX  M4  -2.4285  -2.4285  0.0      4.857  4.857  0.6313
BOX  M13 -2.7127  -2.7127  0.0      5.4254  5.4254  0.6313
*****

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*** MONK9A Input Listing for Assembly 23 homogenised sheath region Mat 12**

* Material 12 is changed and the void regions by the sheath removed
* Plate cells, blanket and shield as for 22 Model B

* Minicalandria as follows:

* Mini-calandria

*

Mini calandria 3A,

* 16 PUPINC in NACLI

* Pin C in square of sodium

PART 24 NEST

ZROD P19 0.0 0.0 0.0 0.513 29.18

BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18

* array of pins in sodium

PART 25 ARRAY

4 4 1 (24)*16

* mini-calandria in the element sheath (M12)

PART 26 NEST

BOX P25 -2.38 -2.38 0.44 4.76 4.76 29.18

BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18

BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73

BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73

*

*

Mini calandria 3B,

* 11 PUPINB and 5 PUPINF in NACLI

* Pin B in square of sodium

PART 27 NEST

ZROD P18 0.0 0.0 0.0 0.513 29.18

BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18

* Pin F in square of sodium

PART 28 NEST

ZROD P22 0.0 0.0 0.0 0.513 29.18

BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18

* array of pins in sodium

PART 29 ARRAY

4 4 1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27

* mini-calandria in the element sheath (M12)

PART 30 NEST

BOX P29 -2.38 -2.38 0.44 4.76 4.76 29.18

BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18

BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73

BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73

*

*

Mini calandria 3H,

* 11 PUPINB and 5 PUPINF in NACLIV

* Pin B in square of NACLIV sodium

PART 31 NEST

ZROD P18 0.0 0.0 0.0 0.513 29.18

BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18

* Pin F in square of sodium

PART 32 NEST

ZROD P22 0.0 0.0 0.0 0.513 29.18

BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18

* array of pins in sodium

PART 33 ARRAY

4 4 1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31

* mini-calandria in the element sheath (M12)

PART 34 NEST

BOX P33 -2.38 -2.38 0.44 4.76 4.76 29.18

BOX M40 -2.45 -2.45 0.44 4.9 4.9 29.18

BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73

BOX M35 -2.5335 -2.5335 0.0 5.067 5.067 29.73

BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73

*

*

Mini calandria 3L,

* 11 PUPINB and 5 PUPINF in NACLIV

* Pin B in square of NACLIV sodium

PART 35 NEST

ZROD P18 0.0 0.0 0.0 0.513 29.18

BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18

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* Pin F in square of sodium
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35
* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
Mini calandria 3C,
* 8 PUPINA and 8 PUPINE in NACLIII
* Pin A in square of NACLIII sodium
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin E in square of sodium
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
Mini calandria 3D,
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in square of NACLIII sodium
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
Mini calandria 3E,
* 8 PUPIND and 8 PUPINF in NACLIIIS
* Pin D in square of NACLIIIS sodium
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 48 47 48 47
* mini-calandria in the element sheath (M12)

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PART 50 NEST
BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M37 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****
*
* 12 PUPINE and 4 UO2PINC in NACLIV
* Pin E in square of NACLIV sodium
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)
PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.68605 -2.68605 0.0 5.3721 5.3721 29.73
*
*****

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* MONK9A Input Listing for Assembly 23 regular lattice pitch 5.4254cm
* Assembly 23 is the Pin Geometry Version of the Cadenza cores.
* it also includes an outer ring of plate geometry elements
* Reactor structure: elements arranged on a square grid
* The Pin Elements in the core contain 3 minicalandria and an Axial
* Region Cell, enclosed in a mild steel sheath.
* The plate elements contain 24 cells, the plates having width 5.067cm
* The Element sheath has an inner width 5.102 cm, outer width 5.2544cm
* The elements occupy a lattice area of 5.3721 cm square.
* Groups of 5x5 elements form the superlattice
* with a space between them
* The Radial Blanket Elements contain 10 U3 blocks and a MST3 block
* enclosed in a mild steel sheath with reflection in the midplane.
* The radial shielding elements consist of the Steel bar MST9F10
* which is about 300 cm high.
* These are represented explicitly within an outer radius and also
* homogenised (over the overall average lattice area) to fill the
* remaining space in the outer cylinder (pitch 5.4254 cm)
* Elements are grouped in square arrays containing 5x5 = 25 elements
* plus edge groups with 3x5 elements. The Assembly is built from these
* There is a gap between these groups of elements of 0.2667 cm
* Core Plate Geometry Element structure:
*   The plate element consists of combinations of the following:
*   Core Cell PART 1, Core Cell PART 2, an inversion of PART 1,
*   Core Cell PART 3, which is the same as PART 1
*   but with the 40%Steel plate omitted, and the inversion of
*   this cell which forms PART 4
*   the Axial Region Cell is PART5.
* Structure of Core Plate Cell 1, PART 1, 7 plates.
*   Cell height 3.748082 cm. Enclosed in mild steel sheath.
*   Outer area of all plates is 5.067 cm x 5.067 cm
* From the top down:
*   Sodium (0.613694 cm thick, core 0.541 cm x 4.963 cm square)
*   UO2 (0.6313 cm thick, core 0.558 cm x 4.857 cm square)
*   Sodium (0.613694 cm thick,)
*   Pu Metal (0.3274 cm thick, core 0.236 cm x 4.671cm x 4.671 cm)
*   40%Steel (0.317 cm thick, void core 0.317 cm x 3.925 cm square)
*   UO2 (0.6313 cm thick)
*   Sodium (0.613694 cm thick)
* Structure of Core Plate Cell 2 PART 2. The inverse of PART 1
* Structure of Core Plate Cell PART 3. PART 1 without 40%Steel plate.
*   Cell height 3.431082 cm.
* Structure of the Axial Region cell. Enclosed in mild steel sheath.
*   Cell height From the top:
*   MST3 Block (7.60628 cm thick)
*   U3 Block (7.6225 cm thick,)
*   U2 region (10 plates, total thickness 12.723 cm )
*   U8 region (31 plates, total thickness 9.827 cm)
* Structure of the Radial Blanket element.
*   Height of the reflected half height element
*   MST3 Block (7.60628 cm thick)
*   U3 Block composition (height above mid-plane to match the core
*   element blanket height of 74.83248 cm)
MATERIAL 12
H1 3.1777E-05 C 9.9996E-05 AL 8.3095E-06 CR 1.5399E-06
MN 1.0785E-04 FE 3.2538E-02 NI 6.0027E-06 CU 9.3243E-06
*****
* Mini-calandria
*
* Mini calandria 3A,
* 16 PUPINC in NACLI
* Pin C in square of sodium
PART 24 NEST
ZROD P19 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 25 ARRAY
4 4 1 (24)*16
* mini-calandria in the element sheath (M12)
PART 26 NEST
BOX P25 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73

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*
*****
*
Mini calandria 3B,
* 11 PUPINB and 5 PUPINF in NACLI
* Pin B in square of sodium
PART 27 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 28 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M36 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 29 ARRAY
4 4 1 27 27 28 27 27 27 27 28 28 27 28 27 27 28 27 27
* mini-calandria in the element sheath (M12)
PART 30 NEST
BOX P29 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M36 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M31 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3H,
* 11 PUPINB and 5 PUPINF in NACLIV
* Pin B in square of NACLIV sodium
PART 31 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 32 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M40 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 33 ARRAY
4 4 1 31 31 32 31 31 31 31 32 32 31 32 31 31 32 31 31
* mini-calandria in the element sheath (M12)
PART 34 NEST
BOX P33 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M40 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M35 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3L,
* 11 PUPINB and 5 PUPINF in NACLIV
* Pin B in square of NACLIV sodium
PART 35 NEST
ZROD P18 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 36 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 37 ARRAY
4 4 1 35 35 36 35 35 35 35 36 36 35 36 35 35 36 35 35
* mini-calandria in the element sheath (M12)
PART 38 NEST
BOX P37 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3C,
* 8 PUPINA and 8 PUPINE in NACLIII
* Pin A in square of NACLIII sodium
PART 39 NEST
ZROD P17 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18

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* Pin E in square of sodium
PART 40 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 41 ARRAY
4 4 1 39 40 39 40 40 39 40 39 39 40 39 40 40 39 40 39
* mini-calandria in the element sheath (M12)
PART 42 NEST
BOX P41 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3D,
* 8 PUPIND and 8 PUPINF in NACLIII
* Pin D in square of NACLIII sodium
PART 43 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 44 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M38 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 45 ARRAY
4 4 1 43 44 43 44 44 43 44 43 43 44 43 44 44 43 44 43
* mini-calandria in the element sheath (M12)
PART 46 NEST
BOX P45 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M38 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M33 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3E,
* 8 PUPIND and 8 PUPINF in NACLIIS
* Pin D in square of NACLIIS sodium
PART 47 NEST
ZROD P20 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 48 NEST
ZROD P22 0.0 0.0 0.0 0.513 29.18
BOX M37 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 49 ARRAY
4 4 1 47 48 47 48 48 47 48 47 47 48 47 48 48 47 48 47
* mini-calandria in the element sheath (M12)
PART 50 NEST
BOX P49 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M37 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M32 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
*
Mini calandria 3J,
* 12 PUPINE and 4 UO2PINC in NACLIV
* Pin E in square of NACLIV sodium
PART 51 NEST
ZROD P21 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* Pin F in square of sodium
PART 52 NEST
ZROD P23 0.0 0.0 0.0 0.513 29.18
BOX M39 -0.595 -0.595 0.0 1.19 1.19 29.18
* array of pins in sodium
PART 53 ARRAY
4 4 1 (51)*3 52 51 52 (51)*5 52 51 52 (51)*2
* mini-calandria in the element sheath (M12)

```

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```

PART 54 NEST
BOX P53 -2.38 -2.38 0.44 4.76 4.76 29.18
BOX M39 -2.45 -2.45 0.44 4.9 4.9 29.18
BOX M30 -2.45 -2.45 0.0 4.9 4.9 29.73
BOX M34 -2.5335 -2.5335 0.0 5.067 5.067 29.73
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 29.73
*
*****
* form the elements 3A to 3L
* Element 3A
PART 55 ARRAY
1 1 11 14 11 10 9 (26)*3 9 10 11 14
* Element 3B
PART 56 ARRAY
1 1 11 14 11 10 9 (30)*3 9 10 11 14
* Element 3C
PART 57 ARRAY
1 1 11 14 11 10 9 (42)*3 9 10 11 14
* Element 3D
PART 58 ARRAY
1 1 11 14 11 10 9 (46)*3 9 10 11 14
* Element 3E
PART 59 ARRAY
1 1 11 14 11 10 9 (50)*3 9 10 11 14
* Element 3H
PART 60 ARRAY
1 1 11 14 11 10 9 (34)*3 9 10 11 14
* Element 3J
PART 61 ARRAY
1 1 11 14 11 10 9 (54)*3 9 10 11 14
* Element 3L
PART 62 ARRAY
1 1 11 14 11 10 9 (38)*3 9 10 11 14
*
*****
* Steel reflector bars
PART 63 NEST
BOX M13 -2.54 -2.54 0.0 5.08 5.08 164.877528
BOX M0 -2.7127 -2.7127 0.0 5.4254 5.4254 164.877528
*
*****
* assemble the arrays of elements
*
* Groups of 5x5 elements surrounded by the superlattice gap
* With groups of 5x3 in rows 1 and 7 and 3x5 in rows 3 and 5
*****
* Row 1, the lowest set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 64 ARRAY
5 3 1 (63)*13 (16)*2
* Centre
PART 65 ARRAY
5 3 1 (63)* 10 (16)*5
* Right side
PART 66 ARRAY
5 3 1 (63)*10 (16)*2 (63)*3
* combine these arrays to form the row 1 array
PART 67 ARRAY
3 1 1 64 65 66
*
*****
* A 5x5 array of blanket elements
PART 68 ARRAY
5 5 1 (16)*25
*
*****
* Row 2. 5 arrays of 5x5 elements, two being PART 68
* Left hand array
PART 69 ARRAY
5 5 1 (63)*9 16 (63)*3 (16)*2 (63)*2 (16)*3 63 (16)*4
*
* Middle array
PART 70 ARRAY

```

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```

5  5  1  (16)*20  (15)*5
*
* Right hand array
PART 71 ARRAY
5  5  1  (63)*5 16 (63)*4 (16)*2 (63)*3 (16)*3 (63)*2 (16)*4 63
*
* Form row 2 array
PART 72 ARRAY
5  1  1  69 68 70 68 71
*
*****
* Row 3, 7 groups, the two end groups being 3x5 arrays
* Left hand array
PART 73 ARRAY
3  5  1  (63)*11 16 (63)*2 16
* Core lower left hand array
PART 74 ARRAY
5  5  1  (16)*3 (15)*2 16 (15)*2 (60)*2 16 15 55 58 60
15 (58)*2 57 59 15 (58)*2 57 59
*
* Core lower middle array
PART 75 ARRAY
5  5  1  (62)*5 (56)*10 (57)*10
*
* Core lower right hand array
PART 76 ARRAY
5  5  1  (15)*2 (16)*3 (60)*2 (15)*2 16 60 58 55 15 16
59 57 58 59 15 59 57 58 59 15
*
* right hand array
PART 77 ARRAY
3  5  1  (63)*9 16 (63)*2 16 (63)*2
* Form the row 3 array
PART 78 ARRAY
7  1  1  73 68 74 75 76 68 77
*
*****
* Row 4 (the middle row) 7 groups of 5x5 elements
* Left hand shield group
PART 79 ARRAY
5  5  1  (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16
*
* Left hand blanket group
PART 80 ARRAY
5  5  1  (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15
*
* Left hand core group
PART 81 ARRAY
5  5  1  55 61 58 (59)*2 55 (58)*2 (59)*2 56 (59)*4
55 58 55 (59)*2 55 61 55 (59)*2
*
* Centre core group
PART 82 ARRAY
5  5  1  (57)*25
*
* Right hand core group
PART 83 ARRAY
5  5  1  (59)*2 58 61 55 (59)*2 (58)*2 55 (59)*4 56
(59)*2 55 58 55 (59)*2 55 61 55
*
* Right hand blanket group
PART 84 ARRAY
5  5  1  15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4 15 (16)*4
*
* Right hand shield group
PART 85 ARRAY
5  5  1  16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4 16 (63)*4
*
* Form the row 4 array
PART 86 ARRAY
7  1  1  79 80 81 82 83 84 85
*
*****
* Row 5. 7 arrays, the first and last being 3x5 and the remainder 5x5

```

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```

* including the two blanket 5x5 groups.
*
* Left hand shield array
PART 87 ARRAY
3 5 1 (63)*2 16 (63)*2 16 (63)*9
* Core upper left hand array
PART 88 ARRAY
5 5 1 15 (58)*2 57 59 15 56 58 57 59 16 15 55 58 58
16 (15)*2 (60)*2 (16)*3 (15)*2
*
* Core upper middle array
PART 89 ARRAY
5 5 1 (57)*10 (56)*10 (62)*5
*
* Core upper right hand array
PART 90 ARRAY
5 5 1 59 57 58 58 15 59 57 58 56 15 58 58 55 15
16 (60)*2 (15)*2 16 (15)*2 (16)*3
*
* right hand shield array
PART 91 ARRAY
3 5 1 16 (63)*2 16 (63)*2 (63)*9
*
* Form the row 5 array
PART 92 ARRAY
7 1 1 87 68 88 89 90 68 91
*
*****
* Row 6 arrays 5 groups of 5x5, one being PART 68
*
* Left hand array
PART 93 ARRAY
5 5 1 63 (16)*4 (63)*2 (16)*3 (63)*3 (16)*2 (63)*4 16 (63)*5
*
* Middle array
PART 94 ARRAY
5 5 1 (15)*5 (16)*20
*
* Right middle array
PART 95 ARRAY
5 5 1 15 (16)*24
*
* Right hand array
PART 96 ARRAY
5 5 1 (16)*4 63 (16)*3 (63)*2 (16)*2 (63)*3 16 (63)*9
*
* Form row 6 array
PART 97 ARRAY
5 1 1 93 68 94 95 96
*
*****
* Row 7, the top set of groups of size 5x3 (5 along the x axis)
* 3 arrays
* Left side
PART 98 ARRAY
5 3 1 (63)*3 (16)*2 (63)*10
*
* Centre
PART 99 ARRAY
5 3 1 (16)*5 (63)*10
*
* Right side
PART 100 ARRAY
5 3 1 (16)*2 (63)*13
*
* combine these arrays to form the row 7 array
PART 101 ARRAY
3 1 1 98 99 100
*
*****
* Cluster of superlattice groups in a circle of shield material
PART 102 CLUSTER
BOX P101 -40.6905 67.8175 0.0 81.381 16.2762 164.877528
BOX P97 -67.8175 40.6905 0.0 135.635 27.127 164.877528

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BOX	P92	-84.0937	13.5635	0.0	168.1874	27.127	164.877528
BOX	P86	-94.9445	-13.5635	0.0	189.889	27.127	164.877528
BOX	P78	-84.0937	-40.6905	0.0	168.1874	27.127	164.877528
BOX	P72	-67.8175	-67.8175	0.0	135.635	27.127	164.877528
BOX	P67	-40.6905	-84.0937	0.0	81.381	16.2762	164.877528
ZROD	M14	0.0	0.0	-1.56	96.6	168.0	

*

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*** MONK8B Input Listing for Assembly 23 Model E**

* Uniform lattice with radial homogenisation with the mild steel sheath.
* combination of sheath and plate canning, sheath and calandria walls
* fuel pin canning and calandria tubes

COLUMNS 1 132

BEGIN MATERIAL SPECIFICATION

NUMBER DENSITY

MATERIAL 1

U238 6.8782E-07 PU238 3.0461E-05 PU239 2.8920E-02

PU240 6.9095E-03 PU241 7.3960E-04 PU242 1.8699E-04

AM241 4.5718E-04

H1 1.2764E-04 C 4.2260E-04 N 2.4215E-05 O16 8.8450E-05

AL 2.2973E-05 SI 1.4158E-05 CR 3.5989E-06 MN 1.4902E-06

FE 1.6335E-05 NI 8.5688E-06 GA 2.0166E-03

MATERIAL 2

H1 1.3760E-05 C 1.1393E-04 SI 3.6607E-04 P 1.3731E-05

CR 9.4011E-03 MN 8.5931E-04 FE 3.5542E-02 NI 4.1646E-03

CU 1.6613E-02

MATERIAL 3

H1 3.1773E-05 C 1.1808E-05 O16 4.6008E-02 AL 3.3911E-06

SI 2.2967E-05 MN 8.3273E-08 FE 1.3107E-06 NI 1.2472E-06

MO 3.3379E-07 U235 1.6544E-04 U238 2.2837E-02

MATERIAL 4

H1 1.9035E-05 C 1.2831E-04 SI 6.4475E-04 P 3.5078E-04

S 3.6041E-05 CR 1.3819E-02 MN 8.5559E-04 FE 4.8306E-02

NI 8.4258E-03

MATERIAL 5

H1 1.3900E-05 O16 5.6492E-06 NA 2.3225E-02 CA 3.6083E-06

FE 1.6184E-07

MATERIAL 6

H1 2.1631E-05 C 2.9290E-04 SI 6.0867E-04 P 3.2795E-05

S 3.3219E-05 CR 1.4759E-02 MN 1.3570E-03 FE 5.5054E-02

NI 7.0982E-03 NB 3.1147E-04

MATERIAL 7

H1 2.1952E-05 C 9.1064E-05 AL 8.9052E-05 SI 5.8340E-04

P 2.9292E-05 S 1.0556E-05 TI 1.8157E-04 CR 1.1644E-02

MN 1.1248E-03 FE 4.9247E-02 NI 6.4410E-03 CU 3.9365E-05

NB 3.6597E-06 MO 5.9280E-05

MATERIAL 8

H1 4.2481E-05 C 4.4265E-04 AL 1.0616E-06 SI 1.8383E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2493E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9106E-04 U238 4.0142E-02

MATERIAL 9

H1 4.2351E-05 C 4.1442E-04 AL 1.0616E-06 SI 1.7176E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2433E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9623E-04 U238 4.0808E-02

MATERIAL 10

H1 4.2939E-05 C 4.2396E-04 AL 1.0616E-06 SI 1.7584E-04

CR 1.9673E-07 MN 1.3779E-05 FE 4.2453E-03 NI 7.6688E-07

CU 1.1912E-06

U235 2.9839E-04 U238 4.1132E-02

MATERIAL 11

H1 2.6476E-05 C 4.5820E-04 AL 1.2308E-04 TI 3.4380E-05

CR 2.3941E-05 MN 2.9843E-04 FE 7.7256E-02 NI 4.2839E-05

CU 4.0048E-05 MO 8.5790E-06

MATERIAL 12

H1 2.2655E-05 C 1.0705E-04 AL 4.1025E-06 SI 1.8534E-04

P 6.9518E-06 CR 4.7604E-03 MN 4.8831E-04 FE 3.4059E-02

NI 2.1114E-03 CU 8.4155E-03

MATERIAL 13

H1 2.7234E-05 C 1.1009E-04 AL 5.3465E-06 SI 2.2990E-04

P 1.2508E-04 S 1.2851E-05 CR 4.9286E-03 MN 3.7448E-04

FE 3.8160E-02 NI 3.0083E-03 CU 5.9995E-06

MATERIAL 14

H1 4.0597E-05 C 6.0468E-04 SI 2.7317E-04 P 3.7649E-05

S 3.2535E-05 MN 6.2488E-04 FE 7.1392E-02

* Fuel pin cans homogenised with the calandria tubes

MATERIAL 22

H1 1.0832E-05 C 5.3887E-05 SI 6.6291E-04 P 1.5357E-05

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S 9.9700E-06 CR 1.2375E-02 MN 1.0382E-03 FE 4.2250E-02
NI 5.8244E-03
MATERIAL 23
H1 9.2847E-06 C 9.6091E-05 SI 7.8508E-04 P 1.6869E-05
S 9.2404E-06 CR 1.1062E-02 MN 1.0424E-03 FE 3.9613E-02
NI 5.7832E-03 NB 1.1919E-04
MATERIAL 24
H1 1.0832E-05 C 5.5189E-05 SI 6.5458E-04 P 1.4602E-05
S 9.9700E-06 CR 1.2228E-02 MN 1.0254E-03 FE 4.1778E-02
NI 5.7580E-03
MATERIAL 25
H1 1.0058E-05 C 8.1804E-05 AL 2.6012E-06 SI 6.7957E-04
P 1.3847E-05 S 3.6474E-06 TI 1.1726E-05 CR 1.1439E-02
MN 8.7351E-04 FE 4.0660E-02 CO 1.7202E-06 NI 5.3049E-03
CU 2.4544E-06 MO 8.9408E-07
MATERIAL 26
H1 1.0058E-05 C 2.9866E-05 AL 2.6012E-06 SI 7.4068E-04
P 5.5388E-06 S 7.0518E-06 TI 1.1726E-05 CR 1.1517E-02
MN 8.0111E-04 FE 4.1082E-02 CO 1.7202E-06 NI 5.4737E-03
CU 2.4544E-06 MO 8.6970E-06
MATERIAL 27
H1 1.0058E-05 C 2.9217E-05 AL 1.7341E-06 SI 7.4343E-04
P 5.5388E-06 S 7.2951E-06 TI 8.7948E-06 CR 1.1591E-02
MN 8.0253E-04 FE 4.1309E-02 CO 1.3232E-06 NI 5.5122E-03
CU 1.8407E-06 MO 8.6159E-06
MATERIAL 28
H1 1.0832E-05 C 5.3887E-05 SI 6.6291E-04 P 1.5357E-05
S 9.9700E-06 CR 1.2390E-02 MN 1.0396E-03 FE 4.2298E-02
NI 5.8324E-03
*
*****
* Composition of calandria tubes
MATERIAL 29
SI 1.0632E-03 CR 1.6787E-02 MN 1.3588E-03 FE 6.0762E-02
NI 7.4360E-03
* Composition of Calandria end plate regions
MATERIAL 30
SI 5.5206E-04 CR 1.0016E-02 MN 7.7198E-04 FE 3.5578E-02
NI 4.4601E-03
* Compositions of Calandria outer walls homogenised with the sheath
MATERIAL 31
H1 3.4252E-05 C 1.5574E-04 AL 5.7600E-06 SI 1.8479E-04
P 2.2542E-05 S 1.1293E-05 CR 4.6018E-03 MN 4.4951E-04
FE 3.7562E-02 NI 2.2268E-03 CU 6.4634E-06
MATERIAL 32
H1 3.3882E-05 C 2.6983E-04 AL 5.7600E-06 SI 2.9953E-04
P 1.4586E-05 S 1.0129E-05 TI 7.4864E-05 CR 4.4131E-03
MN 4.1410E-04 FE 3.7011E-02 CO 3.4213E-06 NI 2.2908E-03
CU 9.6362E-06 MO 1.0508E-06
MATERIAL 33
H1 3.4252E-05 C 1.1825E-04 AL 5.7600E-06 SI 2.3771E-04
P 1.6057E-05 S 7.5327E-06 CR 4.3370E-03 MN 3.2969E-04
FE 3.8130E-02 NI 2.3562E-03 CU 6.4634E-06 MO 7.6282E-06
MATERIAL 34
H1 3.3511E-05 C 1.7719E-04 AL 5.7600E-06 SI 2.5220E-04
P 1.9107E-05 S 5.0414E-06 CR 4.1625E-03 MN 3.8238E-04
FE 3.7022E-02 NI 1.9847E-03 CU 6.4634E-06 MO 2.7243E-06
MATERIAL 35
H1 3.3882E-05 C 1.5014E-04 AL 5.7600E-06 SI 1.9756E-04
P 2.1036E-05 S 5.2742E-06 CR 4.2444E-03 MN 3.7217E-04
FE 3.7713E-02 NI 2.2296E-03 CU 6.4634E-06 MO 2.7243E-06

*
BEGIN MATERIAL GEOMETRY
*
* Plate 1, the Pu metal plate
PART 1 NEST
BOX M1 -2.3355 -2.3355 0.0457 4.671 4.671 0.236
BOX M2 -2.3355 -2.3355 0.0 4.671 4.671 0.3274
BOX M12 -2.7127 -2.7127 0.0 5.4254 5.4254 0.3274
*
* Plate 2, the UO2 plate
PART 2 NEST
BOX M3 -2.4285 -2.4285 0.03665 4.857 4.857 0.558

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BOX      M4  -2.4285  -2.4285  0.0      4.857  4.857  0.6313
BOX      M13 -2.7127  -2.7127  0.0      5.4254 5.4254 0.6313
*
* Plate 3, the sodium plate
PART 3 NEST
BOX      M5  -2.4815  -2.4815  0.036347 4.963 4.963 0.541
BOX      M6  -2.4815  -2.4815  0.0      4.963 4.963 0.613694
BOX      M41 -2.7127  -2.7127  0.0      5.4254 5.4254 0.613694
*
* Plate 4, the 40% steel plate
PART 4 NEST
BOX      M0  -1.9625  -1.9625  0.0      3.925 3.925 0.317
BOX      M7  -2.7127  -2.7127  0.0      5.4254 5.4254 0.317
*
* Core Cell 1
PART 5 ARRAY
1 1 7 3 2 4 1 3 2 3
* Core Cell 2, the reflection of cell 1
PART 6 ARRAY
1 1 7 3 2 3 1 4 2 3
*
* Core Cell 3 This is Cell 1 minus Plate 4
PART 7 ARRAY
1 1 6 3 2 1 3 2 3
*Core Cell 4 the reflection of cell 3, Cell 2 minus Plate 4
PART 8 ARRAY
1 1 6 3 2 3 1 2 3
*
*****
* Axial blanket U8 section
PART 9 NEST
BOX      M8      -2.7127  -2.7127  0.0 5.4254 5.4254 9.827
*
* Axial blanket U2 section
PART 10 NEST
BOX      M9      -2.7127  -2.7127  0.0 5.4254 5.4254 12.723
*
* Axial blanket U3 section
PART 11 NEST
BOX      M10     -2.7127  -2.7127  0.0 5.4254 5.4254 7.6225
*
* Axial reflector MST3 section
PART 12 NEST
BOX      M11     -2.7127  -2.7127  0.0 5.4254 5.4254 7.60628
*
*****
* Radial blanket U3 section (over half core height)
PART 13 NEST
BOX      M10     -2.7127  -2.7127  0.0 5.4254 5.4254 74.83248
*
*****
* A whole height model.
* The axial height of the pin cell core is slightly less than
* that of the plate cell core, 89.19 cm compared with 89.32 cm.
* (0.13 cm = 2 * 0.065 cm)
* The axial shielding material is extended in the model nce.
* to cover this dista
* Axial steel reflector section extended 0.065 cm in length
PART 14 NEST
BOX      M11     -2.7127  -2.7127  0.0 5.4254 5.4254 7.67128
*
*****
* The Core Element (full height)
PART 15 ARRAY
1 1 32 12 11 10 9 8 (5 6)*11 7 9 10 11 12
*
*The Radial Blanket element
PART 16 ARRAY
1 1 4 12 13 13 12
*
*****
* Specification of the pin cells, A to F and U/C
* Pin cell A
PART 17 NEST

```

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ZROD	M15	0.0	0.0	0.0	0.423	29.18
ZROD	M22	0.0	0.0	0.0	0.513	29.18

*

* Pin cell B

PART 18 NEST

ZROD	M16	0.0	0.0	0.0	0.423	29.18
ZROD	M23	0.0	0.0	0.0	0.513	29.18

*

* Pin cell C

PART 19 NEST

ZROD	M17	0.0	0.0	0.0	0.423	29.18
ZROD	M24	0.0	0.0	0.0	0.513	29.18

*

* Pin cell D

PART 20 NEST

ZROD	M18	0.0	0.0	0.0	0.423	29.18
ZROD	M25	0.0	0.0	0.0	0.513	29.18

*

* Pin cell E

PART 21 NEST

ZROD	M19	0.0	0.0	0.0	0.423	29.18
ZROD	M26	0.0	0.0	0.0	0.513	29.18

*

* Pin cell F

PART 22 NEST

ZROD	M20	0.0	0.0	0.0	0.423	29.18
ZROD	M27	0.0	0.0	0.0	0.513	29.18

*

* Pin cell U/C

PART 23 NEST

ZROD	M21	0.0	0.0	0.0	0.423	29.18
ZROD	M28	0.0	0.0	0.0	0.513	29.18

*

* Mini-calandria

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

A.2 Input data for the KENO5a+CONSYST+ABBN-93 System Calculations
made by Anatoly Tsiboulia and Mikhail Semenov.

```
=cons9901
TASK:
  MULTIC= 1
  NOUT  = 2
  IHT   = 4
  IHS   = 77
  NG    = 299
  IPRIB = 0
  idelta= 1
  NMOM  = 5
  IZT   = 16
  NRZT  = 13
  INZ   = 28
NAME=
'PU38' 'PU39' 'PU40' 'PU41' 'PU42' 'AM41' 'GA'
'U235' 'U238NR'
'NA'
'H+H(FREE)' 'C' 'N' 'O' 'AL' 'SI' 'CR' 'MN' 'FE' 'NI' 'MO'
'NB' 'TI' 'CU' 'P' 'S' 'CA' 'D-SC'
RO=
*1 PU
3.0461E-05 2.8920E-02 6.9095E-03 7.3960E-04 1.8699E-04 4.5718E-04 2.0166E-03
0.0000E+00 6.8782E-07 0.0000E+00 1.2764E-04 4.2260E-04 2.4215E-05 8.8450E-05
2.2973E-05 1.4158E-05 3.5989E-06 1.4902E-06 1.6335E-05 8.5688E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*2 CAN
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.3760E-05 1.1393E-04 0.0000E+00 0.0000E+00
0.0000E+00 3.6607E-04 9.4011E-03 8.5931E-04 3.5542E-02 4.1646E-03 0.0000E+00
0.0000E+00 0.0000E+00 1.6613E-02 1.3731E-05 0.0000E+00 0.0000E+00 0.0000E+00
*3 UO2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.6585E-04 2.2894E-02 0.0000E+00 3.1852E-05 1.1837E-05 0.0000E+00 4.6122E-02
3.3995E-06 2.3024E-05 0.0000E+00 8.3479E-08 1.3139E-06 1.2503E-06 3.3462E-07
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*4 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.8834E-05 1.2695E-04 0.0000E+00 0.0000E+00
0.0000E+00 6.3794E-04 1.3673E-02 8.4655E-04 4.7796E-02 8.3368E-03 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 3.4708E-04 3.5660E-05 0.0000E+00 0.0000E+00
*5 na
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 2.3225E-02 1.3900E-05 0.0000E+00 0.0000E+00 5.6492E-06
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.6184E-07 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.6083E-06 0.0000E+00
*6 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.1631E-05 2.9290E-04 0.0000E+00 0.0000E+00
0.0000E+00 6.0867E-04 1.4759E-02 1.3570E-03 5.5054E-02 7.0982E-03 0.0000E+00
3.1147E-04 0.0000E+00 0.0000E+00 3.2795E-05 3.3219E-05 0.0000E+00 0.0000E+00
*7 ss
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.8355E-05 8.7794E-05 0.0000E+00 0.0000E+00
1.1862E-04 7.9703E-04 1.5908E-02 1.4972E-03 5.5367E-02 8.7976E-03 8.0988E-05
5.0000E-06 2.4806E-04 5.0365E-05 4.0018E-05 1.4422E-05 0.0000E+00 0.0000E+00
*8 sheath
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 7.5712E-05 2.3825E-04 0.0000E+00 0.0000E+00
1.9798E-05 0.0000E+00 3.6690E-06 2.5697E-04 7.7524E-02 1.4302E-05 0.0000E+00
0.0000E+00 0.0000E+00 2.2216E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*9 U8
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.3369E-04 4.6021E-02 0.0000E+00 4.4048E-05 4.9283E-04 0.0000E+00 0.0000E+00
0.0000E+00 2.1076E-04 0.0000E+00 0.0000E+00 1.0599E-04 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*10 U2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.3962E-04 4.6785E-02 0.0000E+00 4.3899E-05 4.6047E-04 0.0000E+00 0.0000E+00
0.0000E+00 1.9692E-04 0.0000E+00 0.0000E+00 9.9032E-05 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

*11 U3
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.4209E-04 4.7156E-02 0.0000E+00 4.4574E-05 4.7140E-04 0.0000E+00 0.0000E+00
0.0000E+00 2.0160E-04 0.0000E+00 0.0000E+00 1.0138E-04 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*12 mst3
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.5700E-05 5.1066E-04 0.0000E+00 0.0000E+00
1.3989E-04 0.0000E+00 2.7222E-05 3.2634E-04 8.3806E-02 4.8234E-05 9.8355E-06
0.0000E+00 3.9416E-05 4.4548E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*13 mst9f10
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.6306E-05 6.8972E-04 0.0000E+00 0.0000E+00
0.0000E+00 3.1158E-04 0.0000E+00 7.1275E-04 8.1432E-02 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.2944E-05 3.7110E-05 0.0000E+00 0.0000E+00

*14 HOMO
1.4500E-06 1.3767E-03 3.2891E-04 3.5207E-05 8.9013E-06 2.1763E-05 9.5996E-05
4.0267E-05 5.5585E-03 8.5835E-03 2.6584E-05 6.9062E-05 1.1527E-06 1.1204E-02
6.5715E-06 1.1860E-04 2.5351E-03 2.2472E-04 1.3408E-02 1.3445E-03 2.5185E-06
2.1148E-05 7.4651E-06 5.0291E-04 2.3577E-05 4.7025E-06 1.3336E-06 0.0000E+00

***** D-SC
*15 PU
3.0461E-05 2.8920E-02 6.9095E-03 7.3960E-04 1.8699E-04 4.5718E-04 2.0166E-03
0.0000E+00 6.8782E-07 0.0000E+00 1.2764E-04 4.2260E-04 2.4215E-05 8.8450E-05
2.2973E-05 1.4158E-05 3.5989E-06 1.4902E-06 1.6335E-05 8.5688E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.3327E+00
*16 UO2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.6585E-04 2.2894E-02 0.0000E+00 3.1852E-05 1.1837E-05 0.0000E+00 4.6122E-02
3.3995E-06 2.3024E-05 0.0000E+00 8.3479E-08 1.3139E-06 1.2503E-06 3.3462E-07
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.1022E+00

ICOR =
15 14 16 14 14 14 14
9 10 11 12 13
14 15 16
NAMSUB='U238NR' 'PU39'
NGSUB=10 11 12 13 14 15 16 17 18 19 20 21 22 23
END
end
=subgran
end
=lava
-1$$ 2500000
0$$ 71 72 18 19
1$$ 13 755 4 91 845 61 0 -1 1 t
2$$ 11I1000 13000
3$$ F5
4$$ 11I100 1300
5$$ 1 1452 27 1018
7**
2.00000E+07 1.86181E+07 1.73316E+07 1.61341E+07 1.50192E+07
1.39818E+07 1.30158E+07 1.21165E+07 1.12793E+07 1.05000E+07
9.69341E+06 8.94878E+06 8.26136E+06 7.62674E+06 7.04086E+06
6.50000E+06 5.99475E+06 5.52877E+06 5.09902E+06 4.70267E+06
4.33713E+06 4.00000E+06 3.69862E+06 3.41995E+06 3.16228E+06
2.92402E+06 2.70371E+06 2.50000E+06 2.32522E+06 2.16265E+06
2.01146E+06 1.87083E+06 1.74003E+06 1.61838E+06 1.50524E+06
1.40000E+06 1.30541E+06 1.21722E+06 1.13498E+06 1.05830E+06
9.86800E+05 9.20131E+05 8.57965E+05 8.00000E+05 7.40700E+05
6.85795E+05 6.34960E+05 5.87894E+05 5.44316E+05 5.03968E+05
4.66612E+05 4.32024E+05 4.00000E+05 3.70350E+05 3.42898E+05
3.17480E+05 2.93947E+05 2.72158E+05 2.51984E+05 2.33306E+05
2.16012E+05 2.00000E+05 1.91435E+05 1.85175E+05 1.77154E+05
1.71449E+05 1.63937E+05 1.58740E+05 1.51708E+05 1.46973E+05
1.40390E+05 1.36079E+05 1.29916E+05 1.25992E+05 1.20222E+05
1.16653E+05 1.11251E+05 1.08006E+05 1.02951E+05 1.00000E+05
9.60586E+04 9.38042E+04 9.00741E+04 8.79923E+04 8.44625E+04
8.25404E+04 7.92005E+04 7.74264E+04 7.42663E+04 7.26292E+04
6.96395E+04 6.81292E+04 6.53014E+04 6.39081E+04 6.12343E+04
5.99484E+04 5.74205E+04 5.62341E+04 5.38442E+04 5.27500E+04
5.04907E+04 4.94817E+04 4.73460E+04 4.64159E+04 4.52365E+04

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

4.43972E+04	4.38990E+04	4.35400E+04	4.24188E+04	4.16320E+04
4.11705E+04	4.08424E+04	3.97762E+04	3.90389E+04	3.86114E+04
3.83119E+04	3.72981E+04	3.66074E+04	3.62115E+04	3.59381E+04
3.49744E+04	3.43274E+04	3.39609E+04	3.37115E+04	3.27956E+04
3.21894E+04	3.18504E+04	3.16227E+04	3.07523E+04	3.01846E+04
2.98710E+04	2.96635E+04	2.88362E+04	2.83046E+04	2.80147E+04
2.78256E+04	2.70395E+04	2.65418E+04	2.62738E+04	2.61015E+04
2.53546E+04	2.48887E+04	2.46412E+04	2.44843E+04	2.37747E+04
2.33386E+04	2.31100E+04	2.29673E+04	2.22931E+04	2.18850E+04
2.16741E+04	2.15443E+04	2.09038E+04	2.05218E+04	2.03274E+04
2.02095E+04	1.96011E+04	1.92437E+04	1.90644E+04	1.89573E+04
1.83795E+04	1.80451E+04	1.78800E+04	1.77828E+04	1.72340E+04
1.69213E+04	1.67692E+04	1.66810E+04	1.61599E+04	1.58674E+04
1.57274E+04	1.56475E+04	1.51527E+04	1.48791E+04	1.47504E+04
1.46780E+04	1.42082E+04	1.39524E+04	1.38342E+04	1.37686E+04
1.33225E+04	1.30834E+04	1.29748E+04	1.29155E+04	1.24919E+04
1.22685E+04	1.21100E+04	1.21153E+04	1.17131E+04	1.15044E+04
1.14130E+04	1.13646E+04	1.09828E+04	1.07879E+04	1.07041E+04
1.06605E+04	1.02980E+04	1.01159E+04	1.00393E+04	1.00000E+04
9.65597E+03	9.48588E+03	9.41580E+03	9.38042E+03	9.05389E+03
8.89508E+03	8.83104E+03	8.79923E+03	8.48930E+03	8.34103E+03
8.28260E+03	8.25404E+03	7.95994E+03	7.82153E+03	7.76826E+03
7.74264E+03	7.46356E+03	7.33439E+03	7.28588E+03	7.26292E+03
6.99809E+03	6.87754E+03	6.83345E+03	6.81292E+03	6.56175E+03
6.44928E+03	6.40918E+03	6.39081E+03	6.15266E+03	6.04776E+03
6.01129E+03	5.99484E+03	5.76907E+03	5.67124E+03	5.63811E+03
5.62341E+03	5.40937E+03	5.31816E+03	5.28811E+03	5.27500E+03
5.07209E+03	4.98706E+03	4.95985E+03	4.94817E+03	4.75585E+03
4.67660E+03	4.65199E+03	4.64159E+03	4.45930E+03	4.38545E+03
4.36323E+03	4.35400E+03	4.18123E+03	4.11242E+03	4.09241E+03
4.08424E+03	3.92049E+03	3.85639E+03	3.83841E+03	3.83119E+03
3.67600E+03	3.61629E+03	3.60018E+03	3.59381E+03	3.44677E+03
3.39115E+03	3.37674E+03	3.37114E+03	3.23181E+03	3.18002E+03
3.16718E+03	3.16227E+03	3.03025E+03	2.98204E+03	2.97063E+03
2.96635E+03	2.84126E+03	2.79638E+03	2.78628E+03	2.78256E+03
2.66404E+03	2.62228E+03	2.61338E+03	2.61015E+03	2.49787E+03
2.45903E+03	2.45121E+03	2.44843E+03	2.34207E+03	2.30593E+03
2.29911E+03	2.29673E+03	2.19597E+03	2.16237E+03	2.15646E+03
2.15443E+03	2.08156E+03	2.05753E+03	2.03423E+03	2.02643E+03
2.02233E+03	2.02095E+03	1.94867E+03	1.92530E+03	1.91246E+03
1.90823E+03	1.90091E+03	1.89850E+03	1.89642E+03	1.89573E+03
1.82083E+03	1.79713E+03	1.78450E+03	1.78042E+03	1.77880E+03
1.77828E+03	1.71599E+03	1.69659E+03	1.68085E+03	1.67586E+03
1.67210E+03	1.67091E+03	1.66878E+03	1.66810E+03	1.62473E+03
1.61140E+03	1.58045E+03	1.57089E+03	1.56621E+03	1.56475E+03
1.50398E+03	1.48581E+03	1.47431E+03	1.47080E+03	1.46850E+03
1.46780E+03	1.41805E+03	1.40341E+03	1.38536E+03	1.37998E+03
1.37758E+03	1.37686E+03	1.31491E+03	1.29719E+03	1.29283E+03
1.29155E+03	1.24774E+03	1.23536E+03	1.21853E+03	1.21371E+03
1.21202E+03	1.21153E+03	1.17775E+03	1.16836E+03	1.14755E+03
1.14173E+03	1.13762E+03	1.13646E+03	1.10141E+03	1.09189E+03
1.07319E+03	1.06806E+03	1.06649E+03	1.06605E+03	1.02376E+03
1.01259E+03	1.00357E+03	1.00114E+03	1.00024E+03	1.00000E+03
9.66236E+02	9.57470E+02	9.49570E+02	9.47485E+02	9.42407E+02
9.41065E+02	9.38675E+02	9.38042E+02	8.99406E+02	8.89639E+02
8.83723E+02	8.82194E+02	8.80390E+02	8.79923E+02	8.46636E+02
8.38387E+02	8.30030E+02	8.27921E+02	8.25913E+02	8.25404E+02
7.89300E+02	7.80584E+02	7.76423E+02	7.75394E+02	7.74492E+02
7.74269E+02	7.37010E+02	7.28241E+02	7.26676E+02	7.26296E+02
6.95229E+02	6.88058E+02	6.84227E+02	6.83321E+02	6.81684E+02
6.81296E+02	6.51912E+02	6.45279E+02	6.41161E+02	6.40210E+02
6.39296E+02	6.39085E+02	6.11590E+02	6.05519E+02	6.01580E+02
6.00689E+02	5.99710E+02	5.99488E+02	5.75586E+02	5.70412E+02
5.65542E+02	5.64467E+02	5.62730E+02	5.62345E+02	5.36729E+02
5.31326E+02	5.29011E+02	5.28509E+02	5.27682E+02	5.27503E+02
5.03701E+02	4.98792E+02	4.96329E+02	4.95808E+02	4.94993E+02
4.94820E+02	4.70155E+02	4.65202E+02	4.64340E+02	4.64162E+02
4.40985E+02	4.36438E+02	4.35577E+02	4.35403E+02	4.17034E+02
4.13497E+02	4.10542E+02	4.09960E+02	4.08679E+02	4.08426E+02
3.89954E+02	3.86488E+02	3.84318E+02	3.83901E+02	3.83247E+02
3.83121E+02	3.63761E+02	3.60231E+02	3.59518E+02	3.59384E+02
3.46541E+02	3.44235E+02	3.40010E+02	3.39241E+02	3.38106E+02
3.37898E+02	3.37238E+02	3.37117E+02	3.19313E+02	3.16230E+02
3.07376E+02	3.02104E+02	2.97359E+02	2.97025E+02	2.96822E+02

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

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2.96637E+02 2.82831E+02 2.80486E+02 2.79215E+02 2.78994E+02
2.78367E+02 2.78258E+02 2.70318E+02 2.65502E+02 2.63863E+02
2.62708E+02 2.61994E+02 2.61748E+02 2.61349E+02 2.61102E+02
2.61017E+02 2.47008E+02 2.44845E+02 2.37617E+02 2.34994E+02
2.32422E+02 2.31245E+02 2.30811E+02 2.30381E+02 2.29975E+02
2.29824E+02 2.29675E+02 2.19156E+02 2.15445E+02 2.10258E+02
2.09166E+02 2.04427E+02 2.03428E+02 2.02821E+02 2.02692E+02
2.02201E+02 2.02096E+02 1.97202E+02 1.93488E+02 1.91406E+02
1.90813E+02 1.90355E+02 1.90094E+02 1.89860E+02 1.89678E+02
1.89575E+02 1.82295E+02 1.79185E+02 1.78715E+02 1.78509E+02
1.78209E+02 1.78077E+02 1.77905E+02 1.77829E+02 1.71468E+02
1.68053E+02 1.66811E+02 1.58152E+02 1.57088E+02 1.56545E+02
1.56476E+02 1.48817E+02 1.46781E+02 1.39817E+02 1.38221E+02
1.37789E+02 1.37687E+02 1.33160E+02 1.29901E+02 1.29156E+02
1.24352E+02 1.22028E+02 1.21154E+02 1.19058E+02 1.17703E+02
1.17309E+02 1.16008E+02 1.15163E+02 1.14916E+02 1.14504E+02
1.14234E+02 1.14155E+02 1.13880E+02 1.13700E+02 1.13647E+02
1.08936E+02 1.07009E+02 1.06606E+02 1.04367E+02 1.02788E+02
1.02221E+02 1.01371E+02 1.00765E+02 1.00546E+02 1.00270E+02
1.00072E+02 1.00001E+02 9.49147E+01 9.38048E+01 9.00591E+01
8.84578E+01 8.79928E+01 8.53864E+01 8.29607E+01 8.25409E+01
8.00020E+01 7.87116E+01 7.81267E+01 7.78241E+01 7.75626E+01
7.74269E+01 7.48414E+01 7.31916E+01 7.26296E+01 6.81296E+01
6.64990E+01 6.57970E+01 6.55235E+01 6.47774E+01 6.44532E+01
6.43264E+01 6.40667E+01 6.39533E+01 6.39089E+01 6.16780E+01
5.99492E+01 5.77630E+01 5.69789E+01 5.62349E+01 5.43365E+01
5.31530E+01 5.27507E+01 5.12878E+01 5.00051E+01 4.94823E+01
4.71930E+01 4.64165E+01 4.39677E+01 4.35406E+01 4.15092E+01
4.08429E+01 3.86248E+01 3.83124E+01 3.71495E+01 3.62881E+01
3.59386E+01 3.40190E+01 3.37119E+01 3.20656E+01 3.16232E+01
2.96639E+01 2.78259E+01 2.70538E+01 2.63962E+01 2.61019E+01
2.44847E+01 2.33182E+01 2.29676E+01 2.24015E+01 2.18633E+01
2.15446E+01 2.10496E+01 2.09018E+01 2.05679E+01 2.04677E+01
2.02695E+01 2.02098E+01 1.89576E+01 1.81519E+01 1.78913E+01
1.77830E+01 1.69505E+01 1.66812E+01 1.60901E+01 1.56477E+01
1.48289E+01 1.46782E+01 1.37687E+01 1.29157E+01 1.22858E+01
1.21154E+01 1.17726E+01 1.15521E+01 1.13648E+01 1.09868E+01
1.06606E+01 1.02388E+01 1.00001E+01 9.62837E+00 9.38054E+00
8.79934E+00 8.46274E+00 8.25415E+00 8.07648E+00 7.90335E+00
7.74274E+00 7.49870E+00 7.33772E+00 7.26301E+00 6.81301E+00
6.64826E+00 6.50284E+00 6.39089E+00 5.99492E+00 5.62349E+00
5.27506E+00 4.94823E+00 4.64165E+00 4.35406E+00 4.08429E+00
3.83124E+00 3.59386E+00 3.37119E+00 3.16232E+00 2.96639E+00
2.78259E+00 2.61019E+00 2.44847E+00 2.29676E+00 2.15446E+00
2.02098E+00 1.89576E+00 1.77830E+00 1.66812E+00 1.56477E+00
1.46782E+00 1.37687E+00 1.29157E+00 1.21154E+00 1.13648E+00
1.06606E+00 1.00001E+00 9.38054E-01 8.79934E-01 8.25415E-01
7.74274E-01 7.26301E-01 6.81301E-01 6.39089E-01 5.99492E-01
5.62348E-01 5.27506E-01 4.94823E-01 4.64165E-01 4.35406E-01
4.08429E-01 3.83124E-01 3.59386E-01 3.37119E-01 3.16232E-01
2.96639E-01 2.78259E-01 2.61019E-01 2.44847E-01 2.29676E-01
2.15446E-01 1.89576E-01 1.66812E-01 1.46782E-01 1.29157E-01
1.13647E-01 1.00001E-01 8.25415E-02 6.81301E-02 5.62348E-02
4.64165E-02 3.83124E-02 3.16232E-02 2.61019E-02 2.15446E-02
1.77830E-02 1.46782E-02 1.21155E-02 1.00001E-02 6.81301E-03
4.64164E-03 3.16231E-03 2.15446E-03 1.00001E-03 1.00001E-04
1.00001E-05
9$$$ F0 t
end
#sc_bin
72
75
end
#kenova
zebra 22-b
read param
tme=1000
lib=75
lng=25000000
nb8=70000
gen=2020
npg=10000
nsk=20
run=yes

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

plt=no
end param
read mixt
sct=3
eps=1.
mix=1 100 1.
mix=2 200 1.
mix=3 300 1.
mix=4 400 1.
mix=5 500 1.
mix=6 600 1.
mix=7 700 1.
mix=8 800 1.
mix=9 900 1.
mix=10 1000 1.
mix=11 1100 1.
mix=12 1200 1.
mix=13 1300 1.
end mixt
read geometry
unit 1
com='core'
array 111 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 111
com='pu'
cuboid 1 1 4p2.3355 0.28170 0.0457
cuboid 2 1 4p2.5335 0.32740 0
unit 112
com='uo2'
cuboid 3 1 4p2.4255 0.59465 0.03665
cuboid 4 1 4p2.5335 0.63130 0
unit 113
com='na'
cuboid 5 1 4p2.4815 0.577347 0.036347
cuboid 6 1 4p2.5335 0.613694 0
unit 114
com='ss'
cuboid 0 1 4p1.9625 0.31700 0
cuboid 7 1 4p2.5335 0.31700 0
unit 211
com='u8'
cuboid 9 1 4p2.5335 9.82700 0
unit 212
com='u2'
cuboid 10 1 4p2.5335 12.72300 0
unit 213
com='u3'
cuboid 11 1 4p2.5335 7.62250 0
unit 311
com='mst3'
cuboid 12 1 4p2.5335 7.60628 0
unit 511
com='air'
cuboid 0 1 4p2.5335 1.392516 0
unit 2
com='u3-radial'
cuboid 12 1 4p2.5335 7.60628 0
cuboid 11 1 4p2.5335 160.05628 0
cuboid 12 1 4p2.5335 167.66256 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 3
com='mst9f10'
cuboid 13 1 4p2.54000 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 4
com='empty tube'
cuboid 0 1 4p2.55100 167.66256 0
cuboid 8 1 4p2.62720 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

unit 11
com='2'
array 11 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 12
com='2'
array 12 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 13
com='2'
array 13 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 14
com='2'
array 14 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 15
com='2'
array 15 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 16
com='2'
array 16 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 17
com='2'
array 17 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 21
com='2'
array 21 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 22
com='2'
array 22 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 23
com='2'
array 23 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 24
com='2'
array 24 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 25
com='2'
array 25 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 26
com='2'
array 26 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 27
com='2'
array 27 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 31
com='2'
array 31 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 32
com='2'
array 32 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 33
com='2'
array 33 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 34
com='2'
array 34 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 35
com='2'

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

array 35 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 36
com='2'
array 36 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 37
com='2'
array 37 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 41
com='2'
array 41 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 42
com='2'
array 42 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 43
com='2'
array 43 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 44
com='2'
array 44 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 45
com='2'
array 45 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 46
com='2'
array 46 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 47
com='2'
array 47 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 51
com='2'
array 51 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 52
com='2'
array 52 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 53
com='2'
array 53 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 54
com='2'
array 54 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 55
com='2'
array 55 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 56
com='2'
array 56 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 57
com='2'
array 57 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 61
com='2'
array 61 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 62
com='2'
array 62 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

unit 63
com='2'
array 63 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 64
com='2'
array 64 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 65
com='2'
array 65 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 66
com='2'
array 66 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 67
com='2'
array 67 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 71
com='2'
array 71 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 72
com='2'
array 72 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 73
com='2'
array 73 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 74
com='2'
array 74 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 75
com='2'
array 75 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 76
com='2'
array 76 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 77
com='2'
array 77 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
global unit 100
com='reactor'
array 100 3*0
end geometry
read array
ara=111 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
113 112 113 111 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 111 113 112 113
211 212 213 311 511
end fill
ara=11 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=12 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 3 3
4 4 3 3 3
end fill
ara=13 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 3 3
3 3 3 3 3
3 3 3 3 3
3 3 3 2 2
end fill
ara=14 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
2 2 2 2 2
end fill
ara=15 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 4 4 4
3 3 3 3 3
3 3 3 3 3
2 2 3 3 3
end fill
ara=16 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
3 3 4 4 4
3 3 3 4 4
end fill
ara=17 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=21 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 3
4 4 4 3 3
4 4 4 3 3
end fill
ara=22 nux=5 nuy=5 nuz=1
fill
4 3 3 3 3
3 3 3 3 2
3 3 3 2 2
3 3 2 2 2
3 2 2 2 2
end fill
ara=23 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
2 2 2 2 2
2 2 2 2 2
end fill
ara=24 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 1 1 1 2
end fill
ara=25 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=26 nux=5 nuy=5 nuz=1
fill
3 3 3 3 4
2 3 3 3 3
2 2 3 3 3
2 2 2 3 3
2 2 2 2 3
end fill
ara=27 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
3 4 4 4 4
3 3 4 4 4
3 3 4 4 4
end fill
ara=31 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
4 3 3 3 2
4 3 3 3 2
end fill
ara=32 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=33 nux=5 nuy=5 nuz=1
fill
2 2 2 1 1
2 2 1 1 1
2 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=34 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=35 nux=5 nuy=5 nuz=1
fill
1 1 2 2 2
1 1 1 1 2
1 1 1 1 2
1 1 1 1 1
1 1 1 1 1
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
end fill
ara=36 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=37 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=41 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
end fill
ara=42 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 1
2 2 2 2 1
2 2 2 2 1
2 2 2 2 2
end fill
ara=43 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=44 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=45 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=46 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
1 2 2 2 2
1 2 2 2 2
1 2 2 2 2
2 2 2 2 2
end fill
ara=47 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=51 nux=5 nuy=5 nuz=1
```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
fill
4 3 3 3 2
4 3 3 3 2
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
end fill
ara=52 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=53 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
2 1 1 1 1
2 1 1 1 1
2 2 2 1 1
end fill
ara=54 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
end fill
ara=55 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
1 1 1 1 1
1 1 1 1 2
1 1 1 2 2
1 1 2 2 2
end fill
ara=56 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=57 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
end fill
ara=61 nux=5 nuy=5 nuz=1
fill
4 4 4 3 3
4 4 4 3 3
4 4 4 4 3
4 4 4 4 4
4 4 4 4 4
end fill
ara=62 nux=5 nuy=5 nuz=1
fill
3 2 2 2 2
3 3 2 2 2
3 3 3 2 2
3 3 3 3 2
4 3 3 3 3
end fill
ara=63 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=64 nux=5 nuy=5 nuz=1
fill
2 1 1 1 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=65 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=66 nux=5 nuy=5 nuz=1
fill
2 2 2 2 3
2 2 2 3 3
2 2 3 3 3
2 3 3 3 3
3 3 3 3 4
end fill
ara=67 nux=5 nuy=5 nuz=1
fill
3 3 4 4 4
3 3 4 4 4
3 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=71 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=72 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 4 3 3
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=73 nux=5 nuy=5 nuz=1
fill
3 3 3 2 2
3 3 3 3 3
3 3 3 3 3
4 4 4 3 3
4 4 4 4 4
end fill
ara=74 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
4 4 4 4 4
end fill
ara=75 nux=5 nuy=5 nuz=1
fill
2 2 3 3 3
3 3 3 3 3
3 3 3 3 3

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
3 3 4 4 4
4 4 4 4 4
end fill
ara=76 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=77 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=100 nux=7 nuy=7 nuz=1
fill
11 12 13 14 15 16 17
21 22 23 24 25 26 27
31 32 33 34 35 36 37
41 42 43 44 45 46 47
51 52 53 54 55 56 57
61 62 63 64 65 66 67
71 72 73 74 75 76 77
end fill
end array
read plot
ttl='simple plot 1'
pic=mix
xul= 0 yul= 190 zul= 100
xlr= 190 ylr= 0 zlr= 100
uax=1.0 vdn=-1.0
nax=1200
lpi=10
scr=yes end
ttl='simple plot 4'
pic=mix
xul= 0 yul= 95 zul= 168
xlr= 190 ylr= 95 zlr= 0
uax=1.0 wdn=-1.0
nax=800
scr=yes end
end plot
end data
end
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
=cons9901
TASK:
  MULTIC= 1
  NOUT  = 2
  IHT   = 4
  IHS   = 77
  NG    = 299
  IPRIB = 0
  idelta= 1
  NMOM  = 5
  IZT   = 50
  NRZT  = 39
  INZ   = 32
NAME=
'U234' 'U235' 'U236' 'U238NR' 'PU38' 'PU39' 'PU40' 'PU41' 'PU42' 'AM41'
'O' 'NA' 'FE' 'CR' 'NI' 'MN' 'MO' 'TI' 'NB' 'CU' 'AL' 'SI' 'CA' 'C'
'P' 'S' 'H+H(FREE)' 'CO' 'K' 'N' 'GA' 'D-SC'
RO=

*****PLATES

*1 PU
0.0000E+00 0.0000E+00 0.0000E+00 6.8782E-07 3.0461E-05 2.8920E-02 6.9095E-03
7.3960E-04 1.8699E-04 4.5718E-04 8.8450E-05 0.0000E+00 1.6335E-05 3.5989E-06
8.5688E-06 1.4902E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.2973E-05
1.4158E-05 0.0000E+00 4.2260E-04 0.0000E+00 0.0000E+00 1.2764E-04 0.0000E+00
0.0000E+00 2.4215E-05 2.0166E-03 0.0000E+00

*2 CAN
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.5542E-02 9.4011E-03
4.1646E-03 8.5931E-04 0.0000E+00 0.0000E+00 0.0000E+00 1.6613E-02 0.0000E+00
3.6607E-04 0.0000E+00 1.1393E-04 1.3731E-05 0.0000E+00 1.3760E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*3 UO2
0.0000E+00 1.6585E-04 0.0000E+00 2.2894E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.6122E-02 0.0000E+00 1.3139E-06 0.0000E+00
1.2503E-06 8.3479E-08 3.3462E-07 0.0000E+00 0.0000E+00 0.0000E+00 3.3995E-06
2.3024E-05 0.0000E+00 1.1837E-05 0.0000E+00 0.0000E+00 3.1852E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*4 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 4.7796E-02 1.3673E-02
8.3368E-03 8.4655E-04 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
6.3794E-04 0.0000E+00 1.2695E-04 3.4708E-04 3.5660E-05 1.8834E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*5 na
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 5.6492E-06 2.3225E-02 1.6184E-07 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 3.6083E-06 0.0000E+00 0.0000E+00 0.0000E+00 1.3900E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*6 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.5054E-02 1.4759E-02
7.0982E-03 1.3570E-03 0.0000E+00 0.0000E+00 3.1147E-04 0.0000E+00 0.0000E+00
6.0867E-04 0.0000E+00 2.9290E-04 3.2795E-05 3.3219E-05 2.1631E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*7 ss
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.5367E-02 1.5908E-02
8.7976E-03 1.4972E-03 8.0988E-05 2.4806E-04 5.0000E-06 5.0365E-05 1.1862E-04
7.9703E-04 0.0000E+00 8.7794E-05 4.0018E-05 1.4422E-05 1.8355E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*8 sheath
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 7.7524E-02 3.6690E-06
1.4302E-05 2.5697E-04 0.0000E+00 0.0000E+00 0.0000E+00 2.2216E-05 1.9798E-05
0.0000E+00 0.0000E+00 2.3825E-04 0.0000E+00 0.0000E+00 7.5712E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

*9 U8
0.0000E+00 3.3369E-04 0.0000E+00 4.6021E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.0599E-04 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
2.1076E-04 0.0000E+00 4.9283E-04 0.0000E+00 0.0000E+00 4.4048E-05 0.0000E+00
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*10 U2
0.0000E+00 3.3962E-04 0.0000E+00 4.6785E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 9.9032E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.9692E-04 0.0000E+00 4.6047E-04 0.0000E+00 0.0000E+00 4.3899E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*11 U3
0.0000E+00 3.4209E-04 0.0000E+00 4.7156E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.0138E-04 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
2.0160E-04 0.0000E+00 4.7140E-04 0.0000E+00 0.0000E+00 4.4574E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*12 mst3
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 8.3806E-02 2.7222E-05
4.8234E-05 3.2634E-04 9.8355E-06 3.9416E-05 0.0000E+00 4.4548E-05 1.3989E-04
0.0000E+00 0.0000E+00 5.1066E-04 0.0000E+00 0.0000E+00 2.5700E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*13 mst9f10
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 8.1432E-02 0.0000E+00
0.0000E+00 7.1275E-04 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.1158E-04 0.0000E+00 6.8972E-04 4.2944E-05 3.7110E-05 4.6306E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

***** PINS

*14 PUPINA
1.3805E-06 1.4114E-04 7.9324E-07 1.9379E-02 3.7786E-06 2.9689E-03 6.7253E-04
7.0350E-05 1.7488E-05 4.7854E-05 4.6606E-02 0.0000E+00 5.6537E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.1702E-05
0.0000E+00 7.8782E-06 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*15 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.9675E-02 1.8218E-02
8.9153E-03 1.5646E-03 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
8.5585E-04 0.0000E+00 1.3288E-04 3.7870E-05 2.4585E-05 2.6710E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*16 PUPINB
1.3177E-06 1.3457E-04 7.4658E-07 1.8472E-02 5.8915E-06 3.7341E-03 9.5200E-04
1.1199E-04 2.7984E-05 5.5789E-05 4.6993E-02 0.0000E+00 0.0000E+00 0.0000E+00
5.4424E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
9.0199E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*17 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.3171E-02 1.4981E-02
8.8137E-03 1.5751E-03 0.0000E+00 0.0000E+00 2.9391E-04 0.0000E+00 0.0000E+00
1.1571E-03 0.0000E+00 2.3695E-04 4.1596E-05 2.2786E-05 2.2895E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*18 PUPINC
1.2863E-06 1.2997E-04 7.3103E-07 1.7843E-02 6.9094E-06 4.4708E-03 1.0602E-03
1.1598E-04 3.0047E-05 5.7784E-05 4.7434E-02 0.0000E+00 7.6916E-06 0.0000E+00
1.0947E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.9730E-05
7.9741E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*19 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.8512E-02 1.7856E-02
8.7515E-03 1.5331E-03 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
8.3531E-04 0.0000E+00 1.3609E-04 3.6008E-05 2.4585E-05 2.6710E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*20 PUPIND
1.4118E-06 1.4266E-04 7.9324E-07 1.9584E-02 4.7348E-06 3.0189E-03 7.5441E-04
8.8443E-05 2.0961E-05 4.0742E-05 4.7314E-02 0.0000E+00 6.9027E-06 0.0000E+00
1.4138E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.8914E-05
2.5099E-05 1.5940E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*21 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.5753E-02 1.5910E-02
7.6341E-03 1.1586E-03 2.2047E-06 2.8916E-05 0.0000E+00 6.0522E-06 6.4142E-06

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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
8.9693E-04 0.0000E+00 2.0172E-04 3.4145E-05 8.9942E-06 2.4802E-05 4.2418E-06
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*22 PUPINE
1.1295E-06 1.1465E-04 6.3771E-07 1.5739E-02 9.4851E-06 6.0438E-03 1.5103E-03
1.7707E-04 4.1953E-05 8.1559E-05 4.7299E-02 0.0000E+00 1.0321E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 9.5250E-06
4.5753E-05 3.2062E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*23 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.6794E-02 1.6102E-02
8.0503E-03 9.8006E-04 2.1446E-05 2.8916E-05 0.0000E+00 6.0522E-06 6.4142E-06
1.0476E-03 0.0000E+00 7.3646E-05 1.3658E-05 1.7389E-05 2.4802E-05 4.2418E-06
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*24 PUPINF
1.1452E-06 1.1526E-04 6.3771E-07 1.5824E-02 9.5005E-06 6.0112E-03 1.5285E-03
1.9723E-04 4.4380E-05 6.8035E-05 4.7482E-02 0.0000E+00 1.1505E-05 4.9427E-06
2.1895E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.4287E-05
0.0000E+00 6.7514E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*25 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.7354E-02 1.6284E-02
8.1453E-03 9.8357E-04 2.1246E-05 2.1687E-05 0.0000E+00 4.5391E-06 4.2762E-06
1.0544E-03 0.0000E+00 7.2045E-05 1.3658E-05 1.7989E-05 2.4802E-05 3.2629E-06
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*26 UO2PINC
9.7268E-07 1.7084E-04 0.0000E+00 2.3588E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.7501E-02 0.0000E+00 1.1176E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.3812E-05
4.0001E-05 1.2825E-05 3.2095E-05 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*27 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.9792E-02 1.8255E-02
8.9349E-03 1.5681E-03 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
8.5585E-04 0.0000E+00 1.3288E-04 3.7870E-05 2.4585E-05 2.6710E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

***** WALLS

*28 NACLI
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 4.8911E-02 1.4995E-02
7.2440E-03 1.2214E-03 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
6.0229E-04 0.0000E+00 2.8167E-04 7.3471E-05 3.6808E-05 3.9844E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*29 NACLIIS
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 4.7118E-02 1.4380E-02
7.4526E-03 1.1060E-03 3.4248E-06 2.4400E-04 0.0000E+00 1.0341E-05 0.0000E+00
9.7623E-04 0.0000E+00 6.5351E-04 4.7540E-05 3.3014E-05 3.8637E-05 1.1151E-05
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*30 NACLIII
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 5.0764E-02 1.4132E-02
7.6658E-03 8.3089E-04 2.4862E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
7.7474E-04 0.0000E+00 1.5948E-04 5.2334E-05 2.4551E-05 3.9844E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*31 NACLIV
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 4.7151E-02 1.3563E-02
6.4549E-03 1.0026E-03 8.8791E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
8.2197E-04 0.0000E+00 3.5158E-04 6.2274E-05 1.6431E-05 3.7430E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*32 NACLIV
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 4.9404E-02 1.3830E-02
7.2532E-03 9.6934E-04 8.8791E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
6.4389E-04 0.0000E+00 2.6343E-04 6.8560E-05 1.7190E-05 3.8637E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
```

*****NA

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

*33 NaCLi

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	6.4605E-06	2.4129E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	1.1080E-06	0.0000E+00	0.0000E+00	0.0000E+00	5.5075E-06	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00			

*34 NaCLiIS

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.0767E-06	2.4379E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	9.5521E-08	0.0000E+00	0.0000E+00	0.0000E+00	1.1205E-05	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00			

*35 NaCLiIII

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	3.5892E-06	2.3888E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	6.6865E-07	0.0000E+00	0.0000E+00	0.0000E+00	7.5966E-06	0.0000E+00
3.4270E-07	0.0000E+00	0.0000E+00	0.0000E+00			

*36 NaCLIV

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	3.5892E-06	2.4037E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	6.6865E-07	0.0000E+00	0.0000E+00	0.0000E+00	7.5966E-06	0.0000E+00
3.4270E-07	0.0000E+00	0.0000E+00	0.0000E+00			

*37 NaCLV

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	3.5892E-06	2.3829E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	6.6865E-07	0.0000E+00	0.0000E+00	0.0000E+00	7.5966E-06	0.0000E+00
3.4270E-07	0.0000E+00	0.0000E+00	0.0000E+00			

*38 TUBES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	6.0762E-02	1.6787E-02
7.4360E-03	1.3588E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.0632E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00			

*39 PLATES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3.5578E-02	1.0016E-02
4.4601E-03	7.7198E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.5206E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00			

*40 HOMO PLATE

0.0000E+00	4.0267E-05	0.0000E+00	5.5585E-03	1.4500E-06	1.3767E-03	3.2891E-04
3.5207E-05	8.9013E-06	2.1763E-05	1.1204E-02	8.5835E-03	1.3408E-02	2.5351E-03
1.3445E-03	2.2472E-04	2.5185E-06	7.4651E-06	2.1148E-05	5.0291E-04	6.5715E-06
1.1860E-04	1.3336E-06	6.9062E-05	2.3577E-05	4.7025E-06	2.6584E-05	0.0000E+00
0.0000E+00	1.1527E-06	9.5996E-05	0.0000E+00			

*41 HOMO PIN

3.9345E-07	3.9755E-05	2.2361E-07	5.4578E-03	2.1135E-06	1.3675E-03	3.2429E-04
3.5476E-05	9.1908E-06	1.7675E-05	1.4512E-02	8.8477E-03	1.3627E-02	2.7802E-03
1.3198E-03	2.4404E-04	0.0000E+00	0.0000E+00	0.0000E+00	1.2150E-06	7.1178E-06
1.3994E-04	4.0628E-07	3.7223E-05	6.3404E-06	3.5587E-06	2.0046E-05	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00			

***** D-SC

*42 PU

0.0000E+00	0.0000E+00	0.0000E+00	6.8782E-07	3.0461E-05	2.8920E-02	6.9095E-03
7.3960E-04	1.8699E-04	4.5718E-04	8.8450E-05	0.0000E+00	1.6335E-05	3.5989E-06
8.5688E-06	1.4902E-06	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	2.2973E-05
1.4158E-05	0.0000E+00	4.2260E-04	0.0000E+00	0.0000E+00	1.2764E-04	0.0000E+00
0.0000E+00	2.4215E-05	2.0166E-03	2.3327E+00			

*43 UO2

0.0000E+00	1.6585E-04	0.0000E+00	2.2894E-02	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	4.6122E-02	0.0000E+00	1.3139E-06	0.0000E+00
1.2503E-06	8.3479E-08	3.3462E-07	0.0000E+00	0.0000E+00	0.0000E+00	3.3995E-06
2.3024E-05	0.0000E+00	1.1837E-05	0.0000E+00	0.0000E+00	3.1852E-05	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.1022E+00			

*44 PUPINA

1.3805E-06	1.4114E-04	7.9324E-07	1.9379E-02	3.7786E-06	2.9689E-03	6.7253E-04
7.0350E-05	1.7488E-05	4.7854E-05	4.6606E-02	0.0000E+00	5.6537E-06	0.0000E+00

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.1702E-05
0.0000E+00 7.8782E-06 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*45 PUPINB
1.3177E-06 1.3457E-04 7.4658E-07 1.8472E-02 5.8915E-06 3.7341E-03 9.5200E-04
1.1199E-04 2.7984E-05 5.5789E-05 4.6993E-02 0.0000E+00 0.0000E+00 0.0000E+00
5.4424E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
9.0199E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*46 PUPINC
1.2863E-06 1.2997E-04 7.3103E-07 1.7843E-02 6.9094E-06 4.4708E-03 1.0602E-03
1.1598E-04 3.0047E-05 5.7784E-05 4.7434E-02 0.0000E+00 7.6916E-06 0.0000E+00
1.0947E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.9730E-05
7.9741E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*47 PUPIND
1.4118E-06 1.4266E-04 7.9324E-07 1.9584E-02 4.7348E-06 3.0189E-03 7.5441E-04
8.8443E-05 2.0961E-05 4.0742E-05 4.7314E-02 0.0000E+00 6.9027E-06 0.0000E+00
1.4138E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.8914E-05
2.5099E-05 1.5940E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*48 PUPINE
1.1295E-06 1.1465E-04 6.3771E-07 1.5739E-02 9.4851E-06 6.0438E-03 1.5103E-03
1.7707E-04 4.1953E-05 8.1559E-05 4.7299E-02 0.0000E+00 1.0321E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 9.5250E-06
4.5753E-05 3.2062E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*49 PUPINF
1.1452E-06 1.1526E-04 6.3771E-07 1.5824E-02 9.5005E-06 6.0112E-03 1.5285E-03
1.9723E-04 4.4380E-05 6.8035E-05 4.7482E-02 0.0000E+00 1.1505E-05 4.9427E-06
2.1895E-06 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.4287E-05
0.0000E+00 6.7514E-05 0.0000E+00 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00
*50 UO2PINC
9.7268E-07 1.7084E-04 0.0000E+00 2.3588E-02 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.7501E-02 0.0000E+00 1.1176E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.3812E-05
4.0001E-05 1.2825E-05 3.2095E-05 0.0000E+00 0.0000E+00 3.2784E-05 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.8460E+00

ICOR =
42 40 43 40 40 40 40 40
9 10 11 12 13
44 41 45 41 46 41 47 41 48 41 49 41 50 41
5*41 5*41 41 41
40 41 42 43 44 45 46 47 48 49 50

NAMSUB='U238NR' 'PU39'
NGSUB=10 11 12 13 14 15 16 17 18 19 20 21 22 23
END
end
=subgran
end
=lava
-1$$ 2500000
0$$ 71 72 18 19
1$$ 39 755 4 91 845 61 0 -1 1 t
2$$ 37I1000 39000
3$$ F5
4$$ 37I100 3900
5$$ 1 1452 27 1018
7**
2.00000E+07 1.86181E+07 1.73316E+07 1.61341E+07 1.50192E+07
1.39818E+07 1.30158E+07 1.21165E+07 1.12793E+07 1.05000E+07
9.69341E+06 8.94878E+06 8.26136E+06 7.62674E+06 7.04086E+06
6.50000E+06 5.99475E+06 5.52877E+06 5.09902E+06 4.70267E+06
4.33713E+06 4.00000E+06 3.69862E+06 3.41995E+06 3.16228E+06
2.92402E+06 2.70371E+06 2.50000E+06 2.32522E+06 2.16265E+06
2.01146E+06 1.87083E+06 1.74003E+06 1.61838E+06 1.50524E+06
1.40000E+06 1.30541E+06 1.21722E+06 1.13498E+06 1.05830E+06
9.86800E+05 9.20131E+05 8.57965E+05 8.00000E+05 7.40700E+05
6.85795E+05 6.34960E+05 5.87894E+05 5.44316E+05 5.03968E+05
4.66612E+05 4.32024E+05 4.00000E+05 3.70350E+05 3.42898E+05
3.17480E+05 2.93947E+05 2.72158E+05 2.51984E+05 2.33306E+05

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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

2.16012E+05	2.00000E+05	1.91435E+05	1.85175E+05	1.77154E+05
1.71449E+05	1.63937E+05	1.58740E+05	1.51708E+05	1.46973E+05
1.40390E+05	1.36079E+05	1.29916E+05	1.25992E+05	1.20222E+05
1.16653E+05	1.11251E+05	1.08006E+05	1.02951E+05	1.00000E+05
9.60586E+04	9.38042E+04	9.00741E+04	8.79923E+04	8.44625E+04
8.25404E+04	7.92005E+04	7.74264E+04	7.42663E+04	7.26292E+04
6.96395E+04	6.81292E+04	6.53014E+04	6.39081E+04	6.12343E+04
5.99484E+04	5.74205E+04	5.62341E+04	5.38442E+04	5.27500E+04
5.04907E+04	4.94817E+04	4.73460E+04	4.64159E+04	4.52365E+04
4.43972E+04	4.38990E+04	4.35400E+04	4.24188E+04	4.16320E+04
4.11705E+04	4.08424E+04	3.97762E+04	3.90389E+04	3.86114E+04
3.83119E+04	3.72981E+04	3.66074E+04	3.62115E+04	3.59381E+04
3.49744E+04	3.43274E+04	3.39609E+04	3.37115E+04	3.27956E+04
3.21894E+04	3.18504E+04	3.16227E+04	3.07523E+04	3.01846E+04
2.98710E+04	2.96635E+04	2.88362E+04	2.83046E+04	2.80147E+04
2.78256E+04	2.70395E+04	2.65418E+04	2.62738E+04	2.61015E+04
2.53546E+04	2.48887E+04	2.46412E+04	2.44843E+04	2.37747E+04
2.33386E+04	2.31100E+04	2.29673E+04	2.22931E+04	2.18850E+04
2.16741E+04	2.15443E+04	2.09038E+04	2.05218E+04	2.03274E+04
2.02095E+04	1.96011E+04	1.92437E+04	1.90644E+04	1.89573E+04
1.83795E+04	1.80451E+04	1.78800E+04	1.77828E+04	1.72340E+04
1.69213E+04	1.67692E+04	1.66810E+04	1.61599E+04	1.58674E+04
1.57274E+04	1.56475E+04	1.51527E+04	1.48791E+04	1.47504E+04
1.46780E+04	1.42082E+04	1.39524E+04	1.38342E+04	1.37686E+04
1.33225E+04	1.30834E+04	1.29748E+04	1.29155E+04	1.24919E+04
1.22685E+04	1.21688E+04	1.21153E+04	1.17131E+04	1.15044E+04
1.14130E+04	1.13646E+04	1.09828E+04	1.07879E+04	1.07041E+04
1.06605E+04	1.02980E+04	1.01159E+04	1.00393E+04	1.00000E+04
9.65597E+03	9.48588E+03	9.41580E+03	9.38042E+03	9.05389E+03
8.89508E+03	8.83104E+03	8.79923E+03	8.48930E+03	8.34103E+03
8.28260E+03	8.25404E+03	7.95994E+03	7.82153E+03	7.76826E+03
7.74264E+03	7.46356E+03	7.33439E+03	7.28588E+03	7.26292E+03
6.99809E+03	6.87754E+03	6.83345E+03	6.81292E+03	6.56175E+03
6.44928E+03	6.40918E+03	6.39081E+03	6.15266E+03	6.04776E+03
6.01129E+03	5.99484E+03	5.76907E+03	5.67124E+03	5.63811E+03
5.62341E+03	5.40937E+03	5.31816E+03	5.28811E+03	5.27500E+03
5.07209E+03	4.98706E+03	4.95985E+03	4.94817E+03	4.75585E+03
4.67660E+03	4.65199E+03	4.64159E+03	4.45930E+03	4.38545E+03
4.36323E+03	4.35400E+03	4.18123E+03	4.11242E+03	4.09241E+03
4.08424E+03	3.92049E+03	3.85639E+03	3.83841E+03	3.83119E+03
3.67600E+03	3.61629E+03	3.60018E+03	3.59381E+03	3.44677E+03
3.39115E+03	3.37674E+03	3.37114E+03	3.23181E+03	3.18002E+03
3.16718E+03	3.16227E+03	3.03025E+03	2.98204E+03	2.97063E+03
2.96635E+03	2.84126E+03	2.79638E+03	2.78628E+03	2.78256E+03
2.66404E+03	2.62228E+03	2.61338E+03	2.61015E+03	2.49787E+03
2.45903E+03	2.45121E+03	2.44843E+03	2.34207E+03	2.30593E+03
2.29911E+03	2.29673E+03	2.19597E+03	2.16237E+03	2.15646E+03
2.15443E+03	2.08156E+03	2.05753E+03	2.03423E+03	2.02643E+03
2.02233E+03	2.02095E+03	1.94867E+03	1.92530E+03	1.91246E+03
1.90823E+03	1.90091E+03	1.89850E+03	1.89642E+03	1.89573E+03
1.82083E+03	1.79713E+03	1.78450E+03	1.78042E+03	1.77880E+03
1.77828E+03	1.71599E+03	1.69659E+03	1.68085E+03	1.67586E+03
1.67210E+03	1.67091E+03	1.66878E+03	1.66810E+03	1.62473E+03
1.61140E+03	1.60455E+03	1.57089E+03	1.56621E+03	1.56475E+03
1.50398E+03	1.48581E+03	1.47431E+03	1.47080E+03	1.46850E+03
1.46780E+03	1.41805E+03	1.40341E+03	1.38536E+03	1.37998E+03
1.37758E+03	1.37686E+03	1.31491E+03	1.29719E+03	1.29283E+03
1.29155E+03	1.24774E+03	1.23536E+03	1.21853E+03	1.21371E+03
1.21202E+03	1.21153E+03	1.17775E+03	1.16836E+03	1.14755E+03
1.14173E+03	1.13762E+03	1.13646E+03	1.10141E+03	1.09189E+03
1.07319E+03	1.06806E+03	1.06649E+03	1.06605E+03	1.02376E+03
1.01259E+03	1.00357E+03	1.00114E+03	1.00024E+03	1.00000E+03
9.66236E+02	9.57470E+02	9.49570E+02	9.47485E+02	9.42407E+02
9.41065E+02	9.38675E+02	9.38042E+02	8.99406E+02	8.89639E+02
8.83723E+02	8.82194E+02	8.80390E+02	8.79923E+02	8.46636E+02
8.38387E+02	8.30030E+02	8.27921E+02	8.25913E+02	8.25404E+02
7.89300E+02	7.80584E+02	7.76423E+02	7.75394E+02	7.74492E+02
7.74269E+02	7.37010E+02	7.28241E+02	7.26676E+02	7.26296E+02
6.95229E+02	6.88058E+02	6.84227E+02	6.83321E+02	6.81684E+02
6.81296E+02	6.51912E+02	6.45279E+02	6.41161E+02	6.40210E+02
6.39296E+02	6.39085E+02	6.11590E+02	6.05519E+02	6.01580E+02
6.00689E+02	5.99710E+02	5.99488E+02	5.75586E+02	5.70412E+02
5.65542E+02	5.64467E+02	5.62730E+02	5.62345E+02	5.36729E+02
5.31326E+02	5.29011E+02	5.28509E+02	5.27682E+02	5.27503E+02

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

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5.03701E+02 4.98792E+02 4.96329E+02 4.95808E+02 4.94993E+02
4.94820E+02 4.70155E+02 4.65202E+02 4.64340E+02 4.64162E+02
4.40985E+02 4.36438E+02 4.35577E+02 4.35403E+02 4.17034E+02
4.13497E+02 4.10542E+02 4.09960E+02 4.08679E+02 4.08426E+02
3.89954E+02 3.86488E+02 3.84318E+02 3.83901E+02 3.83247E+02
3.83121E+02 3.63761E+02 3.60231E+02 3.59518E+02 3.59384E+02
3.46541E+02 3.44235E+02 3.40010E+02 3.39241E+02 3.38106E+02
3.37898E+02 3.37238E+02 3.37117E+02 3.19313E+02 3.16230E+02
3.07376E+02 3.02104E+02 2.97359E+02 2.97025E+02 2.96822E+02
2.96637E+02 2.82831E+02 2.80486E+02 2.79215E+02 2.78994E+02
2.78367E+02 2.78258E+02 2.70318E+02 2.65502E+02 2.63863E+02
2.62708E+02 2.61994E+02 2.61748E+02 2.61349E+02 2.61102E+02
2.61017E+02 2.47008E+02 2.44845E+02 2.37617E+02 2.34994E+02
2.32422E+02 2.31245E+02 2.30811E+02 2.30381E+02 2.29975E+02
2.29824E+02 2.29675E+02 2.19156E+02 2.15445E+02 2.10258E+02
2.09166E+02 2.04427E+02 2.03428E+02 2.02821E+02 2.02692E+02
2.02201E+02 2.02096E+02 1.97202E+02 1.93488E+02 1.91406E+02
1.90813E+02 1.90355E+02 1.90094E+02 1.89860E+02 1.89678E+02
1.89575E+02 1.82295E+02 1.79185E+02 1.78715E+02 1.78509E+02
1.78209E+02 1.78077E+02 1.77905E+02 1.77829E+02 1.71468E+02
1.68053E+02 1.66811E+02 1.58152E+02 1.57088E+02 1.56545E+02
1.56476E+02 1.48817E+02 1.46781E+02 1.39817E+02 1.38221E+02
1.37789E+02 1.37687E+02 1.33160E+02 1.29901E+02 1.29156E+02
1.24352E+02 1.22028E+02 1.21154E+02 1.19058E+02 1.17703E+02
1.17309E+02 1.16008E+02 1.15163E+02 1.14916E+02 1.14504E+02
1.14234E+02 1.14155E+02 1.13880E+02 1.13700E+02 1.13647E+02
1.08936E+02 1.07009E+02 1.06606E+02 1.04367E+02 1.02788E+02
1.02221E+02 1.01371E+02 1.00765E+02 1.00546E+02 1.00270E+02
1.00072E+02 1.00001E+02 9.49147E+01 9.38048E+01 9.00591E+01
8.84578E+01 8.79928E+01 8.53864E+01 8.29607E+01 8.25409E+01
8.00020E+01 7.87116E+01 7.81267E+01 7.78241E+01 7.75626E+01
7.74269E+01 7.48414E+01 7.31916E+01 7.26296E+01 6.81296E+01
6.64990E+01 6.57970E+01 6.55235E+01 6.47774E+01 6.44532E+01
6.43264E+01 6.40667E+01 6.39533E+01 6.39089E+01 6.16780E+01
5.99492E+01 5.77630E+01 5.69789E+01 5.62349E+01 5.43365E+01
5.31530E+01 5.27507E+01 5.12878E+01 5.00051E+01 4.94823E+01
4.71930E+01 4.64165E+01 4.39677E+01 4.35406E+01 4.15092E+01
4.08429E+01 3.86248E+01 3.83124E+01 3.71495E+01 3.62881E+01
3.59386E+01 3.40190E+01 3.37119E+01 3.20656E+01 3.16232E+01
2.96639E+01 2.78259E+01 2.70538E+01 2.63962E+01 2.61019E+01
2.44847E+01 2.33182E+01 2.29676E+01 2.24015E+01 2.18633E+01
2.15446E+01 2.10496E+01 2.09018E+01 2.05679E+01 2.04677E+01
2.02695E+01 2.02098E+01 1.89576E+01 1.81519E+01 1.78913E+01
1.77830E+01 1.69505E+01 1.66812E+01 1.60901E+01 1.56477E+01
1.48289E+01 1.46782E+01 1.37687E+01 1.29157E+01 1.22858E+01
1.21154E+01 1.17726E+01 1.15521E+01 1.13648E+01 1.09868E+01
1.06606E+01 1.02388E+01 1.00001E+01 9.62837E+00 9.38054E+00
8.79934E+00 8.46274E+00 8.25415E+00 8.07648E+00 7.90335E+00
7.74274E+00 7.49870E+00 7.33772E+00 7.26301E+00 6.81301E+00
6.64826E+00 6.50284E+00 6.39089E+00 5.99492E+00 5.62349E+00
5.27506E+00 4.94823E+00 4.64165E+00 4.35406E+00 4.08429E+00
3.83124E+00 3.59386E+00 3.37119E+00 3.16232E+00 2.96639E+00
2.78259E+00 2.61019E+00 2.44847E+00 2.29676E+00 2.15446E+00
2.02098E+00 1.89576E+00 1.77830E+00 1.66812E+00 1.56477E+00
1.46782E+00 1.37687E+00 1.29157E+00 1.21154E+00 1.13648E+00
1.06606E+00 1.00001E+00 9.38054E-01 8.79934E-01 8.25415E-01
7.74274E-01 7.26301E-01 6.81301E-01 6.39089E-01 5.99492E-01
5.62348E-01 5.27506E-01 4.94823E-01 4.64165E-01 4.35406E-01
4.08429E-01 3.83124E-01 3.59386E-01 3.37119E-01 3.16232E-01
2.96639E-01 2.78259E-01 2.61019E-01 2.44847E-01 2.29676E-01
2.15446E-01 1.89576E-01 1.66812E-01 1.46782E-01 1.29157E-01
1.13647E-01 1.00001E-01 8.25415E-02 6.81301E-02 5.62348E-02
4.64165E-02 3.83124E-02 3.16232E-02 2.61019E-02 2.15446E-02
1.77830E-02 1.46782E-02 1.21155E-02 1.00001E-02 6.81301E-03
4.64164E-03 3.16231E-03 2.15446E-03 1.00001E-03 1.00001E-04
1.00001E-05
9$$ F0 t
end
#sc_bin
72
75
end

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
#kenova
zebra 23
read param
tme=1000
lib=75
lng=70000000
nb8=90000
nl8=2000
gen=2020
npg=10000
nsk=20
run=yes
plt=no
end param
read mixt
sct=3
eps=1.
mix=1 100 1.
mix=2 200 1.
mix=3 300 1.
mix=4 400 1.
mix=5 500 1.
mix=6 600 1.
mix=7 700 1.
mix=8 800 1.
mix=9 900 1.
mix=10 1000 1.
mix=11 1100 1.
mix=12 1200 1.
mix=13 1300 1.
mix=14 1400 1.
mix=15 1500 1.
mix=16 1600 1.
mix=17 1700 1.
mix=18 1800 1.
mix=19 1900 1.
mix=20 2000 1.
mix=21 2100 1.
mix=22 2200 1.
mix=23 2300 1.
mix=24 2400 1.
mix=25 2500 1.
mix=26 2600 1.
mix=27 2700 1.
mix=28 2800 1.
mix=29 2900 1.
mix=30 3000 1.
mix=31 3100 1.
mix=32 3200 1.
mix=33 3300 1.
mix=34 3400 1.
mix=35 3500 1.
mix=36 3600 1.
mix=37 3700 1.
mix=38 3800 1.
mix=39 3900 1.
end mixt
read geometry
unit 1
com='core'
array 111 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 111
com='pu'
cuboid 1 1 4p2.3355 0.28170 0.0457
cuboid 2 1 4p2.5335 0.32740 0
unit 112
com='uo2'
cuboid 3 1 4p2.4255 0.59465 0.03665
cuboid 4 1 4p2.5335 0.63130 0
unit 113
com='na'
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

cuboid 5 1 4p2.4815      0.577347 0.036347
cuboid 6 1 4p2.5335      0.613694 0
unit 114
com='ss'
cuboid 0 1 4p1.9625      0.31700 0
cuboid 7 1 4p2.5335      0.31700 0
unit 211
com='u8'
cuboid 9 1 4p2.5335      9.82700 0
unit 212
com='u2'
cuboid 10 1 4p2.5335     12.72300 0
unit 213
com='u3'
cuboid 11 1 4p2.5335      7.62250 0
unit 311
com='mst3'
cuboid 12 1 4p2.5335      7.60628 0
unit 511
com='air-PLATE'
cuboid 0 1 4p2.5335      1.392516 0
unit 611
com='air-PIN'
cuboid 0 1 4p2.5335      1.4575 0
unit 2
com='u3-radial'
cuboid 12 1 4p2.5335      7.60628 0
cuboid 11 1 4p2.5335     160.05628 0
cuboid 12 1 4p2.5335     167.66256 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 3
com='mst9f10'
cuboid 13 1 4p2.54000     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 4
com='empty tube'
cuboid 0 1 4p2.55100     167.66256 0
cuboid 8 1 4p2.62720     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 81
com='3A'
array 91 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 82
com='3B'
array 92 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 83
com='3C'
array 93 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 84
com='3D'
array 94 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 85
com='3E'
array 95 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605     167.66256 0
unit 86
com='3H'
array 96 -2.5335 -2.5335 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 87
com='3J'
array 97 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 88
com='3L'
array 98 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 91
com='CAL-A'
cuboid 33 1 4p2.45 29.62 0.44
,
hole 203 -1.785 -1.785 0.44
hole 203 -0.595 -1.785 0.44
hole 203 0.595 -1.785 0.44
hole 203 1.785 -1.785 0.44
hole 203 -1.785 -0.595 0.44
hole 203 -0.595 -0.595 0.44
hole 203 0.595 -0.595 0.44
hole 203 1.785 -0.595 0.44
hole 203 -1.785 0.595 0.44
hole 203 -0.595 0.595 0.44
hole 203 0.595 0.595 0.44
hole 203 1.785 0.595 0.44
hole 203 -1.785 1.785 0.44
hole 203 -0.595 1.785 0.44
hole 203 0.595 1.785 0.44
hole 203 1.785 1.785 0.44
,
cuboid 39 1 4p2.45 29.73 0
cuboid 28 1 4p2.5335 29.73 0
unit 92
com='CAL-B'
cuboid 33 1 4p2.45 29.62 0.44
,
hole 202 -1.785 -1.785 0.44
hole 202 -0.595 -1.785 0.44
hole 206 0.595 -1.785 0.44
hole 202 1.785 -1.785 0.44
hole 202 -1.785 -0.595 0.44
hole 202 -0.595 -0.595 0.44
hole 202 0.595 -0.595 0.44
hole 206 1.785 -0.595 0.44
hole 206 -1.785 0.595 0.44
hole 202 -0.595 0.595 0.44
hole 206 0.595 0.595 0.44
hole 202 1.785 0.595 0.44
hole 202 -1.785 1.785 0.44
hole 206 -0.595 1.785 0.44
hole 202 0.595 1.785 0.44
hole 202 1.785 1.785 0.44
,
cuboid 39 1 4p2.45 29.73 0
cuboid 28 1 4p2.5335 29.73 0
unit 93
com='CAL-C'
cuboid 35 1 4p2.45 29.62 0.44
,
hole 201 -1.785 -1.785 0.44
hole 205 -0.595 -1.785 0.44
hole 201 0.595 -1.785 0.44
hole 205 1.785 -1.785 0.44
hole 205 -1.785 -0.595 0.44
hole 201 -0.595 -0.595 0.44
hole 205 0.595 -0.595 0.44
hole 201 1.785 -0.595 0.44
hole 201 -1.785 0.595 0.44

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
hole 205 -0.595 0.595 0.44
hole 201 0.595 0.595 0.44
hole 205 1.785 0.595 0.44
hole 205 -1.785 1.785 0.44
hole 201 -0.595 1.785 0.44
hole 205 0.595 1.785 0.44
hole 201 1.785 1.785 0.44
```

```
,
cuboid 39 1 4p2.45 29.73 0
cuboid 30 1 4p2.5335 29.73 0
unit 94
com='CAL-D'
```

```
cuboid 35 1 4p2.45 29.62 0.44
```

```
,
hole 204 -1.785 -1.785 0.44
hole 206 -0.595 -1.785 0.44
hole 204 0.595 -1.785 0.44
hole 206 1.785 -1.785 0.44
hole 206 -1.785 -0.595 0.44
hole 204 -0.595 -0.595 0.44
hole 206 0.595 -0.595 0.44
hole 204 1.785 -0.595 0.44
hole 204 -1.785 0.595 0.44
hole 206 -0.595 0.595 0.44
hole 204 0.595 0.595 0.44
hole 206 1.785 0.595 0.44
hole 206 -1.785 1.785 0.44
hole 204 -0.595 1.785 0.44
hole 206 0.595 1.785 0.44
hole 204 1.785 1.785 0.44
```

```
,
cuboid 39 1 4p2.45 29.73 0
cuboid 30 1 4p2.5335 29.73 0
unit 95
com='CAL-E'
```

```
cuboid 34 1 4p2.45 29.62 0.44
```

```
,
hole 204 -1.785 -1.785 0.44
hole 206 -0.595 -1.785 0.44
hole 204 0.595 -1.785 0.44
hole 206 1.785 -1.785 0.44
hole 206 -1.785 -0.595 0.44
hole 204 -0.595 -0.595 0.44
hole 206 0.595 -0.595 0.44
hole 204 1.785 -0.595 0.44
hole 204 -1.785 0.595 0.44
hole 206 -0.595 0.595 0.44
hole 204 0.595 0.595 0.44
hole 206 1.785 0.595 0.44
hole 206 -1.785 1.785 0.44
hole 204 -0.595 1.785 0.44
hole 206 0.595 1.785 0.44
hole 204 1.785 1.785 0.44
```

```
,
cuboid 39 1 4p2.45 29.73 0
cuboid 29 1 4p2.5335 29.73 0
unit 96
```

```
com='CAL-H'
```

```
cuboid 37 1 4p2.45 29.62 0.44
```

```
,
hole 202 -1.785 -1.785 0.44
hole 202 -0.595 -1.785 0.44
hole 206 0.595 -1.785 0.44
hole 202 1.785 -1.785 0.44
hole 202 -1.785 -0.595 0.44
hole 202 -0.595 -0.595 0.44
hole 202 0.595 -0.595 0.44
hole 206 1.785 -0.595 0.44
hole 206 -1.785 0.595 0.44
hole 202 -0.595 0.595 0.44
hole 206 0.595 0.595 0.44
hole 202 1.785 0.595 0.44
hole 202 -1.785 1.785 0.44
hole 206 -0.595 1.785 0.44
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

hole 202 0.595 1.785 0.44
hole 202 1.785 1.785 0.44
,
cuboid 39 1 4p2.45 29.73 0
cuboid 32 1 4p2.5335 29.73 0
unit 97
com='CAL-J'
cuboid 36 1 4p2.45 29.62 0.44
,
hole 205 -1.785 -1.785 0.44
hole 205 -0.595 -1.785 0.44
hole 205 0.595 -1.785 0.44
hole 207 1.785 -1.785 0.44
hole 205 -1.785 -0.595 0.44
hole 207 -0.595 -0.595 0.44
hole 205 0.595 -0.595 0.44
hole 205 1.785 -0.595 0.44
hole 205 -1.785 0.595 0.44
hole 205 -0.595 0.595 0.44
hole 205 0.595 0.595 0.44
hole 207 1.785 0.595 0.44
hole 205 -1.785 1.785 0.44
hole 207 -0.595 1.785 0.44
hole 205 0.595 1.785 0.44
hole 205 1.785 1.785 0.44
,
cuboid 39 1 4p2.45 29.73 0
cuboid 311 4p2.5335 29.73 0
unit 98
com='CAL-L'
cuboid 36 1 4p2.45 29.62 0.44
,
hole 202 -1.785 -1.785 0.44
hole 202 -0.595 -1.785 0.44
hole 206 0.595 -1.785 0.44
hole 202 1.785 -1.785 0.44
hole 202 -1.785 -0.595 0.44
hole 202 -0.595 -0.595 0.44
hole 202 0.595 -0.595 0.44
hole 206 1.785 -0.595 0.44
hole 206 -1.785 0.595 0.44
hole 202 -0.595 0.595 0.44
hole 206 0.595 0.595 0.44
hole 202 1.785 0.595 0.44
hole 202 -1.785 1.785 0.44
hole 206 -0.595 1.785 0.44
hole 202 0.595 1.785 0.44
hole 202 1.785 1.785 0.44
,
cuboid 39 1 4p2.45 29.73 0
cuboid 31 1 4p2.5335 29.73 0
unit 201
com='PIN-A'
cylinder 14 1 0.4230 29.18 0
cylinder 0 1 0.4305 29.18 0
cylinder 15 1 0.4685 29.18 0
cylinder 0 1 0.4880 29.18 0
cylinder 38 1 0.5130 29.18 0
unit 202
com='PIN-B'
cylinder 16 1 0.4230 29.18 0
cylinder 0 1 0.4305 29.18 0
cylinder 17 1 0.4685 29.18 0
cylinder 0 1 0.4880 29.18 0
cylinder 38 1 0.5130 29.18 0
unit 203
com='PIN-C'
cylinder 18 1 0.4230 29.18 0
cylinder 0 1 0.4305 29.18 0
cylinder 19 1 0.4685 29.18 0
cylinder 0 1 0.4880 29.18 0
cylinder 38 1 0.5130 29.18 0
unit 204
com='PIN-D'

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

cylinder 20 1      0.4230      29.18      0
cylinder  0 1      0.4305      29.18      0
cylinder 21 1      0.4685      29.18      0
cylinder  0 1      0.4880      29.18      0
cylinder 38 1      0.5130      29.18      0
unit 205
com='PIN-E'
cylinder 22 1      0.4230      29.18      0
cylinder  0 1      0.4305      29.18      0
cylinder 23 1      0.4685      29.18      0
cylinder  0 1      0.4880      29.18      0
cylinder 38 1      0.5130      29.18      0
unit 206
com='PIN-F'
cylinder 24 1      0.4230      29.18      0
cylinder  0 1      0.4305      29.18      0
cylinder 25 1      0.4685      29.18      0
cylinder  0 1      0.4880      29.18      0
cylinder 38 1      0.5130      29.18      0
unit 207
com='PIN-UO2'
cylinder 26 1      0.4230      29.18      0
cylinder  0 1      0.4305      29.18      0
cylinder 27 1      0.4685      29.18      0
cylinder  0 1      0.4880      29.18      0
cylinder 38 1      0.5130      29.18      0
unit 11
com='2'
array  11      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 12
com='2'
array  12      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 13
com='2'
array  13      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 14
com='2'
array  14      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 15
com='2'
array  15      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 16
com='2'
array  16      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 17
com='2'
array  17      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 21
com='2'
array  21      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 22
com='2'
array  22      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 23
com='2'
array  23      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 24
com='2'
array  24      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0
unit 25
com='2'
array  25      -13.43025 -13.43025      0
cuboid  0 1 4p13.5635      167.66256 0

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

unit 26
com='2'
array 26 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 27
com='2'
array 27 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 31
com='2'
array 31 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 32
com='2'
array 32 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 33
com='2'
array 33 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 34
com='2'
array 34 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 35
com='2'
array 35 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 36
com='2'
array 36 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 37
com='2'
array 37 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 41
com='2'
array 41 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 42
com='2'
array 42 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 43
com='2'
array 43 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 44
com='2'
array 44 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 45
com='2'
array 45 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 46
com='2'
array 46 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 47
com='2'
array 47 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 51
com='2'
array 51 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 52
com='2'
array 52 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 53
com='2'

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

array 53 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 54
com='2'
array 54 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 55
com='2'
array 55 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 56
com='2'
array 56 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 57
com='2'
array 57 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 61
com='2'
array 61 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 62
com='2'
array 62 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 63
com='2'
array 63 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 64
com='2'
array 64 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 65
com='2'
array 65 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 66
com='2'
array 66 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 67
com='2'
array 67 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 71
com='2'
array 71 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 72
com='2'
array 72 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 73
com='2'
array 73 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 74
com='2'
array 74 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 75
com='2'
array 75 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 76
com='2'
array 76 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 77
com='2'
array 77 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

global unit 100
com='reactor'
array 100 3*0
end geometry
read array
ara=111 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
113 112 113 111 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 114 111 113 112 113 113 112 113 111 114 112 113
113 112 111 113 112 113
211 212 213 311 511
end fill
ara=91 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
91 91 91
211 212 213 311 611
end fill
ara=92 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
92 92 92
211 212 213 311 611
end fill
ara=93 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
93 93 93
211 212 213 311 611
end fill
ara=94 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
94 94 94
211 212 213 311 611
end fill
ara=95 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
95 95 95
211 212 213 311 611
end fill
ara=96 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
96 96 96
211 212 213 311 611
end fill
ara=97 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
97 97 97
211 212 213 311 611
end fill
ara=98 nux=1 nuy=1 nuz=13
fill
611 311 213 212 211
98 98 98
211 212 213 311 611
end fill
ara=11 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=12 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 3 3
4 4 3 3 3
end fill
ara=13 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 3 3
3 3 3 3 3
3 3 3 3 3
3 3 3 2 2
end fill
ara=14 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
2 2 2 2 2
end fill
ara=15 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 4 4 4
3 3 3 3 3
3 3 3 3 3
2 2 3 3 3
end fill
ara=16 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
3 3 4 4 4
3 3 3 4 4
end fill
ara=17 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=21 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 3
4 4 4 3 3
4 4 4 3 3
end fill
ara=22 nux=5 nuy=5 nuz=1
fill
4 3 3 3 3
3 3 3 3 2
3 3 3 2 2
3 3 2 2 2
3 2 2 2 2
end fill
ara=23 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
2 2 2 2 2
2 2 2 2 2
end fill
ara=24 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
1 1 1 1 1
end fill
ara=25 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=26 nux=5 nuy=5 nuz=1
fill
3 3 3 3 4
2 3 3 3 3
2 2 3 3 3
2 2 2 3 3
2 2 2 2 3
end fill
ara=27 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
3 4 4 4 4
3 3 4 4 4
3 3 4 4 4
end fill
ara=31 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
4 3 3 3 2
4 3 3 3 2
end fill
ara=32 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=33 nux=5 nuy=5 nuz=1
fill
2 2 2 1 1
2 1 1 86 86
2 1 81 84 86
1 84 84 83 85
1 84 84 83 85
end fill
ara=34 nux=5 nuy=5 nuz=1
fill
88 88 88 88 88
82 82 82 82 82
82 82 82 82 82
83 83 83 83 83
83 83 83 83 83
end fill
ara=35 nux=5 nuy=5 nuz=1
fill
1 1 2 2 2
86 86 1 1 2
86 84 81 1 2
85 83 84 85 1
85 83 84 85 1
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
end fill
ara=36 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=37 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=41 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
end fill
ara=42 nux=5 nuy=5 nuz=1
fill
2 2 2 2 1
2 2 2 2 1
2 2 2 2 1
2 2 2 2 1
2 2 2 2 1
end fill
ara=43 nux=5 nuy=5 nuz=1
fill
81 87 84 85 85
81 84 84 85 85
82 85 85 85 85
81 84 81 85 85
81 87 81 85 85
end fill
ara=44 nux=5 nuy=5 nuz=1
fill
83 83 83 83 83
83 83 83 83 83
83 83 83 83 83
83 83 83 83 83
83 83 83 83 83
end fill
ara=45 nux=5 nuy=5 nuz=1
fill
85 85 84 87 81
85 85 84 84 81
85 85 85 85 82
85 85 81 84 81
85 85 81 87 81
end fill
ara=46 nux=5 nuy=5 nuz=1
fill
1 2 2 2 2
1 2 2 2 2
1 2 2 2 2
1 2 2 2 2
1 2 2 2 2
end fill
ara=47 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=51 nux=5 nuy=5 nuz=1
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
fill
4 3 3 3 2
4 3 3 3 2
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
end fill
ara=52 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=53 nux=5 nuy=5 nuz=1
fill
1 84 84 83 85
1 82 84 83 85
2 1 81 84 84
2 1 1 86 86
2 2 2 1 1
end fill
ara=54 nux=5 nuy=5 nuz=1
fill
83 83 83 83 83
83 83 83 83 83
82 82 82 82 82
82 82 82 82 82
88 88 88 88 88
end fill
ara=55 nux=5 nuy=5 nuz=1
fill
85 83 84 84 1
85 83 84 82 1
84 84 81 1 2
86 86 1 1 2
1 1 2 2 2
end fill
ara=56 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=57 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
end fill
ara=61 nux=5 nuy=5 nuz=1
fill
4 4 4 3 3
4 4 4 3 3
4 4 4 4 3
4 4 4 4 4
4 4 4 4 4
end fill
ara=62 nux=5 nuy=5 nuz=1
fill
3 2 2 2 2
3 3 2 2 2
3 3 3 2 2
3 3 3 3 2
4 3 3 3 3
end fill
ara=63 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=64 nux=5 nuy=5 nuz=1
fill
1 1 1 1 1
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=65 nux=5 nuy=5 nuz=1
fill
1 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=66 nux=5 nuy=5 nuz=1
fill
2 2 2 2 3
2 2 2 3 3
2 2 3 3 3
2 3 3 3 3
3 3 3 3 4
end fill
ara=67 nux=5 nuy=5 nuz=1
fill
3 3 4 4 4
3 3 4 4 4
3 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=71 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=72 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 4 3 3
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=73 nux=5 nuy=5 nuz=1
fill
3 3 3 2 2
3 3 3 3 3
3 3 3 3 3
4 4 4 3 3
4 4 4 4 4
end fill
ara=74 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
4 4 4 4 4
end fill
ara=75 nux=5 nuy=5 nuz=1
fill
2 2 3 3 3
3 3 3 3 3
3 3 3 3 3

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3 3 4 4 4
4 4 4 4 4
end fill
ara=76 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=77 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=100 nux=7 nuy=7 nuz=1
fill
11 12 13 14 15 16 17
21 22 23 24 25 26 27
31 32 33 34 35 36 37
41 42 43 44 45 46 47
51 52 53 54 55 56 57
61 62 63 64 65 66 67
71 72 73 74 75 76 77
end fill
end array
read plot
ttl='simple plot 1'
pic=mix
xul= 0 yul= 190 zul= 100.5
xlr= 190 ylr= 0 zlr= 100.5
uax=1.0 vdn=-1.0
nax=1200
lpi=10
scr=yes end
ttl='simple plot 1'
pic=mix
xul= 45 yul= 145 zul= 100.5
xlr= 145 ylr= 45 zlr= 100.5
uax=1.0 vdn=-1.0
nax=1200
lpi=10
scr=yes end
ttl='simple plot 4'
pic=mix
xul= 0 yul= 95.6 zul= 168
xlr= 190 ylr= 95.6 zlr= 0
uax=1.0 wdn=-1.0
nax=800
scr=yes end
end plot
end data
end

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
=cons9901
TASK:
  MULTIC= 1
  NOUT  = 2
  IHT   = 4
  IHS   = 77
  NG    = 299
  IPRIB = 0
  idelta= 1
  NMOM  = 5
  IZT   = 19
  NRZT  = 16
  INZ   = 28
NAME=
'PU38' 'PU39' 'PU40' 'PU41' 'PU42' 'AM41' 'GA'
'U235' 'U238NR'
'NA'
'H+H(FREE)' 'C' 'N' 'O' 'AL' 'SI' 'CR' 'MN' 'FE' 'NI' 'MO'
'NB' 'TI' 'CU' 'P' 'S' 'CA' 'D-SC'
RO=
*1 PU
3.0461E-05 2.8920E-02 6.9095E-03 7.3960E-04 1.8699E-04 4.5718E-04 2.0166E-03
0.0000E+00 6.8782E-07 0.0000E+00 1.2764E-04 4.2260E-04 2.4215E-05 8.8450E-05
2.2973E-05 1.4158E-05 3.5989E-06 1.4902E-06 1.6335E-05 8.5688E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*2 CAN
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.3760E-05 1.1393E-04 0.0000E+00 0.0000E+00
0.0000E+00 3.6607E-04 9.4011E-03 8.5931E-04 3.5542E-02 4.1646E-03 0.0000E+00
0.0000E+00 0.0000E+00 1.6613E-02 1.3731E-05 0.0000E+00 0.0000E+00 0.0000E+00
*3 UO2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.6585E-04 2.2894E-02 0.0000E+00 3.1852E-05 1.1837E-05 0.0000E+00 4.6122E-02
3.3995E-06 2.3024E-05 0.0000E+00 8.3479E-08 1.3139E-06 1.2503E-06 3.3462E-07
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*4 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.8834E-05 1.2695E-04 0.0000E+00 0.0000E+00
0.0000E+00 6.3794E-04 1.3673E-02 8.4655E-04 4.7796E-02 8.3368E-03 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 3.4708E-04 3.5660E-05 0.0000E+00 0.0000E+00
*5 na
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 2.3225E-02 1.3900E-05 0.0000E+00 0.0000E+00 5.6492E-06
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.6184E-07 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 3.6083E-06 0.0000E+00
*6 can
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.1631E-05 2.9290E-04 0.0000E+00 0.0000E+00
0.0000E+00 6.0867E-04 1.4759E-02 1.3570E-03 5.5054E-02 7.0982E-03 0.0000E+00
3.1147E-04 0.0000E+00 0.0000E+00 3.2795E-05 3.3219E-05 0.0000E+00 0.0000E+00
*7 ss
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 1.8355E-05 8.7794E-05 0.0000E+00 0.0000E+00
1.1862E-04 7.9703E-04 1.5908E-02 1.4972E-03 5.5367E-02 8.7976E-03 8.0988E-05
5.0000E-06 2.4806E-04 5.0365E-05 4.0018E-05 1.4422E-05 0.0000E+00 0.0000E+00
*8 sheath
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 7.5712E-05 2.3825E-04 0.0000E+00 0.0000E+00
1.9798E-05 0.0000E+00 3.6690E-06 2.5697E-04 7.7524E-02 1.4302E-05 0.0000E+00
0.0000E+00 0.0000E+00 2.2216E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*9 U8
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.3369E-04 4.6021E-02 0.0000E+00 4.4048E-05 4.9283E-04 0.0000E+00 0.0000E+00
0.0000E+00 2.1076E-04 0.0000E+00 0.0000E+00 1.0599E-04 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*10 U2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.3962E-04 4.6785E-02 0.0000E+00 4.3899E-05 4.6047E-04 0.0000E+00 0.0000E+00
0.0000E+00 1.9692E-04 0.0000E+00 0.0000E+00 9.9032E-05 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*11 U3
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
3.4209E-04 4.7156E-02 0.0000E+00 4.4574E-05 4.7140E-04 0.0000E+00 0.0000E+00
0.0000E+00 2.0160E-04 0.0000E+00 0.0000E+00 1.0138E-04 0.0000E+00 0.0000E+00
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*12 mst3
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.5700E-05 5.1066E-04 0.0000E+00 0.0000E+00
1.3989E-04 0.0000E+00 2.7222E-05 3.2634E-04 8.3806E-02 4.8234E-05 9.8355E-06
0.0000E+00 3.9416E-05 4.4548E-05 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*13 mst9f10
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.6306E-05 6.8972E-04 0.0000E+00 0.0000E+00
0.0000E+00 3.1158E-04 0.0000E+00 7.1275E-04 8.1432E-02 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 4.2944E-05 3.7110E-05 0.0000E+00 0.0000E+00
*14 stnavr4
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.4073E-05 2.7547E-04 0.0000E+00 0.0000E+00
0.0000E+00 7.5592E-04 1.6594E-02 1.1688E-03 5.9245E-02 9.9342E-03 0.0000E+00
4.0746E-04 0.0000E+00 0.0000E+00 4.5399E-05 1.2036E-05 0.0000E+00 0.0000E+00
*15 stnavs4
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 2.4073E-05 2.5251E-04 0.0000E+00 0.0000E+00
0.0000E+00 7.4610E-04 1.6248E-02 1.5006E-03 5.9881E-02 9.4005E-03 0.0000E+00
3.7393E-04 0.0000E+00 0.0000E+00 1.7803E-05 1.7195E-05 0.0000E+00 0.0000E+00
*16 stnav4
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 3.3245E-06 3.3477E-05 0.0000E+00 0.0000E+00
0.0000E+00 1.2169E-04 2.4643E-03 1.9518E-04 8.0717E-03 1.2195E-03 0.0000E+00
5.2657E-05 0.0000E+00 0.0000E+00 4.9764E-06 2.5076E-06 0.0000E+00 0.0000E+00

*17 HOMO
1.4474E-06 1.3741E-03 3.2831E-04 3.5142E-05 8.8849E-06 2.1723E-05 9.5819E-05
4.0193E-05 5.5482E-03 0.0000E+00 2.1415E-05 6.4517E-05 1.1506E-06 1.1182E-02
6.5613E-06 1.2254E-04 2.5197E-03 2.2375E-04 1.3307E-02 1.4328E-03 2.5139E-06
2.2759E-05 7.4514E-06 5.0199E-04 2.2403E-05 3.4982E-06 0.0000E+00 0.0000E+00

***** D-SC
*18 PU
3.0461E-05 2.8920E-02 6.9095E-03 7.3960E-04 1.8699E-04 4.5718E-04 2.0166E-03
0.0000E+00 6.8782E-07 0.0000E+00 1.2764E-04 4.2260E-04 2.4215E-05 8.8450E-05
2.2973E-05 1.4158E-05 3.5989E-06 1.4902E-06 1.6335E-05 8.5688E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.3327E+00
*19 UO2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.6585E-04 2.2894E-02 0.0000E+00 3.1852E-05 1.1837E-05 0.0000E+00 4.6122E-02
3.3995E-06 2.3024E-05 0.0000E+00 8.3479E-08 1.3139E-06 1.2503E-06 3.3462E-07
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.1022E+00

ICOR =
18 17 19 17 17 17 17 17
9 10 11 12 13 17 17 17
17 18 19
NAMESUB='U238NR' 'PU39'
NGSUB=10 11 12 13 14 15 16 17 18 19 20 21 22 23
END
end
=subgran
end
=lava
-1$$ 2500000
0$$ 71 72 18 19
1$$ 16 755 4 91 845 61 0 -1 1 t
2$$ 1411000 16000
3$$ F5
4$$ 141100 1600
5$$ 1 1452 27 1018
7**
2.00000E+07 1.86181E+07 1.73316E+07 1.61341E+07 1.50192E+07
1.39818E+07 1.30158E+07 1.21165E+07 1.12793E+07 1.05000E+07
9.69341E+06 8.94878E+06 8.26136E+06 7.62674E+06 7.04086E+06
6.50000E+06 5.99475E+06 5.52877E+06 5.09902E+06 4.70267E+06
4.33713E+06 4.00000E+06 3.69862E+06 3.41995E+06 3.16228E+06
2.92402E+06 2.70371E+06 2.50000E+06 2.32522E+06 2.16265E+06
2.01146E+06 1.87083E+06 1.74003E+06 1.61838E+06 1.50524E+06
1.40000E+06 1.30541E+06 1.21722E+06 1.13498E+06 1.05830E+06
9.86800E+05 9.20131E+05 8.57965E+05 8.00000E+05 7.40700E+05
6.85795E+05 6.34960E+05 5.87894E+05 5.44316E+05 5.03968E+05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

4.66612E+05	4.32024E+05	4.00000E+05	3.70350E+05	3.42898E+05
3.17480E+05	2.93947E+05	2.72158E+05	2.51984E+05	2.33306E+05
2.16012E+05	2.00000E+05	1.91435E+05	1.85175E+05	1.77154E+05
1.71449E+05	1.63937E+05	1.58740E+05	1.51708E+05	1.46973E+05
1.40390E+05	1.36079E+05	1.29916E+05	1.25992E+05	1.20222E+05
1.16653E+05	1.11251E+05	1.08006E+05	1.02951E+05	1.00000E+05
9.60586E+04	9.38042E+04	9.00741E+04	8.79923E+04	8.44625E+04
8.25404E+04	7.92005E+04	7.74264E+04	7.42663E+04	7.26292E+04
6.96395E+04	6.81292E+04	6.53014E+04	6.39081E+04	6.12343E+04
5.99484E+04	5.74205E+04	5.62341E+04	5.38442E+04	5.27500E+04
5.04907E+04	4.94817E+04	4.73460E+04	4.64159E+04	4.52365E+04
4.43972E+04	4.38990E+04	4.35400E+04	4.24188E+04	4.16320E+04
4.11705E+04	4.08424E+04	3.97762E+04	3.90389E+04	3.86114E+04
3.83119E+04	3.72981E+04	3.66074E+04	3.62115E+04	3.59381E+04
3.49744E+04	3.43274E+04	3.39609E+04	3.37115E+04	3.27956E+04
3.21894E+04	3.18504E+04	3.16227E+04	3.07523E+04	3.01846E+04
2.98710E+04	2.96635E+04	2.88362E+04	2.83046E+04	2.80147E+04
2.78256E+04	2.70395E+04	2.65418E+04	2.62738E+04	2.61015E+04
2.53546E+04	2.48887E+04	2.46412E+04	2.44843E+04	2.37747E+04
2.33386E+04	2.31100E+04	2.29673E+04	2.22931E+04	2.18850E+04
2.16741E+04	2.13643E+04	2.09038E+04	2.05218E+04	2.03274E+04
2.02095E+04	1.96011E+04	1.92437E+04	1.90644E+04	1.89573E+04
1.83795E+04	1.80451E+04	1.78800E+04	1.77828E+04	1.72340E+04
1.69213E+04	1.67692E+04	1.66810E+04	1.61599E+04	1.58674E+04
1.57274E+04	1.56475E+04	1.51527E+04	1.48791E+04	1.47504E+04
1.46780E+04	1.42082E+04	1.39524E+04	1.38342E+04	1.37686E+04
1.33225E+04	1.30834E+04	1.29748E+04	1.29155E+04	1.24919E+04
1.22685E+04	1.21688E+04	1.21153E+04	1.17131E+04	1.15044E+04
1.14130E+04	1.13646E+04	1.09828E+04	1.07879E+04	1.07041E+04
1.06605E+04	1.02980E+04	1.01159E+04	1.00393E+04	1.00000E+04
9.65597E+03	9.48588E+03	9.41580E+03	9.38042E+03	9.05389E+03
8.89508E+03	8.83104E+03	8.79923E+03	8.48930E+03	8.34103E+03
8.28260E+03	8.25404E+03	7.95994E+03	7.82153E+03	7.76826E+03
7.74264E+03	7.46356E+03	7.33439E+03	7.28588E+03	7.26292E+03
6.99809E+03	6.87754E+03	6.83345E+03	6.81292E+03	6.56175E+03
6.44928E+03	6.40918E+03	6.39081E+03	6.15266E+03	6.04776E+03
6.01129E+03	5.99484E+03	5.76907E+03	5.67124E+03	5.63811E+03
5.62341E+03	5.40937E+03	5.31816E+03	5.28811E+03	5.27500E+03
5.07209E+03	4.98706E+03	4.95985E+03	4.94817E+03	4.75585E+03
4.67660E+03	4.65199E+03	4.64159E+03	4.45930E+03	4.38545E+03
4.36323E+03	4.35400E+03	4.18123E+03	4.11242E+03	4.09241E+03
4.08424E+03	3.92049E+03	3.85639E+03	3.83841E+03	3.83119E+03
3.67600E+03	3.61629E+03	3.60018E+03	3.59381E+03	3.44677E+03
3.39115E+03	3.37674E+03	3.37114E+03	3.23181E+03	3.18002E+03
3.16718E+03	3.16227E+03	3.03025E+03	2.98204E+03	2.97063E+03
2.96635E+03	2.84126E+03	2.79638E+03	2.78628E+03	2.78256E+03
2.66404E+03	2.62228E+03	2.61338E+03	2.61015E+03	2.49787E+03
2.45903E+03	2.45121E+03	2.44843E+03	2.34207E+03	2.30593E+03
2.29911E+03	2.29673E+03	2.19597E+03	2.16237E+03	2.15646E+03
2.15443E+03	2.08156E+03	2.05753E+03	2.03423E+03	2.02643E+03
2.02233E+03	2.02095E+03	1.94867E+03	1.92530E+03	1.91246E+03
1.90823E+03	1.90091E+03	1.89850E+03	1.89642E+03	1.89573E+03
1.82083E+03	1.79713E+03	1.78450E+03	1.78042E+03	1.77880E+03
1.77828E+03	1.71599E+03	1.69659E+03	1.68085E+03	1.67586E+03
1.67210E+03	1.67091E+03	1.66878E+03	1.66810E+03	1.62473E+03
1.61140E+03	1.58045E+03	1.57089E+03	1.56621E+03	1.56475E+03
1.50398E+03	1.48581E+03	1.47431E+03	1.47080E+03	1.46850E+03
1.46780E+03	1.41805E+03	1.40341E+03	1.38536E+03	1.37998E+03
1.37758E+03	1.37686E+03	1.31491E+03	1.29719E+03	1.29283E+03
1.29155E+03	1.24774E+03	1.23536E+03	1.21853E+03	1.21371E+03
1.21202E+03	1.21153E+03	1.17775E+03	1.16836E+03	1.14755E+03
1.14173E+03	1.13762E+03	1.13646E+03	1.10141E+03	1.09189E+03
1.07319E+03	1.06806E+03	1.06649E+03	1.06605E+03	1.02376E+03
1.01259E+03	1.00357E+03	1.00114E+03	1.00024E+03	1.00000E+03
9.66236E+02	9.57470E+02	9.49570E+02	9.47485E+02	9.42407E+02
9.41065E+02	9.38675E+02	9.38042E+02	8.99406E+02	8.89639E+02
8.83723E+02	8.82194E+02	8.80390E+02	8.79923E+02	8.46636E+02
8.38387E+02	8.30030E+02	8.27921E+02	8.25913E+02	8.25404E+02
7.89300E+02	7.80584E+02	7.76423E+02	7.75394E+02	7.74492E+02
7.74269E+02	7.37010E+02	7.28241E+02	7.26676E+02	7.26296E+02
6.95229E+02	6.88058E+02	6.84227E+02	6.83321E+02	6.81684E+02
6.81296E+02	6.51912E+02	6.45279E+02	6.41161E+02	6.40210E+02
6.39296E+02	6.39085E+02	6.11590E+02	6.05519E+02	6.01580E+02
6.00689E+02	5.99710E+02	5.99488E+02	5.75586E+02	5.70412E+02

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

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5.65542E+02 5.64467E+02 5.62730E+02 5.62345E+02 5.36729E+02
5.31326E+02 5.29011E+02 5.28509E+02 5.27682E+02 5.27503E+02
5.03701E+02 4.98792E+02 4.96329E+02 4.95808E+02 4.94993E+02
4.94820E+02 4.70155E+02 4.65202E+02 4.64340E+02 4.64162E+02
4.40985E+02 4.36438E+02 4.35577E+02 4.35403E+02 4.17034E+02
4.13497E+02 4.10542E+02 4.09960E+02 4.08679E+02 4.08426E+02
3.89954E+02 3.86488E+02 3.84318E+02 3.83901E+02 3.83247E+02
3.83121E+02 3.63761E+02 3.60231E+02 3.59518E+02 3.59384E+02
3.46541E+02 3.44235E+02 3.40010E+02 3.39241E+02 3.38106E+02
3.37898E+02 3.37238E+02 3.37117E+02 3.19313E+02 3.16230E+02
3.07376E+02 3.02104E+02 2.97359E+02 2.97025E+02 2.96822E+02
2.96637E+02 2.82831E+02 2.80486E+02 2.79215E+02 2.78994E+02
2.78367E+02 2.78258E+02 2.70318E+02 2.65502E+02 2.63863E+02
2.62708E+02 2.61994E+02 2.61748E+02 2.61349E+02 2.61102E+02
2.61017E+02 2.47008E+02 2.44845E+02 2.37617E+02 2.34994E+02
2.32422E+02 2.31245E+02 2.30811E+02 2.30381E+02 2.29975E+02
2.29824E+02 2.29675E+02 2.19156E+02 2.15445E+02 2.10258E+02
2.09166E+02 2.04427E+02 2.03428E+02 2.02821E+02 2.02692E+02
2.02201E+02 2.02096E+02 1.97202E+02 1.93488E+02 1.91406E+02
1.90813E+02 1.90355E+02 1.90094E+02 1.89860E+02 1.89678E+02
1.89575E+02 1.82295E+02 1.79185E+02 1.78715E+02 1.78509E+02
1.78209E+02 1.78077E+02 1.77905E+02 1.77829E+02 1.71468E+02
1.68053E+02 1.66811E+02 1.58152E+02 1.57088E+02 1.56545E+02
1.56476E+02 1.48817E+02 1.46781E+02 1.39817E+02 1.38221E+02
1.37789E+02 1.37687E+02 1.33160E+02 1.29901E+02 1.29156E+02
1.24352E+02 1.22028E+02 1.21154E+02 1.19058E+02 1.17703E+02
1.17309E+02 1.16008E+02 1.15163E+02 1.14916E+02 1.14504E+02
1.14234E+02 1.14155E+02 1.13880E+02 1.13700E+02 1.13647E+02
1.08936E+02 1.07009E+02 1.06606E+02 1.04367E+02 1.02788E+02
1.02221E+02 1.01371E+02 1.00765E+02 1.00546E+02 1.00270E+02
1.00072E+02 1.00001E+02 9.49147E+01 9.38048E+01 9.00591E+01
8.84578E+01 8.79928E+01 8.53864E+01 8.29607E+01 8.25409E+01
8.00020E+01 7.87116E+01 7.81267E+01 7.78241E+01 7.75626E+01
7.74269E+01 7.48414E+01 7.31916E+01 7.26296E+01 6.81296E+01
6.64990E+01 6.57970E+01 6.55235E+01 6.47774E+01 6.44532E+01
6.43264E+01 6.40667E+01 6.39533E+01 6.39089E+01 6.16780E+01
5.99492E+01 5.77630E+01 5.69789E+01 5.62349E+01 5.43365E+01
5.31530E+01 5.27507E+01 5.12878E+01 5.00051E+01 4.94823E+01
4.71930E+01 4.64165E+01 4.39677E+01 4.35406E+01 4.15092E+01
4.08429E+01 3.86248E+01 3.83124E+01 3.71495E+01 3.62881E+01
3.59386E+01 3.40190E+01 3.37119E+01 3.20656E+01 3.16232E+01
2.96639E+01 2.78259E+01 2.70538E+01 2.63962E+01 2.61019E+01
2.44847E+01 2.33182E+01 2.29676E+01 2.24015E+01 2.18633E+01
2.15446E+01 2.10496E+01 2.09018E+01 2.05679E+01 2.04677E+01
2.02695E+01 2.02098E+01 1.89576E+01 1.81519E+01 1.78913E+01
1.77830E+01 1.69505E+01 1.66812E+01 1.60901E+01 1.56477E+01
1.48289E+01 1.46782E+01 1.37687E+01 1.29157E+01 1.22858E+01
1.21154E+01 1.17726E+01 1.15521E+01 1.13648E+01 1.09868E+01
1.06606E+01 1.02388E+01 1.00001E+01 9.62837E+00 9.38054E+00
8.79934E+00 8.46274E+00 8.25415E+00 8.07648E+00 7.90335E+00
7.74274E+00 7.49870E+00 7.33772E+00 7.26301E+00 6.81301E+00
6.64826E+00 6.50284E+00 6.39089E+00 5.99492E+00 5.62349E+00
5.27506E+00 4.94823E+00 4.64165E+00 4.35406E+00 4.08429E+00
3.83124E+00 3.59386E+00 3.37119E+00 3.16232E+00 2.96639E+00
2.78259E+00 2.61019E+00 2.44847E+00 2.29676E+00 2.15446E+00
2.02098E+00 1.89576E+00 1.77830E+00 1.66812E+00 1.56477E+00
1.46782E+00 1.37687E+00 1.29157E+00 1.21154E+00 1.13648E+00
1.06606E+00 1.00001E+00 9.38054E-01 8.79934E-01 8.25415E-01
7.74274E-01 7.26301E-01 6.81301E-01 6.39089E-01 5.99492E-01
5.62348E-01 5.27506E-01 4.94823E-01 4.64165E-01 4.35406E-01
4.08429E-01 3.83124E-01 3.59386E-01 3.37119E-01 3.16232E-01
2.96639E-01 2.78259E-01 2.61019E-01 2.44847E-01 2.29676E-01
2.15446E-01 1.89576E-01 1.66812E-01 1.46782E-01 1.29157E-01
1.13647E-01 1.00001E-01 8.25415E-02 6.81301E-02 5.62348E-02
4.64165E-02 3.83124E-02 3.16232E-02 2.61019E-02 2.15446E-02
1.77830E-02 1.46782E-02 1.21155E-02 1.00001E-02 6.81301E-03
4.64164E-03 3.16231E-03 2.15446E-03 1.00001E-03 1.00001E-04
1.00001E-05
9$$ F0 t
end
#sc_bin
72
75
end

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
#kenova
zebra 24b (215)
read param
tme=1000
lib=75
lng=25000000
nb8=70000
gen=2020
npg=10000
nsk=20
run=yes
plt=no
end param
read mixt
sct=3
eps=1.
mix=1 100 1.
mix=2 200 1.
mix=3 300 1.
mix=4 400 1.
mix=5 500 1.
mix=6 600 1.
mix=7 700 1.
mix=8 800 1.
mix=9 900 1.
mix=10 1000 1.
mix=11 1100 1.
mix=12 1200 1.
mix=13 1300 1.
mix=14 1400 1.
mix=15 1500 1.
mix=16 1600 1.
end mixt
read geometry
unit 1
com='core'
array 111 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 111
com='pu'
cuboid 1 1 4p2.3355 0.28170 0.0457
cuboid 2 1 4p2.5335 0.32740 0
unit 112
com='uo2'
cuboid 3 1 4p2.4255 0.59465 0.03665
cuboid 4 1 4p2.5335 0.63130 0
unit 113
com='na'
cuboid 5 1 4p2.4815 0.577347 0.036347
cuboid 6 1 4p2.5335 0.613694 0
unit 114
com='ss'
cuboid 0 1 4p1.9625 0.31700 0
cuboid 7 1 4p2.5335 0.31700 0
unit 115
com='stnavr4'
cylinder 0 1 2.3000 0.61600 0
cylinder 14 1 2.5335 0.61600 0
cuboid 0 1 4p2.5335 0.61600 0
unit 116
com='stnavs4'
cylinder 0 1 2.3000 0.61600 0
cylinder 15 1 2.5335 0.61600 0
cuboid 0 1 4p2.5335 0.61600 0
unit 117
com='stnav4'
cuboid 16 1 4p2.5335 0.61600 0
unit 211
com='u8'
cuboid 9 1 4p2.5335 9.82700 0
unit 212
com='u2'
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

cuboid 10 1 4p2.5335      12.72300 0
unit 213
com='u3'
cuboid 11 1 4p2.5335      7.62250 0
unit 311
com='mst3'
cuboid 12 1 4p2.5335      7.60628 0
unit 511
com='air'
cuboid 0 1 4p2.5335      1.3095 0
unit 2
com='u3-radial'
cuboid 12 1 4p2.5335      7.60628 0
cuboid 11 1 4p2.5335     160.05628 0
cuboid 12 1 4p2.5335     167.66256 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 3
com='mst9f10'
cuboid 13 1 4p2.54000    167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 4
com='empty tube'
cuboid 0 1 4p2.55100    167.66256 0
cuboid 8 1 4p2.62720    167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 5
com='core'
array 115 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 6
com='core'
array 116 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 7
com='core'
array 117 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510     167.66256 0
cuboid 8 1 4p2.6272     167.66256 0
cuboid 0 1 4p2.68605    167.66256 0
unit 11
com='2'
array 11 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 12
com='2'
array 12 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 13
com='2'
array 13 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 14
com='2'
array 14 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 15
com='2'
array 15 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 16
com='2'
array 16 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 17
com='2'
array 17 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635    167.66256 0
unit 21

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

com='2'
array 21  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 22
com='2'
array 22  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 23
com='2'
array 23  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 24
com='2'
array 24  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 25
com='2'
array 25  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 26
com='2'
array 26  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 27
com='2'
array 27  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 31
com='2'
array 31  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 32
com='2'
array 32  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 33
com='2'
array 33  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 34
com='2'
array 34  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 35
com='2'
array 35  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 36
com='2'
array 36  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 37
com='2'
array 37  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 41
com='2'
array 41  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 42
com='2'
array 42  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 43
com='2'
array 43  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 44
com='2'
array 44  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 45
com='2'
array 45  -13.43025 -13.43025  0

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

cuboid 0 1 4p13.5635 167.66256 0
unit 46
com='2'
array 46 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 47
com='2'
array 47 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 51
com='2'
array 51 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 52
com='2'
array 52 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 53
com='2'
array 53 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 54
com='2'
array 54 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 55
com='2'
array 55 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 56
com='2'
array 56 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 57
com='2'
array 57 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 61
com='2'
array 61 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 62
com='2'
array 62 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 63
com='2'
array 63 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 64
com='2'
array 64 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 65
com='2'
array 65 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 66
com='2'
array 66 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 67
com='2'
array 67 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 71
com='2'
array 71 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 72
com='2'
array 72 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 73

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
com='2'
array 73 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 74
com='2'
array 74 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 75
com='2'
array 75 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 76
com='2'
array 76 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 77
com='2'
array 77 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
global unit 100
com='reactor'
array 100 3*0
end geometry
read array
ara=115 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
115 112 115 111 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 111 115 112 115
211 212 213 311 511
end fill
ara=116 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
116 112 116 111 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 111 116 112 116
211 212 213 311 511
end fill
ara=117 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
117 112 117 111 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
117 112 114 111 117 112 117   117 112 117 111 114 112 117
117 112 111 117 112 117
211 212 213 311 511
end fill
ara=11 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=12 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 3 3
4 4 3 3 3
end fill
ara=13 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 3 3
3 3 3 3 3
3 3 3 3 3
3 3 3 2 2
end fill
ara=14 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
2 2 2 2 2
end fill
ara=15 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 4 4 4
3 3 3 3 3
3 3 3 3 3
2 2 3 3 3
end fill
ara=16 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
3 3 4 4 4
3 3 3 4 4
end fill
ara=17 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=21 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 3
4 4 4 3 3
4 4 4 3 3
end fill
ara=22 nux=5 nuy=5 nuz=1
fill
4 3 3 3 3
3 3 3 3 2
3 3 3 2 2
3 3 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
3 2 2 2 2
end fill
ara=23 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=24 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 7 7 7 2
end fill
ara=25 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=26 nux=5 nuy=5 nuz=1
fill
3 3 3 3 4
2 3 3 3 3
2 2 3 3 3
2 2 2 3 3
2 2 2 2 3
end fill
ara=27 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
3 4 4 4 4
3 3 4 4 4
3 3 4 4 4
end fill
ara=31 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
4 3 3 3 2
4 3 3 3 2
end fill
ara=32 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=33 nux=5 nuy=5 nuz=1
fill
2 2 2 7 7
2 2 7 6 6
2 7 6 6 6
7 6 6 6 6
7 6 6 6 5
end fill
ara=34 nux=5 nuy=5 nuz=1
fill
6 6 6 6 6
6 6 6 6 6
6 6 6 6 6
5 5 5 5 5
5 5 5 5 5
end fill
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
ara=35 nux=5 nuy=5 nuz=1
fill
7 7 2 2 2
6 6 7 7 2
6 6 6 7 2
6 6 6 6 7
5 6 6 6 6
end fill
ara=36 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=37 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=41 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
end fill
ara=42 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 7
2 2 2 2 7
2 2 2 2 7
2 2 2 2 2
end fill
ara=43 nux=5 nuy=5 nuz=1
fill
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
end fill
ara=44 nux=5 nuy=5 nuz=1
fill
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
end fill
ara=45 nux=5 nuy=5 nuz=1
fill
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
end fill
ara=46 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
7 2 2 2 2
7 2 2 2 2
7 2 2 2 2
2 2 2 2 2
end fill
ara=47 nux=5 nuy=5 nuz=1
fill
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=51 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
end fill
ara=52 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=53 nux=5 nuy=5 nuz=1
fill
7 6 6 6 5
7 6 6 6 6
2 7 6 6 6
2 7 7 6 6
2 2 2 7 7
end fill
ara=54 nux=5 nuy=5 nuz=1
fill
5 5 6 5 5
5 5 6 5 5
6 6 5 6 6
6 6 5 6 6
6 6 6 6 6
end fill
ara=55 nux=5 nuy=5 nuz=1
fill
5 6 6 6 7
6 6 6 6 7
6 6 6 7 2
6 6 7 2 2
7 7 2 2 2
end fill
ara=56 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=57 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
end fill
ara=61 nux=5 nuy=5 nuz=1
fill
4 4 4 3 3
4 4 4 3 3
4 4 4 4 3
4 4 4 4 4
4 4 4 4 4
end fill
ara=62 nux=5 nuy=5 nuz=1
fill
3 2 2 2 2
3 3 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
3 3 3 2 2
3 3 3 3 2
4 3 3 3 3
end fill
ara=63 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=64 nux=5 nuy=5 nuz=1
fill
2 7 7 7 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=65 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=66 nux=5 nuy=5 nuz=1
fill
2 2 2 2 3
2 2 2 3 3
2 2 3 3 3
2 3 3 3 3
3 3 3 3 4
end fill
ara=67 nux=5 nuy=5 nuz=1
fill
3 3 4 4 4
3 3 4 4 4
3 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=71 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=72 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 4 3 3
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=73 nux=5 nuy=5 nuz=1
fill
3 3 3 2 2
3 3 3 3 3
3 3 3 3 3
4 4 4 3 3
4 4 4 4 4
end fill
ara=74 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4 4 4 4 4
end fill
ara=75 nux=5 nuy=5 nuz=1
fill
2 2 3 3 3
3 3 3 3 3
3 3 3 3 3
3 3 4 4 4
4 4 4 4 4
end fill
ara=76 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=77 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=100 nux=7 nuy=7 nuz=1
fill
11 12 13 14 15 16 17
21 22 23 24 25 26 27
31 32 33 34 35 36 37
41 42 43 44 45 46 47
51 52 53 54 55 56 57
61 62 63 64 65 66 67
71 72 73 74 75 76 77
end fill
end array
read plot
ttl='simple plot 1'
pic=mix
xul= 0 yul= 190 zul= 100
xlr= 190 ylr= 0 zlr= 100
uax=1.0 vdn=-1.0
nax=1200
lpi=10
scr=yes end
ttl='simple plot 4'
pic=mix
xul= 0 yul= 95 zul= 168
xlr= 190 ylr= 95 zlr= 0
uax=1.0 wdn=-1.0
nax=800
scr=yes end
end plot
end data
end
=cons9901
TASK:
MULTIC= 1
NOUT = 2
IHT = 4
IHS = 77
NG = 299
IPRIB = 0
idelta= 1
NMOM = 5
IZT = 19
NRZT = 16
INZ = 28
NAME=
'PU38' 'PU39' 'PU40' 'PU41' 'PU42' 'AM41' 'GA'
'U235' 'U238NR'
'NA'
'H+H(FREE)' 'C' 'N' 'O' 'AL' 'SI' 'CR' 'MN' 'FE' 'NI' 'MO'

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

'NB' 'TI' 'CU' 'P' 'S' 'CA' 'D-SC'

RO=

*1 PU

3.0461E-05	2.8920E-02	6.9095E-03	7.3960E-04	1.8699E-04	4.5718E-04	2.0166E-03
0.0000E+00	6.8782E-07	0.0000E+00	1.2764E-04	4.2260E-04	2.4215E-05	8.8450E-05
2.2973E-05	1.4158E-05	3.5989E-06	1.4902E-06	1.6335E-05	8.5688E-06	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*2 CAN

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.3760E-05	1.1393E-04	0.0000E+00	0.0000E+00
0.0000E+00	3.6607E-04	9.4011E-03	8.5931E-04	3.5542E-02	4.1646E-03	0.0000E+00
0.0000E+00	0.0000E+00	1.6613E-02	1.3731E-05	0.0000E+00	0.0000E+00	0.0000E+00

*3 UO2

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.6585E-04	2.2894E-02	0.0000E+00	3.1852E-05	1.1837E-05	0.0000E+00	4.6122E-02
3.3995E-06	2.3024E-05	0.0000E+00	8.3479E-08	1.3139E-06	1.2503E-06	3.3462E-07
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*4 can

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.8834E-05	1.2695E-04	0.0000E+00	0.0000E+00
0.0000E+00	6.3794E-04	1.3673E-02	8.4655E-04	4.7796E-02	8.3368E-03	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	3.4708E-04	3.5660E-05	0.0000E+00	0.0000E+00

*5 na

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	2.3225E-02	1.3900E-05	0.0000E+00	0.0000E+00	5.6492E-06
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.6184E-07	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3.6083E-06	0.0000E+00

*6 can

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	2.1631E-05	2.9290E-04	0.0000E+00	0.0000E+00
0.0000E+00	6.0867E-04	1.4759E-02	1.3570E-03	5.5054E-02	7.0982E-03	0.0000E+00
3.1147E-04	0.0000E+00	0.0000E+00	3.2795E-05	3.3219E-05	0.0000E+00	0.0000E+00

*7 ss

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.8355E-05	8.7794E-05	0.0000E+00	0.0000E+00
1.1862E-04	7.9703E-04	1.5908E-02	1.4972E-03	5.5367E-02	8.7976E-03	8.0988E-05
5.0000E-06	2.4806E-04	5.0365E-05	4.0018E-05	1.4422E-05	0.0000E+00	0.0000E+00

*8 sheath

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	7.5712E-05	2.3825E-04	0.0000E+00	0.0000E+00
1.9798E-05	0.0000E+00	3.6690E-06	2.5697E-04	7.7524E-02	1.4302E-05	0.0000E+00
0.0000E+00	0.0000E+00	2.2216E-05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*9 U8

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.3369E-04	4.6021E-02	0.0000E+00	4.4048E-05	4.9283E-04	0.0000E+00	0.0000E+00
0.0000E+00	2.1076E-04	0.0000E+00	0.0000E+00	1.0599E-04	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*10 U2

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.3962E-04	4.6785E-02	0.0000E+00	4.3899E-05	4.6047E-04	0.0000E+00	0.0000E+00
0.0000E+00	1.9692E-04	0.0000E+00	0.0000E+00	9.9032E-05	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*11 U3

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.4209E-04	4.7156E-02	0.0000E+00	4.4574E-05	4.7140E-04	0.0000E+00	0.0000E+00
0.0000E+00	2.0160E-04	0.0000E+00	0.0000E+00	1.0138E-04	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*12 mst3

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	2.5700E-05	5.1066E-04	0.0000E+00	0.0000E+00
1.3989E-04	0.0000E+00	2.7222E-05	3.2634E-04	8.3806E-02	4.8234E-05	9.8355E-06
0.0000E+00	3.9416E-05	4.4548E-05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

*13 mst9f10

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	4.6306E-05	6.8972E-04	0.0000E+00	0.0000E+00
0.0000E+00	3.1158E-04	0.0000E+00	7.1275E-04	8.1432E-02	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	4.2944E-05	3.7110E-05	0.0000E+00	0.0000E+00

*14 stnavr4

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	2.4073E-05	2.7547E-04	0.0000E+00	0.0000E+00
0.0000E+00	7.5592E-04	1.6594E-02	1.1688E-03	5.9245E-02	9.9342E-03	0.0000E+00
4.0746E-04	0.0000E+00	0.0000E+00	4.5399E-05	1.2036E-05	0.0000E+00	0.0000E+00

*15 stnavs4

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
0.0000E+00 0.0000E+00 0.0000E+00 2.4073E-05 2.5251E-04 0.0000E+00 0.0000E+00
0.0000E+00 7.4610E-04 1.6248E-02 1.5006E-03 5.9881E-02 9.4005E-03 0.0000E+00
3.7393E-04 0.0000E+00 0.0000E+00 1.7803E-05 1.7195E-05 0.0000E+00 0.0000E+00
*16 stnav4
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 3.3245E-06 3.3477E-05 0.0000E+00 0.0000E+00
0.0000E+00 1.2169E-04 2.4643E-03 1.9518E-04 8.0717E-03 1.2195E-03 0.0000E+00
5.2657E-05 0.0000E+00 0.0000E+00 4.9764E-06 2.5076E-06 0.0000E+00 0.0000E+00
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*17 HOMO
1.4474E-06 1.3741E-03 3.2831E-04 3.5142E-05 8.8849E-06 2.1723E-05 9.5819E-05
4.0193E-05 5.5482E-03 0.0000E+00 2.1415E-05 6.4517E-05 1.1506E-06 1.1182E-02
6.5613E-06 1.2254E-04 2.5197E-03 2.2375E-04 1.3307E-02 1.4328E-03 2.5139E-06
2.2759E-05 7.4514E-06 5.0199E-04 2.2403E-05 3.4982E-06 0.0000E+00 0.0000E+00
```

***** D-SC

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*18 PU
3.0461E-05 2.8920E-02 6.9095E-03 7.3960E-04 1.8699E-04 4.5718E-04 2.0166E-03
0.0000E+00 6.8782E-07 0.0000E+00 1.2764E-04 4.2260E-04 2.4215E-05 8.8450E-05
2.2973E-05 1.4158E-05 3.5989E-06 1.4902E-06 1.6335E-05 8.5688E-06 0.0000E+00
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 2.3327E+00
*19 UO2
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
1.6585E-04 2.2894E-02 0.0000E+00 3.1852E-05 1.1837E-05 0.0000E+00 4.6122E-02
3.3995E-06 2.3024E-05 0.0000E+00 8.3479E-08 1.3139E-06 1.2503E-06 3.3462E-07
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 1.1022E+00
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ICOR =

18 17 19 17 17 17 17 17

9 10 11 12 13 17 17 17

17 18 19

NAMSUB='U238NR' 'PU39'

NGSUB=10 11 12 13 14 15 16 17 18 19 20 21 22 23

END

end

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end

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-1\$\$ 2500000

0\$\$ 71 72 18 19

1\$\$ 16 755 4 91 845 61 0 -1 1 t

2\$\$ 14I1000 16000

3\$\$ F5

4\$\$ 14I100 1600

5\$\$ 1 1452 27 1018

7**

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2.00000E+07 1.86181E+07 1.73316E+07 1.61341E+07 1.50192E+07
1.39818E+07 1.30158E+07 1.21165E+07 1.12793E+07 1.05000E+07
9.69341E+06 8.94878E+06 8.26136E+06 7.62674E+06 7.04086E+06
6.50000E+06 5.99475E+06 5.52877E+06 5.09902E+06 4.70267E+06
4.33713E+06 4.00000E+06 3.69862E+06 3.41995E+06 3.16228E+06
2.92402E+06 2.70371E+06 2.50000E+06 2.32522E+06 2.16265E+06
2.01146E+06 1.87083E+06 1.74003E+06 1.61838E+06 1.50524E+06
1.40000E+06 1.30541E+06 1.21722E+06 1.13498E+06 1.05830E+06
9.86800E+05 9.20131E+05 8.57965E+05 8.00000E+05 7.40700E+05
6.85795E+05 6.34960E+05 5.87894E+05 5.44316E+05 5.03968E+05
4.66612E+05 4.32024E+05 4.00000E+05 3.70350E+05 3.42898E+05
3.17480E+05 2.93947E+05 2.72158E+05 2.51984E+05 2.33306E+05
2.16012E+05 2.00000E+05 1.91435E+05 1.85175E+05 1.77154E+05
1.71449E+05 1.63937E+05 1.58740E+05 1.51708E+05 1.46973E+05
1.40390E+05 1.36079E+05 1.29916E+05 1.25992E+05 1.20222E+05
1.16653E+05 1.11251E+05 1.08006E+05 1.02951E+05 1.00000E+05
9.60586E+04 9.38042E+04 9.00741E+04 8.79923E+04 8.44625E+04
8.25404E+04 7.92005E+04 7.74264E+04 7.42663E+04 7.26292E+04
6.96395E+04 6.81292E+04 6.53014E+04 6.39081E+04 6.12343E+04
5.99484E+04 5.74205E+04 5.62341E+04 5.38442E+04 5.27500E+04
5.04907E+04 4.94817E+04 4.73460E+04 4.64159E+04 4.52365E+04
4.43972E+04 4.38990E+04 4.35400E+04 4.24188E+04 4.16320E+04
4.11705E+04 4.08424E+04 3.97762E+04 3.90389E+04 3.86114E+04
3.83119E+04 3.72981E+04 3.66074E+04 3.62115E+04 3.59381E+04
3.49744E+04 3.43274E+04 3.39609E+04 3.37115E+04 3.27956E+04
3.21894E+04 3.18504E+04 3.16227E+04 3.07523E+04 3.01846E+04
2.98710E+04 2.96635E+04 2.88362E+04 2.83046E+04 2.80147E+04
2.78256E+04 2.70395E+04 2.65418E+04 2.62738E+04 2.61015E+04
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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

2.53546E+04	2.48887E+04	2.46412E+04	2.44843E+04	2.37747E+04
2.33386E+04	2.31100E+04	2.29673E+04	2.22931E+04	2.18850E+04
2.16741E+04	2.15443E+04	2.09038E+04	2.05218E+04	2.03274E+04
2.02095E+04	1.96011E+04	1.92437E+04	1.90644E+04	1.89573E+04
1.83795E+04	1.80451E+04	1.78800E+04	1.77828E+04	1.72340E+04
1.69213E+04	1.67692E+04	1.66810E+04	1.61599E+04	1.58674E+04
1.57274E+04	1.56475E+04	1.51527E+04	1.48791E+04	1.47504E+04
1.46780E+04	1.42082E+04	1.39524E+04	1.38342E+04	1.37686E+04
1.33225E+04	1.30834E+04	1.29748E+04	1.29155E+04	1.24919E+04
1.22685E+04	1.21688E+04	1.21153E+04	1.17131E+04	1.15044E+04
1.14130E+04	1.13646E+04	1.09828E+04	1.07879E+04	1.07041E+04
1.06605E+04	1.02980E+04	1.01159E+04	1.00393E+04	1.00000E+04
9.65597E+03	9.48588E+03	9.41580E+03	9.38042E+03	9.05389E+03
8.89508E+03	8.83104E+03	8.79923E+03	8.48930E+03	8.34103E+03
8.28260E+03	8.25404E+03	7.95994E+03	7.82153E+03	7.76826E+03
7.74264E+03	7.46356E+03	7.33439E+03	7.28588E+03	7.26292E+03
6.99809E+03	6.87754E+03	6.83345E+03	6.81292E+03	6.56175E+03
6.44928E+03	6.40918E+03	6.39081E+03	6.15266E+03	6.04776E+03
6.01129E+03	5.99484E+03	5.76907E+03	5.67124E+03	5.63811E+03
5.62341E+03	5.40937E+03	5.31816E+03	5.28811E+03	5.27500E+03
5.07209E+03	4.98706E+03	4.95985E+03	4.94817E+03	4.75585E+03
4.67660E+03	4.65199E+03	4.64159E+03	4.45930E+03	4.38545E+03
4.36323E+03	4.35400E+03	4.18123E+03	4.11242E+03	4.09241E+03
4.08424E+03	3.92049E+03	3.85639E+03	3.83841E+03	3.83119E+03
3.67600E+03	3.61629E+03	3.60018E+03	3.59381E+03	3.44677E+03
3.39115E+03	3.37674E+03	3.37114E+03	3.23181E+03	3.18002E+03
3.16718E+03	3.16227E+03	3.03025E+03	2.98204E+03	2.97063E+03
2.96635E+03	2.84126E+03	2.79638E+03	2.78628E+03	2.78256E+03
2.66404E+03	2.62228E+03	2.61338E+03	2.61015E+03	2.49787E+03
2.45903E+03	2.45121E+03	2.44843E+03	2.34207E+03	2.30593E+03
2.29911E+03	2.29673E+03	2.19597E+03	2.16237E+03	2.15646E+03
2.15443E+03	2.08156E+03	2.05753E+03	2.03423E+03	2.02643E+03
2.02233E+03	2.02095E+03	1.94867E+03	1.92530E+03	1.91246E+03
1.90823E+03	1.90091E+03	1.89850E+03	1.89642E+03	1.89573E+03
1.82083E+03	1.79713E+03	1.78450E+03	1.78042E+03	1.77880E+03
1.77828E+03	1.71599E+03	1.69659E+03	1.68085E+03	1.67586E+03
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1.29155E+03	1.24774E+03	1.23536E+03	1.21853E+03	1.21371E+03
1.21202E+03	1.21153E+03	1.17775E+03	1.16836E+03	1.14755E+03
1.14173E+03	1.13762E+03	1.13646E+03	1.10141E+03	1.09189E+03
1.07319E+03	1.06806E+03	1.06649E+03	1.06605E+03	1.02376E+03
1.01259E+03	1.00357E+03	1.00114E+03	1.00024E+03	1.00000E+03
9.66236E+02	9.57470E+02	9.49570E+02	9.47485E+02	9.42407E+02
9.41065E+02	9.38675E+02	9.38042E+02	8.99406E+02	8.89639E+02
8.83723E+02	8.82194E+02	8.80390E+02	8.79923E+02	8.46636E+02
8.38387E+02	8.30030E+02	8.27921E+02	8.25913E+02	8.25404E+02
7.89300E+02	7.80584E+02	7.76423E+02	7.75394E+02	7.74492E+02
7.74269E+02	7.37010E+02	7.28241E+02	7.26676E+02	7.26296E+02
6.95229E+02	6.88058E+02	6.84227E+02	6.83321E+02	6.81684E+02
6.81296E+02	6.51912E+02	6.45279E+02	6.41161E+02	6.40210E+02
6.39296E+02	6.39085E+02	6.11590E+02	6.05519E+02	6.01580E+02
6.00689E+02	5.99710E+02	5.99488E+02	5.75586E+02	5.70412E+02
5.65542E+02	5.64467E+02	5.62730E+02	5.62345E+02	5.36729E+02
5.31326E+02	5.29011E+02	5.28509E+02	5.27682E+02	5.27503E+02
5.03701E+02	4.98792E+02	4.96329E+02	4.95808E+02	4.94993E+02
4.94820E+02	4.70155E+02	4.65202E+02	4.64340E+02	4.64162E+02
4.40985E+02	4.36438E+02	4.35577E+02	4.35403E+02	4.17034E+02
4.13497E+02	4.10542E+02	4.09960E+02	4.08679E+02	4.08426E+02
3.89954E+02	3.86488E+02	3.84318E+02	3.83901E+02	3.83247E+02
3.83121E+02	3.63761E+02	3.60231E+02	3.59518E+02	3.59384E+02
3.46541E+02	3.44235E+02	3.40010E+02	3.39241E+02	3.38106E+02
3.37898E+02	3.37238E+02	3.37117E+02	3.19313E+02	3.16230E+02
3.07376E+02	3.02104E+02	2.97359E+02	2.97025E+02	2.96822E+02
2.96637E+02	2.82831E+02	2.80486E+02	2.79215E+02	2.78994E+02
2.78367E+02	2.78258E+02	2.70318E+02	2.65502E+02	2.63863E+02
2.62708E+02	2.61994E+02	2.61748E+02	2.61349E+02	2.61102E+02
2.61017E+02	2.47008E+02	2.44845E+02	2.37617E+02	2.34994E+02
2.32422E+02	2.31245E+02	2.30811E+02	2.30381E+02	2.29975E+02
2.29824E+02	2.29675E+02	2.19156E+02	2.15445E+02	2.10258E+02
2.09166E+02	2.04427E+02	2.03428E+02	2.02821E+02	2.02692E+02

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

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2.02201E+02 2.02096E+02 1.97202E+02 1.93488E+02 1.91406E+02
1.90813E+02 1.90355E+02 1.90094E+02 1.89860E+02 1.89678E+02
1.89575E+02 1.82295E+02 1.79185E+02 1.78715E+02 1.78509E+02
1.78209E+02 1.78077E+02 1.77905E+02 1.77829E+02 1.71468E+02
1.68053E+02 1.66811E+02 1.58152E+02 1.57088E+02 1.56545E+02
1.56476E+02 1.48817E+02 1.46781E+02 1.39817E+02 1.38221E+02
1.37789E+02 1.37687E+02 1.33160E+02 1.29901E+02 1.29156E+02
1.24352E+02 1.22028E+02 1.21154E+02 1.19058E+02 1.17703E+02
1.17309E+02 1.16008E+02 1.15163E+02 1.14916E+02 1.14504E+02
1.14234E+02 1.14155E+02 1.13880E+02 1.13700E+02 1.13647E+02
1.08936E+02 1.07009E+02 1.06606E+02 1.04367E+02 1.02788E+02
1.02221E+02 1.01371E+02 1.00765E+02 1.00546E+02 1.00270E+02
1.00072E+02 1.00001E+02 9.49147E+01 9.38048E+01 9.00591E+01
8.84578E+01 8.79928E+01 8.53864E+01 8.29607E+01 8.25409E+01
8.00020E+01 7.87116E+01 7.81267E+01 7.78241E+01 7.75626E+01
7.74269E+01 7.48414E+01 7.31916E+01 7.26296E+01 6.81296E+01
6.64990E+01 6.57970E+01 6.55235E+01 6.47774E+01 6.44532E+01
6.43264E+01 6.40667E+01 6.39533E+01 6.39089E+01 6.16780E+01
5.99492E+01 5.77630E+01 5.69789E+01 5.62349E+01 5.43365E+01
5.31530E+01 5.27507E+01 5.12878E+01 5.00051E+01 4.94823E+01
4.71930E+01 4.64165E+01 4.39677E+01 4.35406E+01 4.15092E+01
4.08429E+01 3.86248E+01 3.83124E+01 3.71495E+01 3.62881E+01
3.59386E+01 3.40190E+01 3.37119E+01 3.20656E+01 3.16232E+01
2.96639E+01 2.78259E+01 2.70538E+01 2.63962E+01 2.61019E+01
2.44847E+01 2.33182E+01 2.29676E+01 2.24015E+01 2.18633E+01
2.15446E+01 2.10496E+01 2.09018E+01 2.05679E+01 2.04677E+01
2.02695E+01 2.02098E+01 1.89576E+01 1.81519E+01 1.78913E+01
1.77830E+01 1.69505E+01 1.66812E+01 1.60901E+01 1.56477E+01
1.48289E+01 1.46782E+01 1.37687E+01 1.29157E+01 1.22858E+01
1.21154E+01 1.17726E+01 1.15521E+01 1.13648E+01 1.09868E+01
1.06606E+01 1.02388E+01 1.00001E+01 9.62837E+00 9.38054E+00
8.79934E+00 8.46274E+00 8.25415E+00 8.07648E+00 7.90335E+00
7.74274E+00 7.49870E+00 7.33772E+00 7.26301E+00 6.81301E+00
6.64826E+00 6.50284E+00 6.39089E+00 5.99492E+00 5.62349E+00
5.27506E+00 4.94823E+00 4.64165E+00 4.35406E+00 4.08429E+00
3.83124E+00 3.59386E+00 3.37119E+00 3.16232E+00 2.96639E+00
2.78259E+00 2.61019E+00 2.44847E+00 2.29676E+00 2.15446E+00
2.02098E+00 1.89576E+00 1.77830E+00 1.66812E+00 1.56477E+00
1.46782E+00 1.37687E+00 1.29157E+00 1.21154E+00 1.13648E+00
1.06606E+00 1.00001E+00 9.38054E-01 8.79934E-01 8.25415E-01
7.74274E-01 7.26301E-01 6.81301E-01 6.39089E-01 5.99492E-01
5.62348E-01 5.27506E-01 4.94823E-01 4.64165E-01 4.35406E-01
4.08429E-01 3.83124E-01 3.59386E-01 3.37119E-01 3.16232E-01
2.96639E-01 2.78259E-01 2.61019E-01 2.44847E-01 2.29676E-01
2.15446E-01 1.89576E-01 1.66812E-01 1.46782E-01 1.29157E-01
1.13647E-01 1.00001E-01 8.25415E-02 6.81301E-02 5.62348E-02
4.64165E-02 3.83124E-02 3.16232E-02 2.61019E-02 2.15446E-02
1.77830E-02 1.46782E-02 1.21155E-02 1.00001E-02 6.81301E-03
4.64164E-03 3.16231E-03 2.15446E-03 1.00001E-03 1.00001E-04
1.00001E-05
9$$ F0 t
end
#sc_bin
72
75
end
#kenova
zebra 24b (231)
read param
tme=1000
lib=75
lng=25000000
nb8=70000
gen=2020
npg=10000
nsk=20
run=yes
plt=no
end param
read mixt
sct=3
eps=1.
mix=1 100 1.
mix=2 200 1.

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

mix=3 300 1.
mix=4 400 1.
mix=5 500 1.
mix=6 600 1.
mix=7 700 1.
mix=8 800 1.
mix=9 900 1.
mix=10 1000 1.
mix=11 1100 1.
mix=12 1200 1.
mix=13 1300 1.
mix=14 1400 1.
mix=15 1500 1.
mix=16 1600 1.
end mixt
read geometry
unit 1
com='core'
array 111 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 111
com='pu'
cuboid 1 1 4p2.3355 0.28170 0.0457
cuboid 2 1 4p2.5335 0.32740 0
unit 112
com='uo2'
cuboid 3 1 4p2.4255 0.59465 0.03665
cuboid 4 1 4p2.5335 0.63130 0
unit 113
com='na'
cuboid 5 1 4p2.4815 0.577347 0.036347
cuboid 6 1 4p2.5335 0.613694 0
unit 114
com='ss'
cuboid 0 1 4p1.9625 0.31700 0
cuboid 7 1 4p2.5335 0.31700 0
unit 115
com='stnavr4'
cylinder 0 1 2.3000 0.61600 0
cylinder 14 1 2.5335 0.61600 0
cuboid 0 1 4p2.5335 0.61600 0
unit 116
com='stnavs4'
cylinder 0 1 2.3000 0.61600 0
cylinder 15 1 2.5335 0.61600 0
cuboid 0 1 4p2.5335 0.61600 0
unit 117
com='stnav4'
cuboid 16 1 4p2.5335 0.61600 0
unit 211
com='u8'
cuboid 9 1 4p2.5335 9.82700 0
unit 212
com='u2'
cuboid 10 1 4p2.5335 12.72300 0
unit 213
com='u3'
cuboid 11 1 4p2.5335 7.62250 0
unit 311
com='mst3'
cuboid 12 1 4p2.5335 7.60628 0
unit 511
com='air'
cuboid 0 1 4p2.5335 1.3095 0
unit 2
com='u3-radial'
cuboid 12 1 4p2.5335 7.60628 0
cuboid 11 1 4p2.5335 160.05628 0
cuboid 12 1 4p2.5335 167.66256 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

unit 3
com='mst9f10'
cuboid 13 1 4p2.54000 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 4
com='empty tube'
cuboid 0 1 4p2.55100 167.66256 0
cuboid 8 1 4p2.62720 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 5
com='core'
array 115 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 6
com='core'
array 116 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 7
com='core'
array 117 -2.5335 -2.5335 0
cuboid 0 1 4p2.5510 167.66256 0
cuboid 8 1 4p2.6272 167.66256 0
cuboid 0 1 4p2.68605 167.66256 0
unit 11
com='2'
array 11 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 12
com='2'
array 12 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 13
com='2'
array 13 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 14
com='2'
array 14 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 15
com='2'
array 15 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 16
com='2'
array 16 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 17
com='2'
array 17 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 21
com='2'
array 21 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 22
com='2'
array 22 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 23
com='2'
array 23 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 24
com='2'
array 24 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 25
com='2'
array 25 -13.43025 -13.43025 0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

cuboid 0 1 4p13.5635 167.66256 0
unit 26
com='2'
array 26 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 27
com='2'
array 27 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 31
com='2'
array 31 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 32
com='2'
array 32 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 33
com='2'
array 33 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 34
com='2'
array 34 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 35
com='2'
array 35 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 36
com='2'
array 36 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 37
com='2'
array 37 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 41
com='2'
array 41 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 42
com='2'
array 42 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 43
com='2'
array 43 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 44
com='2'
array 44 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 45
com='2'
array 45 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 46
com='2'
array 46 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 47
com='2'
array 47 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 51
com='2'
array 51 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 52
com='2'
array 52 -13.43025 -13.43025 0
cuboid 0 1 4p13.5635 167.66256 0
unit 53

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

com='2'
array 53  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 54
com='2'
array 54  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 55
com='2'
array 55  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 56
com='2'
array 56  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 57
com='2'
array 57  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 61
com='2'
array 61  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 62
com='2'
array 62  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 63
com='2'
array 63  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 64
com='2'
array 64  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 65
com='2'
array 65  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 66
com='2'
array 66  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 67
com='2'
array 67  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 71
com='2'
array 71  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 72
com='2'
array 72  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 73
com='2'
array 73  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 74
com='2'
array 74  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 75
com='2'
array 75  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 76
com='2'
array 76  -13.43025 -13.43025  0
cuboid 0 1 4p13.5635  167.66256 0
unit 77
com='2'
array 77  -13.43025 -13.43025  0

```



```

cuboid 0 1 4p13.5635 167.66256 0
global unit 100
com='reactor'
array 100 3*0
end geometry
read array
ara=115 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
115 112 115 111 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 114 111 115 112 115 115 112 115 111 114 112 115
115 112 111 115 112 115
211 212 213 311 511
end fill
ara=116 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
116 112 116 111 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 114 111 116 112 116 116 112 116 111 114 112 116
116 112 111 116 112 116
211 212 213 311 511
end fill
ara=117 nux=1 nuy=1 nuz=176
fill
511 311 213 212 211
117 112 117 111 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 114 111 117 112 117 117 112 117 111 114 112 117
117 112 111 117 112 117
211 212 213 311 511
end fill
ara=11 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=12 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 3 3

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
4 4 3 3 3
end fill
ara=13 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 3 3
3 3 3 3 3
3 3 3 3 3
3 3 3 2 2
end fill
ara=14 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
2 2 2 2 2
end fill
ara=15 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
3 3 4 4 4
3 3 3 3 3
3 3 3 3 3
2 2 3 3 3
end fill
ara=16 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
3 3 4 4 4
3 3 3 4 4
end fill
ara=17 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=21 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 3
4 4 4 3 3
4 4 4 3 3
end fill
ara=22 nux=5 nuy=5 nuz=1
fill
4 3 3 3 3
3 3 3 3 2
3 3 3 2 2
3 3 2 2 2
3 2 2 2 2
end fill
ara=23 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 7
end fill
ara=24 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
7 7 7 7 7
end fill
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
ara=25 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
7 2 2 2 2
end fill
ara=26 nux=5 nuy=5 nuz=1
fill
3 3 3 3 4
2 3 3 3 3
2 2 3 3 3
2 2 2 3 3
2 2 2 2 3
end fill
ara=27 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
3 4 4 4 4
3 3 4 4 4
3 3 4 4 4
end fill
ara=31 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
4 3 3 3 2
4 3 3 3 2
end fill
ara=32 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=33 nux=5 nuy=5 nuz=1
fill
2 2 2 7 7
2 7 7 6 6
2 7 6 6 6
7 6 6 6 6
7 6 6 6 5
end fill
ara=34 nux=5 nuy=5 nuz=1
fill
6 6 6 6 6
6 6 6 6 6
6 6 6 6 6
5 5 5 5 5
5 5 5 5 5
end fill
ara=35 nux=5 nuy=5 nuz=1
fill
7 7 2 2 2
6 6 7 7 2
6 6 6 7 2
6 6 6 6 7
5 6 6 6 6
end fill
ara=36 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
7 2 2 2 2
end fill
ara=37 nux=5 nuy=5 nuz=1
fill
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=41 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
4 3 3 3 2
end fill
ara=42 nux=5 nuy=5 nuz=1
fill
2 2 2 2 7
2 2 2 2 7
2 2 2 2 7
2 2 2 2 7
2 2 2 2 7
end fill
ara=43 nux=5 nuy=5 nuz=1
fill
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
6 6 6 5 5
end fill
ara=44 nux=5 nuy=5 nuz=1
fill
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
5 5 5 5 5
end fill
ara=45 nux=5 nuy=5 nuz=1
fill
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
5 6 6 6 6
end fill
ara=46 nux=5 nuy=5 nuz=1
fill
7 2 2 2 2
7 2 2 2 2
7 2 2 2 2
7 2 2 2 2
7 2 2 2 2
end fill
ara=47 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
2 3 3 3 4
end fill
ara=51 nux=5 nuy=5 nuz=1
fill
4 3 3 3 2
4 3 3 3 2
4 4 3 3 3
4 4 3 3 3
4 4 3 3 3
end fill
ara=52 nux=5 nuy=5 nuz=1
fill
2 2 2 2 7
2 2 2 2 2
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=53 nux=5 nuy=5 nuz=1
fill
7 6 6 6 5
7 6 6 6 6
2 7 6 6 6
2 7 7 6 6
2 2 2 7 7
end fill
ara=54 nux=5 nuy=5 nuz=1
fill
5 5 6 5 5
5 5 6 5 5
6 6 5 6 6
6 6 5 6 6
6 6 6 6 6
end fill
ara=55 nux=5 nuy=5 nuz=1
fill
5 6 6 6 7
6 6 6 6 7
6 6 6 7 2
6 6 7 7 2
7 7 2 2 2
end fill
ara=56 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=57 nux=5 nuy=5 nuz=1
fill
2 3 3 3 4
2 3 3 3 4
3 3 3 4 4
3 3 3 4 4
3 3 3 4 4
end fill
ara=61 nux=5 nuy=5 nuz=1
fill
4 4 4 3 3
4 4 4 3 3
4 4 4 4 3
4 4 4 4 4
4 4 4 4 4
end fill
ara=62 nux=5 nuy=5 nuz=1
fill
3 2 2 2 2
3 3 2 2 2
3 3 3 2 2
3 3 3 3 2
4 3 3 3 3
end fill
ara=63 nux=5 nuy=5 nuz=1
fill
2 2 2 2 7
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=64 nux=5 nuy=5 nuz=1
fill
7 7 7 7 7
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
```

ZEBRA-LMFR-EXP-001
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```
2 2 2 2 2
end fill
ara=65 nux=5 nuy=5 nuz=1
fill
7 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
2 2 2 2 2
end fill
ara=66 nux=5 nuy=5 nuz=1
fill
2 2 2 2 3
2 2 2 3 3
2 2 3 3 3
2 3 3 3 3
3 3 3 3 4
end fill
ara=67 nux=5 nuy=5 nuz=1
fill
3 3 4 4 4
3 3 4 4 4
3 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=71 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=72 nux=5 nuy=5 nuz=1
fill
4 4 3 3 3
4 4 4 3 3
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=73 nux=5 nuy=5 nuz=1
fill
3 3 3 2 2
3 3 3 3 3
3 3 3 3 3
4 4 4 3 3
4 4 4 4 4
end fill
ara=74 nux=5 nuy=5 nuz=1
fill
2 2 2 2 2
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
4 4 4 4 4
end fill
ara=75 nux=5 nuy=5 nuz=1
fill
2 2 3 3 3
3 3 3 3 3
3 3 3 3 3
3 3 4 4 4
4 4 4 4 4
end fill
ara=76 nux=5 nuy=5 nuz=1
fill
3 3 3 4 4
3 3 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
```

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```
ara=77 nux=5 nuy=5 nuz=1
fill
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
4 4 4 4 4
end fill
ara=100 nux=7 nuy=7 nuz=1
fill
11 12 13 14 15 16 17
21 22 23 24 25 26 27
31 32 33 34 35 36 37
41 42 43 44 45 46 47
51 52 53 54 55 56 57
61 62 63 64 65 66 67
71 72 73 74 75 76 77
end fill
end array
read plot
ttl='simple plot 1'
pic=mix
xul= 0 yul= 190 zul= 100
xlr= 190 ylr= 0 zlr= 100
uax=1.0 vdn=-1.0
nax=1200
lpi=10
scr=yes end
ttl='simple plot 4'
pic=mix
xul= 0 yul= 95 zul= 168
xlr= 190 ylr= 95 zlr= 0
uax=1.0 wdn=-1.0
nax=800
scr=yes end
end plot
end data
end
```

A.3 The ERANOS RZ model used for sensitivity calculations.

Data used in ERANOS with CARNAVAL-IV nuclear data

Material compositions

```

MATERIAU_SIMPLE 'UPU02C1' COMBUSTIBLE
  NOMBRE_D_ATOMES
  CORPS
    'U234' 1.2863E-06
    'U235' 1.2997E-04
    'U236' 7.3103E-07
    'U238' 1.7843E-02
    'PU238' 6.9094E-06
    'PU239' 4.4708E-03
    'PU240' 1.0602E-03
    'PU241' 1.1598E-04
    'PU242' 3.0047E-05
    'AM241' 5.7784E-05
    'O' 4.7434E-02
MATERIAU_SIMPLE 'STEEL' STRUCTURE
  NOMBRE_D_ATOMES
  CORPS
    'C' 0.033600E-2
    'CR' 1.113600E-2
    'FE' 6.209600E-2
    'NI' 0.806400E-2
MATERIAU_SIMPLE 'NA' CALOPORTEUR
  NOMBRE_D_ATOMES
  CORPS
    'NA' 2.3225E-02
MATERIAU_SIMPLE 'AX.BLKT' FERTILE
  NOMBRE_D_ATOMES
  CORPS
    'U235' 2.9839E-04
    'U238' 4.1132E-02
    'FE' 4.2453E-03
    'C' 4.2396E-04
    'SI' 1.7584E-04
MATERIAU_SIMPLE 'RAD.BLKT' FERTILE
  NOMBRE_D_ATOMES
  CORPS
    'U235' 2.9839E-04
    'U238' 4.1132E-02
    'FE' 4.2453E-03
    'C' 4.2396E-04
    'SI' 1.7584E-04
MATERIAU_SIMPLE 'PL.CORE' STRUCTURE
  NOMBRE_D_ATOMES
  CORPS
    'FE' 7.7256E-02
    'C' 4.5820E-04
    'H' 2.6476E-05
    'AL' 1.2308E-04
    'MN' 2.9843E-04
MATERIAU_SIMPLE 'RAD.REFL' STRUCTURE
  NOMBRE_D_ATOMES
  CORPS
    'FE' 3.9297E-02
    'CR' 8.0171E-03
    'NI' 3.8059E-03
    'C' 1.0735E-04
    'H' 5.7941E-05
    'CU' 3.5294E-06
    'SI' 4.0353E-04
    'MN' 7.0382E-04
MILIEU 'C1'
  'UPU02C1' 30.00 'STEEL' 34.00 'NA' 36.00
MILIEU 'AX.BLKT'
  'AX.BLKT' 100.00

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

MILIEU 'RAD.BLKT'
  'RAD.BLKT' 100.00
MILIEU 'GAS PLE.'
  'PL.CORE' 100.00
MILIEU 'REFLEC.'
  'RAD.REFL' 100.00
;

TEMPERATURE
  COMBUSTIBLE 300.
  FERTILE 300.
  STRUCTURE 300.
  CALOPORTEUR 300.
;

FINSI ;

EDITION_MILIEU (MIL) ;

ARCHIVE 'ARCHERAN' ->EDLCAR
  CARNAVAL_IV FILE ;

CREATION_BANDE_CARNAVAL_A_PARTIR_EDL (EDLCAR)
  10
;

CREATION_JSEM_HETARED
  MICRO ->MIC
  MACRO ->MAC
  MILIEU (MIL)
FICHIER_HETARED 10
!&F
!&F HETEROGENEITY DATA ARE AVAILABLE ONLY FOR C1
!&F
MILIEU 'C1' HETEROGENE 0.423 0.77229
MILIEU 'AX.BLKT' BUCKLING 0.01542 SOURCE 'C1'
MILIEU 'RAD.BLKT' BUCKLING 0.019038 SOURCE 'C1'
MILIEU 'GAS PLE.' SOURCE 'AX.BLKT'
MILIEU 'REFLEC.' SOURCE 'RAD.BLKT'
SPECTRE_DE_FISSION 'C1'
;

/ (EDLCAR) ;

ITERATIONS_DIFFUSION_RECTANGULAIRE ->FDIR
  METHODE (METH)
  COEFFICIENT (COEF)

PARAMETRES_DE_CALCUL
  ITERATIONS_EXTERNES
    NOMBRE_MAXIMUM 1
    CONVERGENCE_INTEGRALE 1.0E-5
    CONVERGENCE_PONCTUELLE 1.0E-3
  ITERATIONS_INTERNES
    NOMBRE_MAXIMUM 1
  SPECTRE_VARIABLE
  CALCUL DIRECT
;

EDITION_FLUX_RECTANGULAIRE (FDIR) ;

CREATION_COEUR ->CORE
RESEAU
  CENTRE 30
  PERIODICITE 'PI/3'
  NOMBRE_DE_COURENNES 18
  COURENNES 'Z1' 1 9
  'Z2' 10 15
  'Z3' 16 18
  PAS_RESEAU 5.11
  CYLINDRISATION
  'Z1' 46.00

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

      'Z2' 75.00
      'Z3' 90.00
MAILLAGE_DE_BASE
  OZ 2 30.
    3 60.
    4 90.
    2 120.
    4 150.
    3 180.
    2 210.
  OR 20 46.00
    6 75.00
    4 90.00
ASSEMBLAGE 'TYPE 1' COMBUSTIBLE 271 0.865
MILIEU      'GAS PLE.' 0. 210.
            'AX.BLKT' 30. 180.
            'C1'      60. 150.
      ZONE   'Z1'
      SECTION 'C1'      60. 150.
      PARCELLE 90. 120.
ASSEMBLAGE 'TYPE 2' FERTILE 1 0.
MILIEU      'GAS PLE.' 0. 210.
            'RAD.BLKT' 30. 180.
      ZONE   'Z2'
      SECTION 'RAD.BLKT' 30. 180.
      PARCELLE 90. 120.
ASSEMBLAGE 'TYPE 3' STRUCTURE 1 0.
MILIEU      'REFLEC.' 0. 210.
      ZONE   'Z3'
;

CREATION_GEOMETRIE_RZ ->GEOMRZ
                      COEUR (CORE)
                      MILIEU (MIL)
CONFIGURATION
  ZONE 'Z1' 'TYPE 1'
  ZONE 'Z2' 'TYPE 2'
  ZONE 'Z3' 'TYPE 3'
LIMITE
  RSUP VIDE
  ZINF VIDE
  ZSUP VIDE
;

EDITION_GEOMETRIE_RECTANGULAIRE (GEOMRZ) ;

COEFFICIENTS_DIFFUSION_RECTANGULAIRE_2D ->COEF
                                         GEOMETRIE (GEOMRZ)
                                         MACRO (MAC)
      MAILLAGE 1 1
;

METHODE_RESOLUTION_DIFFUSION ->METH
                             COEFFICIENT (COEF)
      PLANE
      GROUPE 1 21 DIRECTIONS_ALTERNEES CALCUL
!&F
!&F SIM PERFORMS BETTER IN THE LOW ENERGY RANGE
!&F
      GROUPE 22 25 SIM
;

ITERATIONS_DIFFUSION_RECTANGULAIRE ->FDIRRZ
                                   METHODE (METH)
                                   COEFFICIENT (COEF)
PARAMETRES_DE_CALCUL
  ITERATIONS_EXTERNES
  NOMBRE_MAXIMUM 40
  CONVERGENCE_INTEGRALE 1.0E-5
  CONVERGENCE_PONCTUELLE 1.0E-3
  ITERATIONS_INTERNES
  NOMBRE_MAXIMUM 6

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

SPECTRE VARIABLE
CALCUL DIRECT
;

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

A4. MCNP – JEFF-3.1 Input Decks

A4.1 MCNP-JEFF-3.1 Zebra22 Model A

Zebra Assembly 22 reference model including Void gaps between elements

```
c JEFF-3.1
c
c ----- Elements of the assembly -----
c
c --- Core Element
c Lower padding
111      16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower Reflector
112      14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
113      15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
114      9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
115      8 4.7208E-02 42 -10 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na plate core
122      5 2.324832E-02 502 -503 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
c Na plate can
123      6 7.9429E-02 10 -504 21 -22 23 -24 &
      (-109:110:-111:112:-502:503) u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
127      3 6.9083E-02 505 -506 105 -106 107 -108 u=5 imp:n=1 TMP=2.5301E-08
c UO2 plate can
128      4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-105:106:-107:108:-505:506) u=5 imp:n=1 TMP=2.5301E-08
c
c Na plate core
132      5 2.324832E-02 508 -509 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
c Na plate can
133      6 7.9429E-02 507 -510 21 -22 23 -24 &
      (-109:110:-111:112:-508:509) u=5 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
135      1 3.9991E-02 101 -102 103 -104 511 -512 u=5 imp:n=1 TMP=2.5301E-08
c Pu canning
136      2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-101:102:-103:104:-511:512) u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
139      3 6.9083E-02 514 -515 105 -106 107 -108 u=5 imp:n=1 TMP=2.5301E-08
c UO2 plate can
140      4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-105:106:-107:108:-514:515) u=5 imp:n=1 TMP=2.5301E-08
c
c Na plate core
142      5 2.324832E-02 517 -518 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
c Na plate can
143      6 7.9429E-02 516 -43 21 -22 23 -24 &
      (-109:110:-111:112:-517:518) u=5 imp:n=1 TMP=2.5301E-08
c
c Insert the 22 central region core cells
c
151      0 43 -44 21 -22 23 -24 fill=3 (0 0 71.209862) u=5 imp:n=1
c
152      0 44 -45 21 -22 23 -24 fill=4 (0 0 74.957944) u=5 imp:n=1
c
c
153      0 45 -46 21 -22 23 -24 fill=3 (0 0 78.706026) u=5 imp:n=1
c
154      0 46 -47 21 -22 23 -24 fill=4 (0 0 82.454108) u=5 imp:n=1
c
c
155      0 47 -48 21 -22 23 -24 fill=3 (0 0 86.202190) u=5 imp:n=1
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
156  0  48 -49 21 -22 23 -24 fill=4 (0 0 89.950272) u=5 imp:n=1
c
c
157  0  49 -50 21 -22 23 -24 fill=3 (0 0 93.698354) u=5 imp:n=1
c
c
158  0  50 -51 21 -22 23 -24 fill=4 (0 0 97.446436) u=5 imp:n=1
c
c
c
159  0  51 -52 21 -22 23 -24 fill=3 (0 0 101.194518) u=5 imp:n=1
c
c
160  0  52 -53 21 -22 23 -24 fill=4 (0 0 104.942600) u=5 imp:n=1
c
c
c
161  0  53 -54 21 -22 23 -24 fill=3 (0 0 108.690682) u=5 imp:n=1
c
c
162  0  54 -55 21 -22 23 -24 fill=4 (0 0 112.438764) u=5 imp:n=1
c
c
c
163  0  55 -56 21 -22 23 -24 fill=3 (0 0 116.186846) u=5 imp:n=1
c
c
164  0  56 -57 21 -22 23 -24 fill=4 (0 0 119.934928) u=5 imp:n=1
c
c
c
165  0  57 -58 21 -22 23 -24 fill=3 (0 0 123.683010) u=5 imp:n=1
c
c
166  0  58 -59 21 -22 23 -24 fill=4 (0 0 127.431092) u=5 imp:n=1
c
c
c
167  0  59 -60 21 -22 23 -24 fill=3 (0 0 131.179174) u=5 imp:n=1
c
c
168  0  60 -61 21 -22 23 -24 fill=4 (0 0 134.927256) u=5 imp:n=1
c
c
c
169  0  61 -62 21 -22 23 -24 fill=3 (0 0 138.675338) u=5 imp:n=1
c
c
170  0  62 -63 21 -22 23 -24 fill=4 (0 0 142.423420) u=5 imp:n=1
c
c
c
171  0  63 -64 21 -22 23 -24 fill=3 (0 0 146.171502) u=5 imp:n=1
c
c
172  0  64 -65 21 -22 23 -24 fill=4 (0 0 149.919584) u=5 imp:n=1
c
c
c
c The top core cell, Cell 2
c
c Na plate core
1002  5 2.324832E-02 402 -403 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
c Na plate can
1003  6 7.9429E-02 65 -404 21 -22 23 -24 &
      (-109:110:-111:112:-402:403) u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1007  3 6.9083E-02 405 -406 105 -106 107 -108 u=5 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1008  4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-105:106:-107:108:-405:406) u=5 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1012  1 3.9991E-02 101 -102 103 -104 408 -409 u=5 imp:n=1 &
      TMP=2.5301E-08
c Pu canning
1013  2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-101:102:-103:104:-408:409) u=5 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1022  5 2.324832E-02 411 -412 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
c Na plate can
1023  6 7.9429E-02 410 -413 21 -22 23 -24 &
      (-109:110:-111:112:-411:412) u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1027  3 6.9083E-02 414 -415 105 -106 107 -108 u=5 imp:n=1 TMP=2.5301E-08
c UO2 plate can

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

1028    4 7.2463E-02 413 -416 21 -22 23 -24 &
        (-105:106:-107:108:-414:415) u=5 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1032    5 2.324832E-02 417 -418 109 -110 111 -112 u=5 imp:n=1 TMP=2.5301E-08
C Na plate can
1033    6 7.9429E-02 416 -11 21 -22 23 -24 &
        (-109:110:-111:112:-417:418) u=5 imp:n=1 TMP=2.5301E-08
c
c
c Upper Axial blanket.
c
1171    8 4.7208E-02 11 -67 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
1172    9 4.7925E-02 67 -68 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
1173    15 4.8317E-02 68 -12 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1176    14 8.4932E-02 12 -13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper padding
1177    16 3.279692E-02 13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Wrapper region
c 1198    17 3.87228E-02 1 -2 3 -4 (-21:22:-23:24) u=5 imp:n=1
c        TMP=2.5301E-08
c gap between plates and wrapper
1191    0 32 -33 34 -35 (-21:22:-23:24) u=5 imp:n=1
c Wrapper
1192    17 7.81552E-02 36 -37 38 -39 (-32:33:-34:35) u=5 imp:n=1 &
        TMP=2.5301E-08
c gap outside wrapper
1193    0 1 -2 3 -4 (-36:37:-38:39) u=5 imp:n=1
c
c --- Radial Blanket Elements
c
c Lower padding
1211    like 111 but u=6 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1212    like 112 but u=6 imp:n=1 TMP=2.5301E-08
c Radial blanket
1214    15 4.8317E-02 9 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper reflector
1216    like 1176 but u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1217    like 1177 but u=6 imp:n=1 TMP=2.5301E-08
c Wrapper region
1257    like 1191 but u=6 imp:n=1
1258    like 1192 but u=6 imp:n=1
1259    like 1193 but u=6 imp:n=1
c
c
c --- Radial shield
c
1326    12 8.32720E-02 28 -29 30 -31 u=7 imp:n=1 TMP=2.5301E-08
c
1327    13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=7 imp:n=1
        TMP=2.5301E-08
c
1400    13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly
c
1419    0 89 -90 91 -92 u=10 lat=1
        fill=-3:3 -3:3 0:0
        201 135 134 133 132 131 201
        138 115 111 109 111 114 137
        168 111 108 101 107 111 167
        158 106 101 101 101 105 157
        148 111 104 101 103 111 147
        128 113 111 102 111 112 127
        201 125 124 123 122 121 201
        imp:n=1
c
c --- Fuel Region
c
1429    0 7 -16 -17 fill=10 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c --- Universe
1430      0 (-7:16:17) imp:n=0
c
c ----- PLATE ELEMENT CELL CARDS -----
c
c The First Regular cell. Cell 1
c
c Na plate
c Na plate core
2162      5 2.324832E-02 802 -803 109 -110 111 -112 u=3 imp:n=1 TMP=2.5301E-08
c Na plate can
2163      6 7.9429E-02 801 -804 21 -22 23 -24 &
      (-109:110:-111:112:-802:803) u=3 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2167      3 6.9083E-02 805 -806 105 -106 107 -108 u=3 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2168      4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=3 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170      7 3.3152E-02 807 -708 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c
c Pu plate
c Plate core
2172      1 3.9991E-02 101 -102 103 -104 709 -710 u=3 imp:n=1 TMP=2.5301E-08
c Pu canning
2173      2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-101:102:-103:104:-709:710) u=3 imp:n=1 TMP=2.5301E-08
c
c
c Na plate
c Na plate core
2182      5 2.324832E-02 712 -713 109 -110 111 -112 u=3 imp:n=1 TMP=2.5301E-08
c Na plate can
2183      6 7.9429E-02 711 -814 21 -22 23 -24 &
      (-109:110:-111:112:-712:713) u=3 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2187      3 6.9083E-02 815 -816 105 -106 107 -108 u=3 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188      4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=3 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2192      5 2.324832E-02 818 -819 109 -110 111 -112 u=3 imp:n=1 TMP=2.5301E-08
c Na plate can
2193      6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-109:110:-111:112:-818:819) u=3 imp:n=1 TMP=2.5301E-08
c
c End of Cell 1 beginning of Cell 2
c Na plate
c Na plate core
2202      5 2.324832E-02 802 -803 109 -110 111 -112 u=4 imp:n=1 TMP=2.5301E-08
c Na plate can
2203      6 7.9429E-02 801 -804 21 -22 23 -24 &
      (-109:110:-111:112:-802:803) u=4 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2207      3 6.9083E-02 805 -806 105 -106 107 -108 u=4 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2208      4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=4 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2211      5 2.324832E-02 808 -809 109 -110 111 -112 u=4 imp:n=1 TMP=2.5301E-08
c Na plate can
2212      6 7.9429E-02 807 -810 21 -22 23 -24 &
      (-109:110:-111:112:-808:809) u=4 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
c Pu plate
C Plate core
2214 1 3.9991E-02 101 -102 103 -104 811 -812 u=4 imp:n=1 TMP=2.5301E-08
C Pu canning
2215 2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-101:102:-103:104:-811:812) u=4 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217 7 3.3152E-02 813 -814 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219 3 6.9083E-02 815 -816 105 -106 107 -108 u=4 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=4 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2222 5 2.324832E-02 818 -819 109 -110 111 -112 u=4 imp:n=1 TMP=2.5301E-08
C Na plate can
2223 6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-109:110:-111:112:-818:819) u=4 imp:n=1 TMP=2.5301E-08
c
c End of plate element cell data
c
c -----
c
c Form arrays of 5x5 elements
c
c
c Central array of 5x5 core elements
c
3001 0 85 -81 87 -83 fill=5 (-10.7442 -10.7442 0) u=101 imp:n=1
c
3002 0 81 -1 87 -83 fill=5 (-5.3721 -10.7442 0) u=101 imp:n=1
c
3003 0 1 -2 87 -83 fill=5 (0 -10.7442 0) u=101 imp:n=1
c
3004 0 2 -82 87 -83 fill=5 (5.3721 -10.7442 0) u=101 imp:n=1
c
3005 0 82 -86 87 -83 fill=5 (10.7442 -10.7442 0) u=101 imp:n=1
c
c
3006 0 85 -81 83 -3 fill=5 (-10.7442 -5.3721 0) u=101 imp:n=1
c
3007 0 81 -1 83 -3 fill=5 (-5.3721 -5.3721 0) u=101 imp:n=1
c
3008 0 1 -2 83 -3 fill=5 (0 -5.3721 0) u=101 imp:n=1
c
3009 0 2 -82 83 -3 fill=5 (5.3721 -5.3721 0) u=101 imp:n=1
c
3010 0 82 -86 83 -3 fill=5 (10.7442 -5.3721 0) u=101 imp:n=1
c
c
3011 0 85 -81 3 -4 fill=5 (-10.7442 0 0) u=101 imp:n=1
c
3012 0 81 -1 3 -4 fill=5 (-5.3721 0 0) u=101 imp:n=1
c
3013 0 1 -2 3 -4 fill=5 (0 0 0) u=101 imp:n=1
c
3014 0 2 -82 3 -4 fill=5 (5.3721 0 0) u=101 imp:n=1
c
3015 0 82 -86 3 -4 fill=5 (10.7442 0 0) u=101 imp:n=1
c
c
3016 0 85 -81 4 -84 fill=5 (-10.7442 5.3721 0) u=101 imp:n=1
c
3017 0 81 -1 4 -84 fill=5 (-5.3721 5.3721 0) u=101 imp:n=1
c
3018 0 1 -2 4 -84 fill=5 (0 5.3721 0) u=101 imp:n=1
c
3019 0 2 -82 4 -84 fill=5 (5.3721 5.3721 0) u=101 imp:n=1

```


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```

c
3020  0 82 -86  4 -84 fill=5 (10.7442 5.3721 0) u=101 imp:n=1
c
c
3021  0 85 -81  84 -88 fill=5 (-10.7442 10.7442 0) u=101 imp:n=1
c
3022  0 81 -1  84 -88 fill=5 (-5.3721 10.7442 0) u=101 imp:n=1
c
3023  0 1 -2  84 -88 fill=5 (0 10.7442 0) u=101 imp:n=1
c
3024  0 2 -82  84 -88 fill=5 (5.3721 10.7442 0) u=101 imp:n=1
c
3025  0 82 -86  84 -88 fill=5 (10.7442 10.7442 0) u=101 imp:n=1
c
c Surround material
c
3026  0 89 -90 91 -92 (-85:86:-87:88) -71 u=101 imp:n=1
c
3027  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=101 imp:n=1
c
3028  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=101 imp:n=1
c
3029  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=101 imp:n=1
c
3030  0 89 -90 91 -92 (-85:86:-87:88) 74 u=101 imp:n=1
c
c
c ROW 3
c
c Bottom left array of 5x5 core elements in Row 3
c
3031  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=103 imp:n=1
c
3032  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=103 imp:n=1
c
3033  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=103 imp:n=1
c
3034  0 2 -82  87 -83 fill=5 (5.3721 -10.7442 0) u=103 imp:n=1
c
3035  0 82 -86  87 -83 fill=5 (10.7442 -10.7442 0) u=103 imp:n=1
c
c
3036  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=103 imp:n=1
c
3037  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=103 imp:n=1
c
3038  0 1 -2  83 -3 fill=5 (0 -5.3721 0) u=103 imp:n=1
c
3039  0 2 -82  83 -3 fill=5 (5.3721 -5.3721 0) u=103 imp:n=1
c
3040  0 82 -86  83 -3 fill=5 (10.7442 -5.3721 0) u=103 imp:n=1
c
c
3041  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=103 imp:n=1
c
3042  0 81 -1  3 -4 fill=5 (-5.3721 0 0) u=103 imp:n=1
c
3043  0 1 -2  3 -4 fill=5 (0 0 0) u=103 imp:n=1
c
3044  0 2 -82  3 -4 fill=5 (5.3721 0 0) u=103 imp:n=1
c
3045  0 82 -86  3 -4 fill=5 (10.7442 0 0) u=103 imp:n=1
c
c
3046  0 85 -81  4 -84 fill=5 (-10.7442 5.3721 0) u=103 imp:n=1
c
3047  0 81 -1  4 -84 fill=5 (-5.3721 5.3721 0) u=103 imp:n=1
c
3048  0 1 -2  4 -84 fill=5 (0 5.3721 0) u=103 imp:n=1
c
3049  0 2 -82  4 -84 fill=5 (5.3721 5.3721 0) u=103 imp:n=1
c
3050  0 82 -86  4 -84 fill=5 (10.7442 5.3721 0) u=103 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
3051  0 85 -81  84 -88 fill=5 (-10.7442 10.7442 0) u=103 imp:n=1
c
3052  0 81 -1  84 -88 fill=5 (-5.3721 10.7442 0) u=103 imp:n=1
c
3053  0 1 -2  84 -88 fill=5 (0 10.7442 0) u=103 imp:n=1
c
3054  0 2 -82  84 -88 fill=5 (5.3721 10.7442 0) u=103 imp:n=1
c
3055  0 82 -86  84 -88 fill=5 (10.7442 10.7442 0) u=103 imp:n=1
c
c Surround material
c
3056  0 89 -90 91 -92 (-85:86:-87:88) -71 u=103 imp:n=1
c
3057  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=103 imp:n=1
c
3058  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=103 imp:n=1
c
3059  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=103 imp:n=1
c
3060  0 89 -90 91 -92 (-85:86:-87:88) 74 u=103 imp:n=1
c
c
c Bottom right array of 5x5 core elements in Row 3
c
3071  0 85 -81  87 -83 fill=5 (-10.7442 -10.7442 0) u=104 imp:n=1
c
3072  0 81 -1  87 -83 fill=5 (-5.3721 -10.7442 0) u=104 imp:n=1
c
3073  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=104 imp:n=1
c
3074  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=104 imp:n=1
c
3075  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=104 imp:n=1
c
c
3076  0 85 -81  83 -3 fill=5 (-10.7442 -5.3721 0) u=104 imp:n=1
c
3077  0 81 -1  83 -3 fill=5 (-5.3721 -5.3721 0) u=104 imp:n=1
c
3078  0 1 -2  83 -3 fill=5 (0 -5.3721 0) u=104 imp:n=1
c
3079  0 2 -82  83 -3 fill=5 (5.3721 -5.3721 0) u=104 imp:n=1
c
3080  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=104 imp:n=1
c
c
3081  0 85 -81  3 -4 fill=5 (-10.7442 0 0) u=104 imp:n=1
c
3082  0 81 -1  3 -4 fill=5 (-5.3721 0 0) u=104 imp:n=1
c
3083  0 1 -2  3 -4 fill=5 (0 0 0) u=104 imp:n=1
c
3084  0 2 -82  3 -4 fill=5 (5.3721 0 0) u=104 imp:n=1
c
3085  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=104 imp:n=1
c
c
3086  0 85 -81  4 -84 fill=5 (-10.7442 5.3721 0) u=104 imp:n=1
c
3087  0 81 -1  4 -84 fill=5 (-5.3721 5.3721 0) u=104 imp:n=1
c
3088  0 1 -2  4 -84 fill=5 (0 5.3721 0) u=104 imp:n=1
c
3089  0 2 -82  4 -84 fill=5 (5.3721 5.3721 0) u=104 imp:n=1
c
3090  0 82 -86  4 -84 fill=5 (10.7442 5.3721 0) u=104 imp:n=1
c
c
3091  0 85 -81  84 -88 fill=5 (-10.7442 10.7442 0) u=104 imp:n=1
c
3092  0 81 -1  84 -88 fill=5 (-5.3721 10.7442 0) u=104 imp:n=1
c

```

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LIQUID METAL FAST REACTOR - LMFR
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```

3093  0 1 -2  84 -88 fill=5 (0 10.7442 0) u=104 imp:n=1
c
3094  0 2 -82  84 -88 fill=5 (5.3721 10.7442 0) u=104 imp:n=1
c
3095  0 82 -86  84 -88 fill=5 (10.7442 10.7442 0) u=104 imp:n=1
c
c Surround material
c
3096  0 89 -90 91 -92 (-85:86:-87:88) -71 u=104 imp:n=1
c
3097  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=104 imp:n=1
c
3098  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=104 imp:n=1
c
3099  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=104 imp:n=1
c
3100  0 89 -90 91 -92 (-85:86:-87:88) 74 u=104 imp:n=1
c
c
c ROW 2
c
c Bottom central array of 5x5 core elements in row 2
c
3201  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=102 imp:n=1
c
3202  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=102 imp:n=1
c
3203  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=102 imp:n=1
c
3204  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=102 imp:n=1
c
3205  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=102 imp:n=1
c
c
3206  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=102 imp:n=1
c
3207  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=102 imp:n=1
c
3208  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=102 imp:n=1
c
3209  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=102 imp:n=1
c
3210  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=102 imp:n=1
c
c
3211  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=102 imp:n=1
c
3212  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=102 imp:n=1
c
3213  0 1 -2  3 -4 fill=6 (0 0 0) u=102 imp:n=1
c
3214  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=102 imp:n=1
c
3215  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=102 imp:n=1
c
c
3216  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=102 imp:n=1
c
3217  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=102 imp:n=1
c
3218  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=102 imp:n=1
c
3219  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=102 imp:n=1
c
3220  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=102 imp:n=1
c
c
3221  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=102 imp:n=1
c
3222  0 81 -1  84 -88 fill=5 (-5.3721 10.7442 0) u=102 imp:n=1
c
3223  0 1 -2  84 -88 fill=5 (0 10.7442 0) u=102 imp:n=1
c
3224  0 2 -82  84 -88 fill=5 (5.3721 10.7442 0) u=102 imp:n=1

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
3225  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=102 imp:n=1
c
c Surround material
c
3226  0 89 -90 91 -92 (-85:86:-87:88) -71 u=102 imp:n=1
c
3227  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=102 imp:n=1
c
3228  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=102 imp:n=1
c
3229  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=102 imp:n=1
c
3230  0 89 -90 91 -92 (-85:86:-87:88) 74 u=102 imp:n=1
c
c
c ROW 4
c
c
c Left edge array of 5x5 core elements in row 4
c
3231  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=105 imp:n=1
c
3232  0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=105 imp:n=1
c
3233  0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=105 imp:n=1
c
3234  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=105 imp:n=1
c
3235  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=105 imp:n=1
c
c
3236  0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=105 imp:n=1
c
3237  0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=105 imp:n=1
c
3238  0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=105 imp:n=1
c
3239  0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=105 imp:n=1
c
3240  0 82 -86 83 -3 fill=5 (10.7442 -5.3721 0) u=105 imp:n=1
c
c
3241  0 85 -81 3 -4 fill=6 (-10.7442 0 0) u=105 imp:n=1
c
3242  0 81 -1 3 -4 fill=6 (-5.3721 0 0) u=105 imp:n=1
c
3243  0 1 -2 3 -4 fill=6 (0 0 0) u=105 imp:n=1
c
3244  0 2 -82 3 -4 fill=6 (5.3721 0 0) u=105 imp:n=1
c
3245  0 82 -86 3 -4 fill=5 (10.7442 0 0) u=105 imp:n=1
c
c
3246  0 85 -81 4 -84 fill=6 (-10.7442 5.3721 0) u=105 imp:n=1
c
3247  0 81 -1 4 -84 fill=6 (-5.3721 5.3721 0) u=105 imp:n=1
c
3248  0 1 -2 4 -84 fill=6 (0 5.3721 0) u=105 imp:n=1
c
3249  0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=105 imp:n=1
c
3250  0 82 -86 4 -84 fill=5 (10.7442 5.3721 0) u=105 imp:n=1
c
c
3251  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=105 imp:n=1
c
3252  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=105 imp:n=1
c
3253  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=105 imp:n=1
c
3254  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=105 imp:n=1
c
3255  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=105 imp:n=1

```

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LIQUID METAL FAST REACTOR - LMFR
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```

c
c Surround material
c
3256  0 89 -90 91 -92 (-85:86:-87:88) -71 u=105 imp:n=1
c
3257  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=105 imp:n=1
c
3258  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=105 imp:n=1
c
3259  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=105 imp:n=1
c
3260  0 89 -90 91 -92 (-85:86:-87:88) 74 u=105 imp:n=1
c
c
c Right edge array of 5x5 core elements in row 4
c
3261  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=106 imp:n=1
c
3262  0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=106 imp:n=1
c
3263  0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=106 imp:n=1
c
3264  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=106 imp:n=1
c
3265  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=106 imp:n=1
c
c
3266  0 85 -81 83 -3 fill=5 (-10.7442 -5.3721 0) u=106 imp:n=1
c
3267  0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=106 imp:n=1
c
3268  0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=106 imp:n=1
c
3269  0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=106 imp:n=1
c
3270  0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=106 imp:n=1
c
c
3271  0 85 -81 3 -4 fill=5 (-10.7442 0 0) u=106 imp:n=1
c
3272  0 81 -1 3 -4 fill=6 (-5.3721 0 0) u=106 imp:n=1
c
3273  0 1 -2 3 -4 fill=6 (0 0 0) u=106 imp:n=1
c
3274  0 2 -82 3 -4 fill=6 (5.3721 0 0) u=106 imp:n=1
c
3275  0 82 -86 3 -4 fill=6 (10.7442 0 0) u=106 imp:n=1
c
c
3276  0 85 -81 4 -84 fill=5 (-10.7442 5.3721 0) u=106 imp:n=1
c
3277  0 81 -1 4 -84 fill=6 (-5.3721 5.3721 0) u=106 imp:n=1
c
3278  0 1 -2 4 -84 fill=6 (0 5.3721 0) u=106 imp:n=1
c
3279  0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=106 imp:n=1
c
3280  0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=106 imp:n=1
c
c
3281  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=106 imp:n=1
c
3282  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=106 imp:n=1
c
3283  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=106 imp:n=1
c
3284  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=106 imp:n=1
c
3285  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=106 imp:n=1
c
c Surround material
c
3286  0 89 -90 91 -92 (-85:86:-87:88) -71 u=106 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

3287  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=106 imp:n=1
c
3288  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=106 imp:n=1
c
3289  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=106 imp:n=1
c
3290  0 89 -90 91 -92 (-85:86:-87:88) 74 u=106 imp:n=1
c
c
c ROW 5
c
c Top left array of 5x5 core elements in Row 5
c
3331  0 85 -81 87 -83 fill=5 (-10.7442 -10.7442 0) u=107 imp:n=1
c
3332  0 81 -1 87 -83 fill=5 (-5.3721 -10.7442 0) u=107 imp:n=1
c
3333  0 1 -2 87 -83 fill=5 (0 -10.7442 0) u=107 imp:n=1
c
3334  0 2 -82 87 -83 fill=5 (5.3721 -10.7442 0) u=107 imp:n=1
c
3335  0 82 -86 87 -83 fill=5 (10.7442 -10.7442 0) u=107 imp:n=1
c
c
3336  0 85 -81 83 -3 fill=5 (-10.7442 -5.3721 0) u=107 imp:n=1
c
3337  0 81 -1 83 -3 fill=5 (-5.3721 -5.3721 0) u=107 imp:n=1
c
3338  0 1 -2 83 -3 fill=5 (0 -5.3721 0) u=107 imp:n=1
c
3339  0 2 -82 83 -3 fill=5 (5.3721 -5.3721 0) u=107 imp:n=1
c
3340  0 82 -86 83 -3 fill=5 (10.7442 -5.3721 0) u=107 imp:n=1
c
c
3341  0 85 -81 3 -4 fill=6 (-10.7442 0 0) u=107 imp:n=1
c
3342  0 81 -1 3 -4 fill=5 (-5.3721 0 0) u=107 imp:n=1
c
3343  0 1 -2 3 -4 fill=5 (0 0 0) u=107 imp:n=1
c
3344  0 2 -82 3 -4 fill=5 (5.3721 0 0) u=107 imp:n=1
c
3345  0 82 -86 3 -4 fill=5 (10.7442 0 0) u=107 imp:n=1
c
c
3346  0 85 -81 4 -84 fill=6 (-10.7442 5.3721 0) u=107 imp:n=1
c
3347  0 81 -1 4 -84 fill=5 (-5.3721 5.3721 0) u=107 imp:n=1
c
3348  0 1 -2 4 -84 fill=5 (0 5.3721 0) u=107 imp:n=1
c
3349  0 2 -82 4 -84 fill=5 (5.3721 5.3721 0) u=107 imp:n=1
c
3350  0 82 -86 4 -84 fill=5 (10.7442 5.3721 0) u=107 imp:n=1
c
c
3351  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=107 imp:n=1
c
3352  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=107 imp:n=1
c
3353  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=107 imp:n=1
c
3354  0 2 -82 84 -88 fill=5 (5.3721 10.7442 0) u=107 imp:n=1
c
3355  0 82 -86 84 -88 fill=5 (10.7442 10.7442 0) u=107 imp:n=1
c
c Surround material
c
3356  0 89 -90 91 -92 (-85:86:-87:88) -71 u=107 imp:n=1
c
3357  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=107 imp:n=1
c
3358  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=107 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
3359  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=107 imp:n=1
c
3360  0 89 -90 91 -92 (-85:86:-87:88) 74 u=107 imp:n=1
c
c Top right array of 5x5 core elements in Row 5
c
3371  0 85 -81 87 -83 fill=5 (-10.7442 -10.7442 0) u=108 imp:n=1
c
3372  0 81 -1 87 -83 fill=5 (-5.3721 -10.7442 0) u=108 imp:n=1
c
3373  0 1 -2 87 -83 fill=5 (0 -10.7442 0) u=108 imp:n=1
c
3374  0 2 -82 87 -83 fill=5 (5.3721 -10.7442 0) u=108 imp:n=1
c
3375  0 82 -86 87 -83 fill=5 (10.7442 -10.7442 0) u=108 imp:n=1
c
c
3376  0 85 -81 83 -3 fill=5 (-10.7442 -5.3721 0) u=108 imp:n=1
c
3377  0 81 -1 83 -3 fill=5 (-5.3721 -5.3721 0) u=108 imp:n=1
c
3378  0 1 -2 83 -3 fill=5 (0 -5.3721 0) u=108 imp:n=1
c
3379  0 2 -82 83 -3 fill=5 (5.3721 -5.3721 0) u=108 imp:n=1
c
3380  0 82 -86 83 -3 fill=5 (10.7442 -5.3721 0) u=108 imp:n=1
c
c
3381  0 85 -81 3 -4 fill=5 (-10.7442 0 0) u=108 imp:n=1
c
3382  0 81 -1 3 -4 fill=5 (-5.3721 0 0) u=108 imp:n=1
c
3383  0 1 -2 3 -4 fill=5 (0 0 0) u=108 imp:n=1
c
3384  0 2 -82 3 -4 fill=5 (5.3721 0 0) u=108 imp:n=1
c
3385  0 82 -86 3 -4 fill=6 (10.7442 0 0) u=108 imp:n=1
c
c
3386  0 85 -81 4 -84 fill=5 (-10.7442 5.3721 0) u=108 imp:n=1
c
3387  0 81 -1 4 -84 fill=5 (-5.3721 5.3721 0) u=108 imp:n=1
c
3388  0 1 -2 4 -84 fill=5 (0 5.3721 0) u=108 imp:n=1
c
3389  0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=108 imp:n=1
c
3390  0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=108 imp:n=1
c
c
3391  0 85 -81 84 -88 fill=5 (-10.7442 10.7442 0) u=108 imp:n=1
c
3392  0 81 -1 84 -88 fill=5 (-5.3721 10.7442 0) u=108 imp:n=1
c
3393  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=108 imp:n=1
c
3394  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=108 imp:n=1
c
3395  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=108 imp:n=1
c
c Surround material
c
3396  0 89 -90 91 -92 (-85:86:-87:88) -71 u=108 imp:n=1
c
3397  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=108 imp:n=1
c
3398  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=108 imp:n=1
c
3399  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=108 imp:n=1
c
3400  0 89 -90 91 -92 (-85:86:-87:88) 74 u=108 imp:n=1
c

```

ROW 6

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Top central group
c
c
3401  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=109 imp:n=1
c
3402  0 81 -1  87 -83 fill=5 (-5.3721 -10.7442 0) u=109 imp:n=1
c
3403  0 1 -2  87 -83 fill=5 (0 -10.7442 0) u=109 imp:n=1
c
3404  0 2 -82  87 -83 fill=5 (5.3721 -10.7442 0) u=109 imp:n=1
c
3405  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=109 imp:n=1
c
c
3406  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=109 imp:n=1
c
3407  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=109 imp:n=1
c
3408  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=109 imp:n=1
c
3409  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=109 imp:n=1
c
3410  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=109 imp:n=1
c
c
3411  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=109 imp:n=1
c
3412  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=109 imp:n=1
c
3413  0 1 -2  3 -4 fill=6 (0 0 0) u=109 imp:n=1
c
3414  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=109 imp:n=1
c
3415  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=109 imp:n=1
c
c
3416  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=109 imp:n=1
c
3417  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=109 imp:n=1
c
3418  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=109 imp:n=1
c
3419  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=109 imp:n=1
c
3420  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=109 imp:n=1
c
c
3421  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=109 imp:n=1
c
3422  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=109 imp:n=1
c
3423  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=109 imp:n=1
c
3424  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=109 imp:n=1
c
3425  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=109 imp:n=1
c
c Surround material
c
3426  0 89 -90 91 -92 (-85:86:-87:88) -71 u=109 imp:n=1
c
3427  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=109 imp:n=1
c
3428  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=109 imp:n=1
c
3429  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=109 imp:n=1
c
3430  0 89 -90 91 -92 (-85:86:-87:88) 74 u=109 imp:n=1
c
c
c 5x5 array of blanket elements
c
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3501  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=111 imp:n=1
c
3502  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=111 imp:n=1
c
3503  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=111 imp:n=1
c
3504  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=111 imp:n=1
c
3505  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=111 imp:n=1
c
c
3506  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=111 imp:n=1
c
3507  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=111 imp:n=1
c
3508  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=111 imp:n=1
c
3509  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=111 imp:n=1
c
3510  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=111 imp:n=1
c
c
3511  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=111 imp:n=1
c
3512  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=111 imp:n=1
c
3513  0 1 -2  3 -4 fill=6 (0 0 0) u=111 imp:n=1
c
3514  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=111 imp:n=1
c
3515  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=111 imp:n=1
c
c
3516  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=111 imp:n=1
c
3517  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=111 imp:n=1
c
3518  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=111 imp:n=1
c
3519  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=111 imp:n=1
c
3520  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=111 imp:n=1
c
c
3521  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=111 imp:n=1
c
3522  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=111 imp:n=1
c
3523  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=111 imp:n=1
c
3524  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=111 imp:n=1
c
3525  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=111 imp:n=1
c
c Surround material
c
3526  0 89 -90 91 -92 (-85:86:-87:88) -71 u=111 imp:n=1
c
3527  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=111 imp:n=1
c
3528  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=111 imp:n=1
c
3529  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=111 imp:n=1
c
3530  0 89 -90 91 -92 (-85:86:-87:88) 74 u=111 imp:n=1
c
c
c Blanket-Reflector Arrays
c
c ROW 2
c
c Bottom Left
c
3531  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=112 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3532  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=112 imp:n=1
c
3533  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=112 imp:n=1
c
3534  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=112 imp:n=1
c
3535  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=112 imp:n=1
c
c
3536  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=112 imp:n=1
c
3537  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=112 imp:n=1
c
3538  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=112 imp:n=1
c
3539  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=112 imp:n=1
c
3540  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=112 imp:n=1
c
c
3541  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=112 imp:n=1
c
3542  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=112 imp:n=1
c
3543  0 1 -2  3 -4 fill=7 (0 0 0) u=112 imp:n=1
c
3544  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=112 imp:n=1
c
3545  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=112 imp:n=1
c
c
3546  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=112 imp:n=1
c
3547  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=112 imp:n=1
c
3548  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=112 imp:n=1
c
3549  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=112 imp:n=1
c
3550  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=112 imp:n=1
c
c
3551  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=112 imp:n=1
c
3552  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=112 imp:n=1
c
3553  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=112 imp:n=1
c
3554  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=112 imp:n=1
c
3555  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=112 imp:n=1
c
c Surround material
c
3556  0 89 -90 91 -92 (-85:86:-87:88) -71 u=112 imp:n=1
c
3557  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=112 imp:n=1
c
3558  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=112 imp:n=1
c
3559  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=112 imp:n=1
c
3560  0 89 -90 91 -92 (-85:86:-87:88) 74 u=112 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
3561  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=113 imp:n=1
c
3562  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=113 imp:n=1
c
3563  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=113 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3564  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=113 imp:n=1
c
3565  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=113 imp:n=1
c
c
3566  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=113 imp:n=1
c
3567  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=113 imp:n=1
c
3568  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=113 imp:n=1
c
3569  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=113 imp:n=1
c
3570  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=113 imp:n=1
c
c
3571  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=113 imp:n=1
c
3572  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=113 imp:n=1
c
3573  0 1 -2  3 -4 fill=7 (0 0 0) u=113 imp:n=1
c
3574  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=113 imp:n=1
c
3575  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=113 imp:n=1
c
c
3576  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=113 imp:n=1
c
3577  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=113 imp:n=1
c
3578  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=113 imp:n=1
c
3579  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=113 imp:n=1
c
3580  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=113 imp:n=1
c
c
3581  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=113 imp:n=1
c
3582  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=113 imp:n=1
c
3583  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=113 imp:n=1
c
3584  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=113 imp:n=1
c
3585  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=113 imp:n=1
c
c Surround material
c
3586  0 89 -90 91 -92 (-85:86:-87:88) -71 u=113 imp:n=1
c
3587  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=113 imp:n=1
c
3588  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=113 imp:n=1
c
3589  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=113 imp:n=1
c
3590  0 89 -90 91 -92 (-85:86:-87:88) 74 u=113 imp:n=1
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
3631  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=114 imp:n=1
c
3632  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=114 imp:n=1
c
3633  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=114 imp:n=1
c
3634  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=114 imp:n=1
c
3635  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=114 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3636  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=114 imp:n=1
c
3637  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=114 imp:n=1
c
3638  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=114 imp:n=1
c
3639  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=114 imp:n=1
c
3640  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=114 imp:n=1
c
c
3641  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=114 imp:n=1
c
3642  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=114 imp:n=1
c
3643  0 1 -2  3 -4 fill=7 (0 0 0) u=114 imp:n=1
c
3644  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=114 imp:n=1
c
3645  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=114 imp:n=1
c
c
3646  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=114 imp:n=1
c
3647  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=114 imp:n=1
c
3648  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=114 imp:n=1
c
3649  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=114 imp:n=1
c
3650  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=114 imp:n=1
c
c
3651  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=114 imp:n=1
c
3652  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=114 imp:n=1
c
3653  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=114 imp:n=1
c
3654  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=114 imp:n=1
c
3655  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=114 imp:n=1
c
c Surround material
c
3656  0 89 -90 91 -92 (-85:86:-87:88) -71 u=114 imp:n=1
c
3657  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=114 imp:n=1
c
3658  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=114 imp:n=1
c
3659  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=114 imp:n=1
c
3660  0 89 -90 91 -92 (-85:86:-87:88) 74 u=114 imp:n=1
c
c
c Row 6 Top Right Blanket Reflector Array
c
3661  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=115 imp:n=1
c
3662  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=115 imp:n=1
c
3663  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=115 imp:n=1
c
3664  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=115 imp:n=1
c
3665  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=115 imp:n=1
c
c
3666  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=115 imp:n=1
c
3667  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=115 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3668  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=115 imp:n=1
c
3669  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=115 imp:n=1
c
3670  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=115 imp:n=1
c
c
3671  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=115 imp:n=1
c
3672  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=115 imp:n=1
c
3673  0 1 -2  3 -4 fill=7 (0 0 0) u=115 imp:n=1
c
3674  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=115 imp:n=1
c
3675  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=115 imp:n=1
c
c
3676  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=115 imp:n=1
c
3677  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=115 imp:n=1
c
3678  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=115 imp:n=1
c
3679  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=115 imp:n=1
c
3680  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=115 imp:n=1
c
c
3681  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=115 imp:n=1
c
3682  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=115 imp:n=1
c
3683  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=115 imp:n=1
c
3684  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=115 imp:n=1
c
3685  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=115 imp:n=1
c
c Surround material
c
3686  0 89 -90 91 -92 (-85:86:-87:88) -71 u=115 imp:n=1
c
3687  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=115 imp:n=1
c
3688  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=115 imp:n=1
c
3689  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=115 imp:n=1
c
3690  0 89 -90 91 -92 (-85:86:-87:88) 74 u=115 imp:n=1
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
3701  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=121 imp:n=1
c
3702  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=121 imp:n=1
c
3703  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=121 imp:n=1
c
3704  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=121 imp:n=1
c
3705  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=121 imp:n=1
c
c
3706  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=121 imp:n=1
c
3707  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=121 imp:n=1
c
3708  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=121 imp:n=1
c
3709  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=121 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3710  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=121 imp:n=1
c
c
3711  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=121 imp:n=1
c
c
3712  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=121 imp:n=1
c
c
3713  0 1 -2  3 -4 fill=9 (0 0 0) u=121 imp:n=1
c
c
3714  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=121 imp:n=1
c
c
3715  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=121 imp:n=1
c
c
c
3716  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=121 imp:n=1
c
c
3717  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=121 imp:n=1
c
c
3718  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=121 imp:n=1
c
c
3719  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=121 imp:n=1
c
c
3720  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=121 imp:n=1
c
c
c
3721  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=121 imp:n=1
c
c
3722  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=121 imp:n=1
c
c
3723  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=121 imp:n=1
c
c
3724  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=121 imp:n=1
c
c
3725  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=121 imp:n=1
c
c
c Surround material
c
c
3726  0 89 -90 91 -92 (-85:86:-87:88) -71 u=121 imp:n=1
c
c
3727  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=121 imp:n=1
c
c
3728  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=121 imp:n=1
c
c
3729  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=121 imp:n=1
c
c
3730  0 89 -90 91 -92 (-85:86:-87:88) 74 u=121 imp:n=1
c
c
c
c Row 1 Mid-Left
c
c
3731  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=122 imp:n=1
c
c
3732  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=122 imp:n=1
c
c
3733  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=122 imp:n=1
c
c
3734  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=122 imp:n=1
c
c
3735  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=122 imp:n=1
c
c
c
3736  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=122 imp:n=1
c
c
3737  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=122 imp:n=1
c
c
3738  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=122 imp:n=1
c
c
3739  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=122 imp:n=1
c
c
3740  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=122 imp:n=1
c
c
c
3741  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=122 imp:n=1
c
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3742  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=122 imp:n=1
c
3743  0 1 -2  3 -4 fill=7 (0 0 0) u=122 imp:n=1
c
3744  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=122 imp:n=1
c
3745  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=122 imp:n=1
c
c
3746  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=122 imp:n=1
c
3747  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=122 imp:n=1
c
3748  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=122 imp:n=1
c
3749  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=122 imp:n=1
c
3750  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=122 imp:n=1
c
c
3751  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=122 imp:n=1
c
3752  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=122 imp:n=1
c
3753  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=122 imp:n=1
c
3754  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=122 imp:n=1
c
3755  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=122 imp:n=1
c
c Surround material
c
3756  0 89 -90 91 -92 (-85:86:-87:88) -71 u=122 imp:n=1
c
3757  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=122 imp:n=1
c
3758  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=122 imp:n=1
c
3759  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=122 imp:n=1
c
3760  0 89 -90 91 -92 (-85:86:-87:88) 74 u=122 imp:n=1
c
c
c Row 1 Central Array
c
3761  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=123 imp:n=1
c
3762  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=123 imp:n=1
c
3763  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=123 imp:n=1
c
3764  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=123 imp:n=1
c
3765  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=123 imp:n=1
c
c
3766  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=123 imp:n=1
c
3767  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=123 imp:n=1
c
3768  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=123 imp:n=1
c
3769  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=123 imp:n=1
c
3770  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=123 imp:n=1
c
c
3771  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=123 imp:n=1
c
3772  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=123 imp:n=1
c
3773  0 1 -2  3 -4 fill=7 (0 0 0) u=123 imp:n=1
c
3774  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=123 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3775  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=123 imp:n=1
c
c
3776  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=123 imp:n=1
c
3777  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=123 imp:n=1
c
3778  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=123 imp:n=1
c
3779  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=123 imp:n=1
c
3780  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=123 imp:n=1
c
c
c
3781  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=123 imp:n=1
c
3782  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=123 imp:n=1
c
3783  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=123 imp:n=1
c
3784  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=123 imp:n=1
c
3785  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=123 imp:n=1
c
c Surround material
c
3786  0 89 -90 91 -92 (-85:86:-87:88) -71 u=123 imp:n=1
c
3787  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=123 imp:n=1
c
3788  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=123 imp:n=1
c
3789  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=123 imp:n=1
c
3790  0 89 -90 91 -92 (-85:86:-87:88) 74 u=123 imp:n=1
c
c
c Row 1 First Right array
c
3801  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=124 imp:n=1
c
3802  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=124 imp:n=1
c
3803  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=124 imp:n=1
c
3804  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=124 imp:n=1
c
3805  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=124 imp:n=1
c
c
3806  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=124 imp:n=1
c
3807  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=124 imp:n=1
c
3808  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=124 imp:n=1
c
3809  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=124 imp:n=1
c
3810  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=124 imp:n=1
c
c
3811  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=124 imp:n=1
c
3812  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=124 imp:n=1
c
3813  0 1 -2  3 -4 fill=7 (0 0 0) u=124 imp:n=1
c
3814  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=124 imp:n=1
c
3815  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=124 imp:n=1
c
c
3816  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=124 imp:n=1

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
3817  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=124 imp:n=1
c
3818  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=124 imp:n=1
c
3819  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=124 imp:n=1
c
3820  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=124 imp:n=1
c
c
3821  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=124 imp:n=1
c
3822  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=124 imp:n=1
c
3823  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=124 imp:n=1
c
3824  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=124 imp:n=1
c
3825  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=124 imp:n=1
c
c Surround material
c
3826  0 89 -90 91 -92 (-85:86:-87:88) -71 u=124 imp:n=1
c
3827  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=124 imp:n=1
c
3828  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=124 imp:n=1
c
3829  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=124 imp:n=1
c
3830  0 89 -90 91 -92 (-85:86:-87:88) 74 u=124 imp:n=1
c
c
c Row 1 Far Right
c
3831  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=125 imp:n=1
c
3832  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=125 imp:n=1
c
3833  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=125 imp:n=1
c
3834  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=125 imp:n=1
c
3835  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=125 imp:n=1
c
c
3836  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=125 imp:n=1
c
3837  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=125 imp:n=1
c
3838  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=125 imp:n=1
c
3839  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=125 imp:n=1
c
3840  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=125 imp:n=1
c
c
3841  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=125 imp:n=1
c
3842  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=125 imp:n=1
c
3843  0 1 -2  3 -4 fill=9 (0 0 0) u=125 imp:n=1
c
3844  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=125 imp:n=1
c
3845  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=125 imp:n=1
c
c
3846  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=125 imp:n=1
c
3847  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=125 imp:n=1
c
3848  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=125 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3849  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=125 imp:n=1
c
3850  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=125 imp:n=1
c
c
3851  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=125 imp:n=1
c
3852  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=125 imp:n=1
c
3853  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=125 imp:n=1
c
3854  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=125 imp:n=1
c
3855  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=125 imp:n=1
c
c Surround material
c
3856  0 89 -90 91 -92 (-85:86:-87:88) -71 u=125 imp:n=1
c
3857  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=125 imp:n=1
c
3858  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=125 imp:n=1
c
3859  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=125 imp:n=1
c
3860  0 89 -90 91 -92 (-85:86:-87:88) 74 u=125 imp:n=1
c
c Row 2 Blanket reflector arrays
c
c Row 2 First Left array
c
3901  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=127 imp:n=1
c
3902  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=127 imp:n=1
c
3903  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=127 imp:n=1
c
3904  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=127 imp:n=1
c
3905  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=127 imp:n=1
c
c
3906  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=127 imp:n=1
c
3907  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=127 imp:n=1
c
3908  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=127 imp:n=1
c
3909  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=127 imp:n=1
c
3910  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=127 imp:n=1
c
c
3911  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=127 imp:n=1
c
3912  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=127 imp:n=1
c
3913  0 1 -2  3 -4 fill=9 (0 0 0) u=127 imp:n=1
c
3914  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=127 imp:n=1
c
3915  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=127 imp:n=1
c
c
3916  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=127 imp:n=1
c
3917  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=127 imp:n=1
c
3918  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=127 imp:n=1
c
3919  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=127 imp:n=1
c
3920  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=127 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
3921  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=127 imp:n=1
c
3922  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=127 imp:n=1
c
3923  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=127 imp:n=1
c
3924  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=127 imp:n=1
c
3925  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=127 imp:n=1
c
c Surround material
c
3926  0 89 -90 91 -92 (-85:86:-87:88) -71 u=127 imp:n=1
c
3927  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=127 imp:n=1
c
3928  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=127 imp:n=1
c
3929  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=127 imp:n=1
c
3930  0 89 -90 91 -92 (-85:86:-87:88) 74 u=127 imp:n=1
c
c
c Row 2 Far Right
c
3931  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=128 imp:n=1
c
3932  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=128 imp:n=1
c
3933  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=128 imp:n=1
c
3934  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=128 imp:n=1
c
3935  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=128 imp:n=1
c
c
3936  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=128 imp:n=1
c
3937  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=128 imp:n=1
c
3938  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=128 imp:n=1
c
3939  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=128 imp:n=1
c
3940  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=128 imp:n=1
c
c
3941  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=128 imp:n=1
c
3942  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=128 imp:n=1
c
3943  0 1 -2  3 -4 fill=9 (0 0 0) u=128 imp:n=1
c
3944  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=128 imp:n=1
c
3945  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=128 imp:n=1
c
c
3946  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=128 imp:n=1
c
3947  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=128 imp:n=1
c
3948  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=128 imp:n=1
c
3949  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=128 imp:n=1
c
3950  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=128 imp:n=1
c
c
3951  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=128 imp:n=1
c
3952  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=128 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3953  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=128 imp:n=1
c
3954  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=128 imp:n=1
c
3955  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=128 imp:n=1
c
c Surround material
c
3956  0 89 -90 91 -92 (-85:86:-87:88) -71 u=128 imp:n=1
c
3957  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=128 imp:n=1
c
3958  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=128 imp:n=1
c
3959  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=128 imp:n=1
c
3960  0 89 -90 91 -92 (-85:86:-87:88) 74 u=128 imp:n=1
c
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
4001  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=157 imp:n=1
c
4002  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=157 imp:n=1
c
4003  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=157 imp:n=1
c
4004  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=157 imp:n=1
c
4005  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=157 imp:n=1
c
c
4006  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=157 imp:n=1
c
4007  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=157 imp:n=1
c
4008  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=157 imp:n=1
c
4009  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=157 imp:n=1
c
4010  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=157 imp:n=1
c
c
4011  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=157 imp:n=1
c
4012  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=157 imp:n=1
c
4013  0 1 -2  3 -4 fill=7 (0 0 0) u=157 imp:n=1
c
4014  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=157 imp:n=1
c
4015  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=157 imp:n=1
c
c
4016  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=157 imp:n=1
c
4017  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=157 imp:n=1
c
4018  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=157 imp:n=1
c
4019  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=157 imp:n=1
c
4020  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=157 imp:n=1
c
c
4021  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=157 imp:n=1
c
4022  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=157 imp:n=1
c
4023  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=157 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

4024    0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=157 imp:n=1
c
4025    0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=157 imp:n=1
c
c Surround material
c
4026    0 89 -90 91 -92 (-85:86:-87:88) -71 u=157 imp:n=1
c
4027    19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=157 imp:n=1
c
4028    0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=157 imp:n=1
c
4029    19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=157 imp:n=1
c
4030    0 89 -90 91 -92 (-85:86:-87:88) 74 u=157 imp:n=1
c
c
c Row 4 Far Right
c
4031    0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=158 imp:n=1
c
4032    0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=158 imp:n=1
c
4033    0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=158 imp:n=1
c
4034    0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=158 imp:n=1
c
4035    0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=158 imp:n=1
c
c
4036    0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=158 imp:n=1
c
4037    0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=158 imp:n=1
c
4038    0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=158 imp:n=1
c
4039    0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=158 imp:n=1
c
4040    0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=158 imp:n=1
c
c
4041    0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=158 imp:n=1
c
4042    0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=158 imp:n=1
c
4043    0 1 -2  3 -4 fill=7 (0 0 0) u=158 imp:n=1
c
4044    0 2 -82  3 -4 fill=7 (5.3721 0 0) u=158 imp:n=1
c
4045    0 82 -86  3 -4 fill=9 (10.7442 0 0) u=158 imp:n=1
c
c
4046    0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=158 imp:n=1
c
4047    0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=158 imp:n=1
c
4048    0 1 -2  4 -84 fill=7 (0 5.3721 0) u=158 imp:n=1
c
4049    0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=158 imp:n=1
c
4050    0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=158 imp:n=1
c
c
4051    0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=158 imp:n=1
c
4052    0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=158 imp:n=1
c
4053    0 1 -2  84 -88 fill=7 (0 10.7442 0) u=158 imp:n=1
c
4054    0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=158 imp:n=1
c
4055    0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=158 imp:n=1
c
c Surround material

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4056  0 89 -90 91 -92 (-85:86:-87:88) -71 u=158 imp:n=1
c
4057  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=158 imp:n=1
c
4058  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=158 imp:n=1
c
4059  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=158 imp:n=1
c
4060  0 89 -90 91 -92 (-85:86:-87:88) 74 u=158 imp:n=1
c
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
4101  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=137 imp:n=1
c
4102  0 81 -1 87 -83 fill=9 (-5.3721 -10.7442 0) u=137 imp:n=1
c
4103  0 1 -2 87 -83 fill=9 (0 -10.7442 0) u=137 imp:n=1
c
4104  0 2 -82 87 -83 fill=7 (5.3721 -10.7442 0) u=137 imp:n=1
c
4105  0 82 -86 87 -83 fill=7 (10.7442 -10.7442 0) u=137 imp:n=1
c
c
4106  0 85 -81 83 -3 fill=9 (-10.7442 -5.3721 0) u=137 imp:n=1
c
4107  0 81 -1 83 -3 fill=9 (-5.3721 -5.3721 0) u=137 imp:n=1
c
4108  0 1 -2 83 -3 fill=9 (0 -5.3721 0) u=137 imp:n=1
c
4109  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=137 imp:n=1
c
4110  0 82 -86 83 -3 fill=7 (10.7442 -5.3721 0) u=137 imp:n=1
c
c
4111  0 85 -81 3 -4 fill=9 (-10.7442 0 0) u=137 imp:n=1
c
4112  0 81 -1 3 -4 fill=9 (-5.3721 0 0) u=137 imp:n=1
c
4113  0 1 -2 3 -4 fill=9 (0 0 0) u=137 imp:n=1
c
4114  0 2 -82 3 -4 fill=9 (5.3721 0 0) u=137 imp:n=1
c
4115  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=137 imp:n=1
c
c
4116  0 85 -81 4 -84 fill=9 (-10.7442 5.3721 0) u=137 imp:n=1
c
4117  0 81 -1 4 -84 fill=9 (-5.3721 5.3721 0) u=137 imp:n=1
c
4118  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=137 imp:n=1
c
4119  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=137 imp:n=1
c
4120  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=137 imp:n=1
c
c
4121  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=137 imp:n=1
c
4122  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=137 imp:n=1
c
4123  0 1 -2 84 -88 fill=9 (0 10.7442 0) u=137 imp:n=1
c
4124  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=137 imp:n=1
c
4125  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=137 imp:n=1
c
c Surround material
c
4126  0 89 -90 91 -92 (-85:86:-87:88) -71 u=137 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4127  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=137 imp:n=1
c
4128  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=137 imp:n=1
c
4129  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=137 imp:n=1
c
4130  0 89 -90 91 -92 (-85:86:-87:88) 74 u=137 imp:n=1
c
c
c Row 6 Far Right
c
4131  0 85 -81 87 -83 fill=7 (-10.7442 -10.7442 0) u=138 imp:n=1
c
4132  0 81 -1 87 -83 fill=7 (-5.3721 -10.7442 0) u=138 imp:n=1
c
4133  0 1 -2 87 -83 fill=9 (0 -10.7442 0) u=138 imp:n=1
c
4134  0 2 -82 87 -83 fill=9 (5.3721 -10.7442 0) u=138 imp:n=1
c
4135  0 82 -86 87 -83 fill=9 (10.7442 -10.7442 0) u=138 imp:n=1
c
c
c
4136  0 85 -81 83 -3 fill=7 (-10.7442 -5.3721 0) u=138 imp:n=1
c
4137  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=138 imp:n=1
c
4138  0 1 -2 83 -3 fill=9 (0 -5.3721 0) u=138 imp:n=1
c
4139  0 2 -82 83 -3 fill=9 (5.3721 -5.3721 0) u=138 imp:n=1
c
4140  0 82 -86 83 -3 fill=9 (10.7442 -5.3721 0) u=138 imp:n=1
c
c
c
4141  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=138 imp:n=1
c
4142  0 81 -1 3 -4 fill=9 (-5.3721 0 0) u=138 imp:n=1
c
4143  0 1 -2 3 -4 fill=9 (0 0 0) u=138 imp:n=1
c
4144  0 2 -82 3 -4 fill=9 (5.3721 0 0) u=138 imp:n=1
c
4145  0 82 -86 3 -4 fill=9 (10.7442 0 0) u=138 imp:n=1
c
c
c
4146  0 85 -81 4 -84 fill=9 (-10.7442 5.3721 0) u=138 imp:n=1
c
4147  0 81 -1 4 -84 fill=9 (-5.3721 5.3721 0) u=138 imp:n=1
c
4148  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=138 imp:n=1
c
4149  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=138 imp:n=1
c
4150  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=138 imp:n=1
c
c
c
4151  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=138 imp:n=1
c
4152  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=138 imp:n=1
c
4153  0 1 -2 84 -88 fill=9 (0 10.7442 0) u=138 imp:n=1
c
4154  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=138 imp:n=1
c
4155  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=138 imp:n=1
c
c Surround material
c
4156  0 89 -90 91 -92 (-85:86:-87:88) -71 u=138 imp:n=1
c
4157  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=138 imp:n=1
c
4158  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=138 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4159  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=138 imp:n=1
c
4160  0 89 -90 91 -92 (-85:86:-87:88) 74 u=138 imp:n=1
c
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
4201  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=167 imp:n=1
c
4202  0 81 -1 87 -83 fill=7 (-5.3721 -10.7442 0) u=167 imp:n=1
c
4203  0 1 -2 87 -83 fill=7 (0 -10.7442 0) u=167 imp:n=1
c
4204  0 2 -82 87 -83 fill=7 (5.3721 -10.7442 0) u=167 imp:n=1
c
4205  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=167 imp:n=1
c
c
c
4206  0 85 -81 83 -3 fill=9 (-10.7442 -5.3721 0) u=167 imp:n=1
c
4207  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=167 imp:n=1
c
4208  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=167 imp:n=1
c
4209  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=167 imp:n=1
c
4210  0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=167 imp:n=1
c
c
c
4211  0 85 -81 3 -4 fill=9 (-10.7442 0 0) u=167 imp:n=1
c
4212  0 81 -1 3 -4 fill=9 (-5.3721 0 0) u=167 imp:n=1
c
4213  0 1 -2 3 -4 fill=7 (0 0 0) u=167 imp:n=1
c
4214  0 2 -82 3 -4 fill=7 (5.3721 0 0) u=167 imp:n=1
c
4215  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=167 imp:n=1
c
c
c
4216  0 85 -81 4 -84 fill=9 (-10.7442 5.3721 0) u=167 imp:n=1
c
4217  0 81 -1 4 -84 fill=9 (-5.3721 5.3721 0) u=167 imp:n=1
c
4218  0 1 -2 4 -84 fill=7 (0 5.3721 0) u=167 imp:n=1
c
4219  0 2 -82 4 -84 fill=7 (5.3721 5.3721 0) u=167 imp:n=1
c
4220  0 82 -86 4 -84 fill=7 (10.7442 5.3721 0) u=167 imp:n=1
c
c
c
4221  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=167 imp:n=1
c
4222  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=167 imp:n=1
c
4223  0 1 -2 84 -88 fill=7 (0 10.7442 0) u=167 imp:n=1
c
4224  0 2 -82 84 -88 fill=7 (5.3721 10.7442 0) u=167 imp:n=1
c
4225  0 82 -86 84 -88 fill=7 (10.7442 10.7442 0) u=167 imp:n=1
c
c Surround material
c
c
4226  0 89 -90 91 -92 (-85:86:-87:88) -71 u=167 imp:n=1
c
4227  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=167 imp:n=1
c
4228  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=167 imp:n=1
c
4229  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=167 imp:n=1

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4230  0 89 -90 91 -92 (-85:86:-87:88) 74 u=167 imp:n=1
c
c
c Row 4 Far Right
c
4231  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=168 imp:n=1
c
4232  0 81 -1 87 -83 fill=7 (-5.3721 -10.7442 0) u=168 imp:n=1
c
4233  0 1 -2 87 -83 fill=7 (0 -10.7442 0) u=168 imp:n=1
c
4234  0 2 -82 87 -83 fill=7 (5.3721 -10.7442 0) u=168 imp:n=1
c
4235  0 82 -86 87 -83 fill=9 (10.7442 -10.7442 0) u=168 imp:n=1
c
c
4236  0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=168 imp:n=1
c
4237  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=168 imp:n=1
c
4238  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=168 imp:n=1
c
4239  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=168 imp:n=1
c
4240  0 82 -86 83 -3 fill=9 (10.7442 -5.3721 0) u=168 imp:n=1
c
c
4241  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=168 imp:n=1
c
4242  0 81 -1 3 -4 fill=7 (-5.3721 0 0) u=168 imp:n=1
c
4243  0 1 -2 3 -4 fill=7 (0 0 0) u=168 imp:n=1
c
4244  0 2 -82 3 -4 fill=9 (5.3721 0 0) u=168 imp:n=1
c
4245  0 82 -86 3 -4 fill=9 (10.7442 0 0) u=168 imp:n=1
c
c
4246  0 85 -81 4 -84 fill=7 (-10.7442 5.3721 0) u=168 imp:n=1
c
4247  0 81 -1 4 -84 fill=7 (-5.3721 5.3721 0) u=168 imp:n=1
c
4248  0 1 -2 4 -84 fill=7 (0 5.3721 0) u=168 imp:n=1
c
4249  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=168 imp:n=1
c
4250  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=168 imp:n=1
c
c
4251  0 85 -81 84 -88 fill=7 (-10.7442 10.7442 0) u=168 imp:n=1
c
4252  0 81 -1 84 -88 fill=7 (-5.3721 10.7442 0) u=168 imp:n=1
c
4253  0 1 -2 84 -88 fill=7 (0 10.7442 0) u=168 imp:n=1
c
4254  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=168 imp:n=1
c
4255  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=168 imp:n=1
c
c Surround material
c
4256  0 89 -90 91 -92 (-85:86:-87:88) -71 u=168 imp:n=1
c
4257  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=168 imp:n=1
c
4258  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=168 imp:n=1
c
4259  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=168 imp:n=1
c
4260  0 89 -90 91 -92 (-85:86:-87:88) 74 u=168 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c
c Row 3 First Left array
c
4301  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=147 imp:n=1
c
4302  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=147 imp:n=1
c
4303  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=147 imp:n=1
c
4304  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=147 imp:n=1
c
4305  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=147 imp:n=1
c
c
c
4306  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=147 imp:n=1
c
4307  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=147 imp:n=1
c
4308  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=147 imp:n=1
c
4309  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=147 imp:n=1
c
4310  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=147 imp:n=1
c
c
c
4311  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=147 imp:n=1
c
4312  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=147 imp:n=1
c
4313  0 1 -2  3 -4 fill=7 (0 0 0) u=147 imp:n=1
c
4314  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=147 imp:n=1
c
4315  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=147 imp:n=1
c
c
c
4316  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=147 imp:n=1
c
4317  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=147 imp:n=1
c
4318  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=147 imp:n=1
c
4319  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=147 imp:n=1
c
4320  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=147 imp:n=1
c
c
c
4321  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=147 imp:n=1
c
4322  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=147 imp:n=1
c
4323  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=147 imp:n=1
c
4324  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=147 imp:n=1
c
4325  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=147 imp:n=1
c
c Surround material
c
4326  0 89 -90 91 -92 (-85:86:-87:88) -71 u=147 imp:n=1
c
4327  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=147 imp:n=1
c
4328  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=147 imp:n=1
c
4329  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=147 imp:n=1
c
4330  0 89 -90 91 -92 (-85:86:-87:88) 74 u=147 imp:n=1
c
c
c Row 3 Far Right
c
4331  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=148 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4332  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=148 imp:n=1
c
4333  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=148 imp:n=1
c
4334  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=148 imp:n=1
c
4335  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=148 imp:n=1
c
c
4336  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=148 imp:n=1
c
4337  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=148 imp:n=1
c
4338  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=148 imp:n=1
c
4339  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=148 imp:n=1
c
4340  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=148 imp:n=1
c
c
4341  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=148 imp:n=1
c
4342  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=148 imp:n=1
c
4343  0 1 -2  3 -4 fill=7 (0 0 0) u=148 imp:n=1
c
4344  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=148 imp:n=1
c
4345  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=148 imp:n=1
c
c
4346  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=148 imp:n=1
c
4347  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=148 imp:n=1
c
4348  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=148 imp:n=1
c
4349  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=148 imp:n=1
c
4350  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=148 imp:n=1
c
c
4351  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=148 imp:n=1
c
4352  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=148 imp:n=1
c
4353  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=148 imp:n=1
c
4354  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=148 imp:n=1
c
4355  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=148 imp:n=1
c
c Surround material
c
4356  0 89 -90 91 -92 (-85:86:-87:88) -71 u=148 imp:n=1
c
4357  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=148 imp:n=1
c
4358  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=148 imp:n=1
c
4359  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=148 imp:n=1
c
4360  0 89 -90 91 -92 (-85:86:-87:88) 74 u=148 imp:n=1
c
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
4701  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=131 imp:n=1
c
4702  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=131 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4703  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=131 imp:n=1
c
4704  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=131 imp:n=1
c
4705  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=131 imp:n=1
c
c
4706  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=131 imp:n=1
c
4707  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=131 imp:n=1
c
4708  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=131 imp:n=1
c
4709  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=131 imp:n=1
c
4710  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=131 imp:n=1
c
c
4711  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=131 imp:n=1
c
4712  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=131 imp:n=1
c
4713  0 1 -2  3 -4 fill=9 (0 0 0) u=131 imp:n=1
c
4714  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=131 imp:n=1
c
4715  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=131 imp:n=1
c
c
4716  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=131 imp:n=1
c
4717  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=131 imp:n=1
c
4718  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=131 imp:n=1
c
4719  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=131 imp:n=1
c
4720  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=131 imp:n=1
c
c
4721  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=131 imp:n=1
c
4722  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=131 imp:n=1
c
4723  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=131 imp:n=1
c
4724  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=131 imp:n=1
c
4725  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=131 imp:n=1
c
c Surround material
c
4726  0 89 -90 91 -92 (-85:86:-87:88) -71 u=131 imp:n=1
c
4727  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=131 imp:n=1
c
4728  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=131 imp:n=1
c
4729  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=131 imp:n=1
c
4730  0 89 -90 91 -92 (-85:86:-87:88) 74 u=131 imp:n=1
c
c
c Row 7 Mid-Left
c
4731  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=132 imp:n=1
c
4732  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=132 imp:n=1
c
4733  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=132 imp:n=1
c
4734  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=132 imp:n=1
c
4735  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=132 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c
4736  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=132 imp:n=1
c
4737  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=132 imp:n=1
c
4738  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=132 imp:n=1
c
4739  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=132 imp:n=1
c
4740  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=132 imp:n=1
c
c
4741  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=132 imp:n=1
c
4742  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=132 imp:n=1
c
4743  0 1 -2  3 -4 fill=7 (0 0 0) u=132 imp:n=1
c
4744  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=132 imp:n=1
c
4745  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=132 imp:n=1
c
c
4746  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=132 imp:n=1
c
4747  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=132 imp:n=1
c
4748  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=132 imp:n=1
c
4749  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=132 imp:n=1
c
4750  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=132 imp:n=1
c
c
4751  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=132 imp:n=1
c
4752  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=132 imp:n=1
c
4753  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=132 imp:n=1
c
4754  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=132 imp:n=1
c
4755  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=132 imp:n=1
c
c Surround material
c
4756  0 89 -90 91 -92 (-85:86:-87:88) -71 u=132 imp:n=1
c
4757  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=132 imp:n=1
c
4758  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=132 imp:n=1
c
4759  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=132 imp:n=1
c
4760  0 89 -90 91 -92 (-85:86:-87:88) 74 u=132 imp:n=1
c
c
c Row 7 Central Array
c
4761  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=133 imp:n=1
c
4762  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=133 imp:n=1
c
4763  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=133 imp:n=1
c
4764  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=133 imp:n=1
c
4765  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=133 imp:n=1
c
c
4766  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=133 imp:n=1
c
4767  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=133 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4768  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=133 imp:n=1
c
4769  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=133 imp:n=1
c
4770  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=133 imp:n=1
c
c
4771  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=133 imp:n=1
c
4772  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=133 imp:n=1
c
4773  0 1 -2  3 -4 fill=7 (0 0 0) u=133 imp:n=1
c
4774  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=133 imp:n=1
c
4775  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=133 imp:n=1
c
c
4776  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=133 imp:n=1
c
4777  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=133 imp:n=1
c
4778  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=133 imp:n=1
c
4779  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=133 imp:n=1
c
4780  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=133 imp:n=1
c
c
4781  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=133 imp:n=1
c
4782  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=133 imp:n=1
c
4783  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=133 imp:n=1
c
4784  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=133 imp:n=1
c
4785  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=133 imp:n=1
c
c Surround material
c
4786  0 89 -90 91 -92 (-85:86:-87:88) -71 u=133 imp:n=1
c
4787  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=133 imp:n=1
c
4788  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=133 imp:n=1
c
4789  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=133 imp:n=1
c
4790  0 89 -90 91 -92 (-85:86:-87:88) 74 u=133 imp:n=1
c
c
c Row 7 First Right array
c
4801  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=134 imp:n=1
c
4802  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=134 imp:n=1
c
4803  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=134 imp:n=1
c
4804  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=134 imp:n=1
c
4805  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=134 imp:n=1
c
c
4806  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=134 imp:n=1
c
4807  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=134 imp:n=1
c
4808  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=134 imp:n=1
c
4809  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=134 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

4810  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=134 imp:n=1
c
c
4811  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=134 imp:n=1
c
4812  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=134 imp:n=1
c
4813  0 1 -2  3 -4 fill=7 (0 0 0) u=134 imp:n=1
c
4814  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=134 imp:n=1
c
4815  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=134 imp:n=1
c
c
4816  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=134 imp:n=1
c
4817  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=134 imp:n=1
c
4818  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=134 imp:n=1
c
4819  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=134 imp:n=1
c
4820  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=134 imp:n=1
c
c
4821  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=134 imp:n=1
c
4822  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=134 imp:n=1
c
4823  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=134 imp:n=1
c
4824  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=134 imp:n=1
c
4825  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=134 imp:n=1
c
c Surround material
c
4826  0 89 -90 91 -92 (-85:86:-87:88) -71 u=134 imp:n=1
c
4827  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=134 imp:n=1
c
4828  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=134 imp:n=1
c
4829  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=134 imp:n=1
c
4830  0 89 -90 91 -92 (-85:86:-87:88) 74 u=134 imp:n=1
c
c
c Row 7 Far Right
c
4831  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=135 imp:n=1
c
4832  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=135 imp:n=1
c
4833  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=135 imp:n=1
c
4834  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=135 imp:n=1
c
4835  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=135 imp:n=1
c
c
4836  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=135 imp:n=1
c
4837  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=135 imp:n=1
c
4838  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=135 imp:n=1
c
4839  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=135 imp:n=1
c
4840  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=135 imp:n=1
c
c
4841  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=135 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4842  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=135 imp:n=1
c
4843  0 1 -2  3 -4 fill=9 (0 0 0) u=135 imp:n=1
c
4844  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=135 imp:n=1
c
4845  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=135 imp:n=1
c
c
4846  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=135 imp:n=1
c
4847  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=135 imp:n=1
c
4848  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=135 imp:n=1
c
4849  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=135 imp:n=1
c
4850  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=135 imp:n=1
c
c
4851  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=135 imp:n=1
c
4852  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=135 imp:n=1
c
4853  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=135 imp:n=1
c
4854  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=135 imp:n=1
c
4855  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=135 imp:n=1
c
c Surround material
c
4856  0 89 -90 91 -92 (-85:86:-87:88) -71 u=135 imp:n=1
c
4857  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=135 imp:n=1
c
4858  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=135 imp:n=1
c
4859  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=135 imp:n=1
c
4860  0 89 -90 91 -92 (-85:86:-87:88) 74 u=135 imp:n=1
c
c
c Beyond the reflector 5x5 Region 9
c
c
5001  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=201 imp:n=1
c
5002  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=201 imp:n=1
c
5003  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=201 imp:n=1
c
5004  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=201 imp:n=1
c
5005  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=201 imp:n=1
c
c
5006  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=201 imp:n=1
c
5007  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=201 imp:n=1
c
5008  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=201 imp:n=1
c
5009  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=201 imp:n=1
c
5010  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=201 imp:n=1
c
c
5011  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=201 imp:n=1
c
5012  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=201 imp:n=1
c
5013  0 1 -2  3 -4 fill=9 (0 0 0) u=201 imp:n=1
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

5014  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=201 imp:n=1
c
5015  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=201 imp:n=1
c
c
5016  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=201 imp:n=1
c
5017  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=201 imp:n=1
c
5018  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=201 imp:n=1
c
5019  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=201 imp:n=1
c
5020  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=201 imp:n=1
c
c
5021  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=201 imp:n=1
c
5022  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=201 imp:n=1
c
5023  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=201 imp:n=1
c
5024  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=201 imp:n=1
c
5025  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=201 imp:n=1
c
c Surround material
c
5026  0 89 -90 91 -92 (-85:86:-87:88) -71 u=201 imp:n=1
c
5027  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=201 imp:n=1
c
5028  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=201 imp:n=1
c
5029  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=201 imp:n=1
c
5030  0 89 -90 91 -92 (-85:86:-87:88) 74 u=201 imp:n=1
c
c -----
c
c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1      px -2.68605
2      px 2.68605
3      py -2.68605
4      py 2.68605
7      pz 0.0 $ Assembly lower limit
8      pz 30.0 $ End Packing, Start Reflector
9      pz 37.60628 $ End Plenum, Start Lower NU
10     pz 67.77878 $ End Lower NU, Start Fuel
11     pz 157.098748 $ End Fuel, Start Upper NU
12     pz 187.271248 $ End Upper NU, Start Top Reflector
13     pz 194.877528 $ End Reflector, Start Packing
16     pz 224.877528 $ Assembly upper limit
17     cz 94.9
21     px -2.5335 $ Nominal half-width of plates
22     px 2.5335
23     py -2.5335
24     py 2.5335
28     px -2.54 $ Radial shield half-width
29     px 2.54
30     py -2.54
31     py 2.54
c
32     px -2.551 $ sheath inner half-width
33     px 2.551
34     py -2.551
35     py 2.551
36     px -2.6272 $ sheath outer half-width
37     px 2.6272
38     py -2.6272

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

39      py 2.6272
c
c
c subdivisions in the plate element axial blanket and core cells
c
c      9 pz 37.60628 $ axial reflector / axial blanket
41      pz 45.228780
42      pz 57.951780
c      10 pz 67.77878 $ axial blanket / core
43      pz 71.209862
44      pz 74.957944
45      pz 78.706026
46      pz 82.454108
47      pz 86.202190
48      pz 89.950272
49      pz 93.698354
50      pz 97.446436
51      pz 101.194518
52      pz 104.942600
53      pz 108.690682
54      pz 112.438764
55      pz 116.186846
56      pz 119.934928
57      pz 123.683010
58      pz 127.431092
59      pz 131.179174
60      pz 134.927256
61      pz 138.675338
62      pz 142.423420
63      pz 146.171502
64      pz 149.919584
65      pz 153.667666
c      11 pz 157.098748 $ core / axial blanket
67      pz 166.925748
68      pz 179.648748
c      12 pz 187.271248 $ axial blanket / reflector
c
c Grid plate heights
c
71      pz 31.8
72      pz 62.2
73      pz 162.6
74      pz 193.0
c
c coordinates of the elements in 5x5 arrays
81      px -8.05815
82      px 8.05815
83      py -8.05815
84      py 8.05815
85      px -13.43025
86      px 13.43025
87      py -13.43025
88      py 13.43025
89      px -13.5635
90      px 13.5635
91      py -13.5635
92      py 13.5635
c
101     px -2.3355 $ Pu plate core width
102     px 2.3355
103     py -2.3355
104     py 2.3355
105     px -2.4255 $ UO2 plate core width
106     px 2.4255
107     py -2.4255
108     py 2.4255
109     px -2.4815 $ Na plate core width
110     px 2.4815
111     py -2.4815
112     py 2.4815
c
c
c Cell 2 Axial heights
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

401	pz	153.667666	
402	pz	153.704013	
403	pz	154.245013	
404	pz	154.281360	
405	pz	154.318010	
406	pz	154.876010	
407	pz	154.912660	
408	pz	154.958360	
409	pz	155.194360	
410	pz	155.240060	
411	pz	155.276407	
412	pz	155.817407	
413	pz	155.853754	
414	pz	155.890404	
415	pz	156.448404	
416	pz	156.485054	
417	pz	156.521401	
418	pz	157.062401	
419	pz	157.098748	
c			
c Cell 12 Axial heights			
c			
501	pz	67.778780	
502	pz	67.815127	
503	pz	68.356127	
504	pz	68.392474	
505	pz	68.429124	
506	pz	68.987124	
507	pz	69.023774	
508	pz	69.060121	
509	pz	69.601121	
510	pz	69.637468	
511	pz	69.683168	
512	pz	69.919168	
513	pz	69.964868	
514	pz	70.001518	
515	pz	70.559518	
516	pz	70.596168	
517	pz	70.632515	
518	pz	71.173515	
519	pz	71.209862	
c			
c Basic Cell 1 data			
c 701	pz	0.000000	
c 702	pz	0.036347	\$ Na can
c 703	pz	0.577347	\$ Na core
c 704	pz	0.613694	
c 705	pz	0.650344	\$ UO2 can
c 706	pz	1.208344	\$ UO2 core
c 707	pz	1.244994	
708	pz	1.561994	\$ SS
709	pz	1.607694	\$ Pu can
710	pz	1.843694	\$ Pu core
711	pz	1.889394	
712	pz	1.925741	\$ Na can
713	pz	2.466741	\$ Na core
c 714	pz	2.503088	
c 715	pz	2.539738	\$ UO2 can
c 716	pz	3.097738	\$ UO2 core
c 717	pz	3.134388	
c 718	pz	3.170735	\$ Na can
c 719	pz	3.711735	\$ Na core
c 720	pz	3.748082	\$ Cell 1
c			
801	pz	0.000000	
802	pz	0.036347	
803	pz	0.577347	\$ Na
804	pz	0.613694	
805	pz	0.650344	
806	pz	1.208344	\$ UO2
807	pz	1.244994	
808	pz	1.281341	
809	pz	1.822341	\$ Na
810	pz	1.858688	

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

811    pz    1.904388
812    pz    2.140388  $ Pu
813    pz    2.186088
814    pz    2.503088  $ SS
815    pz    2.539738
816    pz    3.097738  $ UO2
817    pz    3.134388
818    pz    3.170735
819    pz    3.711735  $ Na
820    pz    3.748082  $ Cell 11

```

c

c -----

c

c

c

c ----- TALLY CARDS -----

c

c --- MATERIALS CARDS ---

c

c

C MATERIAL 1 Pu metal plate core

```

ml      92238.31c  6.8782E-07

```

```

      94238.31c  3.0461E-05

```

```

      94239.31c  2.8920E-02

```

```

      94240.31c  6.9095E-03

```

```

      94241.31c  7.3960E-04

```

```

      94242.31c  1.8699E-04

```

```

      95241.31c  4.5718E-04

```

```

      1001.31c  1.2764E-04

```

```

      6000.31c  4.2260E-04

```

```

      7014.31c  2.4215E-05

```

```

      8016.31c  8.8450E-05

```

```

      13027.31c  2.2973E-05

```

```

      14028.31c  1.4158E-05

```

```

      25055.31c  1.4902E-06

```

```

      24050.31c  1.5637E-07

```

```

      24052.31c  3.0155E-06

```

```

      24053.31c  3.4193E-07

```

```

      24054.31c  8.5114E-08

```

```

      26054.31c  9.5478E-07

```

```

      26056.31c  1.4988E-05

```

```

      26057.31c  3.4614E-07

```

```

      26058.31c  4.6065E-09

```

```

      28058.31c  5.8334E-06

```

```

      28060.31c  2.2470E-06

```

```

      28061.31c  9.7676E-08

```

```

      28062.31c  3.1143E-07

```

```

      28064.31c  7.9313E-08

```

```

      31000.31c  2.0166E-03

```

c total 3.9991E-02

c MATERIAL 2 Pu plate canning

```

m2      1001.31c  1.3760E-05

```

```

      6000.31c  1.1393E-04

```

```

      14028.31c  3.6607E-04

```

```

      15031.31c  1.3731E-05

```

```

      24050.31c  4.0848E-04

```

```

      24052.31c  7.8771E-03

```

```

      24053.31c  8.9320E-04

```

```

      24054.31c  2.2234E-04

```

```

      25055.31c  8.5931E-04

```

```

      26054.31c  2.0774E-03

```

```

      26056.31c  3.2611E-02

```

```

      26057.31c  7.5313E-04

```

```

      26058.31c  1.0023E-05

```

```

      28058.31c  2.8351E-03

```

```

      28060.31c  1.0921E-03

```

```

      28061.31c  4.7472E-05

```

```

      28062.31c  1.5136E-04

```

```

      28064.31c  3.8548E-05

```

```

      29063.31c  1.1629E-02

```

```

      29065.31c  4.9839E-03

```

c total 6.6997E-02

C MATERIAL 3 UO2 plate core

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

m3      1001.31c  3.1773E-05
        6000.31c  1.1808E-05
        8016.31c  4.6008E-02
        13027.31c 3.3911E-06
        14028.31c 2.2967E-05
        25055.31c 8.3273E-08
        26054.31c 7.6610E-08
        26056.31c 1.2026E-06
        26057.31c 2.7774E-08
        26058.31c 3.6962E-10
        28058.31c 8.4906E-07
        28060.31c 3.2705E-07
        28061.31c 1.4217E-08
        28062.31c 4.5329E-08
        28064.31c 1.1544E-08
c      42000.66c  3.3379E-07
        42092.31c 5.0069E-08
        42094.31c 3.3379E-08
        42095.31c 5.0069E-08
        42096.31c 5.0069E-08
        42097.31c 3.3379E-08
        42098.31c 8.3448E-08
        42100.31c 3.3379E-08
        92235.31c 1.6544E-04
        92238.31c 2.2837E-02
c total 6.9083E-02
c MATERIAL 4 UO2 plate canning
m4      1001.31c  1.9035E-05
        6000.31c  1.2831E-04
        14028.31c 6.4475E-04
        15031.31c 3.5078E-04
        16032.31c 3.6041E-05
        24050.31c 6.0044E-04
        24052.31c 1.1579E-02
        24053.31c 1.3129E-03
        24054.31c 3.2682E-04
        25055.31c 8.5559E-04
        26054.31c 2.8235E-03
        26056.31c 4.4323E-02
        26057.31c 1.0236E-03
        26058.31c 1.3622E-05
        28058.31c 5.7360E-03
        28060.31c 2.2095E-03
        28061.31c 9.6046E-05
        28062.31c 3.0624E-04
        28064.31c 7.7989E-05
c total 7.2463E-02
C MATERIAL 5 sodium plate core
m5      1001.31c  1.3900E-05
        8016.31c  5.6492E-06
        11023.31c 2.3225E-02
        20040.31c 3.6083E-06
        26054.31c 9.4595E-09
        26056.31c 1.4849E-07
        26057.31c 3.4294E-09
        26058.31c 4.5639E-11
c total 2.324832E-02
c MATERIAL 6 Sodium plate canning
m6      1001.31c  2.1631E-05
        6000.31c  2.9290E-04
        14028.31c 6.0867E-04
        15031.31c 3.2795E-05
        16032.31c 3.3219E-05
        24050.31c 6.4128E-04
        24052.31c 1.2366E-02
        24053.31c 1.4023E-03
        24054.31c 3.4905E-04
        25055.31c 1.3570E-03
        26054.31c 3.2179E-03
        26056.31c 5.0514E-02
        26057.31c 1.1666E-03
        26058.31c 1.5525E-05
        28058.31c 4.8322E-03
        28060.31c 1.8614E-03

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

28061.31c 8.0912E-05
28062.31c 2.5798E-04
28064.31c 6.5701E-05
41093.31c 3.1147E-04
c total 7.9429E-02
C MATERIAL 7 40% steel plate
c m7 1001.31c 1.8355E-05
c 6000.31c 8.7794E-05
c 13027.31c 1.1862E-04
c 14028.31c 7.9703E-04
c 15031.31c 4.0018E-05
c 16032.31c 1.4422E-05
c 22048.31c 2.4806E-04
c 24050.31c 6.9120E-04
c 24052.31c 1.3329E-02
c 24053.31c 1.5114E-03
c 24054.31c 3.7622E-04
c 25055.31c 1.4972E-03
c 26054.31c 3.2362E-03
c 26056.31c 5.0801E-02
c 26057.31c 1.1732E-03
c 26058.31c 1.5613E-05
c 28058.31c 5.9891E-03
c 28060.31c 2.3070E-03
c 28061.31c 1.0028E-04
c 28062.31c 3.1975E-04
c 28064.31c 8.1431E-05
c 29063.31c 5.0365E-05
c 41093.31c 4.9781E-06
c 42000.66c 8.0988E-05
c
c 40% ss plate smeared over plate region
c
m7 1001.31c 7.3413E-06
6000.31c 3.5114E-05
13027.31c 4.7443E-05
14028.31c 3.1878E-04
15031.31c 1.6006E-05
16032.31c 5.7682E-06
22048.31c 9.9214E-05
24050.31c 2.7645E-04
24052.31c 5.3311E-03
24053.31c 6.0450E-04
24054.31c 1.5047E-04
25055.31c 5.9882E-04
26054.31c 1.2944E-03
26056.31c 2.0318E-02
26057.31c 4.6923E-04
26058.31c 6.2446E-06
28058.31c 2.3954E-03
28060.31c 9.2271E-04
28061.31c 4.0108E-05
28062.31c 1.2789E-04
28064.31c 3.2569E-05
29063.31c 1.4101E-05
29065.31c 6.0432E-06
41093.31c 1.9910E-06
c 42000.66c 3.2392E-05
42092.31c 4.8588E-06
42094.31c 3.2392E-06
42095.31c 4.8588E-06
42096.31c 4.8588E-06
42097.31c 3.2392E-06
42098.31c 8.0980E-06
42100.31c 3.2392E-06
c total 3.3152E-02
c
C MATERIAL 8 U8 metal plate
m8 1001.31c 4.4048E-05
6000.31c 4.9283E-04
14028.31c 2.1076E-04
26054.31c 6.1951E-06
26056.31c 9.7250E-05
26057.31c 2.2459E-06

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

26058.31c 2.9889E-08
92235.31c 3.3369E-04
92238.31c 4.6021E-02
c total 4.7208E-02
C MATERIAL 9 U2 metal plate
m9      1001.31c 4.3899E-05
        6000.31c 4.6047E-04
        14028.31c 1.9692E-04
        26054.31c 5.7884E-06
        26056.31c 9.0866E-05
        26057.31c 2.0985E-06
        26058.31c 2.7927E-08
        92235.31c 3.3962E-04
        92238.31c 4.6785E-02
c total 4.7925E-02
c
c radial shield
ml2      1001.31c 4.6306E-05
        6000.31c 6.8972E-04
        14028.31c 3.1158E-04
        15031.31c 4.2944E-05
        16032.31c 3.7110E-05
        25055.31c 7.1275E-04
        26054.31c 4.9065E-03
        26056.31c 7.4517E-02
        26057.31c 1.7491E-03
        26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
ml3      1001.31c 4.6306E-08
        6000.31c 6.8972E-07
        14028.31c 3.1158E-07
        15031.31c 4.2944E-08
        16032.31c 3.7110E-08
        25055.31c 7.1275E-07
        26054.31c 4.9065E-06
        26056.31c 7.4517E-05
        26057.31c 1.7491E-06
        26058.31c 2.5903E-07
c total 8.32720E-05
c
c Axial shield
ml4      1001.31c 2.5700E-05
        6000.31c 5.1066E-04
        13027.31c 1.3989E-04
        22048.31c 3.9416E-05
        24050.31c 1.2213E-06
        24052.31c 2.2823E-05
        24053.31c 2.5531E-06
        24054.31c 6.2449E-07
        25055.31c 3.2634E-04
        26054.31c 5.0496E-03
        26056.31c 7.6690E-02
        26057.31c 1.8001E-03
        26058.31c 2.6658E-04
        28058.31c 1.2564E-06
        28060.31c 4.6968E-07
        28061.31c 2.2000E-08
        28062.31c 6.2769E-08
        28064.31c 1.6774E-08
        29063.31c 3.1184E-05
        29065.31c 1.3364E-05
        42092.31c 1.4753E-06
        42094.31c 9.8355E-07
        42095.31c 1.4753E-06
        42096.31c 1.4753E-06
        42097.31c 9.8355E-07
        42098.31c 2.4589E-06
        42100.31c 9.8355E-07
c total 8.4932E-02
c
c Natural Uranium Breeder
ml5      1001.31c 4.4574E-05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

6000.31c 4.7140E-04
14028.31c 2.0160E-04
26054.31c 6.1085E-06
26056.31c 9.2771E-05
26057.31c 2.1776E-06
26058.31c 3.2248E-07
92235.31c 3.4209E-04
92238.31c 4.7156E-02
c Total 4.8317E-02
c
c Element top and bottom packing
ml6 1001.31c 3.1777E-05
6000.31c 9.9996E-05
13027.31c 8.3095E-06
24050.31c 6.9087E-08
24052.31c 1.2911E-06
24053.31c 1.4442E-07
24054.31c 3.5326E-08
25055.31c 1.0785E-04
26054.31c 1.9605E-03
26056.31c 2.9775E-02
26057.31c 6.9890E-04
26058.31c 1.0350E-04
28058.31c 1.5636E-07
28060.31c 5.8452E-08
28061.31c 2.7378E-09
28062.31c 7.8115E-09
28064.31c 2.0875E-09
29063.31c 6.5270E-06
29065.31c 2.7973E-06
c Total 3.279692E-02
c
c wrapper material
ml7 1001.31c 7.5725E-05
6000.31c 2.3828E-04
13027.31c 1.9802E-05
24050.31c 1.6463E-07
24052.31c 3.0767E-06
24053.31c 3.4414E-07
24054.31c 8.4182E-08
25055.31c 2.5701E-04
26054.31c 4.6718E-03
26056.31c 7.0954E-02
26057.31c 1.6655E-03
26058.31c 2.4664E-04
28058.31c 3.7260E-07
28060.31c 1.3929E-07
28061.31c 6.5242E-09
28062.31c 1.8615E-08
28064.31c 4.9746E-09
29063.31c 1.5554E-05
29065.31c 6.6660E-06
c Total 7.81552E-02
c
c
c Superlattice grid plate
c
ml9 1001.31c 2.4442E-04
6000.31c 2.9057E-04
14028.31c 4.3858E-05
15031.31c 1.3256E-05
16032.31c 4.3530E-05
25055.31c 2.5785E-04
26054.31c 4.2756E-03
26056.31c 6.7114E-02
26057.31c 1.5500E-03
26058.31c 2.0627E-04
c Total 19 7.403935E-02
c
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 100 1500
ksrc 0.0 0.0 77.0 0.0 0.0 87.9 0.0 0.0 107.0

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
0.0 0.0 117.9 0.0 0.0 137.0 0.0 0.0 147.9
10.74 0.0 77.0 10.74 0.0 87.9 10.74 0.0 107.0
10.74 0.0 117.9 10.74 0.0 137.0 10.74 0.0 147.9
-10.74 0.0 77.0 -10.74 0.0 87.9 -10.74 0.0 107.0
-10.74 0.0 117.9 -10.74 0.0 137.0 -10.74 0.0 147.9
0.0 10.74 77.0 0.0 10.74 87.9 0.0 10.74 107.0
0.0 10.74 117.9 0.0 10.74 137.0 0.0 10.74 147.9
0.0 -10.74 77.0 0.0 -10.74 87.9 -10.74 0.0 107.0
0.0 -10.74 117.9 0.0 -10.74 137.0 0.0 -10.74 147.9
10.74 10.74 77.0 10.74 10.74 87.9 10.74 10.74 107.0
10.74 10.74 117.9 10.74 10.74 137.0 10.74 10.74 147.9
-10.74 10.74 77.0 -10.74 10.74 87.9 -10.74 10.74 107.0
-10.74 10.74 117.9 -10.74 10.74 137.0 -10.74 10.74 147.9
10.74 -10.74 77.0 10.74 -10.74 87.9 10.74 -10.74 107.0
10.74 -10.74 117.9 10.74 -10.74 137.0 10.74 -10.74 147.9
-10.74 -10.74 77.0 -10.74 -10.74 87.9 -10.74 -10.74 107.0
-10.74 -10.74 117.9 -10.74 -10.74 137.0 -10.74 -10.74 147.9
25.335 0.0 77.0 25.335 0.0 87.9 25.335 0.0 107.0
25.335 0.0 117.9 25.335 0.0 137.0 25.335 0.0 147.9
-25.335 0.0 77.0 -25.335 0.0 87.9 -25.335 0.0 107.0
-25.335 0.0 117.9 -25.335 0.0 137.0 -25.335 0.0 147.9
0.0 25.335 77.0 0.0 25.335 87.9 0.0 25.335 107.0
0.0 25.335 117.9 0.0 25.335 137.0 0.0 25.335 147.9
0.0 -25.335 77.0 0.0 -25.335 87.9 -25.335 0.0 107.0
0.0 -25.335 117.9 0.0 -25.335 137.0 0.0 -25.335 147.9
25.335 25.335 77.0 25.335 25.335 87.9 25.335 25.335 107.0
25.335 25.335 117.9 25.335 25.335 137.0 25.335 25.335 147.9
-25.335 25.335 77.0 -25.335 25.335 87.9 -25.335 25.335 107.0
-25.335 25.335 117.9 -25.335 25.335 137.0 -25.335 25.335 147.9
25.335 -25.335 77.0 25.335 -25.335 87.9 25.335 -25.335 107.0
25.335 -25.335 117.9 25.335 -25.335 137.0 25.335 -25.335 147.9
-25.335 -25.335 77.0 -25.335 -25.335 87.9 -25.335 -25.335 107.0
37.6 0.0 77.0 37.6 0.0 87.9 37.6 0.0 107.0
37.6 0.0 117.9 37.6 0.0 137.0 37.6 0.0 147.9
-37.6 0.0 77.0 -37.6 0.0 87.9 -37.6 0.0 107.0
-37.6 0.0 117.9 -37.6 0.0 137.0 -37.6 0.0 147.9
0.0 37.6 77.0 0.0 37.6 87.9 0.0 37.6 107.0
0.0 37.6 117.9 0.0 37.6 137.0 0.0 37.6 147.9
0.0 -37.6 77.0 0.0 -37.6 87.9 -37.6 0.0 107.0
0.0 -37.6 117.9 0.0 -37.6 137.0 0.0 -37.6 147.9
```

print

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

A4.2 MCNP-JEFF-3.1 Zebra 23 Model A.

```
Z23 detailed model. Superlattice and interelement gaps. JEFF-3.1.
c
c
c ----- CELL CARDS -----
c
c --- Core Pin Geometry Element C Calandria NACLIII Pins 8xA and 8xE
c Fuel m21 and m25, can + tube m31 and m35
c Lower padding
c   1   16 3.279692E-02 -8 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower Reflector
c   2   14 8.4932E-02 8 -9 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
c   3   15 4.8317E-02 9 -41 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
c   4    9 4.7925E-02 41 -42 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
c   5    8 4.7208E-02 42 -10 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
c   9   27 0.0513781 33 -34 35 -36 10 -82 u=1 imp:n=1 TMP=2.5301E-08
c
c
c  10   25 7.1167E-02 -91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  11   21 0.069985 -92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  12   25 7.1167E-02 -93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  13   21 0.069985 -94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  14   21 0.069985 -95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  15   25 7.1167E-02 -96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  16   21 0.069985 -97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  17   25 7.1167E-02 -98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  18   25 7.1167E-02 -99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  19   21 0.069985 -100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  20   25 7.1167E-02 -101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  21   21 0.069985 -102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  22   21 0.069985 -103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  23   25 7.1167E-02 -104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  24   21 0.069985 -105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  25   25 7.1167E-02 -106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c
c  30   35 0.0596942 -111 91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  31   31 0.062241 -112 92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  32   35 0.0596942 -113 93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  33   31 0.062241 -114 94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  34   31 0.062241 -115 95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  35   35 0.0596942 -116 96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  36   31 0.062241 -117 97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c  37   35 0.0596942 -118 98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
38      35 0.0596942 -119 99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
39      31 0.062241 -120 100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
40      35 0.0596942 -121 101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
41      31 0.062241 -122 102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
42      31 0.062241 -123 103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
43      35 0.0596942 -124 104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
44      31 0.062241 -125 105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
45      35 0.0596942 -126 106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
46      43 2.3900E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
48      27 0.0513781 33 -34 35 -36 83 -85 u=1 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
50      25 7.1167E-02 -91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
51      21 0.069985 -92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
52      25 7.1167E-02 -93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
53      21 0.069985 -94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
54      21 0.069985 -95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
55      25 7.1167E-02 -96 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
56      21 0.069985 -97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
57      25 7.1167E-02 -98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
58      25 7.1167E-02 -99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
59      21 0.069985 -100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
60      25 7.1167E-02 -101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
61      21 0.069985 -102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
62      21 0.069985 -103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
63      25 7.1167E-02 -104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
64      21 0.069985 -105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
65      25 7.1167E-02 -106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
70      35 0.0596942 -111 91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
71      31 0.062241 -112 92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
72      35 0.0596942 -113 93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
73      31 0.062241 -114 94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
74      31 0.062241 -115 95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
75      35 0.0596942 -116 96 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
76      31 0.062241 -117 97 85 -86 u=1 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
77      35 0.0596942 -118 98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
78      35 0.0596942 -119 99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
79      31 0.062241 -120 100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
80      35 0.0596942 -121 101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
81      31 0.062241 -122 102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
82      31 0.062241 -123 103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
83      35 0.0596942 -124 104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
84      31 0.062241 -125 105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
85      35 0.0596942 -126 106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
86      43 2.3900E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
88      27 0.0513781 33 -34 35 -36 86 -88 u=1 imp:n=1 TMP=2.5301E-08
c
c Top calandria
c
90      25 7.1167E-02 -91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
91      21 0.069985 -92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
92      25 7.1167E-02 -93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
93      21 0.069985 -94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
94      21 0.069985 -95 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
95      25 7.1167E-02 -96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
96      21 0.069985 -97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
97      25 7.1167E-02 -98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
98      25 7.1167E-02 -99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
99      21 0.069985 -100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
100     25 7.1167E-02 -101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
101     21 0.069985 -102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
102     21 0.069985 -103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
103     25 7.1167E-02 -104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
104     21 0.069985 -105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
105     25 7.1167E-02 -106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
110     35 0.0596942 -111 91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
111     31 0.062241 -112 92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
112     35 0.0596942 -113 93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
113     31 0.062241 -114 94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
114     31 0.062241 -115 95 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
115     35 0.0596942 -116 96 88 -89 u=1 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
116      31 0.062241 -117 97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
117      35 0.0596942 -118 98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
118      35 0.0596942 -119 99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
119      31 0.062241 -120 100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
120      35 0.0596942 -121 101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
121      31 0.062241 -122 102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
122      31 0.062241 -123 103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
123      35 0.0596942 -124 104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
124      31 0.062241 -125 105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
125      35 0.0596942 -126 106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
126      43 2.3900E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
128      27 0.0513781 33 -34 35 -36 89 -11 u=1 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
129      53 7.44684E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=1 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
131      8 4.7208E-02 11 -67 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
132      9 4.7925E-02 67 -68 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
133      15 4.8317E-02 68 -12 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
134      14 8.4932E-02 12 -13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper padding
135      16 3.279692E-02 13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
136      0 132 -133 134 -135 (-21:22:-23:24) u=1 imp:n=1
c   Wrapper
137      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=1 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
138      0 1 -2 3 -4 (-136:137:-138:139) u=1 imp:n=1
c
c   End of Core Pin Geometry Element C
c
c
c   --- Core Pin geometry Element E (& D) NACLIIIS Pins 8xD and 8xF
c   D 24 7.1085E-02 F 26 7.1415E-02 clad D 34 5.9086E-02 F 36 6.0033E-02
c   Lower padding
201      16 3.279692E-02 -8 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
202      14 8.4932E-02 8 -9 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
203      15 4.8317E-02 9 -41 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
204      9 4.7925E-02 41 -42 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
205      8 4.7208E-02 42 -10 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
209      27 0.0513781 33 -34 35 -36 10 -82 u=2 imp:n=1 TMP=2.5301E-08
c
c
210      26 7.1415E-02 -91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
211      24 7.1085E-02 -92 82 -83 u=2 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
212      26 7.1415E-02 -93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
213      24 7.1085E-02 -94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
214      24 7.1085E-02 -95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
215      26 7.1415E-02 -96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
216      24 7.1085E-02 -97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
217      26 7.1415E-02 -98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
218      26 7.1415E-02 -99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
219      24 7.1085E-02 -100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
220      26 7.1415E-02 -101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
221      24 7.1085E-02 -102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
222      24 7.1085E-02 -103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
223      26 7.1415E-02 -104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
224      24 7.1085E-02 -105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
225      26 7.1415E-02 -106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c
230      36 6.0033E-02 -111 91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
231      34 5.9086E-02 -112 92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
232      36 6.0033E-02 -113 93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
233      34 5.9086E-02 -114 94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
234      34 5.9086E-02 -115 95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
235      36 6.0033E-02 -116 96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
236      34 5.9086E-02 -117 97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
237      36 6.0033E-02 -118 98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
238      36 6.0033E-02 -119 99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
239      34 5.9086E-02 -120 100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
240      36 6.0033E-02 -121 101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
241      34 5.9086E-02 -122 102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
242      34 5.9086E-02 -123 103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
243      36 6.0033E-02 -124 104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
244      34 5.9086E-02 -125 105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
245      36 6.0033E-02 -126 106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
246      42 2.43914E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
248      27 0.0513781 33 -34 35 -36 83 -85 u=2 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
250      26 7.1415E-02 -91 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c

```

[illegible]

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

290	26	7.1415E-02	-91	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
291	24	7.1085E-02	-92	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
292	26	7.1415E-02	-93	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
293	24	7.1085E-02	-94	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
294	24	7.1085E-02	-95	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
295	26	7.1415E-02	-96	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
296	24	7.1085E-02	-97	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
297	26	7.1415E-02	-98	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
298	26	7.1415E-02	-99	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
299	24	7.1085E-02	-100	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
300	26	7.1415E-02	-101	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
301	24	7.1085E-02	-102	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
302	24	7.1085E-02	-103	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
303	26	7.1415E-02	-104	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
304	24	7.1085E-02	-105	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
305	26	7.1415E-02	-106	88	-89	u=2	imp:n=1	TMP=2.5301E-08
c								
c								
c								
310	36	6.0033E-02	-111	91	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
311	34	5.9086E-02	-112	92	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
312	36	6.0033E-02	-113	93	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
313	34	5.9086E-02	-114	94	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
314	34	5.9086E-02	-115	95	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
315	36	6.0033E-02	-116	96	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
316	34	5.9086E-02	-117	97	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
317	36	6.0033E-02	-118	98	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
318	36	6.0033E-02	-119	99	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
319	34	5.9086E-02	-120	100	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
320	36	6.0033E-02	-121	101	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
321	34	5.9086E-02	-122	102	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
322	34	5.9086E-02	-123	103	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
323	36	6.0033E-02	-124	104	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
324	34	5.9086E-02	-125	105	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
325	36	6.0033E-02	-126	106	88	-89	u=2	imp:n=1 TMP=2.5301E-08
c								
326	42	2.43914E-02	33	-34	35	-36	88	-89 &
			111	112	113	114	115	116 117 118 119 120 121 122 123 124 125 126 &
			u=2	imp:n=1	TMP=2.5301E-08			
c								
c	Top plate of top calandria							
c								
328	27	0.0513781	33	-34	35	-36	89	-11 u=2 imp:n=1 TMP=2.5301E-08
c								

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c Calandria outer wall
c
329      52  7.20749E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=2 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
331      8  4.7208E-02 11 -67  21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
332      9  4.7925E-02 67 -68  21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
333     15  4.8317E-02 68 -12  21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper Reflector
334     14  8.4932E-02 12 -13  21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper padding
335     16  3.279692E-02 13  21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
336      0 132 -133 134 -135 (-21:22:-23:24) u=2 imp:n=1
c Wrapper
337     17  7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=2 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
338      0  1 -2 3 -4 (-136:137:-138:139) u=2 imp:n=1
c
c End of Core Pin Geometry Element E (D)
c
c
c --- Core Pin Geometry Element B (H, L) Calandria NACL Pins 11xB and 5xF
c B 22 7.0537E-02 F 26 7.1415E-02 clad  32 5.8537E-02 F 36 6.0033E-02
c Pin F is in circles 93 98 99 101 and 104
c
c Lower padding
401     16  3.279692E-02 -8 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower Reflector
402     14  8.4932E-02 8 -9  21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
403     15  4.8317E-02 9 -41  21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
404      9  4.7925E-02 41 -42  21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
405      8  4.7208E-02 42 -10  21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
409     27  0.0513781 33 -34 35 -36 10 -82 u=3 imp:n=1 TMP=2.5301E-08
c
c
410     22  7.0537E-02 -91 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
411     22  7.0537E-02 -92 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
412     26  7.1415E-02 -93 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
413     22  7.0537E-02 -94 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
414     22  7.0537E-02 -95 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
415     22  7.0537E-02 -96 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
416     22  7.0537E-02 -97 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
417     26  7.1415E-02 -98 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
418     26  7.1415E-02 -99 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
419     22  7.0537E-02 -100 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
420     26  7.1415E-02 -101 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
421     22  7.0537E-02 -102 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
422     22  7.0537E-02 -103 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
423     26  7.1415E-02 -104 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
424     22  7.0537E-02 -105 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

425      22 7.0537E-02 -106 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
c
430      32 5.8537E-02 -111 91 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
431      32 5.8537E-02 -112 92 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
432      36 6.0033E-02 -113 93 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
433      32 5.8537E-02 -114 94 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
434      32 5.8537E-02 -115 95 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
435      32 5.8537E-02 -116 96 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
436      32 5.8537E-02 -117 97 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
437      36 6.0033E-02 -118 98 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
438      36 6.0033E-02 -119 99 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
439      32 5.8537E-02 -120 100 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
440      36 6.0033E-02 -121 101 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
441      32 5.8537E-02 -122 102 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
442      32 5.8537E-02 -123 103 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
443      36 6.0033E-02 -124 104 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
444      32 5.8537E-02 -125 105 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
445      32 5.8537E-02 -126 106 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
446      41 2.41414E-02 33 -34 35 -36 82 -83  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
448      27 0.0513781 33 -34 35 -36 83 -85 u=3 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
450      22 7.0537E-02 -91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
451      22 7.0537E-02 -92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
452      26 7.1415E-02 -93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
453      22 7.0537E-02 -94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
454      22 7.0537E-02 -95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
455      22 7.0537E-02 -96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
456      22 7.0537E-02 -97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
457      26 7.1415E-02 -98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
458      26 7.1415E-02 -99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
459      22 7.0537E-02 -100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
460      26 7.1415E-02 -101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
461      22 7.0537E-02 -102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
462      22 7.0537E-02 -103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
463      26 7.1415E-02 -104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
464      22 7.0537E-02 -105 85 -86  u=3 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
465      22 7.0537E-02 -106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
c
c
470      32 5.8537E-02 -111 91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
471      32 5.8537E-02 -112 92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
472      36 6.0033E-02 -113 93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
473      32 5.8537E-02 -114 94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
474      32 5.8537E-02 -115 95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
475      32 5.8537E-02 -116 96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
476      32 5.8537E-02 -117 97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
477      36 6.0033E-02 -118 98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
478      36 6.0033E-02 -119 99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
479      32 5.8537E-02 -120 100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
480      36 6.0033E-02 -121 101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
481      32 5.8537E-02 -122 102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
482      32 5.8537E-02 -123 103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
483      36 6.0033E-02 -124 104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
484      32 5.8537E-02 -125 105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
485      32 5.8537E-02 -126 106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
486      41 2.41414E-02 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c  Top and bottom calandria plates
c
488      27 0.0513781 33 -34 35 -36 86 -88 u=3 imp:n=1 TMP=2.5301E-08
c
c  Top calandria
c
490      22 7.0537E-02 -91 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
491      22 7.0537E-02 -92 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
492      26 7.1415E-02 -93 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
493      22 7.0537E-02 -94 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
494      22 7.0537E-02 -95 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
495      22 7.0537E-02 -96 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
496      22 7.0537E-02 -97 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
497      26 7.1415E-02 -98 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
498      26 7.1415E-02 -99 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
499      22 7.0537E-02 -100 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
500      26 7.1415E-02 -101 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
501      22 7.0537E-02 -102 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
502      22 7.0537E-02 -103 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
503      26 7.1415E-02 -104 88 -89  u=3 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
504      22 7.0537E-02 -105 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
505      22 7.0537E-02 -106 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
c
c
510      32 5.8537E-02 -111 91 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
511      32 5.8537E-02 -112 92 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
512      36 6.0033E-02 -113 93 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
513      32 5.8537E-02 -114 94 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
514      32 5.8537E-02 -115 95 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
515      32 5.8537E-02 -116 96 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
516      32 5.8537E-02 -117 97 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
517      36 6.0033E-02 -118 98 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
518      36 6.0033E-02 -119 99 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
519      32 5.8537E-02 -120 100 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
520      36 6.0033E-02 -121 101 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
521      32 5.8537E-02 -122 102 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
522      32 5.8537E-02 -123 103 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
523      36 6.0033E-02 -124 104 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
524      32 5.8537E-02 -125 105 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
525      32 5.8537E-02 -126 106 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
526      41 2.41414E-02 33 -34 35 -36 88 -89  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
528      27 0.0513781 33 -34 35 -36 89 -11 u=3 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
529      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=3 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
531      8 4.7208E-02 11 -67 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
532      9 4.7925E-02 67 -68 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
533      15 4.8317E-02 68 -12 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
534      14 8.4932E-02 12 -13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper padding
535      16 3.279692E-02 13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
536      0 132 -133 134 -135 (-21:22:-23:24) u=3 imp:n=1
c   Wrapper
537      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=3 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
538      0 1 -2 3 -4 (-136:137:-138:139) u=3 imp:n=1
c
c   End of Core Pin Geometry Element B (H, L)
c
c
c   --- Core Pin Geometry Element A Calandria NACLI Pins 16xC
c   c 23 7.1230E-02 clad 33 6.15349E-02
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c Lower padding
601      16 3.279692E-02 -8 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower Reflector
602      14 8.4932E-02 8 -9 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
603      15 4.8317E-02 9 -41 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
604      9 4.7925E-02 41 -42 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
605      8 4.7208E-02 42 -10 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
609      27 0.0513781 33 -34 35 -36 10 -82 u=4 imp:n=1 TMP=2.5301E-08
c
c
610      23 7.1230E-02 -91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
611      23 7.1230E-02 -92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
612      23 7.1230E-02 -93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
613      23 7.1230E-02 -94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
614      23 7.1230E-02 -95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
615      23 7.1230E-02 -96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
616      23 7.1230E-02 -97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
617      23 7.1230E-02 -98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
618      23 7.1230E-02 -99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
619      23 7.1230E-02 -100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
620      23 7.1230E-02 -101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
621      23 7.1230E-02 -102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
622      23 7.1230E-02 -103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
623      23 7.1230E-02 -104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
624      23 7.1230E-02 -105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
625      23 7.1230E-02 -106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c
630      33 6.15349E-02 -111 91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
631      33 6.15349E-02 -112 92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
632      33 6.15349E-02 -113 93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
633      33 6.15349E-02 -114 94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
634      33 6.15349E-02 -115 95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
635      33 6.15349E-02 -116 96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
636      33 6.15349E-02 -117 97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
637      33 6.15349E-02 -118 98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
638      33 6.15349E-02 -119 99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
639      33 6.15349E-02 -120 100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
640      33 6.15349E-02 -121 101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
641      33 6.15349E-02 -122 102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
642      33 6.15349E-02 -123 103 82 -83 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
643      33 6.15349E-02 -124 104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
644      33 6.15349E-02 -125 105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
645      33 6.15349E-02 -126 106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
646      41 2.41414E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
648      27 0.0513781 33 -34 35 -36 83 -85 u=4 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
650      23 7.1230E-02 -91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
651      23 7.1230E-02 -92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
652      23 7.1230E-02 -93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
653      23 7.1230E-02 -94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
654      23 7.1230E-02 -95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
655      23 7.1230E-02 -96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
656      23 7.1230E-02 -97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
657      23 7.1230E-02 -98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
658      23 7.1230E-02 -99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
659      23 7.1230E-02 -100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
660      23 7.1230E-02 -101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
661      23 7.1230E-02 -102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
662      23 7.1230E-02 -103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
663      23 7.1230E-02 -104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
664      23 7.1230E-02 -105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
665      23 7.1230E-02 -106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
670      33 6.15349E-02 -111 91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
671      33 6.15349E-02 -112 92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
672      33 6.15349E-02 -113 93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
673      33 6.15349E-02 -114 94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
674      33 6.15349E-02 -115 95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
675      33 6.15349E-02 -116 96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
676      33 6.15349E-02 -117 97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
677      33 6.15349E-02 -118 98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
678      33 6.15349E-02 -119 99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
679      33 6.15349E-02 -120 100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
680      33 6.15349E-02 -121 101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
681      33 6.15349E-02 -122 102 85 -86 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
682      33 6.15349E-02 -123 103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
683      33 6.15349E-02 -124 104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
684      33 6.15349E-02 -125 105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
685      33 6.15349E-02 -126 106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
686      41 2.41414E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
688      27 0.0513781 33 -34 35 -36 86 -88 u=4 imp:n=1 TMP=2.5301E-08
c
c Top calandria
c
690      23 7.1230E-02 -91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
691      23 7.1230E-02 -92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
692      23 7.1230E-02 -93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
693      23 7.1230E-02 -94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
694      23 7.1230E-02 -95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
695      23 7.1230E-02 -96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
696      23 7.1230E-02 -97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
697      23 7.1230E-02 -98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
698      23 7.1230E-02 -99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
699      23 7.1230E-02 -100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
700      23 7.1230E-02 -101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
701      23 7.1230E-02 -102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
702      23 7.1230E-02 -103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
703      23 7.1230E-02 -104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
704      23 7.1230E-02 -105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
705      23 7.1230E-02 -106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
c
710      33 6.15349E-02 -111 91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
711      33 6.15349E-02 -112 92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
712      33 6.15349E-02 -113 93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
713      33 6.15349E-02 -114 94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
714      33 6.15349E-02 -115 95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
715      33 6.15349E-02 -116 96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
716      33 6.15349E-02 -117 97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
717      33 6.15349E-02 -118 98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
718      33 6.15349E-02 -119 99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
719      33 6.15349E-02 -120 100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
720      33 6.15349E-02 -121 101 88 -89 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
721      33 6.15349E-02 -122 102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
722      33 6.15349E-02 -123 103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
723      33 6.15349E-02 -124 104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
724      33 6.15349E-02 -125 105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
725      33 6.15349E-02 -126 106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
726      41 2.41414E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
728      27 0.0513781 33 -34 35 -36 89 -11 u=4 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
729      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=4 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
731      8 4.7208E-02 11 -67 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
732      9 4.7925E-02 67 -68 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
733      15 4.8317E-02 68 -12 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
734      14 8.4932E-02 12 -13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper padding
735      16 3.279692E-02 13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
736      0 132 -133 134 -135 (-21:22:-23:24) u=4 imp:n=1
c   Wrapper
737      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=4 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
738      0 1 -2 3 -4 (-136:137:-138:139) u=4 imp:n=1
c
c   End of Core Pin Geometry Element A
c
c
c --- Core Pin Geometry Element J Calandria NACLIV Pins 12xE and 4xUO2
c E 25 7.1167E-02 28 7.140034E-02 35 5.96942E-02
c The positions of pin UO2 are the circles 94, 96, 102 and 104
c Lower padding
801      16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower Reflector
802      14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
803      15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
804      9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
805      8 4.7208E-02 42 -10 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c   Bottom plate
809      27 0.0513781 33 -34 35 -36 10 -82 u=5 imp:n=1 TMP=2.5301E-08
c
c
810      25 7.1167E-02 -91 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
811      25 7.1167E-02 -92 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
812      25 7.1167E-02 -93 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
813      28 7.14034E-02 -94 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
814      25 7.1167E-02 -95 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
815      28 7.14034E-02 -96 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

816	25	7.1167E-02	-97	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
817	25	7.1167E-02	-98	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
818	25	7.1167E-02	-99	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
819	25	7.1167E-02	-100	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
820	25	7.1167E-02	-101	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
821	28	7.14034E-02	-102	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
822	25	7.1167E-02	-103	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
823	28	7.14034E-02	-104	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
824	25	7.1167E-02	-105	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
825	25	7.1167E-02	-106	82	-83	u=5	imp:n=1	TMP=2.5301E-08
c								
c								
830	35	5.96942E-02	-111	91	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
831	35	5.96942E-02	-112	92	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
832	35	5.96942E-02	-113	93	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
833	35	5.96942E-02	-114	94	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
834	35	5.96942E-02	-115	95	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
835	35	5.96942E-02	-116	96	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
836	35	5.96942E-02	-117	97	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
837	35	5.96942E-02	-118	98	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
838	35	5.96942E-02	-119	99	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
839	35	5.96942E-02	-120	100	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
840	35	5.96942E-02	-121	101	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
841	35	5.96942E-02	-122	102	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
842	35	5.96942E-02	-123	103	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
843	35	5.96942E-02	-124	104	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
844	35	5.96942E-02	-125	105	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
845	35	5.96942E-02	-126	106	82	-83	u=5	imp:n=1
c								TMP=2.5301E-08
846	44	2.4049E-02	33	-34	35	-36	82	-83
			111	112	113	114	115	116
			117	118	119	120	121	122
			123	124	125	126	&	
			u=5	imp:n=1	TMP=2.5301E-08			
c								
c								
848	27	0.0513781	33	-34	35	-36	83	-85
c								u=5
								imp:n=1
								TMP=2.5301E-08
c								
c								
850	25	7.1167E-02	-91	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
851	25	7.1167E-02	-92	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
852	25	7.1167E-02	-93	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
853	28	7.14034E-02	-94	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
854	25	7.1167E-02	-95	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
855	28	7.14034E-02	-96	85	-86	u=5	imp:n=1	TMP=2.5301E-08

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LIQUID METAL FAST REACTOR – LMFR
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```

c
856      25 7.1167E-02 -97 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
857      25 7.1167E-02 -98 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
858      25 7.1167E-02 -99 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
859      25 7.1167E-02 -100 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
860      25 7.1167E-02 -101 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
861      28 7.14034E-02 -102 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
862      25 7.1167E-02 -103 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
863      28 7.14034E-02 -104 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
864      25 7.1167E-02 -105 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
865      25 7.1167E-02 -106 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
870      35 5.96942E-02 -111 91 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
871      35 5.96942E-02 -112 92 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
872      35 5.96942E-02 -113 93 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
873      35 5.96942E-02 -114 94 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
874      35 5.96942E-02 -115 95 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
875      35 5.96942E-02 -116 96 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
876      35 5.96942E-02 -117 97 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
877      35 5.96942E-02 -118 98 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
878      35 5.96942E-02 -119 99 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
879      35 5.96942E-02 -120 100 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
880      35 5.96942E-02 -121 101 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
881      35 5.96942E-02 -122 102 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
882      35 5.96942E-02 -123 103 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
883      35 5.96942E-02 -124 104 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
884      35 5.96942E-02 -125 105 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
885      35 5.96942E-02 -126 106 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
886      44 2.4049E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
888      27 0.0513781 33 -34 35 -36 86 -88 u=5 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
890      25 7.1167E-02 -91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
891      25 7.1167E-02 -92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
892      25 7.1167E-02 -93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
893      28 7.14034E-02 -94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
894      25 7.1167E-02 -95 88 -89 u=5 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR - LMFR
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```

c
895      28 7.14034E-02 -96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
896      25 7.1167E-02 -97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
897      25 7.1167E-02 -98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
898      25 7.1167E-02 -99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
899      25 7.1167E-02 -100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
900      25 7.1167E-02 -101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
901      28 7.14034E-02 -102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
902      25 7.1167E-02 -103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
903      28 7.14034E-02 -104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
904      25 7.1167E-02 -105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
905      25 7.1167E-02 -106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
910      35 5.96942E-02 -111 91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
911      35 5.96942E-02 -112 92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
912      35 5.96942E-02 -113 93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
913      35 5.96942E-02 -114 94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
914      35 5.96942E-02 -115 95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
915      35 5.96942E-02 -116 96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
916      35 5.96942E-02 -117 97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
917      35 5.96942E-02 -118 98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
918      35 5.96942E-02 -119 99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
919      35 5.96942E-02 -120 100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
920      35 5.96942E-02 -121 101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
921      35 5.96942E-02 -122 102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
922      35 5.96942E-02 -123 103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
923      35 5.96942E-02 -124 104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
924      35 5.96942E-02 -125 105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
925      35 5.96942E-02 -126 106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
926      44 2.4049E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
928      27 0.0513781 33 -34 35 -36 89 -11 u=5 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
929      54 6.94698E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=5 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
931      8 4.7208E-02 11 -67 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
932      9 4.7925E-02 67 -68 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
933      15 4.8317E-02 68 -12 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c Upper Reflector
934      14 8.4932E-02 12 -13  21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper padding
935      16 3.279692E-02 13  21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
936      0 132 -133 134 -135 (-21:22:-23:24) u=5 imp:n=1
c Wrapper
937      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=5 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
938      0  1 -2 3 -4 (-136:137:-138:139) u=5 imp:n=1
c
c End of Core Pin Geometry Element J
c
c
c --- Core Plate Geometry Element
c Lower padding
1011     16 3.279692E-02 -8 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1012     14 8.4932E-02 8 -9  21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
1013     15 4.8317E-02 9 -41  21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
1014     9 4.7925E-02 41 -42  21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
1015     8 4.7208E-02 42 -10  21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na plate core
1022     5 2.324832E-02 502 -503 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1023     6 7.9429E-02 10 -504 21 -22 23 -24 &
      (-159:160:-161:162:-502:503) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1027     3 6.9083E-02 505 -506 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1028     4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-155:156:-157:158:-505:506) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1032     5 2.324832E-02 508 -509 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1033     6 7.9429E-02 507 -510 21 -22 23 -24 &
      (-159:160:-161:162:-508:509) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1035     1 3.9991E-02 151 -152 153 -154 511 -512 u=6 imp:n=1 TMP=2.5301E-08
c Pu canning
1036     2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-151:152:-153:154:-511:512) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1039     3 6.9083E-02 514 -515 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1040     4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-155:156:-157:158:-514:515) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1042     5 2.324832E-02 517 -518 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1043     6 7.9429E-02 516 -43 21 -22 23 -24 &
      (-159:160:-161:162:-517:518) u=6 imp:n=1 TMP=2.5301E-08
c
c Insert the 22 central region core cells
c
1051     0  43 -44 21 -22 23 -24 fill=13 (0 0 71.209862) u=6 imp:n=1
c
1052     0  44 -45 21 -22 23 -24 fill=14 (0 0 74.957944) u=6 imp:n=1
c

```

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```

c
1053  0  45 -46 21 -22 23 -24 fill=13 (0 0 78.706026) u=6 imp:n=1
c
1054  0  46 -47 21 -22 23 -24 fill=14 (0 0 82.454108) u=6 imp:n=1
c
c
1055  0  47 -48 21 -22 23 -24 fill=13 (0 0 86.202190) u=6 imp:n=1
c
1056  0  48 -49 21 -22 23 -24 fill=14 (0 0 89.950272) u=6 imp:n=1
c
c
1057  0  49 -50 21 -22 23 -24 fill=13 (0 0 93.698354) u=6 imp:n=1
c
1058  0  50 -51 21 -22 23 -24 fill=14 (0 0 97.446436) u=6 imp:n=1
c
c
1059  0  51 -52 21 -22 23 -24 fill=13 (0 0 101.194518) u=6 imp:n=1
c
1060  0  52 -53 21 -22 23 -24 fill=14 (0 0 104.942600) u=6 imp:n=1
c
c
1061  0  53 -54 21 -22 23 -24 fill=13 (0 0 108.690682) u=6 imp:n=1
c
1062  0  54 -55 21 -22 23 -24 fill=14 (0 0 112.438764) u=6 imp:n=1
c
c
1063  0  55 -56 21 -22 23 -24 fill=13 (0 0 116.186846) u=6 imp:n=1
c
1064  0  56 -57 21 -22 23 -24 fill=14 (0 0 119.934928) u=6 imp:n=1
c
c
1065  0  57 -58 21 -22 23 -24 fill=13 (0 0 123.683010) u=6 imp:n=1
c
1066  0  58 -59 21 -22 23 -24 fill=14 (0 0 127.431092) u=6 imp:n=1
c
c
1067  0  59 -60 21 -22 23 -24 fill=13 (0 0 131.179174) u=6 imp:n=1
c
1068  0  60 -61 21 -22 23 -24 fill=14 (0 0 134.927256) u=6 imp:n=1
c
c
1069  0  61 -62 21 -22 23 -24 fill=13 (0 0 138.675338) u=6 imp:n=1
c
1070  0  62 -63 21 -22 23 -24 fill=14 (0 0 142.423420) u=6 imp:n=1
c
c
1071  0  63 -64 21 -22 23 -24 fill=13 (0 0 146.171502) u=6 imp:n=1
c
1072  0  64 -65 21 -22 23 -24 fill=14 (0 0 149.919584) u=6 imp:n=1
c
c
c The top core cell, Cell 2
c
c Na plate core
1082  5 2.324832E-02 402 -403 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1083  6 7.9429E-02 65 -404 21 -22 23 -24 &
    (-159:160:-161:162:-402:403) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1087  3 6.9083E-02 405 -406 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1088  4 7.2463E-02 404 -407 21 -22 23 -24 &
    (-155:156:-157:158:-405:406) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1092  1 3.9991E-02 151 -152 153 -154 408 -409 u=6 imp:n=1 &
    TMP=2.5301E-08
c Pu canning
1093  2 6.6997E-02 407 -410 21 -22 23 -24 &
    (-151:152:-153:154:-408:409) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1102  5 2.324832E-02 411 -412 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

C Na plate can
1103   6 7.9429E-02 410 -413 21 -22 23 -24 &
      (-159:160:-161:162:-411:412) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1107   3 6.9083E-02 414 -415 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1108   4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-155:156:-157:158:-414:415) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1112   5 2.324832E-02 417 -418 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
C Na plate can
1113   6 7.9429E-02 416 -66 21 -22 23 -24 &
      (-159:160:-161:162:-417:418) u=6 imp:n=1 TMP=2.5301E-08
c
c
c Upper Axial blanket.
c
1121   8 4.7208E-02 66 -67 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1122   9 4.7925E-02 67 -68 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1123  15 4.8317E-02 68 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1126  14 8.4932E-02 12 -13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1127  16 3.279692E-02 13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Wrapper region
c 1128  17 3.87228E-02 1 -2 3 -4 (-21:22:-23:24) u=6 imp:n=1
c      TMP=2.5301E-08
c gap between plates and wrapper
1131   0 132 -133 134 -135 (-21:22:-23:24) u=6 imp:n=1
c Wrapper
1132  17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=6 &
      imp:n=1 TMP=2.5301E-08
c gap outside wrapper
1133   0 1 -2 3 -4 (-136:137:-138:139) u=6 imp:n=1
c
c
c --- Radial Breeder Element
c Lower padding
1241  16 3.279692E-02 -8 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1242  14 8.4932E-02 8 -9 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Radial blanket
1244  15 4.8317E-02 9 -12 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Upper reflector
1246  like 134 but u=7 imp:n=1 TMP=2.5301E-08
c Upper padding
1247  like 135 but u=7 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
1248   0 132 -133 134 -135 (-21:22:-23:24) u=7 imp:n=1
c Wrapper
1249  17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=7 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
1250   0 1 -2 3 -4 (-136:137:-138:139) u=7 imp:n=1
c
c
c
c --- Radial shield
c
1326  12 8.32720E-02 28 -29 30 -31 u=8 imp:n=1 TMP=2.5301E-08
c
1327  13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=8 imp:n=1 &
      TMP=2.5301E-08
c
c
1400  13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly
c
1419   0 189 -190 191 -192 u=10 lat=1

```

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```

fill=-3:3 -3:3 0:0
199 164 162 161 163 165 199
146 144 132 141 143 145 147
126 132 122 121 123 132 127
106 104 102 101 103 105 107
116 132 112 111 113 132 117
136 134 132 131 132 135 137
199 154 152 151 153 155 199
imp:n=1

c
c --- Fuel Region
c
1429      0 7 -16 -17 fill=10 imp:n=1
c --- Universe
1430      0 -7:16:17 imp:n=0
c
c Cell A
c 501      1 6.9985E-02 -71 u=3 imp:n=1 TMP=2.5301E-08
c
c 502      23 0.062241 -74 71 u=3 imp:n=1 TMP=2.5301E-08
c
c 503      5 2.3900E-02 74 u=3 imp:n=1 TMP=2.5301E-08
c
c 504      0 75 -76 77 -78 u=3 fill=1 imp:n=1
c
c Cell E   Modified compositions
c
c 506      2 7.1167E-02 -71 u=4 imp:n=1 TMP=2.5301E-08
c
c 507      24 0.0596942 -74 71 u=4 imp:n=1 TMP=2.5301E-08
c
c 508      5 2.3900E-02 74 u=4 imp:n=1 TMP=2.5301E-08
c
c 509      0 75 -76 77 -78 u=4 fill=2 imp:n=1
c
c 511      0 75 -76 77 -78 lat=1 &
        fill -2:1 -2:1 0:0 &
c        3 4 3 4 4 3 4 3 3 4 3 4 4 3 4 3 &
c        u=11 imp:n=1
c
c
c ----- PLATE ELEMENT CELL CARDS -----
c
c The First Regular cell. Cell 1
c
c Na plate
c Na plate core
2162      5 2.324832E-02 802 -803 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
c Na plate can
2163      6 7.9429E-02 801 -804 21 -22 23 -24 &
        (-159:160:-161:162:-802:803) u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2167      3 6.9083E-02 805 -806 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2168      4 7.2463E-02 804 -807 21 -22 23 -24 &
        (-155:156:-157:158:-805:806) u=13 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170      7 3.3152E-02 807 -708 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c Pu plate
c Plate core
2172      1 3.9991E-02 151 -152 153 -154 709 -710 u=13 imp:n=1 TMP=2.5301E-08
c Pu canning
2173      2 6.6997E-02 708 -711 21 -22 23 -24 &
        (-151:152:-153:154:-709:710) u=13 imp:n=1 TMP=2.5301E-08
c
c
c Na plate
c Na plate core
2182      5 2.324832E-02 712 -713 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
c Na plate can

```

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LIQUID METAL FAST REACTOR – LMFR
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```

2183   6 7.9429E-02 711 -814 21 -22 23 -24 &
      (-159:160:-161:162:-712:713) u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2187   3 6.9083E-02 815 -816 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188   4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=13 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2192   5 2.324832E-02 818 -819 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
C Na plate can
2193   6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-159:160:-161:162:-818:819) u=13 imp:n=1 TMP=2.5301E-08
c
c End of Cell 1 beginning of Cell 2
c Na plate
c Na plate core
2202   5 2.324832E-02 802 -803 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2203   6 7.9429E-02 801 -804 21 -22 23 -24 &
      (-159:160:-161:162:-802:803) u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2207   3 6.9083E-02 805 -806 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2208   4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=14 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2211   5 2.324832E-02 808 -809 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2212   6 7.9429E-02 807 -810 21 -22 23 -24 &
      (-159:160:-161:162:-808:809) u=14 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2214   1 3.9991E-02 151 -152 153 -154 811 -812 u=14 imp:n=1 TMP=2.5301E-08
C Pu canning
2215   2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-151:152:-153:154:-811:812) u=14 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217   7 3.3152E-02 813 -814 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219   3 6.9083E-02 815 -816 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220   4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=14 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2222   5 2.324832E-02 818 -819 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2223   6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-159:160:-161:162:-818:819) u=14 imp:n=1 TMP=2.5301E-08
c
c
c                                     End of plate element cell data
c
c
c -----
c
c Form the region surrounding groups of 5x5 elements, containing grids
c
c
3001   0 189 -190 191 -192 (-185:186:-187:188) -71 u=100 imp:n=1
c
3002  19 7.403935E-02 189 -190 191 -192 (-185:186:-187:188) 71 -72 &

```


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```

u=100 imp:n=1
c
3003  0  189 -190 191 -192  (-185:186:-187:188) 72 -73 u=100 imp:n=1
c
3004  19 7.403935E-02  189 -190 191 -192  (-185:186:-187:188) 73 -74 &
u=100 imp:n=1
c
3005  0  189 -190 191 -192  (-185:186:-187:188) 74 u=100 imp:n=1
c
c
c -----
c
c Form arrays of 5x5 elements
c
c                               Central row
c
c Central array of 5x5 core elements
c
c
3011  0  1 -2 3 -4 u=201 lat=1
      fill=-2:2 -2:2 0:0
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      imp:n=1
c
3012  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=101 imp:n=1
c
3013  0  7 -16 185 -186 187 -188 fill=201 u=101 imp:n=1
c
c
c Middle Left array of 5x5 core elements in row 4
c
3014  0  1 -2 3 -4 u=202 lat=1
      fill=-2:2 -2:2 0:0
      4 5 4 2 2
      4 2 4 2 2
      3 2 2 2 2
      4 2 2 2 2
      4 5 2 2 2
      imp:n=1
c
c
c Surround material
c
3015  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=102 imp:n=1
c
c
3016  0  7 -16 185 -186 187 -188 fill=202 u=102 imp:n=1
c
c
c Middle Right array of 5x5 core elements in row 4
c
3017  0  1 -2 3 -4 u=203 lat=1
      fill=-2:2 -2:2 0:0
      2 2 4 5 4
      2 2 4 2 4
      2 2 2 2 3
      2 2 2 2 4
      2 2 3 5 4
      imp:n=1
c
c
c Surround material
c
3018  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=103 imp:n=1
c
c
3019  0  7 -16 185 -186 187 -188 fill=203 u=103 imp:n=1
c
c
c

```

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```

c Left edge array of 5x5 core elements in row 4
c
3021    0    1 -2 3 -4 u=204 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 6
      7 7 7 7 6
      7 7 7 7 6
      7 7 7 7 6
      7 7 7 7 6
      imp:n=1

c
c
c Surround material
c
3022    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=104 imp:n=1
c
c
3023    0  7 -16 185 -186 187 -188 fill=204 u=104 imp:n=1
c
c
c Right edge array of 5x5 core elements in row 4
c
3024    0    1 -2 3 -4 u=205 lat=1
      fill=-2:2 -2:2 0:0
      6 7 7 7 7
      6 7 7 7 7
      6 7 7 7 7
      6 7 7 7 7
      6 7 7 7 7
      imp:n=1

c
c
c Surround material
c
3025    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=105 imp:n=1
c
c
3026    0  7 -16 185 -186 187 -188 fill=205 u=105 imp:n=1
c
c
c                               ROW 3 The row below the central line
c
c
c Middle array of 5x5 core elements in Row 3
c
c
3031    0    1 -2 3 -4 u=211 lat=1
      fill=-2:2 -2:2 0:0
      1 1 1 1 1
      1 1 1 1 1
      3 3 3 3 3
      3 3 3 3 3
      3 3 3 3 3
      imp:n=1

c
c Surround material
c
3032    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=111 imp:n=1
c
3033    0  7 -16 185 -186 187 -188 fill=211 u=111 imp:n=1
c
c Lower left array of 5x5 core elements in Row 3
c
c
3034    0    1 -2 3 -4 u=212 lat=1
      fill=-2:2 -2:2 0:0
      6 2 2 1 2
      6 2 2 1 2
      7 6 4 2 3
      7 6 6 3 3
      7 7 7 6 6
      imp:n=1

c
c Surround material

```

```

c
3035  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=112 imp:n=1
c
3036  0  7 -16 185 -186 187 -188 fill=212 u=112 imp:n=1
c
c
c Lower right array of 5x5 core elements in Row 3
c
3037  0  1 -2 3 -4 u=213 lat=1
      fill=-2:2 -2:2 0:0
      2 2 3 3 6
      2 3 3 5 6
      3 3 3 6 7
      3 3 6 6 7
      6 6 7 7 7
      imp:n=1
c
c
c Surround material
c
3038  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=113 imp:n=1
c
c
3039  0  7 -16 185 -186 187 -188 fill=213 u=113 imp:n=1
c
c
c
c ROW 5 the row above the central line
c
c Central array of 5x5 core elements in Row 5
c
3051  0  1 -2 3 -4 u=221 lat=1
      fill=-2:2 -2:2 0:0
      3 3 3 3 3
      3 3 3 3 3
      3 3 3 3 3
      1 1 1 1 1
      1 1 1 1 1
      imp:n=1
c
c
c Surround material
c
3052  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=121 imp:n=1
c
c
3053  0  7 -16 185 -186 187 -188 fill=221 u=121 imp:n=1
c
c
c Top left array of 5x5 core elements in Row 5
c
3054  0  1 -2 3 -4 u=222 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 6 6
      7 6 6 3 3
      7 6 4 2 2
      6 5 2 1 2
      6 2 2 1 2
      imp:n=1
c
c
c Surround material
c
3055  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=122 imp:n=1
c
c
3056  0  7 -16 185 -186 187 -188 fill=222 u=122 imp:n=1
c
c
c Top right array of 5x5 core elements in Row 5
c
3057  0  1 -2 3 -4 u=223 lat=1
      fill=-2:2 -2:2 0:0
      6 6 7 7 7

```

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```

3 3 6 6 7
2 2 4 6 7
2 1 2 3 6
2 1 2 2 6
imp:n=1
c
c
c Surround material
c
3058 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=123 imp:n=1
c
c
3059 0 7 -16 185 -186 187 -188 fill=223 u=123 imp:n=1
c
c
c
c ROW 2 The row two down from the central row
c
c Lower central group
c
c
3071 0 1 -2 3 -4 u=231 lat=1
fill=-2:2 -2:2 0:0
6 6 6 6 6
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3072 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=131 imp:n=1
c
3073 0 7 -16 185 -186 187 -188 fill=231 u=131 imp:n=1
c
c
c ROW 6
c
c Top central array of 5x5 core elements in row 6
c
3074 0 1 -2 3 -4 u=241 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
6 6 6 6 6
imp:n=1
c
c Surround material
c
3075 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=141 imp:n=1
c
3076 0 7 -16 185 -186 187 -188 fill=241 u=141 imp:n=1
c
c Right central array in Row 6 with one core element (plate)
c
c
3077 0 1 -2 3 -4 u=243 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
6 7 7 7 7
imp:n=1
c
c Surround material
c
3078 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=143 imp:n=1
c
3079 0 7 -16 185 -186 187 -188 fill=243 u=143 imp:n=1

```

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```

c
c
c
c 5x5 array of blanket elements
c
c
3101    0    1 -2 3 -4 u=232 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        imp:n=1

c
c
c Surround material
c
3102    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=132 imp:n=1
c
3103    0 7 -16 185 -186 187 -188 fill=232 u=132 imp:n=1
c
c
c *** Blanket-Reflector Arrays ***
c
c ROW 2
c
c Bottom Left
c
c
3111    0    1 -2 3 -4 u=234 lat=1
        fill=-2:2 -2:2 0:0
        8 7 7 7 7
        8 8 7 7 7
        8 8 8 7 7
        8 8 8 8 7
        9 8 8 8 8
        imp:n=1

c
c
c Surround material
c
3112    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=134 imp:n=1
c
3113    0 7 -16 185 -186 187 -188 fill=234 u=134 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
c
3121    0    1 -2 3 -4 u=235 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 8
        7 7 7 8 8
        7 7 8 8 8
        7 8 8 8 8
        8 8 8 8 9
        imp:n=1

c
c
c Surround material
c
3122    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=135 imp:n=1
c
3123    0 7 -16 185 -186 187 -188 fill=235 u=135 imp:n=1
c
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
c
3131    0    1 -2 3 -4 u=244 lat=1
        fill=-2:2 -2:2 0:0

```

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```

      9 8 8 8 8
      8 8 8 8 7
      8 8 8 7 7
      8 8 7 7 7
      8 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3132   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=144 imp:n=1
c
3133   0  7 -16 185 -186 187 -188 fill=244 u=144 imp:n=1
c
c Row 6 Top Right Blanket Reflector Array
c
c
3141     0   1 -2 3 -4 u=245 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 8 9
      7 8 8 8 8
      7 7 8 8 8
      7 7 7 8 8
      7 7 7 7 8
      imp:n=1
c
c
c Surround material
c
3142   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=145 imp:n=1
c
3143   0  7 -16 185 -186 187 -188 fill=245 u=145 imp:n=1
c
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
c
3151     0   1 -2 3 -4 u=254 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1
c
c
c Surround material
c
3152   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=154 imp:n=1
c
3153   0  7 -16 185 -186 187 -188 fill=254 u=154 imp:n=1
c
c Row 1 Mid-Left
c
c
3161     0   1 -2 3 -4 u=252 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 7 7
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      imp:n=1
c
c
c Surround material
c
3162   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=152 imp:n=1
c
3163   0  7 -16 185 -186 187 -188 fill=252 u=152 imp:n=1
c

```

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```

c Row 1 Central Array
c
3171  0  1 -2 3 -4 u=251 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3172  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=151 imp:n=1
c
3173  0 7 -16 185 -186 187 -188 fill=251 u=151 imp:n=1
c
c Row 1 First Right array
c
c
3181  0  1 -2 3 -4 u=253 lat=1
      fill=-2:2 -2:2 0:0
      7 7 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3182  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=153 imp:n=1
c
3183  0 7 -16 185 -186 187 -188 fill=253 u=153 imp:n=1
c
c Row 1 Far Right
c
c
3191  0  1 -2 3 -4 u=255 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3192  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=155 imp:n=1
c
3193  0 7 -16 185 -186 187 -188 fill=255 u=155 imp:n=1
c
c
c Row 2 Blanket reflector arrays
c
c Row 2 First Left array
c
c
3201  0  1 -2 3 -4 u=236 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 8 8
      9 9 9 8 8
      9 9 9 9 8
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c

```

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```

3202   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=136 imp:n=1
c
3203   0  7  -16 185 -186 187 -188 fill=236 u=136 imp:n=1
c
c Row 2 Far Right
c
c
3211   0   1 -2 3 -4 u=237 lat=1
      fill=-2:2 -2:2 0:0
      8 8 9 9 9
      8 8 9 9 9
      8 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1
c
c
c Surround material
c
3212   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=137 imp:n=1
c
3213   0  7  -16 185 -186 187 -188 fill=237 u=137 imp:n=1
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
c
3221   0   1 -2 3 -4 u=206 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3222   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=106 imp:n=1
c
3223   0  7  -16 185 -186 187 -188 fill=206 u=106 imp:n=1
c
c
c Row 4 Far Right
c
c
3231   0   1 -2 3 -4 u=207 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3232   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=107 imp:n=1
c
3233   0  7  -16 185 -186 187 -188 fill=207 u=107 imp:n=1
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
3241   0   1 -2 3 -4 u=246 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9

```


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```

    9 9 9 9 8
    9 9 9 8 8
    9 9 9 8 8
    imp:n=1
c
c
c Surround material
c
3242   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=146 imp:n=1
c
3243   0  7 -16 185 -186 187 -188 fill=246 u=146 imp:n=1
c
c Row 6 Far Right
c
3251   0   1 -2 3 -4 u=247 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      8 9 9 9 9
      8 8 9 9 9
      8 8 9 9 9
      imp:n=1
c
c
c Surround material
c
3252   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=147 imp:n=1
c
3253   0  7 -16 185 -186 187 -188 fill=247 u=147 imp:n=1
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
c
3261   0   1 -2 3 -4 u=226 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3262   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=126 imp:n=1
c
3263   0  7 -16 185 -186 187 -188 fill=226 u=126 imp:n=1
c
c Row 4 Far Right
c
3271   0   1 -2 3 -4 u=227 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3272   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=127 imp:n=1
c
3273   0  7 -16 185 -186 187 -188 fill=227 u=127 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays
c

```

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```

c Row 3 First Left array
c
3281    0    1 -2 3 -4 u=216 lat=1
        fill=-2:2 -2:2 0:0
        9 8 8 8 7
        9 8 8 8 7
        9 9 8 8 8
        9 9 8 8 8
        9 9 8 8 8
        imp:n=1

c
c
c Surround material
c
3282    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=116 imp:n=1
c
3283    0  7 -16 185 -186 187 -188 fill=216 u=116 imp:n=1
c
c Row 3 Far Right
c
3291    0    1 -2 3 -4 u=217 lat=1
        fill=-2:2 -2:2 0:0
        7 8 8 8 9
        7 8 8 8 9
        8 8 8 9 9
        8 8 8 9 9
        8 8 8 9 9
        imp:n=1

c
c
c Surround material
c
3292    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=117 imp:n=1
c
3293    0  7 -16 185 -186 187 -188 fill=217 u=117 imp:n=1
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
c
3301    0    1 -2 3 -4 u=264 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 8 8
        9 9 8 8 8
        imp:n=1

c
c
c Surround material
c
3302    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=164 imp:n=1
c
3303    0  7 -16 185 -186 187 -188 fill=264 u=164 imp:n=1
c
c Row 7 Mid-Left
c
3311    0    1 -2 3 -4 u=262 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        9 9 9 8 8
        8 8 8 8 8
        8 8 8 8 8
        8 8 8 7 7
        imp:n=1

c
c
c Surround material
c
3312    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=162 imp:n=1
c
3313    0  7 -16 185 -186 187 -188 fill=262 u=162 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Row 7 Central Array
c
3321    0   1 -2 3 -4 u=261 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        8 8 8 8 8
        8 8 8 8 8
        8 8 8 8 8
        7 7 7 7 7
        imp:n=1

c
c
c Surround material
c
3322    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=161 imp:n=1
c
3323    0  7 -16 185 -186 187 -188 fill=261 u=161 imp:n=1
c
c Row 7 First Right array
c
3331    0   1 -2 3 -4 u=263 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        8 8 9 9 9
        8 8 8 8 8
        8 8 8 8 8
        7 7 8 8 8
        imp:n=1

c
c
c Surround material
c
3332    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=163 imp:n=1
c
3333    0  7 -16 185 -186 187 -188 fill=263 u=163 imp:n=1
c
c Row 7 Far Right
c
3341    0   1 -2 3 -4 u=265 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        8 8 9 9 9
        8 8 8 9 9
        imp:n=1

c
c
c Surround material
c
3342    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=165 imp:n=1
c
3343    0  7 -16 185 -186 187 -188 fill=265 u=165 imp:n=1
c
c Beyond the reflector 5x5 Region 9
c
3351    0   1 -2 3 -4 u=299 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3352    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=199 imp:n=1
c
c
3353    0  7 -16 185 -186 187 -188 fill=299 u=199 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c
c -----
c
c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1    px -2.68605
2    px 2.68605
3    py -2.68605
4    py 2.68605
7    pz 0.0 $ Assembly lower limit
8    pz 30.0 $ End Packing, Start Reflector
9    pz 37.60628 $ End Plenum, Start Lower NU
10   pz 67.77878 $ End Lower NU, Start Fuel
c
11   pz 156.96878 $ End Fuel, Start Upper NU for Pin element
c
12   pz 187.271248 $ End Upper NU, Start Top Reflector
13   pz 194.877528 $ End Reflector, Start Packing
16   pz 224.877528 $ Assembly upper limit
c
17   cz 94.9
c
21   px -2.5335 $ Nominal half-width of plates
22   px 2.5335 $ and calandria outer half-width
23   py -2.5335
24   py 2.5335
28   px -2.54 $ Radial shield half-width
29   px 2.54
30   py -2.54
31   py 2.54
c
33   px -2.45 $ inner half-width of calandria
34   px 2.45
35   py -2.45
36   py 2.45
c
c
c subdivisions in the plate element axial blanket and core cells
c
c    9 pz 37.60628 $ axial reflector / axial blanket
41   pz 45.228780
42   pz 57.951780
c    10 pz 67.77878 $ axial blanket / core
43   pz 71.209862
44   pz 74.957944
45   pz 78.706026
46   pz 82.454108
47   pz 86.202190
48   pz 89.950272
49   pz 93.698354
50   pz 97.446436
51   pz 101.194518
52   pz 104.942600
53   pz 108.690682
54   pz 112.438764
55   pz 116.186846
56   pz 119.934928
57   pz 123.683010
58   pz 127.431092
59   pz 131.179174
60   pz 134.927256
61   pz 138.675338
62   pz 142.423420
63   pz 146.171502
64   pz 149.919584
65   pz 153.667666
c
66   pz 157.098748 $ core / axial blanket
c    in plate elements (this replaces pz=11)
67   pz 166.925748

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

68      pz 179.648748
c      12 pz 187.271248 $ axial blanket / reflector
c
c differences in the pin elements ?
c 67      pz 166.925748
c 68      pz 179.648748
c      12 pz 187.271248 $ axial blanket / reflector
c
c Grid plate heights
c
71      pz 31.8
72      pz 62.2
73      pz 162.6
74      pz 193.0
c
c 71      c/z 0 0 0.423          $ fuel pin radius
c 71      c/z 0.6125 0.6125 0.423
c 72      c/z 0 0 0.4305        $ fuel can inner radius
c 73      c/z 0 0 0.488         $ calandria tube inner radius
c 74      c/z 0 0 0.513         $ calandria tube outer radius
c 74      c/z 0.6125 0.6125 0.513
c 75      px 0.0
c 76      px 1.225
c 77      py 0.0
c 78      py 1.225
c 79      cz 1.692
c 80      cz 2.052
c
81      pz 67.77878 $ 0.0
82      pz 68.21878 $ 0.44
83      pz 97.39878 $ 29.62
c 84      pz 97.50878 $ 29.73
85      pz 97.94878 $ 0.44
86      pz 127.12878 $ 29.62
c 87      pz 127.23878 $ 29.73
88      pz 127.67878 $ 0.44
89      pz 156.85878 $ 29.62
90      pz 156.96878 $ 29.73
c
91      c/z -1.785 -1.785 0.423
92      c/z -0.595 -1.785 0.423
93      c/z 0.595 -1.785 0.423
94      c/z 1.785 -1.785 0.423
95      c/z -1.785 -0.595 0.423
96      c/z -0.595 -0.595 0.423
97      c/z 0.595 -0.595 0.423
98      c/z 1.785 -0.595 0.423
99      c/z -1.785 0.595 0.423
100     c/z -0.595 0.595 0.423
101     c/z 0.595 0.595 0.423
102     c/z 1.785 0.595 0.423
103     c/z -1.785 1.785 0.423
104     c/z -0.595 1.785 0.423
105     c/z 0.595 1.785 0.423
106     c/z 1.785 1.785 0.423
c
c
111     c/z -1.785 -1.785 0.513
112     c/z -0.595 -1.785 0.513
113     c/z 0.595 -1.785 0.513
114     c/z 1.785 -1.785 0.513
115     c/z -1.785 -0.595 0.513
116     c/z -0.595 -0.595 0.513
117     c/z 0.595 -0.595 0.513
118     c/z 1.785 -0.595 0.513
119     c/z -1.785 0.595 0.513
120     c/z -0.595 0.595 0.513
121     c/z 0.595 0.595 0.513
122     c/z 1.785 0.595 0.513
123     c/z -1.785 1.785 0.513
124     c/z -0.595 1.785 0.513
125     c/z 0.595 1.785 0.513
126     c/z 1.785 1.785 0.513
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

132     px -2.551 $ sheath inner half-width
133     px 2.551
134     py -2.551
135     py 2.551
136     px -2.6272 $ sheath outer half-width
137     px 2.6272
138     py -2.6272
139     py 2.6272
c
c     Widths of plate cores
c     * in plate geometry cores these are 101 to 112
151     px -2.3355 $ Pu plate core width
152     px 2.3355
153     py -2.3355
154     py 2.3355
155     px -2.4255 $ UO2 plate core width
156     px 2.4255
157     py -2.4255
158     py 2.4255
159     px -2.4815 $ Na plate core width
160     px 2.4815
161     py -2.4815
162     py 2.4815
c
c
c     coordinates of the elements in 5x5 arrays
c     * in the plate geometry cores these are 81 to 92
c 181     px -8.05815
c 182     px 8.05815
c 183     py -8.05815
c 184     py 8.05815
185     px -13.43025
186     px 13.43025
187     py -13.43025
188     py 13.43025
189     px -13.5635
190     px 13.5635
191     py -13.5635
192     py 13.5635
c
c
c     Cell 2 Axial heights
c
401     pz 153.667666
402     pz 153.704013
403     pz 154.245013
404     pz 154.281360
405     pz 154.318010
406     pz 154.876010
407     pz 154.912660
408     pz 154.958360
409     pz 155.194360
410     pz 155.240060
411     pz 155.276407
412     pz 155.817407
413     pz 155.853754
414     pz 155.890404
415     pz 156.448404
416     pz 156.485054
417     pz 156.521401
418     pz 157.062401
419     pz 157.098748
c
c     Cell 12 Axial heights
c
501     pz 67.778780
502     pz 67.815127
503     pz 68.356127
504     pz 68.392474
505     pz 68.429124
506     pz 68.987124
507     pz 69.023774
508     pz 69.060121
509     pz 69.601121

```

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LIQUID METAL FAST REACTOR - LMFR
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```

510    pz    69.637468
511    pz    69.683168
512    pz    69.919168
513    pz    69.964868
514    pz    70.001518
515    pz    70.559518
516    pz    70.596168
517    pz    70.632515
518    pz    71.173515
519    pz    71.209862
c
c Basic Cell 1 data
c 701    pz    0.000000
c 702    pz    0.036347  $ Na can
c 703    pz    0.577347  $ Na core
c 704    pz    0.613694
c 705    pz    0.650344  $ UO2 can
c 706    pz    1.208344  $ UO2 core
c 707    pz    1.244994
708    pz    1.561994  $ SS
709    pz    1.607694  $ Pu can
710    pz    1.843694  $ Pu core
711    pz    1.889394
712    pz    1.925741  $ Na can
713    pz    2.466741  $ Na core
c 714    pz    2.503088
c 715    pz    2.539738  $ UO2 can
c 716    pz    3.097738  $ UO2 core
c 717    pz    3.134388
c 718    pz    3.170735  $ Na can
c 719    pz    3.711735  $ Na core
c 720    pz    3.748082  $          Cell 1
c
801    pz    0.000000
802    pz    0.036347
803    pz    0.577347  $ Na
804    pz    0.613694
805    pz    0.650344
806    pz    1.208344  $ UO2
807    pz    1.244994
808    pz    1.281341
809    pz    1.822341  $ Na
810    pz    1.858688
811    pz    1.904388
812    pz    2.140388  $ Pu
813    pz    2.186088
814    pz    2.503088  $ SS
815    pz    2.539738
816    pz    3.097738  $ UO2
817    pz    3.134388
818    pz    3.170735
819    pz    3.711735  $ Na
820    pz    3.748082  $ Cell 11
c
c -----
c
c
c ----- TALLY CARDS -----
c
c --- MATERIALS CARDS ---
c
C MATERIAL 1 Pu metal plate core
ml    92238.31c  6.8782E-07
      94238.31c  3.0461E-05
      94239.31c  2.8920E-02
      94240.31c  6.9095E-03
      94241.31c  7.3960E-04
      94242.31c  1.8699E-04
      95241.31c  4.5718E-04
      1001.31c   1.2764E-04
      6000.31c   4.2260E-04
      7014.31c   2.4215E-05
      8016.31c   8.8450E-05

```

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LIQUID METAL FAST REACTOR – LMFR
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```

13027.31c  2.2973E-05
14028.31c  1.4158E-05
25055.31c  1.4902E-06
24050.31c  1.5637E-07
24052.31c  3.0155E-06
24053.31c  3.4193E-07
24054.31c  8.5114E-08
26054.31c  9.5478E-07
26056.31c  1.4988E-05
26057.31c  3.4614E-07
26058.31c  4.6065E-09
28058.31c  5.8334E-06
28060.31c  2.2470E-06
28061.31c  9.7676E-08
28062.31c  3.1143E-07
28064.31c  7.9313E-08
31000.31c  2.0166E-03

```

c total 3.9991E-02

c MATERIAL 2 Pu plate canning

```

m2      1001.31c  1.3760E-05
        6000.31c  1.1393E-04
        14028.31c  3.6607E-04
        15031.31c  1.3731E-05
        24050.31c  4.0848E-04
        24052.31c  7.8771E-03
        24053.31c  8.9320E-04
        24054.31c  2.2234E-04
        25055.31c  8.5931E-04
        26054.31c  2.0774E-03
        26056.31c  3.2611E-02
        26057.31c  7.5313E-04
        26058.31c  1.0023E-05
        28058.31c  2.8351E-03
        28060.31c  1.0921E-03
        28061.31c  4.7472E-05
        28062.31c  1.5136E-04
        28064.31c  3.8548E-05
        29063.31c  1.1629E-02
        29065.31c  4.9839E-03

```

c total 6.6997E-02

C MATERIAL 3 UO2 plate core

```

m3      1001.31c  3.1773E-05
        6000.31c  1.1808E-05
        8016.31c  4.6008E-02
        13027.31c  3.3911E-06
        14028.31c  2.2967E-05
        25055.31c  8.3273E-08
        26054.31c  7.6610E-08
        26056.31c  1.2026E-06
        26057.31c  2.7774E-08
        26058.31c  3.6962E-10
        28058.31c  8.4906E-07
        28060.31c  3.2705E-07
        28061.31c  1.4217E-08
        28062.31c  4.5329E-08
        28064.31c  1.1544E-08
        42092.31c  5.0069E-08
        42094.31c  3.3379E-08
        42095.31c  5.0069E-08
        42096.31c  5.0069E-08
        42097.31c  3.3379E-08
        42098.31c  8.3448E-08
        42100.31c  3.3379E-08
        92235.31c  1.6544E-04
        92238.31c  2.2837E-02

```

c total 6.9083E-02

c MATERIAL 4 UO2 plate canning

```

m4      1001.31c  1.9035E-05
        6000.31c  1.2831E-04
        14028.31c  6.4475E-04
        15031.31c  3.5078E-04
        16032.31c  3.6041E-05
        24050.31c  6.0044E-04
        24052.31c  1.1579E-02

```


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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

24053.31c 1.3129E-03
24054.31c 3.2682E-04
25055.31c 8.5559E-04
26054.31c 2.8235E-03
26056.31c 4.4323E-02
26057.31c 1.0236E-03
26058.31c 1.3622E-05
28058.31c 5.7360E-03
28060.31c 2.2095E-03
28061.31c 9.6046E-05
28062.31c 3.0624E-04
28064.31c 7.7989E-05
c total 7.2463E-02
C MATERIAL 5 sodium plate core
m5      1001.31c 1.3900E-05
        8016.31c 5.6492E-06
        11023.31c 2.3225E-02
        20040.31c 3.6083E-06
        26054.31c 9.4595E-09
        26056.31c 1.4849E-07
        26057.31c 3.4294E-09
        26058.31c 4.5639E-11
c total 2.324832E-02
c MATERIAL 6 Sodium plate canning
m6      1001.31c 2.1631E-05
        6000.31c 2.9290E-04
        14028.31c 6.0867E-04
        15031.31c 3.2795E-05
        16032.31c 3.3219E-05
        24050.31c 6.4128E-04
        24052.31c 1.2366E-02
        24053.31c 1.4023E-03
        24054.31c 3.4905E-04
        25055.31c 1.3570E-03
        26054.31c 3.2179E-03
        26056.31c 5.0514E-02
        26057.31c 1.1666E-03
        26058.31c 1.5525E-05
        28058.31c 4.8322E-03
        28060.31c 1.8614E-03
        28061.31c 8.0912E-05
        28062.31c 2.5798E-04
        28064.31c 6.5701E-05
        41093.31c 3.1147E-04
c total 7.9429E-02
C MATERIAL 7 40% steel plate
c m7      1001.31c 1.8355E-05
c        6000.31c 8.7794E-05
c        13027.31c 1.1862E-04
c        14028.31c 7.9703E-04
c        15031.31c 4.0018E-05
c        16032.31c 1.4422E-05
c        22048.31c 2.4806E-04
c        24050.31c 6.9120E-04
c        24052.31c 1.3329E-02
c        24053.31c 1.5114E-03
c        24054.31c 3.7622E-04
c        25055.31c 1.4972E-03
c        26054.31c 3.2362E-03
c        26056.31c 5.0801E-02
c        26057.31c 1.1732E-03
c        26058.31c 1.5613E-05
c        28058.31c 5.9891E-03
c        28060.31c 2.3070E-03
c        28061.31c 1.0028E-04
c        28062.31c 3.1975E-04
c        28064.31c 8.1431E-05
c        29063.31c 5.0365E-05
c        41093.31c 4.9781E-06
c        42000.66c 8.0988E-05
c
c 40% ss plate smeared over plate region
c
m7      1001.31c 7.3413E-06

```

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LIQUID METAL FAST REACTOR – LMFR
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```

6000.31c 3.5114E-05
13027.31c 4.7443E-05
14028.31c 3.1878E-04
15031.31c 1.6006E-05
16032.31c 5.7682E-06
22048.31c 9.9214E-05
24050.31c 2.7645E-04
24052.31c 5.3311E-03
24053.31c 6.0450E-04
24054.31c 1.5047E-04
25055.31c 5.9882E-04
26054.31c 1.2944E-03
26056.31c 2.0318E-02
26057.31c 4.6923E-04
26058.31c 6.2446E-06
28058.31c 2.3954E-03
28060.31c 9.2271E-04
28061.31c 4.0108E-05
28062.31c 1.2789E-04
28064.31c 3.2569E-05
29063.31c 1.4101E-05
29065.31c 6.0432E-06
41093.31c 1.9910E-06
42092.31c 4.8588E-06
42094.31c 3.2392E-06
42095.31c 4.8588E-06
42096.31c 4.8588E-06
42097.31c 3.2392E-06
42098.31c 8.0980E-06
42100.31c 3.2392E-06
c total 3.3152E-02
c
C MATERIAL 8 U8 metal plate
m8 1001.31c 4.4048E-05
    6000.31c 4.9283E-04
    14028.31c 2.1076E-04
    26054.31c 6.1951E-06
    26056.31c 9.7250E-05
    26057.31c 2.2459E-06
    26058.31c 2.9889E-08
    92235.31c 3.3369E-04
    92238.31c 4.6021E-02
c total 4.7208E-02
C MATERIAL 9 U2 metal plate
m9 1001.31c 4.3899E-05
    6000.31c 4.6047E-04
    14028.31c 1.9692E-04
    26054.31c 5.7884E-06
    26056.31c 9.0866E-05
    26057.31c 2.0985E-06
    26058.31c 2.7927E-08
    92235.31c 3.3962E-04
    92238.31c 4.6785E-02
c total 4.7925E-02
c
c radial shield
m12 1001.31c 4.6306E-05
    6000.31c 6.8972E-04
    14028.31c 3.1158E-04
    15031.31c 4.2944E-05
    16032.31c 3.7110E-05
    25055.31c 7.1275E-04
    26054.31c 4.9065E-03
    26056.31c 7.4517E-02
    26057.31c 1.7491E-03
    26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
m13 1001.31c 4.6306E-08
    6000.31c 6.8972E-07
    14028.31c 3.1158E-07
    15031.31c 4.2944E-08
    16032.31c 3.7110E-08

```

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LIQUID METAL FAST REACTOR - LMFR
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25055.31c	7.1275E-07
26054.31c	4.9065E-06
26056.31c	7.4517E-05
26057.31c	1.7491E-06
26058.31c	2.5903E-07
c total 8.32720E-05	
c	
c Axial shield	
m14	1001.31c 2.5700E-05
	6000.31c 5.1066E-04
	13027.31c 1.3989E-04
	22048.31c 3.9416E-05
	24050.31c 1.2213E-06
	24052.31c 2.2823E-05
	24053.31c 2.5531E-06
	24054.31c 6.2449E-07
	25055.31c 3.2634E-04
	26054.31c 5.0496E-03
	26056.31c 7.6690E-02
	26057.31c 1.8001E-03
	26058.31c 2.6658E-04
	28058.31c 1.2564E-06
	28060.31c 4.6968E-07
	28061.31c 2.2000E-08
	28062.31c 6.2769E-08
	28064.31c 1.6774E-08
	29063.31c 3.1184E-05
	29065.31c 1.3364E-05
	42092.31c 1.4753E-06
	42094.31c 9.8355E-07
	42095.31c 1.4753E-06
	42096.31c 1.4753E-06
	42097.31c 9.8355E-07
	42098.31c 2.4589E-06
	42100.31c 9.8355E-07
c total 8.4932E-02	
c	
c Natural Uranium Breeder	
m15	1001.31c 4.4574E-05
	6000.31c 4.7140E-04
	14028.31c 2.0160E-04
	26054.31c 6.1085E-06
	26056.31c 9.2771E-05
	26057.31c 2.1776E-06
	26058.31c 3.2248E-07
	92235.31c 3.4209E-04
	92238.31c 4.7156E-02
c Total 4.8317E-02	
c	
c Element top and bottom packing	
m16	1001.31c 3.1777E-05
	6000.31c 9.9996E-05
	13027.31c 8.3095E-06
	24050.31c 6.9087E-08
	24052.31c 1.2911E-06
	24053.31c 1.4442E-07
	24054.31c 3.5326E-08
	25055.31c 1.0785E-04
	26054.31c 1.9605E-03
	26056.31c 2.9775E-02
	26057.31c 6.9890E-04
	26058.31c 1.0350E-04
	28058.31c 1.5636E-07
	28060.31c 5.8452E-08
	28061.31c 2.7378E-09
	28062.31c 7.8115E-09
	28064.31c 2.0875E-09
	29063.31c 6.5270E-06
	29065.31c 2.7973E-06
c Total 3.279692E-02	
c	
c mild steel wrapper material	
m17	1001.31c 7.5725E-05
	6000.31c 2.3828E-04

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
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```

13027.31c 1.9802E-05
24050.31c 1.6463E-07
24052.31c 3.0767E-06
24053.31c 3.4414E-07
24054.31c 8.4182E-08
25055.31c 2.5701E-04
26054.31c 4.6718E-03
26056.31c 7.0954E-02
26057.31c 1.6655E-03
26058.31c 2.4664E-04
28058.31c 3.7260E-07
28060.31c 1.3929E-07
28061.31c 6.5242E-09
28062.31c 1.8615E-08
28064.31c 4.9746E-09
29063.31c 1.5554E-05
29065.31c 6.6660E-06
c Total      7.81552E-02
c
c
C MATERIAL 18 U8 metal plate
c m18      1001.31c  4.4048E-05
c      6000.31c  4.9283E-04
c      14028.31c  2.1076E-04
c      26054.31c  6.1951E-06
c      26056.31c  9.7250E-05
c      26057.31c  2.2459E-06
c      26058.31c  2.9889E-08
c      92235.31c  3.3369E-04
c      92238.31c  4.6021E-02
c total 4.7208E-02
c
c Superlattice grid plate
c
m19      1001.31c  2.4442E-04
      6000.31c  2.9057E-04
      14028.31c  4.3858E-05
      15031.31c  1.3256E-05
      16032.31c  4.3530E-05
      25055.31c  2.5785E-04
      26054.31c  4.2756E-03
      26056.31c  6.7114E-02
      26057.31c  1.5500E-03
      26058.31c  2.0627E-04
c Total 19 7.403935E-02
c
c -----
c
c Element C Pin fuel A and E, Calandria NACLIII
c Pin A
m21      1001.31c  3.2784E-05
      8016.31c  4.6624E-02
      13027.31c  1.1702E-05
      20040.31c  7.8782E-06
      26054.31c  3.3046E-07
      26056.31c  5.1875E-06
      26057.31c  1.1980E-07
      26058.31c  1.5943E-08
      92234.31c  1.3805E-06
      92235.31c  1.4114E-04
      92236.31c  7.9324E-07
      92238.31c  1.9379E-02
      94238.31c  3.7786E-06
      94239.31c  2.9689E-03
      94240.31c  6.7253E-04
      94241.31c  7.0350E-05
      94242.31c  1.7488E-05
      95241.31c  4.7854E-05
c      total 21 6.9985E-02
c
c PinB
c
m22      1001.31c  3.2784E-05
      8016.31c  4.6994E-02

```

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LIQUID METAL FAST REACTOR - LMFR
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```

14028.31c  9.0199E-06
28058.31c  3.7050E-06
28060.31c  1.4272E-06
28061.31c  6.2038E-08
28062.31c  1.9780E-07
28064.31c  5.0375E-08
92234.31c  1.3177E-06
92235.31c  1.3457E-04
92236.31c  7.4658E-07
92238.31c  1.8472E-02
94238.31c  5.8915E-06
94239.31c  3.7341E-03
94240.31c  9.5200E-04
94241.31c  1.1199E-04
94242.31c  2.7984E-05
95241.31c  5.5789E-05

```

c total 22 7.0537E-02 F 26 7.1415E-02

c

c Pin C

c

M23 1001.31c 3.2784E-05

```

8016.31c  4.7434E-02
13027.31c 1.9730E-05
14028.31c  7.9741E-06
26054.31c  4.4958E-07
26056.31c  7.0574E-06
26057.31c  1.6298E-07
26058.31c  2.1690E-08
28058.31c  7.4523E-06
28060.31c  2.8707E-06
28061.31c  1.2478E-07
28062.31c  3.9787E-07
28064.31c  1.0132E-07
92234.31c  1.2863E-06
92235.31c  1.2997E-04
92236.31c  7.3103E-07
92238.31c  1.7843E-02
94238.31c  6.9094E-06
94239.31c  4.4708E-03
94240.31c  1.0602E-03
94241.31c  1.1598E-04
94242.31c  3.0047E-05
95241.31c  5.7784E-05

```

c total 23 7.1230E-02

c

c Pin D

c

M24 1001.31c 3.2784E-05

```

8016.31c  4.7314E-02
13027.31c  1.8914E-05
14028.31c  2.5099E-05
20040.31c  1.5940E-05
26054.31c  4.0346E-07
26056.31c  6.3335E-06
26057.31c  1.4627E-07
26058.31c  1.9465E-08
28058.31c  9.6247E-06
28060.31c  3.7075E-06
28061.31c  1.6116E-07
28062.31c  5.1385E-07
28064.31c  1.3086E-07
92234.31c  1.4118E-06
92235.31c  1.4266E-04
92236.31c  7.9324E-07
92238.31c  1.9584E-02
94238.31c  4.7348E-06
94239.31c  3.0189E-03
94240.31c  7.5441E-04
94241.31c  8.8443E-05
94242.31c  2.0961E-05
95241.31c  4.0742E-05

```

c total 24 7.1085E-02

c

c Pin E

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LIQUID METAL FAST REACTOR – LMFR
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```

m25      1001.31c    3.2784E-05
          8016.31c    4.7317E-02
          13027.31c   9.5250E-06
          14028.31c   4.5753E-05
          20040.31c   3.2062E-05
          26054.31c    6.0326E-07
          26056.31c    9.4699E-06
          26057.31c    2.1870E-07
          26058.31c    2.9105E-08
          92234.31c    1.1295E-06
          92235.31c    1.1465E-04
          92236.31c    6.3771E-07
          92238.31c    1.5739E-02
          94238.31c    9.4851E-06
          94239.31c    6.0438E-03
          94240.31c    1.5103E-03
          94241.31c    1.7707E-04
          94242.31c    4.1953E-05
          95241.31c    8.1559E-05
c         total 25 7.1167E-02
c
C Pin F
M26      1001.31c    3.2784E-05
          8016.31c    4.7482E-02
          13027.31c    1.4287E-05
          20040.31c    6.7514E-05
          24050.31c    2.1476E-07
          24052.31c    4.1414E-06
          24053.31c    4.6961E-07
          24054.31c    1.1689E-07
          26054.31c    6.7247E-07
          26056.31c    1.0556E-05
          26057.31c    2.4379E-07
          26058.31c    3.2444E-08
          28058.31c    1.4905E-06
          28060.31c    5.7416E-07
          28061.31c    2.4958E-08
          28062.31c    7.9577E-08
          28064.31c    2.0266E-08
          92234.31c    1.1452E-06
          92235.31c    1.1526E-04
          92236.31c    6.3771E-07
          92238.31c    1.5824E-02
          94238.31c    9.5005E-06
          94239.31c    6.0112E-03
          94240.31c    1.5285E-03
          94241.31c    1.9723E-04
          94242.31c    4.4380E-05
          95241.31c    6.8035E-05
C total 26 7.1415E-02
c
c Composition of Calandria end plate regions
m27      14028.31c    5.5206E-04
          24050.31c    4.3520E-04
          24052.31c    8.3923E-03
          24053.31c    9.5162E-04
          24054.31c    2.3688E-04
          25055.31c    7.7198E-04
          26054.31c    2.0795E-03
          26056.31c    3.2644E-02
          26057.31c    7.5390E-04
          26058.31c    1.0033E-04
          28058.31c    3.0363E-03
          28060.31c    1.1696E-03
          28061.31c    5.0841E-05
          28062.31c    1.6210E-04
          28064.31c    4.1283E-05
c total 5.13781E-02
c
c UO2 Pin UO2PINC
c
M28      1001.31c    3.2784E-05
          6000.31c    3.2095E-05
          8016.31c    4.7501E-02

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

13027.31c 2.3812E-05
14028.31c 4.0001E-05
20040.31c 1.2825E-05
26054.31c 6.5324E-08
26056.31c 1.0254E-06
26057.31c 2.3682E-08
26058.31c 3.1516E-09
92234.31c 9.7268E-07
92235.31c 1.7084E-04
92238.31c 2.3588E-02
c total 28 7.14034E-02
c
c -----
c Pin clad plus calandria tube combined
c
C Pin PUPINA clad plus tube (was 23)
c
m31      1001.31c 1.0832E-05
        6000.31c 5.3887E-05
        14028.31c 6.6291E-04
        15031.31c 1.5357E-05
        16032.31c 9.9700E-06
        25055.31c 1.0382E-03
        24050.31c 5.3769E-04
        24052.31c 1.0369E-02
        24053.31c 1.1757E-03
        24054.31c 2.9267E-04
        26054.31c 2.4695E-03
        26056.31c 3.8766E-02
        26057.31c 8.9527E-04
        26058.31c 1.1914E-04
        28058.31c 3.9651E-03
        28060.31c 1.5274E-03
        28061.31c 6.6392E-05
        28062.31c 2.1169E-04
        28064.31c 5.3910E-05
c
C      Total 31 6.2241E-02
c
C Pin PUPINB clad plus tube
c
m32      1001.31c 9.2847E-06
        6000.31c 9.6091E-05
        14028.31c 7.8508E-04
        15031.31c 1.6869E-05
        16032.31c 9.2404E-06
        25055.31c 1.0424E-03
        24050.31c 4.8064E-04
        24052.31c 9.2687E-03
        24053.31c 1.0510E-03
        24054.31c 2.6162E-04
        26054.31c 2.3154E-03
        26056.31c 3.6347E-02
        26057.31c 8.3939E-04
        26058.31c 1.1171E-04
        28058.31c 3.9370E-03
        28060.31c 1.5166E-03
        28061.31c 6.5922E-05
        28062.31c 2.1019E-04
        28064.31c 5.3529E-05
        41093.31c 1.1919E-04
c
C Total 32 5.8537E-02 F 36 6.0033E-02
c
C Pin PUPINC clad plus tube
c
m33      1001.31c 1.0832E-05
        6000.31c 5.5189E-05
        14028.31c 6.5458E-04
        15031.31c 1.4602E-05
        16032.31c 9.9700E-06
        25055.31c 1.0254E-03
        24050.31c 5.3131E-04
        24052.31c 1.0246E-02

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

24053.31c 1.1618E-03
24054.31c 2.8919E-04
26054.31c 2.4419E-03
26056.31c 3.8333E-02
26057.31c 8.8527E-04
26058.31c 1.1781E-04
28058.31c 3.9199E-03
28060.31c 1.5099E-03
28061.31c 6.5635E-05
28062.31c 2.0927E-04
28064.31c 5.3296E-05
c
C Total 33 6.15349E-02
c
c Pin PUPIND can plus tube
c
m34 1001.31c 1.0058E-05
6000.31c 8.1804E-05
13027.31c 2.6012E-06
14028.31c 6.7957E-04
15031.31c 1.3847E-05
16032.31c 3.6474E-06
22048.31c 1.1726E-05
25055.31c 8.7351E-04
27059.31c 1.7202E-06
24050.31c 4.9702E-04
24052.31c 9.5846E-03
24053.31c 1.0868E-03
24054.31c 2.7053E-04
26054.31c 2.3766E-03
26056.31c 3.7307E-02
26057.31c 8.6158E-04
26058.31c 1.1466E-04
28058.31c 3.6114E-03
28060.31c 1.3911E-03
28061.31c 6.0470E-05
28062.31c 1.9281E-04
28064.31c 4.9102E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
c 42000.66c 8.9408E-07
42092.31c 1.3357E-07
42094.31c 8.9408E-08
42095.31c 1.3357E-07
42096.31c 1.3357E-07
42097.31c 8.9408E-08
42098.31c 2.2262E-07
42100.31c 8.9408E-08
c
C Total 34 5.9086E-02
c
c Pin PUPINE clad plus tube (Was 24)
m35 1001.31c 1.0058E-05
6000.31c 2.9866E-05
13027.31c 2.6012E-06
14028.31c 7.4068E-04
15031.31c 5.5388E-06
16032.31c 7.0518E-06
22048.31c 1.1726E-05
25055.31c 8.0111E-04
27059.31c 1.7202E-06
24050.31c 5.0041E-04
24052.31c 9.6500E-03
24053.31c 1.0942E-03
24054.31c 2.7238E-04
26054.31c 2.4012E-03
26056.31c 3.7694E-02
26057.31c 8.7052E-04
26058.31c 1.1585E-04
28058.31c 3.7263E-03
28060.31c 1.4354E-03
28061.31c 6.2394E-05
28062.31c 1.9894E-04
28064.31c 5.0664E-05

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

29063.31c 1.7181E-06
29065.31c 7.3632E-07
c    42000.66c 8.6970E-06
    42092.31c 1.3046E-06
    42094.31c 8.6970E-07
    42095.31c 1.3046E-06
    42096.31c 1.3046E-06
    42097.31c 8.6970E-07
    42098.31c 2.1743E-06
    42100.31c 8.6970E-07
c
C Total      35 5.96942E-02
c
C Pin  PUPINF can plus tube
c
m36      1001.31c 1.0058E-05
    6000.31c 2.9217E-05
    13027.31c 1.7341E-06
    14028.31c 7.4343E-04
    15031.31c 5.5388E-06
    16032.31c 7.2951E-06
    22048.31c 8.7948E-06
    25055.31c 8.0253E-04
    27059.31c 1.3232E-06
    24050.31c 5.0363E-04
    24052.31c 9.7120E-03
    24053.31c 1.1013E-03
    24054.31c 2.7413E-04
    26054.31c 2.4145E-03
    26056.31c 3.7903E-02
    26057.31c 8.7533E-04
    26058.31c 1.1649E-04
    28058.31c 3.7525E-03
    28060.31c 1.4455E-03
    28061.31c 6.2833E-05
    28062.31c 2.0034E-04
    28064.31c 5.1021E-05
    29063.31c 1.2885E-06
    29065.31c 5.5221E-07
c    42000.66c 8.6159E-06
    42092.31c 1.2924E-06
    42094.31c 8.6159E-07
    42095.31c 1.2924E-06
    42096.31c 1.2924E-06
    42097.31c 8.6159E-07
    42098.31c 2.1540E-06
    42100.31c 8.6159E-07
c
c    Total    36 6.0033E-02
c
c -----
c
c Calandria sodium contents
c
C sodium NACLII element A and B
m41      1001.31c 5.5075E-06
    8016.31c 6.4605E-06
    11023.31c 2.4129E-02
    20040.31c 1.1080E-07
    26056.31c 3.0847E-07
c    total 41 2.41414E-02
c
C sodium NACLIIIS element E
m42      1001.31c 1.1205E-05
    8016.31c 1.0767E-06
    11023.31c 2.4379E-02
    20040.31c 9.5521E-08
c    total 42 2.43914E-02
C sodium NACLIIII element C (was 25)
m43      1001.31c 7.5966E-06
    8016.31c 3.5892E-06
    11023.31c 2.3888E-02
    19039.31c 3.4270E-07
    20040.31c 6.6865E-07

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c total 43 2.3900E-02
C sodium NACLIV Element J
m44      1001.31c  7.5966E-06
          8016.31c  3.5892E-06
          11023.31c 2.4037E-02
          19039.31c 3.4270E-07
          20040.31c 6.6865E-07
c total 44 2.4049E-02
C sodium NACLIV Element H
c m45      1001.31c  7.5966E-06
c          8016.31c  3.5892E-06
c          11023.31c 2.3829E-02
c          19039.31c 3.4270E-07
c          20040.31c 6.6865E-07
c total 45 2.3841E-02
c
c -----
c
C Compositions of Calandria outer walls
c
C Calandria Walls NACLI Element Cell A and B
m51      1001.31c  3.9844E-05
          6000.31c  2.8167E-04
          14028.31c 6.0229E-04
          15031.31c  7.3471E-05
          16032.31c  3.6808E-05
          25055.31c  1.2214E-03
          24050.31c  6.5153E-04
          24052.31c  1.2564E-02
          24053.31c  1.4247E-03
          24054.31c  3.5463E-04
          26054.31c  2.8589E-03
          26056.31c  4.4878E-02
          26057.31c  1.0364E-03
          26058.31c  1.3793E-04
          28058.31c  4.9315E-03
          28060.31c  1.8996E-03
          28061.31c  8.2574E-05
          28062.31c  2.6328E-04
          28064.31c  6.7050E-05
C total 51 7.34056E-02
c
C Calandria walls NACLIIS Element Cell E
c
m52      1001.31c  3.8637E-05
          6000.31c  6.5351E-04
          14028.31c  9.7623E-04
          15031.31c  4.7540E-05
          16032.31c  3.3014E-05
          22048.31c  2.4400E-04
          25055.31c  1.1060E-03
          27059.31c  1.1151E-05
          24050.31c  6.2481E-04
          24052.31c  1.2049E-02
          24053.31c  1.3662E-03
          24054.31c  3.4009E-04
          26054.31c  2.7541E-03
          26056.31c  4.3233E-02
          26057.31c  9.9842E-04
          26058.31c  1.3287E-04
          28058.31c  5.0735E-03
          28060.31c  1.9543E-03
          28061.31c  8.4952E-05
          28062.31c  2.7086E-04
          28064.31c  6.8981E-05
          29063.31c  6.9320E-06
          29065.31c  3.1020E-06
c          42000.66c 3.4248E-06
          42092.31c 5.1372E-07
          42094.31c 3.4248E-07
          42095.31c 5.1372E-07
          42096.31c 5.1372E-07
          42097.31c 3.4248E-07
          42098.31c 8.5620E-07

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

42100.31c 3.4248E-07
C total 52 7.20749E-02
c
c Calandria NACLIII Element Cell C and D (was m28)
c
m53      1001.31c 3.9844E-05
        6000.31c 1.5948E-04
        14028.31c 7.7474E-04
        15031.31c 5.2334E-05
        16032.31c 2.4551E-05
        25055.31c 8.3089E-04
        24050.31c 6.1403E-04
        24052.31c 1.1841E-02
        24053.31c 1.3427E-03
        24054.31c 3.3422E-04
        26054.31c 2.9672E-03
        26056.31c 4.6578E-02
        26057.31c 1.0757E-03
        26058.31c 1.4315E-04
        28058.31c 5.2186E-03
        28060.31c 2.0102E-03
        28061.31c 8.7382E-05
        28062.31c 2.7861E-04
        28064.31c 7.0954E-05
c      42000.66c 2.4862E-05
        42092.31c 3.7023E-06
        42094.31c 2.4862E-06
        42095.31c 3.7023E-06
        42096.31c 3.7023E-06
        42097.31c 2.4862E-06
        42098.31c 6.1705E-06
        42100.31c 2.4862E-06
C total 53 7.44684E-02
c
C Calandria NACLIV Element 3J and 3L
m54      1001.31c 3.7430E-05
        6000.31c 3.5158E-04
        14028.31c 8.2197E-04
        15031.31c 6.2274E-05
        16032.31c 1.6431E-05
        25055.31c 1.0026E-03
        24050.31c 5.8931E-04
        24052.31c 1.1364E-02
        24053.31c 1.2886E-03
        24054.31c 3.2077E-04
        26054.31c 2.7560E-03
        26056.31c 4.3263E-02
        26057.31c 9.9912E-04
        26058.31c 1.3296E-04
        28058.31c 4.3943E-03
        28060.31c 1.6927E-03
        28061.31c 7.3579E-05
        28062.31c 2.3460E-04
        28064.31c 5.9746E-05
c      42000.66c 8.8791E-06
        42092.31c 1.3319E-06
        42094.31c 8.8791E-07
        42095.31c 1.3319E-06
        42096.31c 1.3319E-06
        42097.31c 8.8791E-07
        42098.31c 2.2198E-06
        42100.31c 8.8791E-07
C Total 54 6.94698E-02
c
C Calandria NACLIV Element 3H
c m55      1001.31c 3.8637E-05
c      6000.31c 2.6343E-04
c      14028.31c 6.4389E-04
c      15031.31c 6.8560E-05
c      16032.31c 1.7190E-05
c      25055.31c 9.6934E-04
c      24050.31c 6.0091E-04
c      24052.31c 1.1588E-02
c      24053.31c 1.3140E-03

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```

c      24054.31c  3.2708E-04
c      26054.31c  2.8877E-03
c      26056.31c  4.5330E-02
c      26057.31c  1.0469E-03
c      26058.31c  1.3932E-04
c      28058.31c  4.9377E-03
c      28060.31c  1.9020E-03
c      28061.31c  8.2679E-05
c      28062.31c  2.6362E-04
c      28064.31c  6.7135E-05
c      42092.31c  1.3319E-06
c      42094.31c  8.8791E-07
c      42095.31c  1.3319E-06
c      42096.31c  1.3319E-06
c      42097.31c  8.8791E-07
c      42098.31c  2.2198E-06
c      42100.31c  8.8791E-07
C Total 55 7.2497E-02
c
C Calandria VCLVI
c m56      1001.31c  3.8637E-05
c      6000.31c  2.4762E-04
c      14028.31c  9.5110E-04
c      15031.31c  4.5654E-05
c      16032.31c  2.3793E-05
c      25055.31c  8.6191E-04
c      24050.31c  6.0122E-04
c      24052.31c  1.1594E-02
c      24053.31c  1.3147E-03
c      24054.31c  3.2725E-04
c      26054.31c  2.8292E-03
c      26056.31c  4.4413E-02
c      26057.31c  1.0257E-03
c      26058.31c  1.3650E-04
c      28058.31c  4.6653E-03
c      28060.31c  1.7971E-03
c      28061.31c  7.8117E-05
c      28062.31c  2.4907E-04
c      28064.31c  6.3431E-05
c      42092.31c  3.7023E-06
c      42094.31c  2.4862E-06
c      42095.31c  3.7023E-06
c      42096.31c  3.7023E-06
c      42097.31c  2.4862E-06
c      42098.31c  6.1705E-06
c      42100.31c  2.4862E-06
C Total 56 7.12882E-02
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 100 1500
ksrc 0.6125 0.6125 77.0 0.6125 -0.6125 87.9
      -0.6125 -0.6125 107.0
      0.6125 0.6125 117.9 0.6125 -0.6125 137.0
      0.6125 0.6125 147.9
      -0.6125 0.6125 77.0 -0.6125 -0.6125 87.9
      0.6125 0.6125 107.0
      -0.6125 0.6125 117.9 -0.6125 -0.6125 137.0
      -0.6125 0.6125 147.9
      11.4633 -0.6125 77.0 11.4633 -0.6125 87.9
      11.4633 -0.6125 107.0
      11.4633 -0.6125 117.9 11.4633 -0.6125 137.0
      11.4633 -0.6125 147.9
      -11.4633 -0.6125 77.0 -11.4633 -0.6125 87.9
      -11.4633 -0.6125 107.0
      -11.4633 -0.6125 117.9 -11.4633 -0.6125 137.0
      -11.4633 -0.6125 147.9
      -0.6125 11.4633 77.0 -0.6125 11.4633 87.9
      -0.6125 11.4633 107.0
      -0.6125 11.4633 117.9 -0.6125 11.4633 137.0
      -0.6125 11.4633 147.9
      -0.6125 -11.4633 77.0 -0.6125 -11.4633 87.9
      -0.6125 -11.4633 107.0
      -0.6125 -11.4633 117.9 -0.6125 -11.4633 137.0

```

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```

-0.6125 -11.4633 147.9
11.4633 11.4633 77.0 11.4633 11.4633 87.9
11.4633 11.4633 107.0
11.4633 11.4633 117.9 11.4633 11.4633 137.0
11.4633 11.4633 147.9
-11.4633 11.4633 77.0 -11.4633 11.4633 87.9
-11.4633 11.4633 107.0
-11.4633 11.4633 117.9 -11.4633 11.4633 137.0
-11.4633 11.4633 147.9
11.4633 -11.4633 77.0 11.4633 -11.4633 87.9
11.4633 -11.4633 107.0
11.4633 -11.4633 117.9 11.4633 -11.4633 137.0
11.4633 -11.4633 147.9
-11.4633 -11.4633 77.0 -11.4633 -11.4633 87.9
-11.4633 -11.4633 107.0
-11.4633 -11.4633 117.9 -11.4633 -11.4633 137.0
-11.4633 -11.4633 147.9
25.9475 0.6125 77.0 25.9475 0.6125 87.9
-25.9475 0.6125 107.0
25.9475 0.6125 117.9 25.9475 0.6125 137.0
25.9475 0.6125 147.9
-25.9475 0.6125 77.0 -25.9475 0.6125 87.9
-25.9475 0.6125 107.0
-25.9475 0.6125 117.9 -25.9475 0.6125 137.0
-25.9475 0.6125 147.9
0.6125 25.9475 77.0 0.6125 25.9475 87.9
0.6125 25.9475 107.0
0.6125 25.9475 117.9 0.6125 25.9475 137.0
0.6125 25.9475 147.9
0.6125 -25.9475 77.0 0.6125 -25.9475 87.9
-25.9475 0.6125 107.0
0.6125 -25.9475 117.9 0.6125 -25.9475 137.0
0.6125 -25.9475 147.9
25.9475 25.9475 77.0 25.9475 25.9475 87.9
25.9475 25.9475 107.0
25.9475 25.9475 117.9 25.9475 25.9475 137.0
25.9475 25.9475 147.9
-25.9475 25.9475 77.0 -25.9475 25.9475 87.9
-25.9475 25.9475 107.0
-25.9475 25.9475 117.9 -25.9475 25.9475 137.0
-25.9475 25.9475 147.9
25.9475 -25.9475 77.0 25.9475 -25.9475 87.9
25.9475 -25.9475 107.0
25.9475 -25.9475 117.9 25.9475 -25.9475 137.0
25.9475 -25.9475 147.9
-25.9475 -25.9475 77.0 -25.9475 -25.9475 87.9
-25.9475 -25.9475 107.0
36.9875 0.6125 77.0 36.9875 0.6125 87.9
36.9875 0.6125 107.0
36.9875 0.6125 117.9 36.9875 0.6125 137.0
36.9875 0.6125 147.9
-36.9875 0.6125 77.0 -36.9875 0.6125 87.9
-36.9875 0.6125 107.0
-36.9875 0.6125 117.9 -36.9875 0.6125 137.0
-36.9875 0.6125 147.9
0.6125 36.9875 77.0 0.6125 36.9875 87.9
0.6125 36.9875 107.0
0.6125 36.9875 117.9 0.6125 36.9875 137.0
0.6125 36.9875 147.9
0.6125 -36.9875 77.0 0.6125 -36.9875 87.9
-36.9875 0.6125 107.0
0.6125 -36.9875 117.9 0.6125 -36.9875 137.0
0.6125 -36.9875 147.9

```

print

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

A4.3 MCNP-JEFF-3.1 Zebra24 Model A

```
Zebra Assembly 24 superlattice model. Void gaps between elements
c JEFF-3.1
c
c ----- Elements of the assembly -----
c
c --- Core Elements with X dummy plates
c Lower padding
111 16 3.279692E-02 -8 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower Reflector
112 14 8.4932E-02 8 -9 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
113 15 4.8317E-02 9 -41 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
114 9 4.7925E-02 41 -42 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
115 8 4.7208E-02 42 -10 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na dummy region. The X ring
121 0 10 -504 -109 u=1 imp:n=1
c Steel region
122 6 8.84628E-02 10 -504 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
123 0 10 -504 21 -22 23 -24 110 u=1 imp:n=1
c
c UO2 core
127 3 6.9083E-02 505 -506 105 -106 107 -108 u=1 imp:n=1 TMP=2.5301E-08
c UO2 plate can
128 4 7.2463E-02 504 -507 21 -22 23 -24 &
(-105:106:-107:108:-505:506) u=1 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
131 0 507 -510 -109 u=1 imp:n=1
c Steel region
132 6 8.84628E-02 507 -510 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
133 0 507 -510 21 -22 23 -24 110 u=1 imp:n=1
c
c Pu Plate core
135 1 3.9991E-02 101 -102 103 -104 511 -512 u=1 imp:n=1 TMP=2.5301E-08
c Pu canning
136 2 6.6997E-02 510 -513 21 -22 23 -24 &
(-101:102:-103:104:-511:512) u=1 imp:n=1 TMP=2.5301E-08
c
c UO2 core
139 3 6.9083E-02 514 -515 105 -106 107 -108 u=1 imp:n=1 TMP=2.5301E-08
c UO2 plate can
140 4 7.2463E-02 513 -516 21 -22 23 -24 &
(-105:106:-107:108:-514:515) u=1 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
143 0 516 -43 -109 u=1 imp:n=1
c Steel region
144 6 8.84628E-02 516 -43 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
145 0 516 -43 21 -22 23 -24 110 u=1 imp:n=1
c
c Insert the 22 central region core cells
c
151 0 43 -44 21 -22 23 -24 fill=3 (0 0 71.21678) u=1 imp:n=1
c
152 0 44 -45 21 -22 23 -24 fill=4 (0 0 74.97178) u=1 imp:n=1
c
c
153 0 45 -46 21 -22 23 -24 fill=3 (0 0 78.72678) u=1 imp:n=1
c
154 0 46 -47 21 -22 23 -24 fill=4 (0 0 82.48178) u=1 imp:n=1
c
```

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```

c
155  0  47 -48 21 -22 23 -24 fill=3 (0 0 86.23678) u=1 imp:n=1
c
156  0  48 -49 21 -22 23 -24 fill=4 (0 0 89.99178) u=1 imp:n=1
c
c
157  0  49 -50 21 -22 23 -24 fill=3 (0 0 93.74678) u=1 imp:n=1
c
158  0  50 -51 21 -22 23 -24 fill=4 (0 0 97.50178) u=1 imp:n=1
c
c
159  0  51 -52 21 -22 23 -24 fill=3 (0 0 101.25678) u=1 imp:n=1
c
160  0  52 -53 21 -22 23 -24 fill=4 (0 0 105.01178) u=1 imp:n=1
c
c
161  0  53 -54 21 -22 23 -24 fill=3 (0 0 108.76678) u=1 imp:n=1
c
162  0  54 -55 21 -22 23 -24 fill=4 (0 0 112.52178) u=1 imp:n=1
c
c
163  0  55 -56 21 -22 23 -24 fill=3 (0 0 116.27678) u=1 imp:n=1
c
164  0  56 -57 21 -22 23 -24 fill=4 (0 0 120.03178) u=1 imp:n=1
c
c
165  0  57 -58 21 -22 23 -24 fill=3 (0 0 123.78678) u=1 imp:n=1
c
166  0  58 -59 21 -22 23 -24 fill=4 (0 0 127.54178) u=1 imp:n=1
c
c
167  0  59 -60 21 -22 23 -24 fill=3 (0 0 131.29678) u=1 imp:n=1
c
168  0  60 -61 21 -22 23 -24 fill=4 (0 0 135.05178) u=1 imp:n=1
c
c
169  0  61 -62 21 -22 23 -24 fill=3 (0 0 138.80678) u=1 imp:n=1
c
170  0  62 -63 21 -22 23 -24 fill=4 (0 0 142.56178) u=1 imp:n=1
c
c
171  0  63 -64 21 -22 23 -24 fill=3 (0 0 146.31678) u=1 imp:n=1
c
172  0  64 -65 21 -22 23 -24 fill=4 (0 0 150.07178) u=1 imp:n=1
c
c
c The top core cell, Cell 2
c
c Na dummy region. The X ring
175  0  65 -404 -109 u=1 imp:n=1
c Steel region
176  6 8.84628E-02 65 -404 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
177  0  65 -404 21 -22 23 -24 110 u=1 imp:n=1
c
c UO2 core
178  3 6.9083E-02 405 -406 105 -106 107 -108 u=1 imp:n=1 TMP=2.5301E-08
c UO2 plate can
179  4 7.2463E-02 404 -407 21 -22 23 -24 &
    (-105:106:-107:108:-405:406) u=1 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
180  1 3.9991E-02 101 -102 103 -104 408 -409 u=1 imp:n=1 &
    TMP=2.5301E-08
c Pu canning
181  2 6.6997E-02 407 -410 21 -22 23 -24 &
    (-101:102:-103:104:-408:409) u=1 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
182  0  410 -413 -109 u=1 imp:n=1
c Steel region
183  6 8.84628E-02 410 -413 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
184  0  410 -413 21 -22 23 -24 110 u=1 imp:n=1

```

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```

c
c UO2 core
185 3 6.9083E-02 414 -415 105 -106 107 -108 u=1 imp:n=1 TMP=2.5301E-08
c UO2 plate can
186 4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-105:106:-107:108:-414:415) u=1 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
187 0 416 -11 -109 u=1 imp:n=1
C Steel region
188 6 8.84628E-02 416 -11 109 -110 u=1 imp:n=1 TMP=2.5301E-08
c
189 0 416 -11 21 -22 23 -24 110 u=1 imp:n=1
c
c
c Upper Axial blanket.
c
191 8 4.7208E-02 11 -67 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
192 9 4.7925E-02 67 -68 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
193 15 4.8317E-02 68 -12 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
194 14 8.4932E-02 12 -13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Upper padding
195 16 3.279692E-02 13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
196 0 32 -33 34 -35 (-21:22:-23:24) u=1 imp:n=1
c Wrapper
197 17 7.81552E-02 36 -37 38 -39 (-32:33:-34:35) u=1 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
198 0 1 -2 3 -4 (-36:37:-38:39) u=1 imp:n=1
c
c -----
c
c --- Core Elements with Y dummy plates
c Lower padding
211 16 3.279692E-02 -8 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Lower Reflector
212 14 8.4932E-02 8 -9 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
213 15 4.8317E-02 9 -41 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
214 9 4.7925E-02 41 -42 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
215 8 4.7208E-02 42 -10 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na dummy region. The Y ring
221 0 10 -504 -109 u=2 imp:n=1
C Steel region
222 10 8.84614E-02 10 -504 109 -110 u=2 imp:n=1 TMP=2.5301E-08
c
223 0 10 -504 21 -22 23 -24 110 u=2 imp:n=1
c
c UO2 core
227 3 6.9083E-02 505 -506 105 -106 107 -108 u=2 imp:n=1 TMP=2.5301E-08
c UO2 plate can
228 4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-105:106:-107:108:-505:506) u=2 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
231 0 507 -510 -109 u=2 imp:n=1
C Steel region
232 10 8.84614E-02 507 -510 109 -110 u=2 imp:n=1 TMP=2.5301E-08
c
233 0 507 -510 21 -22 23 -24 110 u=2 imp:n=1
c
C Pu Plate core
235 1 3.9991E-02 101 -102 103 -104 511 -512 u=2 imp:n=1 TMP=2.5301E-08

```


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```

C Pu canning
236  2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-101:102:-103:104:-511:512) u=2  imp:n=1 TMP=2.5301E-08
c
c UO2 core
239  3 6.9083E-02 514 -515 105 -106 107 -108 u=2  imp:n=1 TMP=2.5301E-08
c UO2 plate can
240  4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-105:106:-107:108:-514:515) u=2  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
243  0 516 -43 -109 u=2  imp:n=1
C Steel region
244  10 8.84614E-02 516 -43 109 -110 u=2  imp:n=1 TMP=2.5301E-08
c
245  0 516 -43 21 -22 23 -24 110 u=2  imp:n=1
c
c Insert the 22 central region core cells
c
251  0  43 -44 21 -22 23 -24 fill=13 (0 0 71.21678) u=2  imp:n=1
c
252  0  44 -45 21 -22 23 -24 fill=14 (0 0 74.97178) u=2  imp:n=1
c
c
253  0  45 -46 21 -22 23 -24 fill=13 (0 0 78.72678) u=2  imp:n=1
c
254  0  46 -47 21 -22 23 -24 fill=14 (0 0 82.48178) u=2  imp:n=1
c
c
255  0  47 -48 21 -22 23 -24 fill=13 (0 0 86.23678) u=2  imp:n=1
c
256  0  48 -49 21 -22 23 -24 fill=14 (0 0 89.99178) u=2  imp:n=1
c
c
257  0  49 -50 21 -22 23 -24 fill=13 (0 0 93.74678) u=2  imp:n=1
c
258  0  50 -51 21 -22 23 -24 fill=14 (0 0 97.50178) u=2  imp:n=1
c
c
259  0  51 -52 21 -22 23 -24 fill=13 (0 0 101.25678) u=2  imp:n=1
c
260  0  52 -53 21 -22 23 -24 fill=14 (0 0 105.01178) u=2  imp:n=1
c
c
261  0  53 -54 21 -22 23 -24 fill=13 (0 0 108.76678) u=2  imp:n=1
c
262  0  54 -55 21 -22 23 -24 fill=14 (0 0 112.52178) u=2  imp:n=1
c
c
263  0  55 -56 21 -22 23 -24 fill=13 (0 0 116.27678) u=2  imp:n=1
c
264  0  56 -57 21 -22 23 -24 fill=14 (0 0 120.03178) u=2  imp:n=1
c
c
265  0  57 -58 21 -22 23 -24 fill=13 (0 0 123.78678) u=2  imp:n=1
c
266  0  58 -59 21 -22 23 -24 fill=14 (0 0 127.54178) u=2  imp:n=1
c
c
267  0  59 -60 21 -22 23 -24 fill=13 (0 0 131.29678) u=2  imp:n=1
c
268  0  60 -61 21 -22 23 -24 fill=14 (0 0 135.05178) u=2  imp:n=1
c
c
269  0  61 -62 21 -22 23 -24 fill=13 (0 0 138.80678) u=2  imp:n=1
c
270  0  62 -63 21 -22 23 -24 fill=14 (0 0 142.56178) u=2  imp:n=1
c
c
271  0  63 -64 21 -22 23 -24 fill=13 (0 0 146.31678) u=2  imp:n=1
c
272  0  64 -65 21 -22 23 -24 fill=14 (0 0 150.07178) u=2  imp:n=1
c
c

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c The top core cell, Cell 2
c
c Na dummy region. The Y ring
275 0 65 -404 -109 u=2 imp:n=1
c Steel region
276 10 8.84614E-02 65 -404 109 -110 u=2 imp:n=1 TMP=2.5301E-08
c
277 0 65 -404 21 -22 23 -24 110 u=2 imp:n=1
c
c UO2 core
278 3 6.9083E-02 405 -406 105 -106 107 -108 u=2 imp:n=1 TMP=2.5301E-08
c UO2 plate can
279 4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-105:106:-107:108:-405:406) u=2 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
280 1 3.9991E-02 101 -102 103 -104 408 -409 u=2 imp:n=1 &
      TMP=2.5301E-08
c Pu canning
281 2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-101:102:-103:104:-408:409) u=2 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
282 0 410 -413 -109 u=2 imp:n=1
c Steel region
283 10 8.84614E-02 410 -413 109 -110 u=2 imp:n=1 TMP=2.5301E-08
c
284 0 410 -413 21 -22 23 -24 110 u=2 imp:n=1
c
c UO2 core
285 3 6.9083E-02 414 -415 105 -106 107 -108 u=2 imp:n=1 TMP=2.5301E-08
c UO2 plate can
286 4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-105:106:-107:108:-414:415) u=2 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
287 0 416 -11 -109 u=2 imp:n=1
c Steel region
288 10 8.84614E-02 416 -11 109 -110 u=2 imp:n=1 TMP=2.5301E-08
c
289 0 416 -11 21 -22 23 -24 110 u=2 imp:n=1
c
c
c Upper Axial blanket.
c
291 8 4.7208E-02 11 -67 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
292 9 4.7925E-02 67 -68 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
293 15 4.8317E-02 68 -12 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
294 14 8.4932E-02 12 -13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper padding
295 16 3.279692E-02 13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
296 0 32 -33 34 -35 (-21:22:-23:24) u=2 imp:n=1
c Wrapper
297 17 7.81552E-02 36 -37 38 -39 (-32:33:-34:35) u=2 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
298 0 1 -2 3 -4 (-36:37:-38:39) u=2 imp:n=1
c
c -----
c
c --- Core Elements with Honeycomb dummy plates
c Lower padding
311 16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower Reflector
312 14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
313 15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
314 9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket

```

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```

315      8 4.7208E-02 42 -10 21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c
c Na dummy region.
322    11 1.216928E-02 10 -504 21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c
c UO2 core
327      3 6.9083E-02 505 -506 105 -106 107 -108 u=5  imp:n=1 TMP=2.5301E-08
c UO2 plate can
328      4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-105:106:-107:108:-505:506) u=5  imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
332    11 1.216928E-02 507 -510 21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
335      1 3.9991E-02 101 -102 103 -104 511 -512 u=5  imp:n=1 TMP=2.5301E-08
c Pu canning
336      2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-101:102:-103:104:-511:512) u=5  imp:n=1 TMP=2.5301E-08
c
c UO2 core
339      3 6.9083E-02 514 -515 105 -106 107 -108 u=5  imp:n=1 TMP=2.5301E-08
c UO2 plate can
340      4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-105:106:-107:108:-514:515) u=5  imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
344    11 1.216928E-02 516 -43 21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c
c
c Insert the 22 central region core cells
c
351      0 43 -44 21 -22 23 -24 fill=23 (0 0 71.21678) u=5  imp:n=1
c
352      0 44 -45 21 -22 23 -24 fill=24 (0 0 74.97178) u=5  imp:n=1
c
c
353      0 45 -46 21 -22 23 -24 fill=23 (0 0 78.72678) u=5  imp:n=1
c
354      0 46 -47 21 -22 23 -24 fill=24 (0 0 82.48178) u=5  imp:n=1
c
c
355      0 47 -48 21 -22 23 -24 fill=23 (0 0 86.23678) u=5  imp:n=1
c
356      0 48 -49 21 -22 23 -24 fill=24 (0 0 89.99178) u=5  imp:n=1
c
c
357      0 49 -50 21 -22 23 -24 fill=23 (0 0 93.74678) u=5  imp:n=1
c
358      0 50 -51 21 -22 23 -24 fill=24 (0 0 97.50178) u=5  imp:n=1
c
c
359      0 51 -52 21 -22 23 -24 fill=23 (0 0 101.25678) u=5  imp:n=1
c
360      0 52 -53 21 -22 23 -24 fill=24 (0 0 105.01178) u=5  imp:n=1
c
c
361      0 53 -54 21 -22 23 -24 fill=23 (0 0 108.76678) u=5  imp:n=1
c
362      0 54 -55 21 -22 23 -24 fill=24 (0 0 112.52178) u=5  imp:n=1
c
c
363      0 55 -56 21 -22 23 -24 fill=23 (0 0 116.27678) u=5  imp:n=1
c
364      0 56 -57 21 -22 23 -24 fill=24 (0 0 120.03178) u=5  imp:n=1
c
c
365      0 57 -58 21 -22 23 -24 fill=23 (0 0 123.78678) u=5  imp:n=1
c

```

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```

366    0  58 -59 21 -22 23 -24 fill=24 (0 0 127.54178) u=5  imp:n=1
c
c
367    0  59 -60 21 -22 23 -24 fill=23 (0 0 131.29678) u=5  imp:n=1
c
368    0  60 -61 21 -22 23 -24 fill=24 (0 0 135.05178) u=5  imp:n=1
c
c
369    0  61 -62 21 -22 23 -24 fill=23 (0 0 138.80678) u=5  imp:n=1
c
370    0  62 -63 21 -22 23 -24 fill=24 (0 0 142.56178) u=5  imp:n=1
c
c
371    0  63 -64 21 -22 23 -24 fill=23 (0 0 146.31678) u=5  imp:n=1
c
372    0  64 -65 21 -22 23 -24 fill=24 (0 0 150.07178) u=5  imp:n=1
c
c
c The top core cell, Cell 2
c
c Na dummy region.
376   11 1.216928E-02 65 -404 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
378    3 6.9083E-02 405 -406 105 -106 107 -108 u=5  imp:n=1 TMP=2.5301E-08
c UO2 plate can
379    4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-105:106:-107:108:-405:406) u=5  imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
380    1 3.9991E-02 101 -102 103 -104 408 -409 u=5  imp:n=1 &
      TMP=2.5301E-08
c Pu canning
381    2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-101:102:-103:104:-408:409) u=5  imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
383   11 1.216928E-02 410 -413 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c
c UO2 core
385    3 6.9083E-02 414 -415 105 -106 107 -108 u=5  imp:n=1 TMP=2.5301E-08
c UO2 plate can
386    4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-105:106:-107:108:-414:415) u=5  imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
388   11 1.216928E-02 416 -11 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c
c
c Upper Axial blanket.
c
391    8 4.7208E-02 11 -67  21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
392    9 4.7925E-02 67 -68  21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
393   15 4.8317E-02 68 -12  21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
394   14 8.4932E-02 12 -13  21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c Upper padding
395   16 3.279692E-02 13  21 -22 23 -24 u=5  imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
396    0 32 -33 34 -35 (-21:22:-23:24) u=5  imp:n=1
c Wrapper
397   17 7.81552E-02 36 -37 38 -39 (-32:33:-34:35) u=5  imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
398    0  1 -2 3 -4 (-36:37:-38:39) u=5  imp:n=1
c
c -----
c
c --- Radial Blanket Elements
c
c Lower padding
1211   like 111 but u=6 imp:n=1 TMP=2.5301E-08

```

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```

c Lower Reflector
1212   like 112 but u=6 imp:n=1 TMP=2.5301E-08
c Radial blanket
1214   15 4.8317E-02 9 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper reflector
1216   like 194 but u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1217   like 195 but u=6 imp:n=1 TMP=2.5301E-08
c Wrapper region
1257   like 196 but u=6 imp:n=1
1258   like 197 but u=6 imp:n=1
1259   like 198 but u=6 imp:n=1
c
c
c --- Radial shield
c
1326   12 8.32720E-02 28 -29 30 -31 u=7 imp:n=1 TMP=2.5301E-08
c
1327   13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=7 imp:n=1 &
      TMP=2.5301E-08
c
c Low density surround material
c
1400   13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly
c
1419   0   89 -90 91 -92 u=10 lat=1
      fill=-3:3 -3:3 0:0
      201 135 134 133 132 131 201
      138 115 118 109 119 114 137
      168 111 108 129 107 119 167
      158 106 141 101 126 105 157
      148 117 104 142 103 111 147
      128 113 117 102 116 112 127
      201 125 124 123 122 121 201
      imp:n=1
c
c --- Fuel Region
c
1429   0 7 -16 -17 fill=10 imp:n=1
c --- Universe
1430   0 (-7:16:17) imp:n=0
c
c ----- CELL CARDS -----
c
c The First Regular cell. Cell 1 with the X ring
c
c Na dummy region. The X ring
2161   0 801 -804 -109 u=3 imp:n=1
c Steel region
2162   6 8.84628E-02 801 -804 109 -110 u=3 imp:n=1 TMP=2.5301E-08
c
2163   0 801 -804 21 -22 23 -24 110 u=3 imp:n=1
c
c UO2 plate
c UO2 core
2167   3 6.9083E-02 805 -806 105 -106 107 -108 u=3 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2168   4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=3 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170   7 3.3152E-02 807 -708 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c
c Pu plate
c Plate core
2172   1 3.9991E-02 101 -102 103 -104 709 -710 u=3 imp:n=1 TMP=2.5301E-08
c Pu canning
2173   2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-101:102:-103:104:-709:710) u=3 imp:n=1 TMP=2.5301E-08
c
c
c Na dummy region. The X ring

```

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```

2181    0 711 -814 -109 u=3 imp:n=1
C Steel region
2182    6 8.84628E-02 711 -814 109 -110 u=3 imp:n=1 TMP=2.5301E-08
c
2183    0 711 -814 21 -22 23 -24 110 u=3 imp:n=1
c
c UO2 plate
c UO2 core
2187    3 6.9083E-02 815 -816 105 -106 107 -108 u=3 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188    4 7.2463E-02 814 -817 21 -22 23 -24 &
        (-105:106:-107:108:-815:816) u=3 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
2191    0 817 -820 -109 u=3 imp:n=1
C Steel region
2192    6 8.84628E-02 817 -820 109 -110 u=3 imp:n=1 TMP=2.5301E-08
c
2193    0 817 -820 21 -22 23 -24 110 u=3 imp:n=1
c
c End of Cell 1 beginning of Cell 2
c Na dummy region. The X ring
2201    0 801 -804 -109 u=4 imp:n=1
C Steel region
2202    6 8.84628E-02 801 -804 109 -110 u=4 imp:n=1 TMP=2.5301E-08
c
2203    0 801 -804 21 -22 23 -24 110 u=4 imp:n=1
c
c UO2 plate
c UO2 core
2207    3 6.9083E-02 805 -806 105 -106 107 -108 u=4 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2208    4 7.2463E-02 804 -807 21 -22 23 -24 &
        (-105:106:-107:108:-805:806) u=4 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
2210    0 807 -810 -109 u=4 imp:n=1
C Steel region
2211    6 8.84628E-02 807 -810 109 -110 u=4 imp:n=1 TMP=2.5301E-08
c
2212    0 807 -810 21 -22 23 -24 110 u=4 imp:n=1
c
c Pu plate
C Plate core
2214    1 3.9991E-02 101 -102 103 -104 811 -812 u=4 imp:n=1 TMP=2.5301E-08
C Pu canning
2215    2 6.6997E-02 810 -813 21 -22 23 -24 &
        (-101:102:-103:104:-811:812) u=4 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217    7 3.3152E-02 813 -814 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219    3 6.9083E-02 815 -816 105 -106 107 -108 u=4 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220    4 7.2463E-02 814 -817 21 -22 23 -24 &
        (-105:106:-107:108:-815:816) u=4 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The X ring
2222    0 817 -820 -109 u=4 imp:n=1
C Steel region
2223    6 8.84628E-02 817 -820 109 -110 u=4 imp:n=1 TMP=2.5301E-08
c
2224    0 817 -820 21 -22 23 -24 110 u=4 imp:n=1
c
c
c ----- CELL CARDS with the Y ring-----
c
c The First Regular cell. Cell 1 with the Y ring
c
c Na dummy region. The Y ring
2361    0 801 -804 -109 u=13 imp:n=1
C Steel region

```

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```

2362  10 8.84614E-02 801 -804 109 -110 u=13  imp:n=1 TMP=2.5301E-08
c
2363   0 801 -804 21 -22 23 -24 110 u=13  imp:n=1
c
c UO2 plate
c UO2 core
2367   3 6.9083E-02 805 -806 105 -106 107 -108 u=13  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2368   4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=13  imp:n=1 TMP=2.5301E-08
c
c Steel plate
2370   7 3.3152E-02 807 -708 21 -22 23 -24 u=13  imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2372   1 3.9991E-02 101 -102 103 -104 709 -710 u=13  imp:n=1 TMP=2.5301E-08
C Pu canning
2373   2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-101:102:-103:104:-709:710) u=13  imp:n=1 TMP=2.5301E-08
c
c
c Na dummy region. The Y ring
2381   0 711 -814 -109 u=13  imp:n=1
C Steel region
2382  10 8.84614E-02 711 -814 109 -110 u=13  imp:n=1 TMP=2.5301E-08
c
2383   0 711 -814 21 -22 23 -24 110 u=13  imp:n=1
c
c UO2 plate
c UO2 core
2387   3 6.9083E-02 815 -816 105 -106 107 -108 u=13  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2388   4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=13  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
2391   0 817 -820 -109 u=13  imp:n=1
C Steel region
2392  10 8.84614E-02 817 -820 109 -110 u=13  imp:n=1 TMP=2.5301E-08
c
2393   0 817 -820 21 -22 23 -24 110 u=13 imp:n=1
c
c End of Cell 1 beginning of Cell 2
c Na dummy region. The Y ring
2401   0 801 -804 -109 u=14  imp:n=1
C Steel region
2402  10 8.84614E-02 801 -804 109 -110 u=14  imp:n=1 TMP=2.5301E-08
c
2403   0 801 -804 21 -22 23 -24 110 u=14  imp:n=1
c
c UO2 plate
c UO2 core
2407   3 6.9083E-02 805 -806 105 -106 107 -108 u=14  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2408   4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=14  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
2410   0 807 -810 -109 u=14  imp:n=1
C Steel region
2411  10 8.84614E-02 807 -810 109 -110 u=14  imp:n=1 TMP=2.5301E-08
c
2412   0 807 -810 21 -22 23 -24 110 u=14  imp:n=1
c
c Pu plate
C Plate core
2414   1 3.9991E-02 101 -102 103 -104 811 -812 u=14  imp:n=1 TMP=2.5301E-08
C Pu canning
2415   2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-101:102:-103:104:-811:812) u=14  imp:n=1 TMP=2.5301E-08
c
c Steel plate
2417   7 3.3152E-02 813 -814 21 -22 23 -24 u=14  imp:n=1 TMP=2.5301E-08

```

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```

c
c UO2 plate
c UO2 core
2419 3 6.9083E-02 815 -816 105 -106 107 -108 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2420 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=14 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
2422 0 817 -820 -109 u=14 imp:n=1
C Steel region
2423 10 8.84614E-02 817 -820 109 -110 u=14 imp:n=1 TMP=2.5301E-08
c
2424 0 817 -820 21 -22 23 -24 110 u=14 imp:n=1
c
c
c ----- REPEAT CELL CARDS With THE HONEYCOMB DUMMY-----
c
c The First Regular cell. Cell 1 with the Honeycomb dummy
c
c Na dummy region.
2562 11 1.216928E-02 801 -804 21 -22 23 -24 u=23 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2567 3 6.9083E-02 805 -806 105 -106 107 -108 u=23 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2568 4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=23 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2570 7 3.3152E-02 807 -708 21 -22 23 -24 u=23 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2572 1 3.9991E-02 101 -102 103 -104 709 -710 u=23 imp:n=1 TMP=2.5301E-08
C Pu canning
2573 2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-101:102:-103:104:-709:710) u=23 imp:n=1 TMP=2.5301E-08
c
c
c Na dummy region.
2582 11 1.216928E-02 711 -814 21 -22 23 -24 u=23 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2587 3 6.9083E-02 815 -816 105 -106 107 -108 u=23 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2588 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=23 imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
2592 11 1.216928E-02 817 -820 21 -22 23 -24 u=23 imp:n=1 TMP=2.5301E-08
c
c End of Cell 1 beginning of Cell 2
c Na dummy region.
2602 11 1.216928E-02 801 -804 21 -22 23 -24 u=24 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2607 3 6.9083E-02 805 -806 105 -106 107 -108 u=24 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2608 4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-105:106:-107:108:-805:806) u=24 imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
2611 11 1.216928E-02 807 -810 21 -22 23 -24 u=24 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2614 1 3.9991E-02 101 -102 103 -104 811 -812 u=24 imp:n=1 TMP=2.5301E-08
C Pu canning
2615 2 6.6997E-02 810 -813 21 -22 23 -24 &

```


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```

(-101:102:-103:104:-811:812) u=24 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2617 7 3.3152E-02 813 -814 21 -22 23 -24 u=24 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2619 3 6.9083E-02 815 -816 105 -106 107 -108 u=24 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2620 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-105:106:-107:108:-815:816) u=24 imp:n=1 TMP=2.5301E-08
c
c Na dummy region.
2623 11 1.216928E-02 817 -820 21 -22 23 -24 u=24 imp:n=1 TMP=2.5301E-08
c
c -----
c -----
c
c
c
c Form arrays of 5x5 elements
c
c
c Central array of 5x5 core elements
c
3001 0 85 -81 87 -83 fill=1 (-10.7442 -10.7442 0) u=101 imp:n=1
c
3002 0 81 -1 87 -83 fill=1 (-5.3721 -10.7442 0) u=101 imp:n=1
c
3003 0 1 -2 87 -83 fill=1 (0 -10.7442 0) u=101 imp:n=1
c
3004 0 2 -82 87 -83 fill=1 (5.3721 -10.7442 0) u=101 imp:n=1
c
3005 0 82 -86 87 -83 fill=1 (10.7442 -10.7442 0) u=101 imp:n=1
c
c
3006 0 85 -81 83 -3 fill=1 (-10.7442 -5.3721 0) u=101 imp:n=1
c
3007 0 81 -1 83 -3 fill=1 (-5.3721 -5.3721 0) u=101 imp:n=1
c
3008 0 1 -2 83 -3 fill=1 (0 -5.3721 0) u=101 imp:n=1
c
3009 0 2 -82 83 -3 fill=1 (5.3721 -5.3721 0) u=101 imp:n=1
c
3010 0 82 -86 83 -3 fill=1 (10.7442 -5.3721 0) u=101 imp:n=1
c
c
3011 0 85 -81 3 -4 fill=1 (-10.7442 0 0) u=101 imp:n=1
c
3012 0 81 -1 3 -4 fill=1 (-5.3721 0 0) u=101 imp:n=1
c
3013 0 1 -2 3 -4 fill=1 (0 0 0) u=101 imp:n=1
c
3014 0 2 -82 3 -4 fill=1 (5.3721 0 0) u=101 imp:n=1
c
3015 0 82 -86 3 -4 fill=1 (10.7442 0 0) u=101 imp:n=1
c
c
3016 0 85 -81 4 -84 fill=1 (-10.7442 5.3721 0) u=101 imp:n=1
c
3017 0 81 -1 4 -84 fill=1 (-5.3721 5.3721 0) u=101 imp:n=1
c
3018 0 1 -2 4 -84 fill=1 (0 5.3721 0) u=101 imp:n=1
c
3019 0 2 -82 4 -84 fill=1 (5.3721 5.3721 0) u=101 imp:n=1
c
3020 0 82 -86 4 -84 fill=1 (10.7442 5.3721 0) u=101 imp:n=1
c
c
3021 0 85 -81 84 -88 fill=1 (-10.7442 10.7442 0) u=101 imp:n=1
c
3022 0 81 -1 84 -88 fill=1 (-5.3721 10.7442 0) u=101 imp:n=1
c
3023 0 1 -2 84 -88 fill=1 (0 10.7442 0) u=101 imp:n=1

```

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```

c
3024  0 2 -82  84 -88 fill=1 (5.3721 10.7442 0) u=101 imp:n=1
c
3025  0 82 -86  84 -88 fill=1 (10.7442 10.7442 0) u=101 imp:n=1
c
c Surround material
c
3026  0 89 -90 91 -92 (-85:86:-87:88) -71 u=101 imp:n=1
c
3027  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=101 imp:n=1
c
3028  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=101 imp:n=1
c
3029  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=101 imp:n=1
c
3030  0 89 -90 91 -92 (-85:86:-87:88) 74 u=101 imp:n=1
c
c
c ROW 3
c
c Bottom left array of 5x5 core elements in Row 3
c
3031  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=103 imp:n=1
c
3032  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=103 imp:n=1
c
3033  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=103 imp:n=1
c
3034  0 2 -82  87 -83 fill=5 (5.3721 -10.7442 0) u=103 imp:n=1
c
3035  0 82 -86  87 -83 fill=5 (10.7442 -10.7442 0) u=103 imp:n=1
c
c
3036  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=103 imp:n=1
c
3037  0 81 -1  83 -3 fill=5 (-5.3721 -5.3721 0) u=103 imp:n=1
c
3038  0 1 -2  83 -3 fill=5 (0 -5.3721 0) u=103 imp:n=1
c
3039  0 2 -82  83 -3 fill=2 (5.3721 -5.3721 0) u=103 imp:n=1
c
3040  0 82 -86  83 -3 fill=2 (10.7442 -5.3721 0) u=103 imp:n=1
c
c
3041  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=103 imp:n=1
c
3042  0 81 -1  3 -4 fill=5 (-5.3721 0 0) u=103 imp:n=1
c
3043  0 1 -2  3 -4 fill=2 (0 0 0) u=103 imp:n=1
c
3044  0 2 -82  3 -4 fill=2 (5.3721 0 0) u=103 imp:n=1
c
3045  0 82 -86  3 -4 fill=2 (10.7442 0 0) u=103 imp:n=1
c
c
3046  0 85 -81  4 -84 fill=5 (-10.7442 5.3721 0) u=103 imp:n=1
c
3047  0 81 -1  4 -84 fill=2 (-5.3721 5.3721 0) u=103 imp:n=1
c
3048  0 1 -2  4 -84 fill=2 (0 5.3721 0) u=103 imp:n=1
c
3049  0 2 -82  4 -84 fill=2 (5.3721 5.3721 0) u=103 imp:n=1
c
3050  0 82 -86  4 -84 fill=2 (10.7442 5.3721 0) u=103 imp:n=1
c
c
3051  0 85 -81  84 -88 fill=5 (-10.7442 10.7442 0) u=103 imp:n=1
c
3052  0 81 -1  84 -88 fill=2 (-5.3721 10.7442 0) u=103 imp:n=1
c
3053  0 1 -2  84 -88 fill=2 (0 10.7442 0) u=103 imp:n=1
c
3054  0 2 -82  84 -88 fill=2 (5.3721 10.7442 0) u=103 imp:n=1
c

```

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```

3055  0 82 -86 84 -88 fill=1 (10.7442 10.7442 0) u=103 imp:n=1
c
c Surround material
c
3056  0 89 -90 91 -92 (-85:86:-87:88) -71 u=103 imp:n=1
c
3057  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=103 imp:n=1
c
3058  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=103 imp:n=1
c
3059  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=103 imp:n=1
c
3060  0 89 -90 91 -92 (-85:86:-87:88) 74 u=103 imp:n=1
c
c
c Bottom right array of 5x5 core elements in Row 3
c
3071  0 85 -81 87 -83 fill=5 (-10.7442 -10.7442 0) u=104 imp:n=1
c
3072  0 81 -1 87 -83 fill=5 (-5.3721 -10.7442 0) u=104 imp:n=1
c
3073  0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=104 imp:n=1
c
3074  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=104 imp:n=1
c
3075  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=104 imp:n=1
c
c
3076  0 85 -81 83 -3 fill=2 (-10.7442 -5.3721 0) u=104 imp:n=1
c
3077  0 81 -1 83 -3 fill=2 (-5.3721 -5.3721 0) u=104 imp:n=1
c
3078  0 1 -2 83 -3 fill=5 (0 -5.3721 0) u=104 imp:n=1
c
3079  0 2 -82 83 -3 fill=5 (5.3721 -5.3721 0) u=104 imp:n=1
c
3080  0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=104 imp:n=1
c
c
3081  0 85 -81 3 -4 fill=2 (-10.7442 0 0) u=104 imp:n=1
c
3082  0 81 -1 3 -4 fill=2 (-5.3721 0 0) u=104 imp:n=1
c
3083  0 1 -2 3 -4 fill=2 (0 0 0) u=104 imp:n=1
c
3084  0 2 -82 3 -4 fill=5 (5.3721 0 0) u=104 imp:n=1
c
3085  0 82 -86 3 -4 fill=6 (10.7442 0 0) u=104 imp:n=1
c
c
3086  0 85 -81 4 -84 fill=2 (-10.7442 5.3721 0) u=104 imp:n=1
c
3087  0 81 -1 4 -84 fill=2 (-5.3721 5.3721 0) u=104 imp:n=1
c
3088  0 1 -2 4 -84 fill=2 (0 5.3721 0) u=104 imp:n=1
c
3089  0 2 -82 4 -84 fill=2 (5.3721 5.3721 0) u=104 imp:n=1
c
3090  0 82 -86 4 -84 fill=5 (10.7442 5.3721 0) u=104 imp:n=1
c
c
3091  0 85 -81 84 -88 fill=1 (-10.7442 10.7442 0) u=104 imp:n=1
c
3092  0 81 -1 84 -88 fill=2 (-5.3721 10.7442 0) u=104 imp:n=1
c
3093  0 1 -2 84 -88 fill=2 (0 10.7442 0) u=104 imp:n=1
c
3094  0 2 -82 84 -88 fill=2 (5.3721 10.7442 0) u=104 imp:n=1
c
3095  0 82 -86 84 -88 fill=2 (10.7442 10.7442 0) u=104 imp:n=1
c
c Surround material
c
3096  0 89 -90 91 -92 (-85:86:-87:88) -71 u=104 imp:n=1

```

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```

c
3097  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=104 imp:n=1
c
3098  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=104 imp:n=1
c
3099  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=104 imp:n=1
c
3100  0 89 -90 91 -92 (-85:86:-87:88) 74 u=104 imp:n=1
c
c
c ROW 2
c
c
c Bottom left array of 5x5 core elements in Row 2
c
3131  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=116 imp:n=1
c
3132  0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=116 imp:n=1
c
3133  0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=116 imp:n=1
c
3134  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=116 imp:n=1
c
3135  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=116 imp:n=1
c
c
3136  0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=116 imp:n=1
c
3137  0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=116 imp:n=1
c
3138  0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=116 imp:n=1
c
3139  0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=116 imp:n=1
c
3140  0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=116 imp:n=1
c
c
3141  0 85 -81 3 -4 fill=6 (-10.7442 0 0) u=116 imp:n=1
c
3142  0 81 -1 3 -4 fill=6 (-5.3721 0 0) u=116 imp:n=1
c
3143  0 1 -2 3 -4 fill=6 (0 0 0) u=116 imp:n=1
c
3144  0 2 -82 3 -4 fill=6 (5.3721 0 0) u=116 imp:n=1
c
3145  0 82 -86 3 -4 fill=6 (10.7442 0 0) u=116 imp:n=1
c
c
3146  0 85 -81 4 -84 fill=6 (-10.7442 5.3721 0) u=116 imp:n=1
c
3147  0 81 -1 4 -84 fill=6 (-5.3721 5.3721 0) u=116 imp:n=1
c
3148  0 1 -2 4 -84 fill=6 (0 5.3721 0) u=116 imp:n=1
c
3149  0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=116 imp:n=1
c
3150  0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=116 imp:n=1
c
c
3151  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=116 imp:n=1
c
3152  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=116 imp:n=1
c
3153  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=116 imp:n=1
c
3154  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=116 imp:n=1
c
3155  0 82 -86 84 -88 fill=5 (10.7442 10.7442 0) u=116 imp:n=1
c
c Surround material
c
3156  0 89 -90 91 -92 (-85:86:-87:88) -71 u=116 imp:n=1
c
3157  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=116 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

c
3158  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=116 imp:n=1
c
3159  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=116 imp:n=1
c
3160  0 89 -90 91 -92 (-85:86:-87:88) 74 u=116 imp:n=1
c
c
c Bottom right array of 5x5 core elements in Row 2
c
3171  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=117 imp:n=1
c
3172  0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=117 imp:n=1
c
3173  0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=117 imp:n=1
c
3174  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=117 imp:n=1
c
3175  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=117 imp:n=1
c
c
3176  0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=117 imp:n=1
c
3177  0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=117 imp:n=1
c
3178  0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=117 imp:n=1
c
3179  0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=117 imp:n=1
c
3180  0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=117 imp:n=1
c
c
3181  0 85 -81 3 -4 fill=6 (-10.7442 0 0) u=117 imp:n=1
c
3182  0 81 -1 3 -4 fill=6 (-5.3721 0 0) u=117 imp:n=1
c
3183  0 1 -2 3 -4 fill=6 (0 0 0) u=117 imp:n=1
c
3184  0 2 -82 3 -4 fill=6 (5.3721 0 0) u=117 imp:n=1
c
3185  0 82 -86 3 -4 fill=6 (10.7442 0 0) u=117 imp:n=1
c
c
3186  0 85 -81 4 -84 fill=6 (-10.7442 5.3721 0) u=117 imp:n=1
c
3187  0 81 -1 4 -84 fill=6 (-5.3721 5.3721 0) u=117 imp:n=1
c
3188  0 1 -2 4 -84 fill=6 (0 5.3721 0) u=117 imp:n=1
c
3189  0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=117 imp:n=1
c
3190  0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=117 imp:n=1
c
c
3191  0 85 -81 84 -88 fill=5 (-10.7442 10.7442 0) u=117 imp:n=1
c
3192  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=117 imp:n=1
c
3193  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=117 imp:n=1
c
3194  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=117 imp:n=1
c
3195  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=117 imp:n=1
c
c Surround material
c
3196  0 89 -90 91 -92 (-85:86:-87:88) -71 u=117 imp:n=1
c
3197  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=117 imp:n=1
c
3198  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=117 imp:n=1
c
3199  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=117 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

3200   0 89 -90 91 -92 (-85:86:-87:88) 74 u=117 imp:n=1
c
c
c Central array of 5x5 core elements in row 2
c
3201   0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=102 imp:n=1
c
3202   0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=102 imp:n=1
c
3203   0 1 -2 87 -83 fill=6 (0 -10.7442 0) u=102 imp:n=1
c
3204   0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=102 imp:n=1
c
3205   0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=102 imp:n=1
c
c
3206   0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=102 imp:n=1
c
3207   0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=102 imp:n=1
c
3208   0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=102 imp:n=1
c
3209   0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=102 imp:n=1
c
3210   0 82 -86 83 -3 fill=6 (10.7442 -5.3721 0) u=102 imp:n=1
c
c
3211   0 85 -81 3 -4 fill=6 (-10.7442 0 0) u=102 imp:n=1
c
3212   0 81 -1 3 -4 fill=6 (-5.3721 0 0) u=102 imp:n=1
c
3213   0 1 -2 3 -4 fill=6 (0 0 0) u=102 imp:n=1
c
3214   0 2 -82 3 -4 fill=6 (5.3721 0 0) u=102 imp:n=1
c
3215   0 82 -86 3 -4 fill=6 (10.7442 0 0) u=102 imp:n=1
c
c
3216   0 85 -81 4 -84 fill=6 (-10.7442 5.3721 0) u=102 imp:n=1
c
3217   0 81 -1 4 -84 fill=6 (-5.3721 5.3721 0) u=102 imp:n=1
c
3218   0 1 -2 4 -84 fill=6 (0 5.3721 0) u=102 imp:n=1
c
3219   0 2 -82 4 -84 fill=6 (5.3721 5.3721 0) u=102 imp:n=1
c
3220   0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=102 imp:n=1
c
c
3221   0 85 -81 84 -88 fill=5 (-10.7442 10.7442 0) u=102 imp:n=1
c
3222   0 81 -1 84 -88 fill=5 (-5.3721 10.7442 0) u=102 imp:n=1
c
3223   0 1 -2 84 -88 fill=5 (0 10.7442 0) u=102 imp:n=1
c
3224   0 2 -82 84 -88 fill=5 (5.3721 10.7442 0) u=102 imp:n=1
c
3225   0 82 -86 84 -88 fill=5 (10.7442 10.7442 0) u=102 imp:n=1
c
c Surround material
c
3226   0 89 -90 91 -92 (-85:86:-87:88) -71 u=102 imp:n=1
c
3227   19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=102 imp:n=1
c
3228   0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=102 imp:n=1
c
3229   19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=102 imp:n=1
c
3230   0 89 -90 91 -92 (-85:86:-87:88) 74 u=102 imp:n=1
c
c
c ROW 4
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Left edge array of 5x5 core elements in row 4
c
3231  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=105 imp:n=1
c
3232  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=105 imp:n=1
c
3233  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=105 imp:n=1
c
3234  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=105 imp:n=1
c
3235  0 82 -86  87 -83 fill=5 (10.7442 -10.7442 0) u=105 imp:n=1
c
c
3236  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=105 imp:n=1
c
3237  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=105 imp:n=1
c
3238  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=105 imp:n=1
c
3239  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=105 imp:n=1
c
3240  0 82 -86  83 -3 fill=5 (10.7442 -5.3721 0) u=105 imp:n=1
c
c
3241  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=105 imp:n=1
c
3242  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=105 imp:n=1
c
3243  0 1 -2  3 -4 fill=6 (0 0 0) u=105 imp:n=1
c
3244  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=105 imp:n=1
c
3245  0 82 -86  3 -4 fill=5 (10.7442 0 0) u=105 imp:n=1
c
c
3246  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=105 imp:n=1
c
3247  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=105 imp:n=1
c
3248  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=105 imp:n=1
c
3249  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=105 imp:n=1
c
3250  0 82 -86  4 -84 fill=5 (10.7442 5.3721 0) u=105 imp:n=1
c
c
3251  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=105 imp:n=1
c
3252  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=105 imp:n=1
c
3253  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=105 imp:n=1
c
3254  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=105 imp:n=1
c
3255  0 82 -86  84 -88 fill=5 (10.7442 10.7442 0) u=105 imp:n=1
c
c Surround material
c
3256  0 89 -90 91 -92 (-85:86:-87:88) -71 u=105 imp:n=1
c
3257  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=105 imp:n=1
c
3258  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=105 imp:n=1
c
3259  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=105 imp:n=1
c
3260  0 89 -90 91 -92 (-85:86:-87:88) 74 u=105 imp:n=1
c
c
c Right edge array of 5x5 core elements in row 4
c
3261  0 85 -81  87 -83 fill=5 (-10.7442 -10.7442 0) u=106 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3262  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=106 imp:n=1
c
3263  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=106 imp:n=1
c
3264  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=106 imp:n=1
c
3265  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=106 imp:n=1
c
c
3266  0 85 -81  83 -3 fill=5 (-10.7442 -5.3721 0) u=106 imp:n=1
c
3267  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=106 imp:n=1
c
3268  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=106 imp:n=1
c
3269  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=106 imp:n=1
c
3270  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=106 imp:n=1
c
c
3271  0 85 -81  3 -4 fill=5 (-10.7442 0 0) u=106 imp:n=1
c
3272  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=106 imp:n=1
c
3273  0 1 -2  3 -4 fill=6 (0 0 0) u=106 imp:n=1
c
3274  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=106 imp:n=1
c
3275  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=106 imp:n=1
c
c
3276  0 85 -81  4 -84 fill=5 (-10.7442 5.3721 0) u=106 imp:n=1
c
3277  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=106 imp:n=1
c
3278  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=106 imp:n=1
c
3279  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=106 imp:n=1
c
3280  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=106 imp:n=1
c
c
3281  0 85 -81  84 -88 fill=5 (-10.7442 10.7442 0) u=106 imp:n=1
c
3282  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=106 imp:n=1
c
3283  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=106 imp:n=1
c
3284  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=106 imp:n=1
c
3285  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=106 imp:n=1
c
c
c Surround material
c
3286  0 89 -90 91 -92 (-85:86:-87:88) -71 u=106 imp:n=1
c
3287  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=106 imp:n=1
c
3288  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=106 imp:n=1
c
3289  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=106 imp:n=1
c
3290  0 89 -90 91 -92 (-85:86:-87:88) 74 u=106 imp:n=1
c
c
c ROW 5
c
c Left Blanket array with 1 core element
c
3301  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=119 imp:n=1
c
3302  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=119 imp:n=1
c
3303  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=119 imp:n=1

```


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```

c
3304  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=119 imp:n=1
c
3305  0 82 -86  87 -83 fill=5 (10.7442 -10.7442 0) u=119 imp:n=1
c
c
3306  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=119 imp:n=1
c
3307  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=119 imp:n=1
c
3308  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=119 imp:n=1
c
3309  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=119 imp:n=1
c
3310  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=119 imp:n=1
c
c
3311  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=119 imp:n=1
c
3312  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=119 imp:n=1
c
3313  0 1 -2  3 -4 fill=6 (0 0 0) u=119 imp:n=1
c
3314  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=119 imp:n=1
c
3315  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=119 imp:n=1
c
c
3316  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=119 imp:n=1
c
3317  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=119 imp:n=1
c
3318  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=119 imp:n=1
c
3319  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=119 imp:n=1
c
3320  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=119 imp:n=1
c
c
3321  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=119 imp:n=1
c
3322  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=119 imp:n=1
c
3323  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=119 imp:n=1
c
3324  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=119 imp:n=1
c
3325  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=119 imp:n=1
c
c Surround material
c
3326  0 89 -90 91 -92 (-85:86:-87:88) -71 u=119 imp:n=1
c
3327  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=119 imp:n=1
c
3328  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=119 imp:n=1
c
3329  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=119 imp:n=1
c
3330  0 89 -90 91 -92 (-85:86:-87:88) 74 u=119 imp:n=1
c
c
c Top left array of 5x5 core elements in Row 5
c
3331  0 85 -81  87 -83 fill=5 (-10.7442 -10.7442 0) u=107 imp:n=1
c
3332  0 81 -1  87 -83 fill=2 (-5.3721 -10.7442 0) u=107 imp:n=1
c
3333  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=107 imp:n=1
c
3334  0 2 -82  87 -83 fill=2 (5.3721 -10.7442 0) u=107 imp:n=1
c
3335  0 82 -86  87 -83 fill=1 (10.7442 -10.7442 0) u=107 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
3336  0 85 -81  83 -3 fill=5 (-10.7442 -5.3721 0) u=107 imp:n=1
c
3337  0 81 -1  83 -3 fill=2 (-5.3721 -5.3721 0) u=107 imp:n=1
c
3338  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=107 imp:n=1
c
3339  0 2 -82  83 -3 fill=2 (5.3721 -5.3721 0) u=107 imp:n=1
c
3340  0 82 -86  83 -3 fill=2 (10.7442 -5.3721 0) u=107 imp:n=1
c
c
3341  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=107 imp:n=1
c
3342  0 81 -1  3 -4 fill=5 (-5.3721 0 0) u=107 imp:n=1
c
3343  0 1 -2  3 -4 fill=2 (0 0 0) u=107 imp:n=1
c
3344  0 2 -82  3 -4 fill=2 (5.3721 0 0) u=107 imp:n=1
c
3345  0 82 -86  3 -4 fill=2 (10.7442 0 0) u=107 imp:n=1
c
c
3346  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=107 imp:n=1
c
3347  0 81 -1  4 -84 fill=5 (-5.3721 5.3721 0) u=107 imp:n=1
c
3348  0 1 -2  4 -84 fill=5 (0 5.3721 0) u=107 imp:n=1
c
3349  0 2 -82  4 -84 fill=2 (5.3721 5.3721 0) u=107 imp:n=1
c
3350  0 82 -86  4 -84 fill=2 (10.7442 5.3721 0) u=107 imp:n=1
c
c
3351  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=107 imp:n=1
c
3352  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=107 imp:n=1
c
3353  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=107 imp:n=1
c
3354  0 2 -82  84 -88 fill=5 (5.3721 10.7442 0) u=107 imp:n=1
c
3355  0 82 -86  84 -88 fill=5 (10.7442 10.7442 0) u=107 imp:n=1
c
c Surround material
c
3356  0 89 -90 91 -92 (-85:86:-87:88) -71 u=107 imp:n=1
c
3357  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=107 imp:n=1
c
3358  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=107 imp:n=1
c
3359  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=107 imp:n=1
c
3360  0 89 -90 91 -92 (-85:86:-87:88) 74 u=107 imp:n=1
c
c Top right array of 5x5 core elements in Row 5
c
3371  0 85 -81  87 -83 fill=1 (-10.7442 -10.7442 0) u=108 imp:n=1
c
3372  0 81 -1  87 -83 fill=2 (-5.3721 -10.7442 0) u=108 imp:n=1
c
3373  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=108 imp:n=1
c
3374  0 2 -82  87 -83 fill=2 (5.3721 -10.7442 0) u=108 imp:n=1
c
3375  0 82 -86  87 -83 fill=5 (10.7442 -10.7442 0) u=108 imp:n=1
c
c
3376  0 85 -81  83 -3 fill=2 (-10.7442 -5.3721 0) u=108 imp:n=1
c
3377  0 81 -1  83 -3 fill=2 (-5.3721 -5.3721 0) u=108 imp:n=1
c
3378  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=108 imp:n=1

```

C	
3379	0 2 -82 83 -3 fill=2 (5.3721-5.3721 0) u=108 imp:n=1
C	
3380	0 82 -86 83 -3 fill=5 (10.7442 -5.3721 0) u=108 imp:n=1
C	
3381	0 85 -81 3 -4 fill=2 (-10.7442 0 0) u=108 imp:n=1
C	
3382	0 81 -1 3 -4 fill=2 (-5.3721 0 0) u=108 imp:n=1
C	
3383	0 1 -2 3 -4 fill=2 (0 0 0) u=108 imp:n=1
C	
3384	0 2 -82 3 -4 fill=5 (5.3721 0 0) u=108 imp:n=1
C	
3385	0 82 -86 3 -4 fill=6 (10.7442 0 0) u=108 imp:n=1
C	
3386	0 85 -81 4 -84 fill=2 (-10.7442 5.3721 0) u=108 imp:n=1
C	
3387	0 81 -1 4 -84 fill=2 (-5.3721 5.3721 0) u=108 imp:n=1
C	
3388	0 1 -2 4 -84 fill=5 (0 5.3721 0) u=108 imp:n=1
C	
3389	0 2 -82 4 -84 fill=5 (5.3721 5.3721 0) u=108 imp:n=1
C	
3390	0 82 -86 4 -84 fill=6 (10.7442 5.3721 0) u=108 imp:n=1
C	
3391	0 85 -81 84 -88 fill=5 (-10.7442 10.7442 0) u=108 imp:n=1
C	
3392	0 81 -1 84 -88 fill=5 (-5.3721 10.7442 0) u=108 imp:n=1
C	
3393	0 1 -2 84 -88 fill=6 (0 10.7442 0) u=108 imp:n=1
C	
3394	0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=108 imp:n=1
C	
3395	0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=108 imp:n=1
C	
c	Surround material
C	
3396	0 89 -90 91 -92 (-85:86:-87:88) -71 u=108 imp:n=1
C	
3397	19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=108 imp:n=1
C	
3398	0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=108 imp:n=1
C	
3399	19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=108 imp:n=1
C	
3400	0 89 -90 91 -92 (-85:86:-87:88) 74 u=108 imp:n=1
C	
C	
C	ROW 6
C	
c	Top central group
C	
3401	0 85 -81 87 -83 fill=5 (-10.7442 -10.7442 0) u=109 imp:n=1
C	
3402	0 81 -1 87 -83 fill=5 (-5.3721 -10.7442 0) u=109 imp:n=1
C	
3403	0 1 -2 87 -83 fill=5 (0 -10.7442 0) u=109 imp:n=1
C	
3404	0 2 -82 87 -83 fill=5 (5.3721 -10.7442 0) u=109 imp:n=1
C	
3405	0 82 -86 87 -83 fill=5 (10.7442 -10.7442 0) u=109 imp:n=1
C	
3406	0 85 -81 83 -3 fill=6 (-10.7442 -5.3721 0) u=109 imp:n=1
C	
3407	0 81 -1 83 -3 fill=6 (-5.3721 -5.3721 0) u=109 imp:n=1
C	
3408	0 1 -2 83 -3 fill=6 (0 -5.3721 0) u=109 imp:n=1
C	
3409	0 2 -82 83 -3 fill=6 (5.3721 -5.3721 0) u=109 imp:n=1
C	

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LIQUID METAL FAST REACTOR – LMFR
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```

3410  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=109 imp:n=1
c
c
3411  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=109 imp:n=1
c
3412  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=109 imp:n=1
c
3413  0 1 -2  3 -4 fill=6 (0 0 0) u=109 imp:n=1
c
3414  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=109 imp:n=1
c
3415  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=109 imp:n=1
c
c
3416  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=109 imp:n=1
c
3417  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=109 imp:n=1
c
3418  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=109 imp:n=1
c
3419  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=109 imp:n=1
c
3420  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=109 imp:n=1
c
c
3421  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=109 imp:n=1
c
3422  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=109 imp:n=1
c
3423  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=109 imp:n=1
c
3424  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=109 imp:n=1
c
3425  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=109 imp:n=1
c
c Surround material
c
3426  0 89 -90 91 -92 (-85:86:-87:88) -71 u=109 imp:n=1
c
3427  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=109 imp:n=1
c
3428  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=109 imp:n=1
c
3429  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=109 imp:n=1
c
3430  0 89 -90 91 -92 (-85:86:-87:88) 74 u=109 imp:n=1
c
c Right hand blanket array containing one core element
c
3431  0 85 -81  87 -83 fill=5 (-10.7442 -10.7442 0) u=118 imp:n=1
c
3432  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=118 imp:n=1
c
3433  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=118 imp:n=1
c
3434  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=118 imp:n=1
c
3435  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=118 imp:n=1
c
c
3436  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=118 imp:n=1
c
3437  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=118 imp:n=1
c
3438  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=118 imp:n=1
c
3439  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=118 imp:n=1
c
3440  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=118 imp:n=1
c
c
3441  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=118 imp:n=1
c
3442  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=118 imp:n=1

```

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```

c
3443  0 1 -2  3 -4 fill=6 (0 0 0) u=118 imp:n=1
c
3444  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=118 imp:n=1
c
3445  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=118 imp:n=1
c
c
3446  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=118 imp:n=1
c
3447  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=118 imp:n=1
c
3448  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=118 imp:n=1
c
3449  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=118 imp:n=1
c
3450  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=118 imp:n=1
c
c
c
3451  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=118 imp:n=1
c
3452  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=118 imp:n=1
c
3453  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=118 imp:n=1
c
3454  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=118 imp:n=1
c
3455  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=118 imp:n=1
c
c Surround material
c
3456  0 89 -90 91 -92 (-85:86:-87:88) -71 u=118 imp:n=1
c
3457  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=118 imp:n=1
c
3458  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=118 imp:n=1
c
3459  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=118 imp:n=1
c
3460  0 89 -90 91 -92 (-85:86:-87:88) 74 u=118 imp:n=1
c
c
c 5x5 array of blanket elements
c
c
3501  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=111 imp:n=1
c
3502  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=111 imp:n=1
c
3503  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=111 imp:n=1
c
3504  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=111 imp:n=1
c
3505  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=111 imp:n=1
c
c
c
3506  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=111 imp:n=1
c
3507  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=111 imp:n=1
c
3508  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=111 imp:n=1
c
3509  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=111 imp:n=1
c
3510  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=111 imp:n=1
c
c
c
3511  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=111 imp:n=1
c
3512  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=111 imp:n=1
c
3513  0 1 -2  3 -4 fill=6 (0 0 0) u=111 imp:n=1
c
3514  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=111 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3515  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=111 imp:n=1
c
c
3516  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=111 imp:n=1
c
3517  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=111 imp:n=1
c
3518  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=111 imp:n=1
c
3519  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=111 imp:n=1
c
3520  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=111 imp:n=1
c
c
c
3521  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=111 imp:n=1
c
3522  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=111 imp:n=1
c
3523  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=111 imp:n=1
c
3524  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=111 imp:n=1
c
3525  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=111 imp:n=1
c
c Surround material
c
3526  0 89 -90 91 -92 (-85:86:-87:88) -71 u=111 imp:n=1
c
3527  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=111 imp:n=1
c
3528  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=111 imp:n=1
c
3529  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=111 imp:n=1
c
3530  0 89 -90 91 -92 (-85:86:-87:88) 74 u=111 imp:n=1
c
c
c Blanket-Reflector Arrays
c
c ROW 2
c
c Bottom Left
c
3531  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=112 imp:n=1
c
3532  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=112 imp:n=1
c
3533  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=112 imp:n=1
c
3534  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=112 imp:n=1
c
3535  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=112 imp:n=1
c
c
c
3536  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=112 imp:n=1
c
3537  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=112 imp:n=1
c
3538  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=112 imp:n=1
c
3539  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=112 imp:n=1
c
3540  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=112 imp:n=1
c
c
c
3541  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=112 imp:n=1
c
3542  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=112 imp:n=1
c
3543  0 1 -2  3 -4 fill=7 (0 0 0) u=112 imp:n=1
c
3544  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=112 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3545  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=112 imp:n=1
c
c
3546  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=112 imp:n=1
c
3547  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=112 imp:n=1
c
3548  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=112 imp:n=1
c
3549  0 2 -82  4 -84 fill=6 (5.3721 5.3721 0) u=112 imp:n=1
c
3550  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=112 imp:n=1
c
c
3551  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=112 imp:n=1
c
3552  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=112 imp:n=1
c
3553  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=112 imp:n=1
c
3554  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=112 imp:n=1
c
3555  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=112 imp:n=1
c
c Surround material
c
3556  0 89 -90 91 -92 (-85:86:-87:88) -71 u=112 imp:n=1
c
3557  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=112 imp:n=1
c
3558  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=112 imp:n=1
c
3559  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=112 imp:n=1
c
3560  0 89 -90 91 -92 (-85:86:-87:88) 74 u=112 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
3561  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=113 imp:n=1
c
3562  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=113 imp:n=1
c
3563  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=113 imp:n=1
c
3564  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=113 imp:n=1
c
3565  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=113 imp:n=1
c
c
3566  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=113 imp:n=1
c
3567  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=113 imp:n=1
c
3568  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=113 imp:n=1
c
3569  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=113 imp:n=1
c
3570  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=113 imp:n=1
c
c
3571  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=113 imp:n=1
c
3572  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=113 imp:n=1
c
3573  0 1 -2  3 -4 fill=7 (0 0 0) u=113 imp:n=1
c
3574  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=113 imp:n=1
c
3575  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=113 imp:n=1
c
c
3576  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=113 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3577  0 81 -1  4 -84 fill=6 (-5.3721 5.3721 0) u=113 imp:n=1
c
3578  0 1 -2  4 -84 fill=6 (0 5.3721 0) u=113 imp:n=1
c
3579  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=113 imp:n=1
c
3580  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=113 imp:n=1
c
c
3581  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=113 imp:n=1
c
3582  0 81 -1  84 -88 fill=6 (-5.3721 10.7442 0) u=113 imp:n=1
c
3583  0 1 -2  84 -88 fill=6 (0 10.7442 0) u=113 imp:n=1
c
3584  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=113 imp:n=1
c
3585  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=113 imp:n=1
c
c Surround material
c
3586  0 89 -90 91 -92 (-85:86:-87:88) -71 u=113 imp:n=1
c
3587  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=113 imp:n=1
c
3588  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=113 imp:n=1
c
3589  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=113 imp:n=1
c
3590  0 89 -90 91 -92 (-85:86:-87:88) 74 u=113 imp:n=1
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
3631  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=114 imp:n=1
c
3632  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=114 imp:n=1
c
3633  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=114 imp:n=1
c
3634  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=114 imp:n=1
c
3635  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=114 imp:n=1
c
c
3636  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=114 imp:n=1
c
3637  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=114 imp:n=1
c
3638  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=114 imp:n=1
c
3639  0 2 -82  83 -3 fill=6 (5.3721 -5.3721 0) u=114 imp:n=1
c
3640  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=114 imp:n=1
c
c
3641  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=114 imp:n=1
c
3642  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=114 imp:n=1
c
3643  0 1 -2  3 -4 fill=7 (0 0 0) u=114 imp:n=1
c
3644  0 2 -82  3 -4 fill=6 (5.3721 0 0) u=114 imp:n=1
c
3645  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=114 imp:n=1
c
c
3646  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=114 imp:n=1
c
3647  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=114 imp:n=1
c
3648  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=114 imp:n=1
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3649  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=114 imp:n=1
c
3650  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=114 imp:n=1
c
c
3651  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=114 imp:n=1
c
3652  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=114 imp:n=1
c
3653  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=114 imp:n=1
c
3654  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=114 imp:n=1
c
3655  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=114 imp:n=1
c
c Surround material
c
3656  0 89 -90 91 -92 (-85:86:-87:88) -71 u=114 imp:n=1
c
3657  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=114 imp:n=1
c
3658  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=114 imp:n=1
c
3659  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=114 imp:n=1
c
3660  0 89 -90 91 -92 (-85:86:-87:88) 74 u=114 imp:n=1
c
c
c Row 6 Top Right Blanket Reflector Array
c
3661  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=115 imp:n=1
c
3662  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=115 imp:n=1
c
3663  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=115 imp:n=1
c
3664  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=115 imp:n=1
c
3665  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=115 imp:n=1
c
c
3666  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=115 imp:n=1
c
3667  0 81 -1  83 -3 fill=6 (-5.3721 -5.3721 0) u=115 imp:n=1
c
3668  0 1 -2  83 -3 fill=6 (0 -5.3721 0) u=115 imp:n=1
c
3669  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=115 imp:n=1
c
3670  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=115 imp:n=1
c
c
3671  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=115 imp:n=1
c
3672  0 81 -1  3 -4 fill=6 (-5.3721 0 0) u=115 imp:n=1
c
3673  0 1 -2  3 -4 fill=7 (0 0 0) u=115 imp:n=1
c
3674  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=115 imp:n=1
c
3675  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=115 imp:n=1
c
c
3676  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=115 imp:n=1
c
3677  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=115 imp:n=1
c
3678  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=115 imp:n=1
c
3679  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=115 imp:n=1
c
3680  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=115 imp:n=1
c
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

3681  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=115 imp:n=1
c
3682  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=115 imp:n=1
c
3683  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=115 imp:n=1
c
3684  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=115 imp:n=1
c
3685  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=115 imp:n=1
c
c Surround material
c
3686  0 89 -90 91 -92 (-85:86:-87:88) -71 u=115 imp:n=1
c
3687  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=115 imp:n=1
c
3688  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=115 imp:n=1
c
3689  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=115 imp:n=1
c
3690  0 89 -90 91 -92 (-85:86:-87:88) 74 u=115 imp:n=1
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
3701  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=121 imp:n=1
c
3702  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=121 imp:n=1
c
3703  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=121 imp:n=1
c
3704  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=121 imp:n=1
c
3705  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=121 imp:n=1
c
c
3706  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=121 imp:n=1
c
3707  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=121 imp:n=1
c
3708  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=121 imp:n=1
c
3709  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=121 imp:n=1
c
3710  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=121 imp:n=1
c
c
3711  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=121 imp:n=1
c
3712  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=121 imp:n=1
c
3713  0 1 -2  3 -4 fill=9 (0 0 0) u=121 imp:n=1
c
3714  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=121 imp:n=1
c
3715  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=121 imp:n=1
c
c
3716  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=121 imp:n=1
c
3717  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=121 imp:n=1
c
3718  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=121 imp:n=1
c
3719  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=121 imp:n=1
c
3720  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=121 imp:n=1
c
c
3721  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=121 imp:n=1
c
3722  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=121 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3723  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=121 imp:n=1
c
3724  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=121 imp:n=1
c
3725  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=121 imp:n=1
c
c Surround material
c
3726  0 89 -90 91 -92 (-85:86:-87:88) -71 u=121 imp:n=1
c
3727  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=121 imp:n=1
c
3728  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=121 imp:n=1
c
3729  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=121 imp:n=1
c
3730  0 89 -90 91 -92 (-85:86:-87:88) 74 u=121 imp:n=1
c
c
c Row 1 Mid-Left
c
3731  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=122 imp:n=1
c
3732  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=122 imp:n=1
c
3733  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=122 imp:n=1
c
3734  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=122 imp:n=1
c
3735  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=122 imp:n=1
c
c
c
3736  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=122 imp:n=1
c
3737  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=122 imp:n=1
c
3738  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=122 imp:n=1
c
3739  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=122 imp:n=1
c
3740  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=122 imp:n=1
c
c
c
3741  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=122 imp:n=1
c
3742  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=122 imp:n=1
c
3743  0 1 -2  3 -4 fill=7 (0 0 0) u=122 imp:n=1
c
3744  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=122 imp:n=1
c
3745  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=122 imp:n=1
c
c
c
3746  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=122 imp:n=1
c
3747  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=122 imp:n=1
c
3748  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=122 imp:n=1
c
3749  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=122 imp:n=1
c
3750  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=122 imp:n=1
c
c
c
3751  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=122 imp:n=1
c
3752  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=122 imp:n=1
c
3753  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=122 imp:n=1
c
3754  0 2 -82  84 -88 fill=6 (5.3721 10.7442 0) u=122 imp:n=1
c
3755  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=122 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Surround material
c
3756  0 89 -90 91 -92 (-85:86:-87:88) -71 u=122 imp:n=1
c
3757  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=122 imp:n=1
c
3758  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=122 imp:n=1
c
3759  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=122 imp:n=1
c
3760  0 89 -90 91 -92 (-85:86:-87:88) 74 u=122 imp:n=1
c
c
c Row 1 Central Array
c
3761  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=123 imp:n=1
c
3762  0 81 -1 87 -83 fill=9 (-5.3721 -10.7442 0) u=123 imp:n=1
c
3763  0 1 -2 87 -83 fill=9 (0 -10.7442 0) u=123 imp:n=1
c
3764  0 2 -82 87 -83 fill=9 (5.3721 -10.7442 0) u=123 imp:n=1
c
3765  0 82 -86 87 -83 fill=9 (10.7442 -10.7442 0) u=123 imp:n=1
c
c
3766  0 85 -81 83 -3 fill=7 (-10.7442 -5.3721 0) u=123 imp:n=1
c
3767  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=123 imp:n=1
c
3768  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=123 imp:n=1
c
3769  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=123 imp:n=1
c
3770  0 82 -86 83 -3 fill=7 (10.7442 -5.3721 0) u=123 imp:n=1
c
c
3771  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=123 imp:n=1
c
3772  0 81 -1 3 -4 fill=7 (-5.3721 0 0) u=123 imp:n=1
c
3773  0 1 -2 3 -4 fill=7 (0 0 0) u=123 imp:n=1
c
3774  0 2 -82 3 -4 fill=7 (5.3721 0 0) u=123 imp:n=1
c
3775  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=123 imp:n=1
c
c
3776  0 85 -81 4 -84 fill=7 (-10.7442 5.3721 0) u=123 imp:n=1
c
3777  0 81 -1 4 -84 fill=7 (-5.3721 5.3721 0) u=123 imp:n=1
c
3778  0 1 -2 4 -84 fill=7 (0 5.3721 0) u=123 imp:n=1
c
3779  0 2 -82 4 -84 fill=7 (5.3721 5.3721 0) u=123 imp:n=1
c
3780  0 82 -86 4 -84 fill=7 (10.7442 5.3721 0) u=123 imp:n=1
c
c
3781  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=123 imp:n=1
c
3782  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=123 imp:n=1
c
3783  0 1 -2 84 -88 fill=6 (0 10.7442 0) u=123 imp:n=1
c
3784  0 2 -82 84 -88 fill=6 (5.3721 10.7442 0) u=123 imp:n=1
c
3785  0 82 -86 84 -88 fill=6 (10.7442 10.7442 0) u=123 imp:n=1
c
c Surround material
c
3786  0 89 -90 91 -92 (-85:86:-87:88) -71 u=123 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3787  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=123 imp:n=1
c
3788  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=123 imp:n=1
c
3789  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=123 imp:n=1
c
3790  0 89 -90 91 -92 (-85:86:-87:88) 74 u=123 imp:n=1
c
c
c Row 1 First Right array
c
3801  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=124 imp:n=1
c
3802  0 81 -1 87 -83 fill=9 (-5.3721 -10.7442 0) u=124 imp:n=1
c
3803  0 1 -2 87 -83 fill=9 (0 -10.7442 0) u=124 imp:n=1
c
3804  0 2 -82 87 -83 fill=9 (5.3721 -10.7442 0) u=124 imp:n=1
c
3805  0 82 -86 87 -83 fill=9 (10.7442 -10.7442 0) u=124 imp:n=1
c
c
3806  0 85 -81 83 -3 fill=7 (-10.7442 -5.3721 0) u=124 imp:n=1
c
3807  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=124 imp:n=1
c
3808  0 1 -2 83 -3 fill=9 (0 -5.3721 0) u=124 imp:n=1
c
3809  0 2 -82 83 -3 fill=9 (5.3721 -5.3721 0) u=124 imp:n=1
c
3810  0 82 -86 83 -3 fill=9 (10.7442 -5.3721 0) u=124 imp:n=1
c
c
3811  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=124 imp:n=1
c
3812  0 81 -1 3 -4 fill=7 (-5.3721 0 0) u=124 imp:n=1
c
3813  0 1 -2 3 -4 fill=7 (0 0 0) u=124 imp:n=1
c
3814  0 2 -82 3 -4 fill=7 (5.3721 0 0) u=124 imp:n=1
c
3815  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=124 imp:n=1
c
c
3816  0 85 -81 4 -84 fill=7 (-10.7442 5.3721 0) u=124 imp:n=1
c
3817  0 81 -1 4 -84 fill=7 (-5.3721 5.3721 0) u=124 imp:n=1
c
3818  0 1 -2 4 -84 fill=7 (0 5.3721 0) u=124 imp:n=1
c
3819  0 2 -82 4 -84 fill=7 (5.3721 5.3721 0) u=124 imp:n=1
c
3820  0 82 -86 4 -84 fill=7 (10.7442 5.3721 0) u=124 imp:n=1
c
c
3821  0 85 -81 84 -88 fill=6 (-10.7442 10.7442 0) u=124 imp:n=1
c
3822  0 81 -1 84 -88 fill=6 (-5.3721 10.7442 0) u=124 imp:n=1
c
3823  0 1 -2 84 -88 fill=7 (0 10.7442 0) u=124 imp:n=1
c
3824  0 2 -82 84 -88 fill=7 (5.3721 10.7442 0) u=124 imp:n=1
c
3825  0 82 -86 84 -88 fill=7 (10.7442 10.7442 0) u=124 imp:n=1
c
c Surround material
c
3826  0 89 -90 91 -92 (-85:86:-87:88) -71 u=124 imp:n=1
c
3827  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=124 imp:n=1
c
3828  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=124 imp:n=1
c
3829  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=124 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3830  0 89 -90 91 -92 (-85:86:-87:88) 74 u=124 imp:n=1
c
c
c Row 1 Far Right
c
3831  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=125 imp:n=1
c
3832  0 81 -1 87 -83 fill=9 (-5.3721 -10.7442 0) u=125 imp:n=1
c
3833  0 1 -2 87 -83 fill=9 (0 -10.7442 0) u=125 imp:n=1
c
3834  0 2 -82 87 -83 fill=9 (5.3721 -10.7442 0) u=125 imp:n=1
c
3835  0 82 -86 87 -83 fill=9 (10.7442 -10.7442 0) u=125 imp:n=1
c
c
3836  0 85 -81 83 -3 fill=9 (-10.7442 -5.3721 0) u=125 imp:n=1
c
3837  0 81 -1 83 -3 fill=9 (-5.3721 -5.3721 0) u=125 imp:n=1
c
3838  0 1 -2 83 -3 fill=9 (0 -5.3721 0) u=125 imp:n=1
c
3839  0 2 -82 83 -3 fill=9 (5.3721 -5.3721 0) u=125 imp:n=1
c
3840  0 82 -86 83 -3 fill=9 (10.7442 -5.3721 0) u=125 imp:n=1
c
c
3841  0 85 -81 3 -4 fill=9 (-10.7442 0 0) u=125 imp:n=1
c
3842  0 81 -1 3 -4 fill=9 (-5.3721 0 0) u=125 imp:n=1
c
3843  0 1 -2 3 -4 fill=9 (0 0 0) u=125 imp:n=1
c
3844  0 2 -82 3 -4 fill=9 (5.3721 0 0) u=125 imp:n=1
c
3845  0 82 -86 3 -4 fill=9 (10.7442 0 0) u=125 imp:n=1
c
c
3846  0 85 -81 4 -84 fill=7 (-10.7442 5.3721 0) u=125 imp:n=1
c
3847  0 81 -1 4 -84 fill=7 (-5.3721 5.3721 0) u=125 imp:n=1
c
3848  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=125 imp:n=1
c
3849  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=125 imp:n=1
c
3850  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=125 imp:n=1
c
c
3851  0 85 -81 84 -88 fill=7 (-10.7442 10.7442 0) u=125 imp:n=1
c
3852  0 81 -1 84 -88 fill=7 (-5.3721 10.7442 0) u=125 imp:n=1
c
3853  0 1 -2 84 -88 fill=7 (0 10.7442 0) u=125 imp:n=1
c
3854  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=125 imp:n=1
c
3855  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=125 imp:n=1
c
c Surround material
c
3856  0 89 -90 91 -92 (-85:86:-87:88) -71 u=125 imp:n=1
c
3857  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=125 imp:n=1
c
3858  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=125 imp:n=1
c
3859  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=125 imp:n=1
c
3860  0 89 -90 91 -92 (-85:86:-87:88) 74 u=125 imp:n=1
c
c Row 2 Blanket reflector arrays
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

c Row 2 First Left array

```

c
3901  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=127 imp:n=1
c
3902  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=127 imp:n=1
c
3903  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=127 imp:n=1
c
3904  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=127 imp:n=1
c
3905  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=127 imp:n=1
c
c
3906  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=127 imp:n=1
c
3907  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=127 imp:n=1
c
3908  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=127 imp:n=1
c
3909  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=127 imp:n=1
c
3910  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=127 imp:n=1
c
c
3911  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=127 imp:n=1
c
3912  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=127 imp:n=1
c
3913  0 1 -2  3 -4 fill=9 (0 0 0) u=127 imp:n=1
c
3914  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=127 imp:n=1
c
3915  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=127 imp:n=1
c
c
3916  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=127 imp:n=1
c
3917  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=127 imp:n=1
c
3918  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=127 imp:n=1
c
3919  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=127 imp:n=1
c
3920  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=127 imp:n=1
c
c
3921  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=127 imp:n=1
c
3922  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=127 imp:n=1
c
3923  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=127 imp:n=1
c
3924  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=127 imp:n=1
c
3925  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=127 imp:n=1
c
c Surround material
c
3926  0 89 -90 91 -92 (-85:86:-87:88) -71 u=127 imp:n=1
c
3927  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=127 imp:n=1
c
3928  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=127 imp:n=1
c
3929  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=127 imp:n=1
c
3930  0 89 -90 91 -92 (-85:86:-87:88) 74 u=127 imp:n=1
c
c

```

c Row 2 Far Right

```

c
3931  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=128 imp:n=1
c
3932  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=128 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3933  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=128 imp:n=1
c
3934  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=128 imp:n=1
c
3935  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=128 imp:n=1
c
c
3936  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=128 imp:n=1
c
3937  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=128 imp:n=1
c
3938  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=128 imp:n=1
c
3939  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=128 imp:n=1
c
3940  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=128 imp:n=1
c
c
3941  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=128 imp:n=1
c
3942  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=128 imp:n=1
c
3943  0 1 -2  3 -4 fill=9 (0 0 0) u=128 imp:n=1
c
3944  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=128 imp:n=1
c
3945  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=128 imp:n=1
c
c
3946  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=128 imp:n=1
c
3947  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=128 imp:n=1
c
3948  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=128 imp:n=1
c
3949  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=128 imp:n=1
c
3950  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=128 imp:n=1
c
c
3951  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=128 imp:n=1
c
3952  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=128 imp:n=1
c
3953  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=128 imp:n=1
c
3954  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=128 imp:n=1
c
3955  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=128 imp:n=1
c
c Surround material
c
3956  0 89 -90 91 -92 (-85:86:-87:88) -71 u=128 imp:n=1
c
3957  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=128 imp:n=1
c
3958  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=128 imp:n=1
c
3959  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=128 imp:n=1
c
3960  0 89 -90 91 -92 (-85:86:-87:88) 74 u=128 imp:n=1
c
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
4001  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=157 imp:n=1
c
4002  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=157 imp:n=1
c
4003  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=157 imp:n=1

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4004  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=157 imp:n=1
c
4005  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=157 imp:n=1
c
c
4006  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=157 imp:n=1
c
4007  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=157 imp:n=1
c
4008  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=157 imp:n=1
c
4009  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=157 imp:n=1
c
4010  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=157 imp:n=1
c
c
4011  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=157 imp:n=1
c
4012  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=157 imp:n=1
c
4013  0 1 -2  3 -4 fill=7 (0 0 0) u=157 imp:n=1
c
4014  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=157 imp:n=1
c
4015  0 82 -86  3 -4 fill=6 (10.7442 0 0) u=157 imp:n=1
c
c
4016  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=157 imp:n=1
c
4017  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=157 imp:n=1
c
4018  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=157 imp:n=1
c
4019  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=157 imp:n=1
c
4020  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=157 imp:n=1
c
c
4021  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=157 imp:n=1
c
4022  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=157 imp:n=1
c
4023  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=157 imp:n=1
c
4024  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=157 imp:n=1
c
4025  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=157 imp:n=1
c
c Surround material
c
4026  0 89 -90 91 -92 (-85:86:-87:88) -71 u=157 imp:n=1
c
4027  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=157 imp:n=1
c
4028  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=157 imp:n=1
c
4029  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=157 imp:n=1
c
4030  0 89 -90 91 -92 (-85:86:-87:88) 74 u=157 imp:n=1
c
c
c Row 4 Far Right
c
4031  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=158 imp:n=1
c
4032  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=158 imp:n=1
c
4033  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=158 imp:n=1
c
4034  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=158 imp:n=1
c
4035  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=158 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4036  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=158 imp:n=1
c
4037  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=158 imp:n=1
c
4038  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=158 imp:n=1
c
4039  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=158 imp:n=1
c
4040  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=158 imp:n=1
c
c
4041  0 85 -81  3 -4 fill=6 (-10.7442 0 0) u=158 imp:n=1
c
4042  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=158 imp:n=1
c
4043  0 1 -2  3 -4 fill=7 (0 0 0) u=158 imp:n=1
c
4044  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=158 imp:n=1
c
4045  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=158 imp:n=1
c
c
4046  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=158 imp:n=1
c
4047  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=158 imp:n=1
c
4048  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=158 imp:n=1
c
4049  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=158 imp:n=1
c
4050  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=158 imp:n=1
c
c
4051  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=158 imp:n=1
c
4052  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=158 imp:n=1
c
4053  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=158 imp:n=1
c
4054  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=158 imp:n=1
c
4055  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=158 imp:n=1
c
c Surround material
c
4056  0 89 -90 91 -92 (-85:86:-87:88) -71 u=158 imp:n=1
c
4057  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=158 imp:n=1
c
4058  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=158 imp:n=1
c
4059  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=158 imp:n=1
c
4060  0 89 -90 91 -92 (-85:86:-87:88) 74 u=158 imp:n=1
c
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
4101  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=137 imp:n=1
c
4102  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=137 imp:n=1
c
4103  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=137 imp:n=1
c
4104  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=137 imp:n=1
c
4105  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=137 imp:n=1
c
c
4106  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=137 imp:n=1

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4107  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=137 imp:n=1
c
4108  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=137 imp:n=1
c
4109  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=137 imp:n=1
c
4110  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=137 imp:n=1
c
c
4111  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=137 imp:n=1
c
4112  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=137 imp:n=1
c
4113  0 1 -2  3 -4 fill=9 (0 0 0) u=137 imp:n=1
c
4114  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=137 imp:n=1
c
4115  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=137 imp:n=1
c
c
4116  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=137 imp:n=1
c
4117  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=137 imp:n=1
c
4118  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=137 imp:n=1
c
4119  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=137 imp:n=1
c
4120  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=137 imp:n=1
c
c
4121  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=137 imp:n=1
c
4122  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=137 imp:n=1
c
4123  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=137 imp:n=1
c
4124  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=137 imp:n=1
c
4125  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=137 imp:n=1
c
c Surround material
c
4126  0 89 -90 91 -92 (-85:86:-87:88) -71 u=137 imp:n=1
c
4127  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=137 imp:n=1
c
4128  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=137 imp:n=1
c
4129  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=137 imp:n=1
c
4130  0 89 -90 91 -92 (-85:86:-87:88) 74 u=137 imp:n=1
c
c
c Row 6 Far Right
c
4131  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=138 imp:n=1
c
4132  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=138 imp:n=1
c
4133  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=138 imp:n=1
c
4134  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=138 imp:n=1
c
4135  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=138 imp:n=1
c
c
4136  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=138 imp:n=1
c
4137  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=138 imp:n=1
c
4138  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=138 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4139  0 2 -82 83 -3 fill=9 (5.3721 -5.3721 0) u=138 imp:n=1
c
4140  0 82 -86 83 -3 fill=9 (10.7442 -5.3721 0) u=138 imp:n=1
c
c
4141  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=138 imp:n=1
c
4142  0 81 -1 3 -4 fill=9 (-5.3721 0 0) u=138 imp:n=1
c
4143  0 1 -2 3 -4 fill=9 (0 0 0) u=138 imp:n=1
c
4144  0 2 -82 3 -4 fill=9 (5.3721 0 0) u=138 imp:n=1
c
4145  0 82 -86 3 -4 fill=9 (10.7442 0 0) u=138 imp:n=1
c
c
4146  0 85 -81 4 -84 fill=9 (-10.7442 5.3721 0) u=138 imp:n=1
c
4147  0 81 -1 4 -84 fill=9 (-5.3721 5.3721 0) u=138 imp:n=1
c
4148  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=138 imp:n=1
c
4149  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=138 imp:n=1
c
4150  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=138 imp:n=1
c
c
4151  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=138 imp:n=1
c
4152  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=138 imp:n=1
c
4153  0 1 -2 84 -88 fill=9 (0 10.7442 0) u=138 imp:n=1
c
4154  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=138 imp:n=1
c
4155  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=138 imp:n=1
c
c Surround material
c
4156  0 89 -90 91 -92 (-85:86:-87:88) -71 u=138 imp:n=1
c
4157  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=138 imp:n=1
c
4158  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=138 imp:n=1
c
4159  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=138 imp:n=1
c
4160  0 89 -90 91 -92 (-85:86:-87:88) 74 u=138 imp:n=1
c
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
4201  0 85 -81 87 -83 fill=9 (-10.7442 -10.7442 0) u=167 imp:n=1
c
4202  0 81 -1 87 -83 fill=7 (-5.3721 -10.7442 0) u=167 imp:n=1
c
4203  0 1 -2 87 -83 fill=7 (0 -10.7442 0) u=167 imp:n=1
c
4204  0 2 -82 87 -83 fill=7 (5.3721 -10.7442 0) u=167 imp:n=1
c
4205  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=167 imp:n=1
c
c
4206  0 85 -81 83 -3 fill=9 (-10.7442 -5.3721 0) u=167 imp:n=1
c
4207  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=167 imp:n=1
c
4208  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=167 imp:n=1
c
4209  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=167 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4210  0 82 -86  83 -3 fill=6 (10.7442 -5.3721 0) u=167 imp:n=1
c
c
4211  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=167 imp:n=1
c
4212  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=167 imp:n=1
c
4213  0 1 -2  3 -4 fill=7 (0 0 0) u=167 imp:n=1
c
4214  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=167 imp:n=1
c
4215  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=167 imp:n=1
c
c
c
4216  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=167 imp:n=1
c
4217  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=167 imp:n=1
c
4218  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=167 imp:n=1
c
4219  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=167 imp:n=1
c
4220  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=167 imp:n=1
c
c
c
4221  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=167 imp:n=1
c
4222  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=167 imp:n=1
c
4223  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=167 imp:n=1
c
4224  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=167 imp:n=1
c
4225  0 82 -86  84 -88 fill=7 (10.7442 10.7442 0) u=167 imp:n=1
c
c Surround material
c
c
4226  0 89 -90 91 -92 (-85:86:-87:88) -71 u=167 imp:n=1
c
4227  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=167 imp:n=1
c
4228  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=167 imp:n=1
c
4229  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=167 imp:n=1
c
4230  0 89 -90 91 -92 (-85:86:-87:88) 74 u=167 imp:n=1
c
c
c Row 4 Far Right
c
4231  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=168 imp:n=1
c
4232  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=168 imp:n=1
c
4233  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=168 imp:n=1
c
4234  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=168 imp:n=1
c
4235  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=168 imp:n=1
c
c
c
4236  0 85 -81  83 -3 fill=6 (-10.7442 -5.3721 0) u=168 imp:n=1
c
4237  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=168 imp:n=1
c
4238  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=168 imp:n=1
c
4239  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=168 imp:n=1
c
4240  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=168 imp:n=1
c
c
4241  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=168 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4242  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=168 imp:n=1
c
4243  0 1 -2  3 -4 fill=7 (0 0 0) u=168 imp:n=1
c
4244  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=168 imp:n=1
c
4245  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=168 imp:n=1
c
c
4246  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=168 imp:n=1
c
4247  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=168 imp:n=1
c
4248  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=168 imp:n=1
c
4249  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=168 imp:n=1
c
4250  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=168 imp:n=1
c
c
4251  0 85 -81  84 -88 fill=7 (-10.7442 10.7442 0) u=168 imp:n=1
c
4252  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=168 imp:n=1
c
4253  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=168 imp:n=1
c
4254  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=168 imp:n=1
c
4255  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=168 imp:n=1
c
c Surround material
c
4256  0 89 -90 91 -92 (-85:86:-87:88) -71 u=168 imp:n=1
c
4257  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=168 imp:n=1
c
4258  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=168 imp:n=1
c
4259  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=168 imp:n=1
c
4260  0 89 -90 91 -92 (-85:86:-87:88) 74 u=168 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays
c
c Row 3 First Left array
c
4301  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=147 imp:n=1
c
4302  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=147 imp:n=1
c
4303  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=147 imp:n=1
c
4304  0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=147 imp:n=1
c
4305  0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=147 imp:n=1
c
c
4306  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=147 imp:n=1
c
4307  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=147 imp:n=1
c
4308  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=147 imp:n=1
c
4309  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=147 imp:n=1
c
4310  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=147 imp:n=1
c
c
4311  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=147 imp:n=1
c
4312  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=147 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4313  0 1 -2  3 -4 fill=7 (0 0 0) u=147 imp:n=1
c
4314  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=147 imp:n=1
c
4315  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=147 imp:n=1
c
c
4316  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=147 imp:n=1
c
4317  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=147 imp:n=1
c
4318  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=147 imp:n=1
c
4319  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=147 imp:n=1
c
4320  0 82 -86  4 -84 fill=6 (10.7442 5.3721 0) u=147 imp:n=1
c
c
c
4321  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=147 imp:n=1
c
4322  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=147 imp:n=1
c
4323  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=147 imp:n=1
c
4324  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=147 imp:n=1
c
4325  0 82 -86  84 -88 fill=6 (10.7442 10.7442 0) u=147 imp:n=1
c
c Surround material
c
4326  0 89 -90 91 -92 (-85:86:-87:88) -71 u=147 imp:n=1
c
4327  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=147 imp:n=1
c
4328  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=147 imp:n=1
c
4329  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=147 imp:n=1
c
4330  0 89 -90 91 -92 (-85:86:-87:88) 74 u=147 imp:n=1
c
c
c Row 3 Far Right
c
4331  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=148 imp:n=1
c
4332  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=148 imp:n=1
c
4333  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=148 imp:n=1
c
4334  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=148 imp:n=1
c
4335  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=148 imp:n=1
c
c
c
4336  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=148 imp:n=1
c
4337  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=148 imp:n=1
c
4338  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=148 imp:n=1
c
4339  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=148 imp:n=1
c
4340  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=148 imp:n=1
c
c
c
4341  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=148 imp:n=1
c
4342  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=148 imp:n=1
c
4343  0 1 -2  3 -4 fill=7 (0 0 0) u=148 imp:n=1
c
4344  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=148 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4345  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=148 imp:n=1
c
c
4346  0 85 -81  4 -84 fill=6 (-10.7442 5.3721 0) u=148 imp:n=1
c
4347  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=148 imp:n=1
c
4348  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=148 imp:n=1
c
4349  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=148 imp:n=1
c
4350  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=148 imp:n=1
c
c
c
4351  0 85 -81  84 -88 fill=6 (-10.7442 10.7442 0) u=148 imp:n=1
c
4352  0 81 -1  84 -88 fill=7 (-5.3721 10.7442 0) u=148 imp:n=1
c
4353  0 1 -2  84 -88 fill=7 (0 10.7442 0) u=148 imp:n=1
c
4354  0 2 -82  84 -88 fill=7 (5.3721 10.7442 0) u=148 imp:n=1
c
4355  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=148 imp:n=1
c
c Surround material
c
c
4356  0 89 -90 91 -92 (-85:86:-87:88) -71 u=148 imp:n=1
c
4357  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=148 imp:n=1
c
4358  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=148 imp:n=1
c
4359  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=148 imp:n=1
c
4360  0 89 -90 91 -92 (-85:86:-87:88) 74 u=148 imp:n=1
c
c
c Core region with XYZ elements. Central Upper Array
c
4561  0 85 -81  87 -83 fill=1 (-10.7442 -10.7442 0) u=129 imp:n=1
c
4562  0 81 -1  87 -83 fill=1 (-5.3721 -10.7442 0) u=129 imp:n=1
c
4563  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=129 imp:n=1
c
4564  0 2 -82  87 -83 fill=1 (5.3721 -10.7442 0) u=129 imp:n=1
c
4565  0 82 -86  87 -83 fill=1 (10.7442 -10.7442 0) u=129 imp:n=1
c
c
c
4566  0 85 -81  83 -3 fill=1 (-10.7442 -5.3721 0) u=129 imp:n=1
c
4567  0 81 -1  83 -3 fill=1 (-5.3721 -5.3721 0) u=129 imp:n=1
c
4568  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=129 imp:n=1
c
4569  0 2 -82  83 -3 fill=1 (5.3721 -5.3721 0) u=129 imp:n=1
c
4570  0 82 -86  83 -3 fill=1 (10.7442 -5.3721 0) u=129 imp:n=1
c
c
c
4571  0 85 -81  3 -4 fill=2 (-10.7442 0 0) u=129 imp:n=1
c
4572  0 81 -1  3 -4 fill=2 (-5.3721 0 0) u=129 imp:n=1
c
4573  0 1 -2  3 -4 fill=1 (0 0 0) u=129 imp:n=1
c
4574  0 2 -82  3 -4 fill=2 (5.3721 0 0) u=129 imp:n=1
c
4575  0 82 -86  3 -4 fill=2 (10.7442 0 0) u=129 imp:n=1
c
c
c
4576  0 85 -81  4 -84 fill=2 (-10.7442 5.3721 0) u=129 imp:n=1
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

4577  0 81 -1  4 -84 fill=2 (-5.3721 5.3721 0) u=129 imp:n=1
c
4578  0 1 -2  4 -84 fill=1 (0 5.3721 0) u=129 imp:n=1
c
4579  0 2 -82  4 -84 fill=2 (5.3721 5.3721 0) u=129 imp:n=1
c
4580  0 82 -86  4 -84 fill=2 (10.7442 5.3721 0) u=129 imp:n=1
c
c
4581  0 85 -81  84 -88 fill=2 (-10.7442 10.7442 0) u=129 imp:n=1
c
4582  0 81 -1  84 -88 fill=2 (-5.3721 10.7442 0) u=129 imp:n=1
c
4583  0 1 -2  84 -88 fill=2 (0 10.7442 0) u=129 imp:n=1
c
4584  0 2 -82  84 -88 fill=2 (5.3721 10.7442 0) u=129 imp:n=1
c
4585  0 82 -86  84 -88 fill=2 (10.7442 10.7442 0) u=129 imp:n=1
c
c Surround material
c
4586  0 89 -90 91 -92 (-85:86:-87:88) -71 u=129 imp:n=1
c
4587  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=129 imp:n=1
c
4588  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=129 imp:n=1
c
4589  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=129 imp:n=1
c
4590  0 89 -90 91 -92 (-85:86:-87:88) 74 u=129 imp:n=1
c
c
c Core region with XYZ elements. Central line Left array
c
4601  0 85 -81  87 -83 fill=2 (-10.7442 -10.7442 0) u=126 imp:n=1
c
4602  0 81 -1  87 -83 fill=2 (-5.3721 -10.7442 0) u=126 imp:n=1
c
4603  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=126 imp:n=1
c
4604  0 2 -82  87 -83 fill=1 (5.3721 -10.7442 0) u=126 imp:n=1
c
4605  0 82 -86  87 -83 fill=1 (10.7442 -10.7442 0) u=126 imp:n=1
c
c
4606  0 85 -81  83 -3 fill=2 (-10.7442 -5.3721 0) u=126 imp:n=1
c
4607  0 81 -1  83 -3 fill=2 (-5.3721 -5.3721 0) u=126 imp:n=1
c
4608  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=126 imp:n=1
c
4609  0 2 -82  83 -3 fill=1 (5.3721 -5.3721 0) u=126 imp:n=1
c
4610  0 82 -86  83 -3 fill=1 (10.7442 -5.3721 0) u=126 imp:n=1
c
c
4611  0 85 -81  3 -4 fill=2 (-10.7442 0 0) u=126 imp:n=1
c
4612  0 81 -1  3 -4 fill=2 (-5.3721 0 0) u=126 imp:n=1
c
4613  0 1 -2  3 -4 fill=2 (0 0 0) u=126 imp:n=1
c
4614  0 2 -82  3 -4 fill=1 (5.3721 0 0) u=126 imp:n=1
c
4615  0 82 -86  3 -4 fill=1 (10.7442 0 0) u=126 imp:n=1
c
c
4616  0 85 -81  4 -84 fill=2 (-10.7442 5.3721 0) u=126 imp:n=1
c
4617  0 81 -1  4 -84 fill=2 (-5.3721 5.3721 0) u=126 imp:n=1
c
4618  0 1 -2  4 -84 fill=2 (0 5.3721 0) u=126 imp:n=1
c
4619  0 2 -82  4 -84 fill=1 (5.3721 5.3721 0) u=126 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4620  0 82 -86  4 -84 fill=1 (10.7442 5.3721 0) u=126 imp:n=1
c
c
4621  0 85 -81  84 -88 fill=2 (-10.7442 10.7442 0) u=126 imp:n=1
c
4622  0 81 -1  84 -88 fill=2 (-5.3721 10.7442 0) u=126 imp:n=1
c
4623  0 1 -2  84 -88 fill=2 (0 10.7442 0) u=126 imp:n=1
c
4624  0 2 -82  84 -88 fill=1 (5.3721 10.7442 0) u=126 imp:n=1
c
4625  0 82 -86  84 -88 fill=1 (10.7442 10.7442 0) u=126 imp:n=1
c
c Surround material
c
4626  0 89 -90 91 -92 (-85:86:-87:88) -71 u=126 imp:n=1
c
4627  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=126 imp:n=1
c
4628  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=126 imp:n=1
c
4629  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=126 imp:n=1
c
4630  0 89 -90 91 -92 (-85:86:-87:88) 74 u=126 imp:n=1
c
c
c Core region with XYZ elements. Central line Right Array
c
4631  0 85 -81  87 -83 fill=1 (-10.7442 -10.7442 0) u=141 imp:n=1
c
4632  0 81 -1  87 -83 fill=2 (-5.3721 -10.7442 0) u=141 imp:n=1
c
4633  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=141 imp:n=1
c
4634  0 2 -82  87 -83 fill=2 (5.3721 -10.7442 0) u=141 imp:n=1
c
4635  0 82 -86  87 -83 fill=2 (10.7442 -10.7442 0) u=141 imp:n=1
c
c
4636  0 85 -81  83 -3 fill=1 (-10.7442 -5.3721 0) u=141 imp:n=1
c
4637  0 81 -1  83 -3 fill=2 (-5.3721 -5.3721 0) u=141 imp:n=1
c
4638  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=141 imp:n=1
c
4639  0 2 -82  83 -3 fill=2 (5.3721 -5.3721 0) u=141 imp:n=1
c
4640  0 82 -86  83 -3 fill=2 (10.7442 -5.3721 0) u=141 imp:n=1
c
c
4641  0 85 -81  3 -4 fill=1 (-10.7442 0 0) u=141 imp:n=1
c
4642  0 81 -1  3 -4 fill=2 (-5.3721 0 0) u=141 imp:n=1
c
4643  0 1 -2  3 -4 fill=2 (0 0 0) u=141 imp:n=1
c
4644  0 2 -82  3 -4 fill=2 (5.3721 0 0) u=141 imp:n=1
c
4645  0 82 -86  3 -4 fill=2 (10.7442 0 0) u=141 imp:n=1
c
c
4646  0 85 -81  4 -84 fill=1 (-10.7442 5.3721 0) u=141 imp:n=1
c
4647  0 81 -1  4 -84 fill=2 (-5.3721 5.3721 0) u=141 imp:n=1
c
4648  0 1 -2  4 -84 fill=2 (0 5.3721 0) u=141 imp:n=1
c
4649  0 2 -82  4 -84 fill=2 (5.3721 5.3721 0) u=141 imp:n=1
c
4650  0 82 -86  4 -84 fill=2 (10.7442 5.3721 0) u=141 imp:n=1
c
c
4651  0 85 -81  84 -88 fill=1 (-10.7442 10.7442 0) u=141 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4652  0 81 -1  84 -88 fill=2 (-5.3721 10.7442 0) u=141 imp:n=1
c
4653  0 1 -2  84 -88 fill=2 (0 10.7442 0) u=141 imp:n=1
c
4654  0 2 -82  84 -88 fill=2 (5.3721 10.7442 0) u=141 imp:n=1
c
4655  0 82 -86  84 -88 fill=2 (10.7442 10.7442 0) u=141 imp:n=1
c
c Surround material
c
4656  0 89 -90 91 -92 (-85:86:-87:88) -71 u=141 imp:n=1
c
4657  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=141 imp:n=1
c
4658  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=141 imp:n=1
c
4659  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=141 imp:n=1
c
4660  0 89 -90 91 -92 (-85:86:-87:88) 74 u=141 imp:n=1
c
c
c Core region with XYZ elements. Central Lower Array
c
4661  0 85 -81  87 -83 fill=2 (-10.7442 -10.7442 0) u=142 imp:n=1
c
4662  0 81 -1  87 -83 fill=2 (-5.3721 -10.7442 0) u=142 imp:n=1
c
4663  0 1 -2  87 -83 fill=2 (0 -10.7442 0) u=142 imp:n=1
c
4664  0 2 -82  87 -83 fill=2 (5.3721 -10.7442 0) u=142 imp:n=1
c
4665  0 82 -86  87 -83 fill=2 (10.7442 -10.7442 0) u=142 imp:n=1
c
c
4666  0 85 -81  83 -3 fill=2 (-10.7442 -5.3721 0) u=142 imp:n=1
c
4667  0 81 -1  83 -3 fill=2 (-5.3721 -5.3721 0) u=142 imp:n=1
c
4668  0 1 -2  83 -3 fill=2 (0 -5.3721 0) u=142 imp:n=1
c
4669  0 2 -82  83 -3 fill=2 (5.3721 -5.3721 0) u=142 imp:n=1
c
4670  0 82 -86  83 -3 fill=2 (10.7442 -5.3721 0) u=142 imp:n=1
c
c
4671  0 85 -81  3 -4 fill=2 (-10.7442 0 0) u=142 imp:n=1
c
4672  0 81 -1  3 -4 fill=2 (-5.3721 0 0) u=142 imp:n=1
c
4673  0 1 -2  3 -4 fill=2 (0 0 0) u=142 imp:n=1
c
4674  0 2 -82  3 -4 fill=2 (5.3721 0 0) u=142 imp:n=1
c
4675  0 82 -86  3 -4 fill=2 (10.7442 0 0) u=142 imp:n=1
c
c
4676  0 85 -81  4 -84 fill=1 (-10.7442 5.3721 0) u=142 imp:n=1
c
4677  0 81 -1  4 -84 fill=1 (-5.3721 5.3721 0) u=142 imp:n=1
c
4678  0 1 -2  4 -84 fill=1 (0 5.3721 0) u=142 imp:n=1
c
4679  0 2 -82  4 -84 fill=1 (5.3721 5.3721 0) u=142 imp:n=1
c
4680  0 82 -86  4 -84 fill=1 (10.7442 5.3721 0) u=142 imp:n=1
c
c
4681  0 85 -81  84 -88 fill=1 (-10.7442 10.7442 0) u=142 imp:n=1
c
4682  0 81 -1  84 -88 fill=1 (-5.3721 10.7442 0) u=142 imp:n=1
c
4683  0 1 -2  84 -88 fill=1 (0 10.7442 0) u=142 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4684    0 2 -82  84 -88 fill=1 (5.3721 10.7442 0) u=142 imp:n=1
c
4685    0 82 -86  84 -88 fill=1 (10.7442 10.7442 0) u=142 imp:n=1
c
c Surround material
c
4686    0 89 -90 91 -92 (-85:86:-87:88) -71 u=142 imp:n=1
c
4687    19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=142 imp:n=1
c
4688    0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=142 imp:n=1
c
4689    19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=142 imp:n=1
c
4690    0 89 -90 91 -92 (-85:86:-87:88) 74 u=142 imp:n=1
c
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
4701    0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=131 imp:n=1
c
4702    0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=131 imp:n=1
c
4703    0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=131 imp:n=1
c
4704    0 2 -82  87 -83 fill=7 (5.3721 -10.7442 0) u=131 imp:n=1
c
4705    0 82 -86  87 -83 fill=7 (10.7442 -10.7442 0) u=131 imp:n=1
c
c
4706    0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=131 imp:n=1
c
4707    0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=131 imp:n=1
c
4708    0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=131 imp:n=1
c
4709    0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=131 imp:n=1
c
4710    0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=131 imp:n=1
c
c
4711    0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=131 imp:n=1
c
4712    0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=131 imp:n=1
c
4713    0 1 -2  3 -4 fill=9 (0 0 0) u=131 imp:n=1
c
4714    0 2 -82  3 -4 fill=9 (5.3721 0 0) u=131 imp:n=1
c
4715    0 82 -86  3 -4 fill=9 (10.7442 0 0) u=131 imp:n=1
c
c
4716    0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=131 imp:n=1
c
4717    0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=131 imp:n=1
c
4718    0 1 -2  4 -84 fill=9 (0 5.3721 0) u=131 imp:n=1
c
4719    0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=131 imp:n=1
c
4720    0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=131 imp:n=1
c
c
4721    0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=131 imp:n=1
c
4722    0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=131 imp:n=1
c
4723    0 1 -2  84 -88 fill=9 (0 10.7442 0) u=131 imp:n=1
c
4724    0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=131 imp:n=1
c
4725    0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=131 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Surround material
c
4726  0 89 -90 91 -92 (-85:86:-87:88) -71 u=131 imp:n=1
c
4727  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=131 imp:n=1
c
4728  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=131 imp:n=1
c
4729  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=131 imp:n=1
c
4730  0 89 -90 91 -92 (-85:86:-87:88) 74 u=131 imp:n=1
c
c
c Row 7 Mid-Left
c
4731  0 85 -81 87 -83 fill=7 (-10.7442 -10.7442 0) u=132 imp:n=1
c
4732  0 81 -1 87 -83 fill=7 (-5.3721 -10.7442 0) u=132 imp:n=1
c
4733  0 1 -2 87 -83 fill=7 (0 -10.7442 0) u=132 imp:n=1
c
4734  0 2 -82 87 -83 fill=6 (5.3721 -10.7442 0) u=132 imp:n=1
c
4735  0 82 -86 87 -83 fill=6 (10.7442 -10.7442 0) u=132 imp:n=1
c
c
4736  0 85 -81 83 -3 fill=7 (-10.7442 -5.3721 0) u=132 imp:n=1
c
4737  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=132 imp:n=1
c
4738  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=132 imp:n=1
c
4739  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=132 imp:n=1
c
4740  0 82 -86 83 -3 fill=7 (10.7442 -5.3721 0) u=132 imp:n=1
c
c
4741  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=132 imp:n=1
c
4742  0 81 -1 3 -4 fill=7 (-5.3721 0 0) u=132 imp:n=1
c
4743  0 1 -2 3 -4 fill=7 (0 0 0) u=132 imp:n=1
c
4744  0 2 -82 3 -4 fill=7 (5.3721 0 0) u=132 imp:n=1
c
4745  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=132 imp:n=1
c
c
4746  0 85 -81 4 -84 fill=9 (-10.7442 5.3721 0) u=132 imp:n=1
c
4747  0 81 -1 4 -84 fill=9 (-5.3721 5.3721 0) u=132 imp:n=1
c
4748  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=132 imp:n=1
c
4749  0 2 -82 4 -84 fill=7 (5.3721 5.3721 0) u=132 imp:n=1
c
4750  0 82 -86 4 -84 fill=7 (10.7442 5.3721 0) u=132 imp:n=1
c
c
4751  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=132 imp:n=1
c
4752  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=132 imp:n=1
c
4753  0 1 -2 84 -88 fill=9 (0 10.7442 0) u=132 imp:n=1
c
4754  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=132 imp:n=1
c
4755  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=132 imp:n=1
c
c Surround material
c
4756  0 89 -90 91 -92 (-85:86:-87:88) -71 u=132 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4757  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=132 imp:n=1
c
4758  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=132 imp:n=1
c
4759  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=132 imp:n=1
c
4760  0 89 -90 91 -92 (-85:86:-87:88) 74 u=132 imp:n=1
c
c
c   Row 7 Central Array
c
4761  0 85 -81  87 -83 fill=6 (-10.7442 -10.7442 0) u=133 imp:n=1
c
4762  0 81 -1  87 -83 fill=6 (-5.3721 -10.7442 0) u=133 imp:n=1
c
4763  0 1 -2  87 -83 fill=6 (0 -10.7442 0) u=133 imp:n=1
c
4764  0 2 -82  87 -83 fill=6 (5.3721 -10.7442 0) u=133 imp:n=1
c
4765  0 82 -86  87 -83 fill=6 (10.7442 -10.7442 0) u=133 imp:n=1
c
c
c
4766  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=133 imp:n=1
c
4767  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=133 imp:n=1
c
4768  0 1 -2  83 -3 fill=7 (0 -5.3721 0) u=133 imp:n=1
c
4769  0 2 -82  83 -3 fill=7 (5.3721 -5.3721 0) u=133 imp:n=1
c
4770  0 82 -86  83 -3 fill=7 (10.7442 -5.3721 0) u=133 imp:n=1
c
c
c
4771  0 85 -81  3 -4 fill=7 (-10.7442 0 0) u=133 imp:n=1
c
4772  0 81 -1  3 -4 fill=7 (-5.3721 0 0) u=133 imp:n=1
c
4773  0 1 -2  3 -4 fill=7 (0 0 0) u=133 imp:n=1
c
4774  0 2 -82  3 -4 fill=7 (5.3721 0 0) u=133 imp:n=1
c
4775  0 82 -86  3 -4 fill=7 (10.7442 0 0) u=133 imp:n=1
c
c
c
4776  0 85 -81  4 -84 fill=7 (-10.7442 5.3721 0) u=133 imp:n=1
c
4777  0 81 -1  4 -84 fill=7 (-5.3721 5.3721 0) u=133 imp:n=1
c
4778  0 1 -2  4 -84 fill=7 (0 5.3721 0) u=133 imp:n=1
c
4779  0 2 -82  4 -84 fill=7 (5.3721 5.3721 0) u=133 imp:n=1
c
4780  0 82 -86  4 -84 fill=7 (10.7442 5.3721 0) u=133 imp:n=1
c
c
c
4781  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=133 imp:n=1
c
4782  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=133 imp:n=1
c
4783  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=133 imp:n=1
c
4784  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=133 imp:n=1
c
4785  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=133 imp:n=1
c
c   Surround material
c
c
4786  0 89 -90 91 -92 (-85:86:-87:88) -71 u=133 imp:n=1
c
4787  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=133 imp:n=1
c
4788  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=133 imp:n=1
c
4789  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=133 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
4790  0 89 -90 91 -92 (-85:86:-87:88) 74 u=133 imp:n=1
c
c
c Row 7 First Right array
c
4801  0 85 -81 87 -83 fill=6 (-10.7442 -10.7442 0) u=134 imp:n=1
c
4802  0 81 -1 87 -83 fill=6 (-5.3721 -10.7442 0) u=134 imp:n=1
c
4803  0 1 -2 87 -83 fill=7 (0 -10.7442 0) u=134 imp:n=1
c
4804  0 2 -82 87 -83 fill=7 (5.3721 -10.7442 0) u=134 imp:n=1
c
4805  0 82 -86 87 -83 fill=7 (10.7442 -10.7442 0) u=134 imp:n=1
c
c
4806  0 85 -81 83 -3 fill=7 (-10.7442 -5.3721 0) u=134 imp:n=1
c
4807  0 81 -1 83 -3 fill=7 (-5.3721 -5.3721 0) u=134 imp:n=1
c
4808  0 1 -2 83 -3 fill=7 (0 -5.3721 0) u=134 imp:n=1
c
4809  0 2 -82 83 -3 fill=7 (5.3721 -5.3721 0) u=134 imp:n=1
c
4810  0 82 -86 83 -3 fill=7 (10.7442 -5.3721 0) u=134 imp:n=1
c
c
4811  0 85 -81 3 -4 fill=7 (-10.7442 0 0) u=134 imp:n=1
c
4812  0 81 -1 3 -4 fill=7 (-5.3721 0 0) u=134 imp:n=1
c
4813  0 1 -2 3 -4 fill=7 (0 0 0) u=134 imp:n=1
c
4814  0 2 -82 3 -4 fill=7 (5.3721 0 0) u=134 imp:n=1
c
4815  0 82 -86 3 -4 fill=7 (10.7442 0 0) u=134 imp:n=1
c
c
4816  0 85 -81 4 -84 fill=7 (-10.7442 5.3721 0) u=134 imp:n=1
c
4817  0 81 -1 4 -84 fill=7 (-5.3721 5.3721 0) u=134 imp:n=1
c
4818  0 1 -2 4 -84 fill=9 (0 5.3721 0) u=134 imp:n=1
c
4819  0 2 -82 4 -84 fill=9 (5.3721 5.3721 0) u=134 imp:n=1
c
4820  0 82 -86 4 -84 fill=9 (10.7442 5.3721 0) u=134 imp:n=1
c
c
4821  0 85 -81 84 -88 fill=9 (-10.7442 10.7442 0) u=134 imp:n=1
c
4822  0 81 -1 84 -88 fill=9 (-5.3721 10.7442 0) u=134 imp:n=1
c
4823  0 1 -2 84 -88 fill=9 (0 10.7442 0) u=134 imp:n=1
c
4824  0 2 -82 84 -88 fill=9 (5.3721 10.7442 0) u=134 imp:n=1
c
4825  0 82 -86 84 -88 fill=9 (10.7442 10.7442 0) u=134 imp:n=1
c
c Surround material
c
4826  0 89 -90 91 -92 (-85:86:-87:88) -71 u=134 imp:n=1
c
4827  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=134 imp:n=1
c
4828  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=134 imp:n=1
c
4829  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=134 imp:n=1
c
4830  0 89 -90 91 -92 (-85:86:-87:88) 74 u=134 imp:n=1
c
c
c Row 7 Far Right

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
4831  0 85 -81  87 -83 fill=7 (-10.7442 -10.7442 0) u=135 imp:n=1
c
4832  0 81 -1  87 -83 fill=7 (-5.3721 -10.7442 0) u=135 imp:n=1
c
4833  0 1 -2  87 -83 fill=7 (0 -10.7442 0) u=135 imp:n=1
c
4834  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=135 imp:n=1
c
4835  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=135 imp:n=1
c
c
4836  0 85 -81  83 -3 fill=7 (-10.7442 -5.3721 0) u=135 imp:n=1
c
4837  0 81 -1  83 -3 fill=7 (-5.3721 -5.3721 0) u=135 imp:n=1
c
4838  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=135 imp:n=1
c
4839  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=135 imp:n=1
c
4840  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=135 imp:n=1
c
c
4841  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=135 imp:n=1
c
4842  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=135 imp:n=1
c
4843  0 1 -2  3 -4 fill=9 (0 0 0) u=135 imp:n=1
c
4844  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=135 imp:n=1
c
4845  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=135 imp:n=1
c
c
4846  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=135 imp:n=1
c
4847  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=135 imp:n=1
c
4848  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=135 imp:n=1
c
4849  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=135 imp:n=1
c
4850  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=135 imp:n=1
c
c
4851  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=135 imp:n=1
c
4852  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=135 imp:n=1
c
4853  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=135 imp:n=1
c
4854  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=135 imp:n=1
c
4855  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=135 imp:n=1
c
c Surround material
c
4856  0 89 -90 91 -92 (-85:86:-87:88) -71 u=135 imp:n=1
c
4857  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=135 imp:n=1
c
4858  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=135 imp:n=1
c
4859  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=135 imp:n=1
c
4860  0 89 -90 91 -92 (-85:86:-87:88) 74 u=135 imp:n=1
c
c
c Beyond the reflector 5x5 Region 9
c
5001  0 85 -81  87 -83 fill=9 (-10.7442 -10.7442 0) u=201 imp:n=1
c
5002  0 81 -1  87 -83 fill=9 (-5.3721 -10.7442 0) u=201 imp:n=1

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
5003  0 1 -2  87 -83 fill=9 (0 -10.7442 0) u=201 imp:n=1
c
5004  0 2 -82  87 -83 fill=9 (5.3721 -10.7442 0) u=201 imp:n=1
c
5005  0 82 -86  87 -83 fill=9 (10.7442 -10.7442 0) u=201 imp:n=1
c
c
5006  0 85 -81  83 -3 fill=9 (-10.7442 -5.3721 0) u=201 imp:n=1
c
5007  0 81 -1  83 -3 fill=9 (-5.3721 -5.3721 0) u=201 imp:n=1
c
5008  0 1 -2  83 -3 fill=9 (0 -5.3721 0) u=201 imp:n=1
c
5009  0 2 -82  83 -3 fill=9 (5.3721 -5.3721 0) u=201 imp:n=1
c
5010  0 82 -86  83 -3 fill=9 (10.7442 -5.3721 0) u=201 imp:n=1
c
c
5011  0 85 -81  3 -4 fill=9 (-10.7442 0 0) u=201 imp:n=1
c
5012  0 81 -1  3 -4 fill=9 (-5.3721 0 0) u=201 imp:n=1
c
5013  0 1 -2  3 -4 fill=9 (0 0 0) u=201 imp:n=1
c
5014  0 2 -82  3 -4 fill=9 (5.3721 0 0) u=201 imp:n=1
c
5015  0 82 -86  3 -4 fill=9 (10.7442 0 0) u=201 imp:n=1
c
c
5016  0 85 -81  4 -84 fill=9 (-10.7442 5.3721 0) u=201 imp:n=1
c
5017  0 81 -1  4 -84 fill=9 (-5.3721 5.3721 0) u=201 imp:n=1
c
5018  0 1 -2  4 -84 fill=9 (0 5.3721 0) u=201 imp:n=1
c
5019  0 2 -82  4 -84 fill=9 (5.3721 5.3721 0) u=201 imp:n=1
c
5020  0 82 -86  4 -84 fill=9 (10.7442 5.3721 0) u=201 imp:n=1
c
c
5021  0 85 -81  84 -88 fill=9 (-10.7442 10.7442 0) u=201 imp:n=1
c
5022  0 81 -1  84 -88 fill=9 (-5.3721 10.7442 0) u=201 imp:n=1
c
5023  0 1 -2  84 -88 fill=9 (0 10.7442 0) u=201 imp:n=1
c
5024  0 2 -82  84 -88 fill=9 (5.3721 10.7442 0) u=201 imp:n=1
c
5025  0 82 -86  84 -88 fill=9 (10.7442 10.7442 0) u=201 imp:n=1
c
c Surround material
c
5026  0 89 -90 91 -92 (-85:86:-87:88) -71 u=201 imp:n=1
c
5027  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 71 -72 u=201 imp:n=1
c
5028  0 89 -90 91 -92 (-85:86:-87:88) 72 -73 u=201 imp:n=1
c
5029  19 7.403935E-02 89 -90 91 -92 (-85:86:-87:88) 73 -74 u=201 imp:n=1
c
5030  0 89 -90 91 -92 (-85:86:-87:88) 74 u=201 imp:n=1
c
c
c -----
c
c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1      px -2.68605
2      px  2.68605
3      py -2.68605

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

4      py 2.68605
7      pz 0.0 $ Assembly lower limit
8      pz 30.0 $ End Packing, Start Reflector
9      pz 37.60628 $ End Plenum, Start Lower NU
10     pz 67.77878 $ End Lower NU, Start Fuel
11     pz 157.26478 $ End Fuel, Start Upper NU
12     pz 187.43728 $ End Upper NU, Start Top Reflector
13     pz 195.04356 $ End Reflector, Start Packing
16     pz 225.04356 $ Assembly upper limit
17     cz 94.9 $ Outer radius of the assembly
21     px -2.5335 $ Nominal half-width of plates
22     px 2.5335
23     py -2.5335
24     py 2.5335
28     px -2.54 $ Radial shield half-width
29     px 2.54
30     py -2.54
31     py 2.54
32     px -2.551 $ sheath inner half-width
33     px 2.551
34     py -2.551
35     py 2.551
36     px -2.6272 $ sheath outer half-width
37     px 2.6272
38     py -2.6272
39     py 2.6272
c
c
c subdivisions in the axial blanket and core cells
c
c 9      pz 37.60628 $ axial reflector / axial blanket
41     pz 45.228780
42     pz 57.951780
c 10     pz 67.77878 $ axial blanket / core
43     pz 71.21678
44     pz 74.97178
45     pz 78.72678
46     pz 82.48178
47     pz 86.23678
48     pz 89.99178
49     pz 93.74678
50     pz 97.50178
51     pz 101.25678
52     pz 105.01178
53     pz 108.76678
54     pz 112.52178
55     pz 116.27678
56     pz 120.03178
57     pz 123.78678
58     pz 127.54178
59     pz 131.29678
60     pz 135.05178
61     pz 138.80678
62     pz 142.56178
63     pz 146.31678
64     pz 150.07178
65     pz 153.82678
c 11     pz 157.26478 $ core / axial blanket
67     pz 167.09178
68     pz 179.81478
c 12     pz 187.43728 $ axial blanket / reflector
c
c Grid plate heights
c
71     pz 31.8
72     pz 62.2
73     pz 162.6
74     pz 193.0
c
c coordinates of the elements in 5x5 arrays
81     px -8.05815
82     px 8.05815
83     py -8.05815
84     py 8.05815

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

85      px -13.43025
86      px 13.43025
87      py -13.43025
88      py 13.43025
89      px -13.5635
90      px 13.5635
91      py -13.5635
92      py 13.5635
c
c
101     px -2.3355 $ Pu plate core width
102     px 2.3355
103     py -2.3355
104     py 2.3355
105     px -2.4255 $ UO2 plate core width
106     px 2.4255
107     py -2.4255
108     py 2.4255
c the sodium dummy plate type X = STNAVR4 (ring shaped)
109     cz 2.3
c 110    cz 2.5335
110     cz 2.5334
c 109     px -2.4815 $ Na plate core width
c 110     px 2.4815
c 111     py -2.4815
c 112     py 2.4815
c
c
c Cell 2 Axial heights
c
401     pz 153.82678
402     pz 153.86428
403     pz 154.40528
404     pz 154.44278
405     pz 154.47943
406     pz 155.03743
407     pz 155.07408
408     pz 155.11978
409     pz 155.35578
410     pz 155.40148
411     pz 155.43898
412     pz 155.97998
413     pz 156.01748
414     pz 156.05413
415     pz 156.61213
416     pz 156.64878
417     pz 156.68628
418     pz 157.22728
419     pz 157.26478
c
c Cell 12 Axial heights
c
501     pz 67.77878
502     pz 67.816280
503     pz 68.357280
504     pz 68.394780
505     pz 68.431430
506     pz 68.989430
507     pz 69.026080
508     pz 69.063580
509     pz 69.604580
510     pz 69.642080
511     pz 69.687780
512     pz 69.923780
513     pz 69.969480
514     pz 70.006130
515     pz 70.564130
516     pz 70.600780
517     pz 70.638280
518     pz 71.179280
519     pz 71.216780
c
c Basic Cell 1 data
c 701     pz 0.000000

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
c 702    pz    0.037500
c 703    pz    0.578500  $ Na
c 704    pz    0.616000
c 705    pz    0.652650
c 706    pz    1.210650  $ UO2
c 707    pz    1.247300
708      pz    1.564300  $ SS
709      pz    1.610000  $ Pu can
710      pz    1.846000  $ Pu core
711      pz    1.891700
712      pz    1.929200  $ Na can
713      pz    2.470200  $ Na core
c 714      pz    2.507700  $ SS
c 715      pz    2.544350
c 716      pz    3.102350  $ UO2
c 717      pz    3.139000
c 718      pz    3.176500
c 719      pz    3.717500  $ Na
c 720      pz    3.755000  $ Cell 1
```

```
c
801      pz    0.000000
802      pz    0.037500
803      pz    0.578500  $ Na
804      pz    0.616000
805      pz    0.652650
806      pz    1.210650  $ UO2
807      pz    1.247300
808      pz    1.284800
809      pz    1.825800  $ Na
810      pz    1.863300
811      pz    1.909000
812      pz    2.145000  $ Pu
813      pz    2.190700
814      pz    2.507700  $ SS
815      pz    2.544350
816      pz    3.102350  $ UO2
817      pz    3.139000
818      pz    3.176500
819      pz    3.717500  $ Na
820      pz    3.755000  $ Cell 11
```

```
c
c -----
c
```

```
c
c
c ----- TALLY CARDS -----
c
c --- MATERIALS CARDS ---
c
c
```

```
C MATERIAL 1 Pu metal plate core
ml  92238.31c  6.8782E-07
    94238.31c  3.0461E-05
    94239.31c  2.8920E-02
    94240.31c  6.9095E-03
    94241.31c  7.3960E-04
    94242.31c  1.8699E-04
    95241.31c  4.5718E-04
    1001.31c   1.2764E-04
    6000.31c   4.2260E-04
    7014.31c   2.4215E-05
    8016.31c   8.8450E-05
    13027.31c  2.2973E-05
    14028.31c  1.4158E-05
    25055.31c  1.4902E-06
    24050.31c  1.5637E-07
    24052.31c  3.0155E-06
    24053.31c  3.4193E-07
    24054.31c  8.5114E-08
    26054.31c  9.5478E-07
    26056.31c  1.4988E-05
    26057.31c  3.4614E-07
    26058.31c  4.6065E-09
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

28058.31c	5.8334E-06
28060.31c	2.2470E-06
28061.31c	9.7676E-08
28062.31c	3.1143E-07
28064.31c	7.9313E-08
31000.31c	2.0166E-03
c total 3.9991E-02	
c MATERIAL 2 Pu plate canning	
m2	1001.31c 1.3760E-05
6000.31c	1.1393E-04
14028.31c	3.6607E-04
15031.31c	1.3731E-05
24050.31c	4.0848E-04
24052.31c	7.8771E-03
24053.31c	8.9320E-04
24054.31c	2.2234E-04
25055.31c	8.5931E-04
26054.31c	2.0774E-03
26056.31c	3.2611E-02
26057.31c	7.5313E-04
26058.31c	1.0023E-05
28058.31c	2.8351E-03
28060.31c	1.0921E-03
28061.31c	4.7472E-05
28062.31c	1.5136E-04
28064.31c	3.8548E-05
29063.31c	1.1629E-02
29065.31c	4.9839E-03
c total 6.6997E-02	
C MATERIAL 3 UO2 plate core	
m3	1001.31c 3.1773E-05
6000.31c	1.1808E-05
8016.31c	4.6008E-02
13027.31c	3.3911E-06
14028.31c	2.2967E-05
25055.31c	8.3273E-08
26054.31c	7.6610E-08
26056.31c	1.2026E-06
26057.31c	2.7774E-08
26058.31c	3.6962E-10
28058.31c	8.4906E-07
28060.31c	3.2705E-07
28061.31c	1.4217E-08
28062.31c	4.5329E-08
28064.31c	1.1544E-08
42000.66c	3.3379E-07
92235.31c	1.6544E-04
92238.31c	2.2837E-02
c total 6.9083E-02	
c MATERIAL 4 UO2 plate canning	
m4	1001.31c 1.9035E-05
6000.31c	1.2831E-04
14028.31c	6.4475E-04
15031.31c	3.5078E-04
16032.31c	3.6041E-05
24050.31c	6.0044E-04
24052.31c	1.1579E-02
24053.31c	1.3129E-03
24054.31c	3.2682E-04
25055.31c	8.5559E-04
26054.31c	2.8235E-03
26056.31c	4.4323E-02
26057.31c	1.0236E-03
26058.31c	1.3622E-05
28058.31c	5.7360E-03
28060.31c	2.2095E-03
28061.31c	9.6046E-05
28062.31c	3.0624E-04
28064.31c	7.7989E-05
c total 7.2463E-02	
c MATERIAL 6 Dummy plate X	
m6	1001.31c 2.4073E-05
6000.31c	2.7547E-04
14028.31c	7.5592E-04

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

15031.31c  4.5399E-05
16032.31c  1.2036E-05
25055.31c  1.1688E-03
24050.31c  7.2101E-04
24052.31c  1.3904E-02
24053.31c  1.5766E-03
24054.31c  3.9245E-04
26054.31c  3.4629E-03
26056.31c  5.4360E-02
26057.31c  1.2554E-03
26058.31c  1.6707E-04
28058.31c  6.7629E-03
28060.31c  2.6051E-03
28061.31c  1.1324E-04
28062.31c  3.6106E-04
28064.31c  9.1951E-05
41093.31c  4.0746E-04
c total 8.84628E-02
C MATERIAL 7 40% steel plate
c m7      1001.31c  1.8355E-05
c      6000.31c  8.7794E-05
c      13027.31c  1.1862E-04
c      14028.31c  7.9703E-04
c      15031.31c  4.0018E-05
c      16032.31c  1.4422E-05
c      22000.62c  2.4806E-04
c      24050.31c  6.9120E-04
c      24052.31c  1.3329E-02
c      24053.31c  1.5114E-03
c      24054.31c  3.7622E-04
c      25055.31c  1.4972E-03
c      26054.31c  3.2362E-03
c      26056.31c  5.0801E-02
c      26057.31c  1.1732E-03
c      26058.31c  1.5613E-05
c      28058.31c  5.9891E-03
c      28060.31c  2.3070E-03
c      28061.31c  1.0028E-04
c      28062.31c  3.1975E-04
c      28064.31c  8.1431E-05
c      29063.31c  5.0365E-05
c      41093.31c  4.9781E-06
c      42000.66c  8.0988E-05
c
c 40% ss plate smeared over plate region
c
m7      1001.31c  7.3413E-06
      6000.31c  3.5114E-05
      13027.31c  4.7443E-05
      14028.31c  3.1878E-04
      15031.31c  1.6006E-05
      16032.31c  5.7682E-06
      22000.62c  9.9214E-05
      24050.31c  2.7645E-04
      24052.31c  5.3311E-03
      24053.31c  6.0450E-04
      24054.31c  1.5047E-04
      25055.31c  5.9882E-04
      26054.31c  1.2944E-03
      26056.31c  2.0318E-02
      26057.31c  4.6923E-04
      26058.31c  6.2446E-06
      28058.31c  2.3954E-03
      28060.31c  9.2271E-04
      28061.31c  4.0108E-05
      28062.31c  1.2789E-04
      28064.31c  3.2569E-05
      29063.31c  1.4101E-05
      29065.31c  6.0432E-06
      41093.31c  1.9910E-06
      42000.66c  3.2392E-05
c total 3.3152E-02
c
C MATERIAL 8 U8 metal plate

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

m8      1001.31c  4.4048E-05
        6000.31c  4.9283E-04
        14028.31c 2.1076E-04
        26054.31c  6.1951E-06
        26056.31c  9.7250E-05
        26057.31c  2.2459E-06
        26058.31c  2.9889E-08
        92235.31c  3.3369E-04
        92238.31c  4.6021E-02
c total 4.7208E-02
C MATERIAL 9 U2 metal plate
m9      1001.31c  4.3899E-05
        6000.31c  4.6047E-04
        14028.31c 1.9692E-04
        26054.31c  5.7884E-06
        26056.31c  9.0866E-05
        26057.31c  2.0985E-06
        26058.31c  2.7927E-08
        92235.31c  3.3962E-04
        92238.31c  4.6785E-02
c total 4.7925E-02
c
c MATERIAL 10 Dummy plate Y
c
m10     1001.31c  2.4073E-05
        6000.31c  2.5251E-04
        14028.31c 7.4610E-04
        15031.31c  1.7803E-05
        16032.31c  1.7195E-05
        25055.31c  1.5006E-03
        24050.31c  7.0597E-04
        24052.31c  1.3614E-02
        24053.31c  1.5437E-03
        24054.31c  3.8427E-04
        26054.31c  3.5001E-03
        26056.31c  5.4943E-02
        26057.31c  1.2689E-03
        26058.31c  1.6886E-04
        28058.31c  6.3995E-03
        28060.31c  2.4651E-03
        28061.31c  1.0716E-04
        28062.31c  3.4166E-04
        28064.31c  8.7011E-05
        41093.31c  3.7393E-04
c total 8.84614E-02
c MATERIAL 11 Honeycomb dummy plate
c CR 2.4643E-03 FE 8.0717E-03 NI 1.2195E-03
m11     1001.31c  3.3245E-06
        6000.31c  3.3477E-05
        14028.31c 1.2169E-04
        15031.31c  4.9764E-06
        16032.31c  2.5076E-06
        25055.31c  1.9518E-04
        24050.31c  1.0707E-04
        24052.31c  2.0648E-03
        24053.31c  2.3413E-04
        24054.31c  5.8281E-05
        26054.31c  4.7179E-04
        26056.31c  7.4061E-03
        26057.31c  1.7104E-04
        26058.31c  2.2762E-05
        28058.31c  8.3019E-04
        28060.31c  3.1979E-04
        28061.31c  1.3901E-05
        28062.31c  4.4323E-05
        28064.31c  1.1288E-05
        41093.31c  5.2657E-05
c total 1.216928E-02
c
c Material 12 Radial shield
m12     1001.31c  4.6306E-05
        6000.31c  6.8972E-04
        14028.31c 3.1158E-04
        15031.31c  4.2944E-05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

16032.31c 3.7110E-05
25055.31c 7.1275E-04
26054.31c 4.9065E-03
26056.31c 7.4517E-02
26057.31c 1.7491E-03
26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
ml3 1001.31c 4.6306E-08
6000.31c 6.8972E-07
14028.31c 3.1158E-07
15031.31c 4.2944E-08
16032.31c 3.7110E-08
25055.31c 7.1275E-07
26054.31c 4.9065E-06
26056.31c 7.4517E-05
26057.31c 1.7491E-06
26058.31c 2.5903E-07
c total 8.32720E-05
c
c Axial shield
ml4 1001.31c 2.5700E-05
6000.31c 5.1066E-04
13027.31c 1.3989E-04
22000.62c 3.9416E-05
24050.31c 1.2213E-06
24052.31c 2.2823E-05
24053.31c 2.5531E-06
24054.31c 6.2449E-07
25055.31c 3.2634E-04
26054.31c 5.0496E-03
26056.31c 7.6690E-02
26057.31c 1.8001E-03
26058.31c 2.6658E-04
28058.31c 1.2564E-06
28060.31c 4.6968E-07
28061.31c 2.2000E-08
28062.31c 6.2769E-08
28064.31c 1.6774E-08
29063.31c 3.1184E-05
29065.31c 1.3364E-05
42000.66c 9.8355E-06
c total 8.4932E-02
c
c Natural Uranium Breeder
ml5 1001.31c 4.4574E-05
6000.31c 4.7140E-04
14028.31c 2.0160E-04
26054.31c 6.1085E-06
26056.31c 9.2771E-05
26057.31c 2.1776E-06
26058.31c 3.2248E-07
92235.31c 3.4209E-04
92238.31c 4.7156E-02
c Total 4.8317E-02
c
c Assembly Foot and Top Plates
ml6 1001.31c 3.1777E-05
6000.31c 9.9996E-05
13027.31c 8.3095E-06
24050.31c 6.9087E-08
24052.31c 1.2911E-06
24053.31c 1.4442E-07
24054.31c 3.5326E-08
25055.31c 1.0785E-04
26054.31c 1.9605E-03
26056.31c 2.9775E-02
26057.31c 6.9890E-04
26058.31c 1.0350E-04
28058.31c 1.5636E-07
28060.31c 5.8452E-08
28061.31c 2.7378E-09
28062.31c 7.8115E-09

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

28064.31c 2.0875E-09
29063.31c 6.5270E-06
29065.31c 2.7973E-06
c Total 3.279692E-02
c
c wrapper material
m17 1001.31c 7.5725E-05
    6000.31c 2.3828E-04
    13027.31c 1.9802E-05
    24050.31c 1.6463E-07
    24052.31c 3.0767E-06
    24053.31c 3.4414E-07
    24054.31c 8.4182E-08
    25055.31c 2.5701E-04
    26054.31c 4.6718E-03
    26056.31c 7.0954E-02
    26057.31c 1.6655E-03
    26058.31c 2.4664E-04
    28058.31c 3.7260E-07
    28060.31c 1.3929E-07
    28061.31c 6.5242E-09
    28062.31c 1.8615E-08
    28064.31c 4.9746E-09
    29063.31c 1.5554E-05
    29065.31c 6.6660E-06
c Total 7.81552E-02
c
c
c Superlattice grid plate
c
m19 1001.31c 2.4442E-04
    6000.31c 2.9057E-04
    14028.31c 4.3858E-05
    15031.31c 1.3256E-05
    16032.31c 4.3530E-05
    25055.31c 2.5785E-04
    26054.31c 4.2756E-03
    26056.31c 6.7114E-02
    26057.31c 1.5500E-03
    26058.31c 2.0627E-04
c Total 19 7.403935E-02
c
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 100 1500
ksrc 0.0 0.0 77.0 0.0 0.0 87.9 0.0 0.0 107.0
    0.0 0.0 117.9 0.0 0.0 137.0 0.0 0.0 147.9
    10.74 0.0 77.0 10.74 0.0 87.9 10.74 0.0 107.0
    10.74 0.0 117.9 10.74 0.0 137.0 10.74 0.0 147.9
    -10.74 0.0 77.0 -10.74 0.0 87.9 -10.74 0.0 107.0
    -10.74 0.0 117.9 -10.74 0.0 137.0 -10.74 0.0 147.9
    0.0 10.74 77.0 0.0 10.74 87.9 0.0 10.74 107.0
    0.0 10.74 117.9 0.0 10.74 137.0 0.0 10.74 147.9
    0.0 -10.74 77.0 0.0 -10.74 87.9 -10.74 0.0 107.0
    0.0 -10.74 117.9 0.0 -10.74 137.0 0.0 -10.74 147.9
    10.74 10.74 77.0 10.74 10.74 87.9 10.74 10.74 107.0
    10.74 10.74 117.9 10.74 10.74 137.0 10.74 10.74 147.9
    -10.74 10.74 77.0 -10.74 10.74 87.9 -10.74 10.74 107.0
    -10.74 10.74 117.9 -10.74 10.74 137.0 -10.74 10.74 147.9
    10.74 -10.74 77.0 10.74 -10.74 87.9 10.74 -10.74 107.0
    10.74 -10.74 117.9 10.74 -10.74 137.0 10.74 -10.74 147.9
    -10.74 -10.74 77.0 -10.74 -10.74 87.9 -10.74 -10.74 107.0
    -10.74 -10.74 117.9 -10.74 -10.74 137.0 -10.74 -10.74 147.9
    25.335 0.0 77.0 25.335 0.0 87.9 25.335 0.0 107.0
    25.335 0.0 117.9 25.335 0.0 137.0 25.335 0.0 147.9
    -25.335 0.0 77.0 -25.335 0.0 87.9 -25.335 0.0 107.0
    -25.335 0.0 117.9 -25.335 0.0 137.0 -25.335 0.0 147.9
    0.0 25.335 77.0 0.0 25.335 87.9 0.0 25.335 107.0
    0.0 25.335 117.9 0.0 25.335 137.0 0.0 25.335 147.9
    0.0 -25.335 77.0 0.0 -25.335 87.9 -25.335 0.0 107.0
    0.0 -25.335 117.9 0.0 -25.335 137.0 0.0 -25.335 147.9
    25.335 25.335 77.0 25.335 25.335 87.9 25.335 25.335 107.0
    25.335 25.335 117.9 25.335 25.335 137.0 25.335 25.335 147.9

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
-25.335 25.335 77.0 -25.335 25.335 87.9 -25.335 25.335 107.0
-25.335 25.335 117.9 -25.335 25.335 137.0 -25.335 25.335 147.9
25.335 -25.335 77.0 25.335 -25.335 87.9 25.335 -25.335 107.0
25.335 -25.335 117.9 25.335 -25.335 137.0 25.335 -25.335 147.9
-25.335 -25.335 77.0 -25.335 -25.335 87.9 -25.335 -25.335 107.0
37.6 0.0 77.0 37.6 0.0 87.9 37.6 0.0 107.0
37.6 0.0 117.9 37.6 0.0 137.0 37.6 0.0 147.9
-37.6 0.0 77.0 -37.6 0.0 87.9 -37.6 0.0 107.0
-37.6 0.0 117.9 -37.6 0.0 137.0 -37.6 0.0 147.9
0.0 37.6 77.0 0.0 37.6 87.9 0.0 37.6 107.0
0.0 37.6 117.9 0.0 37.6 137.0 0.0 37.6 147.9
0.0 -37.6 77.0 0.0 -37.6 87.9 -37.6 0.0 107.0
0.0 -37.6 117.9 0.0 -37.6 137.0 0.0 -37.6 147.9
print
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

A4.4 MCNP-JEFF-3.1 Zebra25 Model A

```

Z25 model with main elements represented. JENDL-3.3
c Pin Elements C, E, B, A and J are represented and the equivalent pin cells
c for Pin Elements D, H and L.
c
c
c ----- CELL CARDS -----
c
c --- Core Pin Geometry Element C Calandria NACLIII Pins 8xA and 8xE
c Fuel m21 and m25, can + tube m31 and m35
c Lower padding
1   16 3.279692E-02 -8 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower Reflector
2   14 8.4932E-02 8 -9 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
3   15 4.8317E-02 9 -41 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
4   9 4.7925E-02 41 -42 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
5   8 4.7208E-02 42 -10 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
9   27 0.0513781 33 -34 35 -36 10 -82 u=1 imp:n=1 TMP=2.5301E-08
c
c
10  25 7.1167E-02 -91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
11  21 0.069985 -92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
12  25 7.1167E-02 -93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
13  21 0.069985 -94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
14  21 0.069985 -95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
15  25 7.1167E-02 -96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
16  21 0.069985 -97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
17  25 7.1167E-02 -98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
18  25 7.1167E-02 -99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
19  21 0.069985 -100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
20  25 7.1167E-02 -101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
21  21 0.069985 -102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
22  21 0.069985 -103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
23  25 7.1167E-02 -104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
24  21 0.069985 -105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
25  25 7.1167E-02 -106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c
30  35 0.0596942 -111 91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
31  31 0.062241 -112 92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
32  35 0.0596942 -113 93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
33  31 0.062241 -114 94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
34  31 0.062241 -115 95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
35  35 0.0596942 -116 96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
36  31 0.062241 -117 97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
37      35 0.0596942 -118 98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
38      35 0.0596942 -119 99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
39      31 0.062241 -120 100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
40      35 0.0596942 -121 101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
41      31 0.062241 -122 102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
42      31 0.062241 -123 103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
43      35 0.0596942 -124 104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
44      31 0.062241 -125 105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
45      35 0.0596942 -126 106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
46      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
48      27 0.0513781 33 -34 35 -36 83 -85 u=1 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
50      25 7.1167E-02 -91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
51      21 0.069985 -92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
52      25 7.1167E-02 -93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
53      21 0.069985 -94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
54      21 0.069985 -95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
55      25 7.1167E-02 -96 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
56      21 0.069985 -97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
57      25 7.1167E-02 -98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
58      25 7.1167E-02 -99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
59      21 0.069985 -100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
60      25 7.1167E-02 -101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
61      21 0.069985 -102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
62      21 0.069985 -103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
63      25 7.1167E-02 -104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
64      21 0.069985 -105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
65      25 7.1167E-02 -106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
70      35 0.0596942 -111 91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
71      31 0.062241 -112 92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
72      35 0.0596942 -113 93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
73      31 0.062241 -114 94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
74      31 0.062241 -115 95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
75      35 0.0596942 -116 96 85 -86 u=1 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
76      31 0.062241 -117 97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
77      35 0.0596942 -118 98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
78      35 0.0596942 -119 99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
79      31 0.062241 -120 100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
80      35 0.0596942 -121 101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
81      31 0.062241 -122 102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
82      31 0.062241 -123 103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
83      35 0.0596942 -124 104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
84      31 0.062241 -125 105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
85      35 0.0596942 -126 106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
86      0 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
88      27 0.0513781 33 -34 35 -36 86 -88 u=1 imp:n=1 TMP=2.5301E-08
c
c Top calandria
c
90      25 7.1167E-02 -91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
91      21 0.069985 -92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
92      25 7.1167E-02 -93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
93      21 0.069985 -94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
94      21 0.069985 -95 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
95      25 7.1167E-02 -96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
96      21 0.069985 -97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
97      25 7.1167E-02 -98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
98      25 7.1167E-02 -99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
99      21 0.069985 -100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
100     25 7.1167E-02 -101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
101     21 0.069985 -102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
102     21 0.069985 -103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
103     25 7.1167E-02 -104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
104     21 0.069985 -105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
105     25 7.1167E-02 -106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
c
110     35 0.0596942 -111 91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
111     31 0.062241 -112 92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
112     35 0.0596942 -113 93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
113     31 0.062241 -114 94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
114     31 0.062241 -115 95 88 -89 u=1 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
115      35 0.0596942 -116 96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
116      31 0.062241 -117 97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
117      35 0.0596942 -118 98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
118      35 0.0596942 -119 99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
119      31 0.062241 -120 100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
120      35 0.0596942 -121 101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
121      31 0.062241 -122 102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
122      31 0.062241 -123 103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
123      35 0.0596942 -124 104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
124      31 0.062241 -125 105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
125      35 0.0596942 -126 106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
126      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
128      27 0.0513781 33 -34 35 -36 89 -11 u=1 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
129      53 7.44684E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=1 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
131      8 4.7208E-02 11 -67 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
132      9 4.7925E-02 67 -68 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
133      15 4.8317E-02 68 -12 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
134      14 8.4932E-02 12 -13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper padding
135      16 3.279692E-02 13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
136      0 132 -133 134 -135 (-21:22:-23:24) u=1 imp:n=1
c   Wrapper
137      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=1 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
138      0 1 -2 3 -4 (-136:137:-138:139) u=1 imp:n=1
c
c   End of Core Pin Geometry Element C
c
c
c   --- Core Pin geometry Element E (& D) NACLIIS Pins 8xD and 8xF
c   D 24 7.1085E-02 F 26 7.1415E-02 clad D 34 5.9086E-02 F 36 6.0033E-02
c   Lower padding
201      16 3.279692E-02 -8 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
202      14 8.4932E-02 8 -9 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
203      15 4.8317E-02 9 -41 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
204      9 4.7925E-02 41 -42 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
205      8 4.7208E-02 42 -10 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
209      27 0.0513781 33 -34 35 -36 10 -82 u=2 imp:n=1 TMP=2.5301E-08
c
c
210      26 7.1415E-02 -91 82 -83 u=2 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
211      24 7.1085E-02 -92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
212      26 7.1415E-02 -93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
213      24 7.1085E-02 -94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
214      24 7.1085E-02 -95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
215      26 7.1415E-02 -96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
216      24 7.1085E-02 -97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
217      26 7.1415E-02 -98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
218      26 7.1415E-02 -99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
219      24 7.1085E-02 -100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
220      26 7.1415E-02 -101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
221      24 7.1085E-02 -102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
222      24 7.1085E-02 -103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
223      26 7.1415E-02 -104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
224      24 7.1085E-02 -105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
225      26 7.1415E-02 -106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c
230      36 6.0033E-02 -111 91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
231      34 5.9086E-02 -112 92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
232      36 6.0033E-02 -113 93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
233      34 5.9086E-02 -114 94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
234      34 5.9086E-02 -115 95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
235      36 6.0033E-02 -116 96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
236      34 5.9086E-02 -117 97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
237      36 6.0033E-02 -118 98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
238      36 6.0033E-02 -119 99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
239      34 5.9086E-02 -120 100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
240      36 6.0033E-02 -121 101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
241      34 5.9086E-02 -122 102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
242      34 5.9086E-02 -123 103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
243      36 6.0033E-02 -124 104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
244      34 5.9086E-02 -125 105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
245      36 6.0033E-02 -126 106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
246      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
248      27 0.0513781 33 -34 35 -36 83 -85 u=2 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

250      26 7.1415E-02 -91 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
251      24 7.1085E-02 -92 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
252      26 7.1415E-02 -93 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
253      24 7.1085E-02 -94 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
254      24 7.1085E-02 -95 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
255      26 7.1415E-02 -96 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
256      24 7.1085E-02 -97 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
257      26 7.1415E-02 -98 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
258      26 7.1415E-02 -99 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
259      24 7.1085E-02 -100 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
260      26 7.1415E-02 -101 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
261      24 7.1085E-02 -102 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
262      24 7.1085E-02 -103 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
263      26 7.1415E-02 -104 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
264      24 7.1085E-02 -105 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
265      26 7.1415E-02 -106 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
c
c
270      36 6.0033E-02 -111 91 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
271      34 5.9086E-02 -112 92 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
272      36 6.0033E-02 -113 93 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
273      34 5.9086E-02 -114 94 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
274      34 5.9086E-02 -115 95 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
275      36 6.0033E-02 -116 96 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
276      34 5.9086E-02 -117 97 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
277      36 6.0033E-02 -118 98 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
278      36 6.0033E-02 -119 99 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
279      34 5.9086E-02 -120 100 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
280      36 6.0033E-02 -121 101 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
281      34 5.9086E-02 -122 102 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
282      34 5.9086E-02 -123 103 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
283      36 6.0033E-02 -124 104 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
284      34 5.9086E-02 -125 105 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
285      36 6.0033E-02 -126 106 85 -86 u=2 imp:n=1 TMP=2.5301E-08
c
286      0 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
288      27 0.0513781 33 -34 35 -36 86 -88 u=2 imp:n=1 TMP=2.5301E-08
c

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c  Top calandria
c
c  290      26 7.1415E-02 -91 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  291      24 7.1085E-02 -92 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  292      26 7.1415E-02 -93 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  293      24 7.1085E-02 -94 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  294      24 7.1085E-02 -95 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  295      26 7.1415E-02 -96 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  296      24 7.1085E-02 -97 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  297      26 7.1415E-02 -98 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  298      26 7.1415E-02 -99 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  299      24 7.1085E-02 -100 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  300      26 7.1415E-02 -101 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  301      24 7.1085E-02 -102 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  302      24 7.1085E-02 -103 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  303      26 7.1415E-02 -104 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  304      24 7.1085E-02 -105 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  305      26 7.1415E-02 -106 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c
c
c  310      36 6.0033E-02 -111 91 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  311      34 5.9086E-02 -112 92 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  312      36 6.0033E-02 -113 93 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  313      34 5.9086E-02 -114 94 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  314      34 5.9086E-02 -115 95 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  315      36 6.0033E-02 -116 96 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  316      34 5.9086E-02 -117 97 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  317      36 6.0033E-02 -118 98 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  318      36 6.0033E-02 -119 99 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  319      34 5.9086E-02 -120 100 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  320      36 6.0033E-02 -121 101 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  321      34 5.9086E-02 -122 102 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  322      34 5.9086E-02 -123 103 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  323      36 6.0033E-02 -124 104 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  324      34 5.9086E-02 -125 105 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  325      36 6.0033E-02 -126 106 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  326      0 33 -34 35 -36 88 -89  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c  Top plate of top calandria
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

328      27 0.0513781 33 -34 35 -36 89 -11 u=2 imp:n=1 TMP=2.5301E-08
c
c Calandria outer wall
c
329      52 7.20749E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=2 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
331      8 4.7208E-02 11 -67 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
332      9 4.7925E-02 67 -68 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
333     15 4.8317E-02 68 -12 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper Reflector
334     14 8.4932E-02 12 -13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper padding
335     16 3.279692E-02 13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
336      0 132 -133 134 -135 (-21:22:-23:24) u=2 imp:n=1
c Wrapper
337     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=2 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
338      0 1 -2 3 -4 (-136:137:-138:139) u=2 imp:n=1
c
c End of Core Pin Geometry Element E (D)
c
c
c --- Core Pin Geometry Element B (H, L) Calandria NACL Pins 11xB and 5xF
c B 22 7.0537E-02 F 26 7.1415E-02 clad 32 5.8537E-02 F 36 6.0033E-02
c Pin F is in circles 93 98 99 101 and 104
c
c Lower padding
401     16 3.279692E-02 -8 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower Reflector
402     14 8.4932E-02 8 -9 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
403     15 4.8317E-02 9 -41 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
404      9 4.7925E-02 41 -42 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
405      8 4.7208E-02 42 -10 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
409     27 0.0513781 33 -34 35 -36 10 -82 u=3 imp:n=1 TMP=2.5301E-08
c
c
410     22 7.0537E-02 -91 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
411     22 7.0537E-02 -92 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
412     26 7.1415E-02 -93 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
413     22 7.0537E-02 -94 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
414     22 7.0537E-02 -95 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
415     22 7.0537E-02 -96 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
416     22 7.0537E-02 -97 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
417     26 7.1415E-02 -98 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
418     26 7.1415E-02 -99 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
419     22 7.0537E-02 -100 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
420     26 7.1415E-02 -101 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
421     22 7.0537E-02 -102 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
422     22 7.0537E-02 -103 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
423     26 7.1415E-02 -104 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

424      22 7.0537E-02 -105 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
425      22 7.0537E-02 -106 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
c
430      32 5.8537E-02 -111 91 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
431      32 5.8537E-02 -112 92 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
432      36 6.0033E-02 -113 93 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
433      32 5.8537E-02 -114 94 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
434      32 5.8537E-02 -115 95 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
435      32 5.8537E-02 -116 96 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
436      32 5.8537E-02 -117 97 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
437      36 6.0033E-02 -118 98 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
438      36 6.0033E-02 -119 99 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
439      32 5.8537E-02 -120 100 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
440      36 6.0033E-02 -121 101 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
441      32 5.8537E-02 -122 102 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
442      32 5.8537E-02 -123 103 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
443      36 6.0033E-02 -124 104 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
444      32 5.8537E-02 -125 105 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
445      32 5.8537E-02 -126 106 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
446      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
448      27 0.0513781 33 -34 35 -36 83 -85 u=3 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
450      22 7.0537E-02 -91 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
451      22 7.0537E-02 -92 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
452      26 7.1415E-02 -93 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
453      22 7.0537E-02 -94 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
454      22 7.0537E-02 -95 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
455      22 7.0537E-02 -96 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
456      22 7.0537E-02 -97 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
457      26 7.1415E-02 -98 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
458      26 7.1415E-02 -99 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
459      22 7.0537E-02 -100 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
460      26 7.1415E-02 -101 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
461      22 7.0537E-02 -102 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
462      22 7.0537E-02 -103 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
463      26 7.1415E-02 -104 85 -86 u=3 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
464      22 7.0537E-02 -105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
465      22 7.0537E-02 -106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
c
c
470      32 5.8537E-02 -111 91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
471      32 5.8537E-02 -112 92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
472      36 6.0033E-02 -113 93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
473      32 5.8537E-02 -114 94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
474      32 5.8537E-02 -115 95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
475      32 5.8537E-02 -116 96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
476      32 5.8537E-02 -117 97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
477      36 6.0033E-02 -118 98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
478      36 6.0033E-02 -119 99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
479      32 5.8537E-02 -120 100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
480      36 6.0033E-02 -121 101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
481      32 5.8537E-02 -122 102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
482      32 5.8537E-02 -123 103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
483      36 6.0033E-02 -124 104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
484      32 5.8537E-02 -125 105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
485      32 5.8537E-02 -126 106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
486      0 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
488      27 0.0513781 33 -34 35 -36 86 -88 u=3 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
490      22 7.0537E-02 -91 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
491      22 7.0537E-02 -92 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
492      26 7.1415E-02 -93 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
493      22 7.0537E-02 -94 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
494      22 7.0537E-02 -95 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
495      22 7.0537E-02 -96 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
496      22 7.0537E-02 -97 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
497      26 7.1415E-02 -98 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
498      26 7.1415E-02 -99 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
499      22 7.0537E-02 -100 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
500      26 7.1415E-02 -101 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
501      22 7.0537E-02 -102 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
502      22 7.0537E-02 -103 88 -89  u=3 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
503      26 7.1415E-02 -104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
504      22 7.0537E-02 -105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
505      22 7.0537E-02 -106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
c
c
510      32 5.8537E-02 -111 91 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
511      32 5.8537E-02 -112 92 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
512      36 6.0033E-02 -113 93 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
513      32 5.8537E-02 -114 94 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
514      32 5.8537E-02 -115 95 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
515      32 5.8537E-02 -116 96 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
516      32 5.8537E-02 -117 97 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
517      36 6.0033E-02 -118 98 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
518      36 6.0033E-02 -119 99 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
519      32 5.8537E-02 -120 100 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
520      36 6.0033E-02 -121 101 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
521      32 5.8537E-02 -122 102 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
522      32 5.8537E-02 -123 103 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
523      36 6.0033E-02 -124 104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
524      32 5.8537E-02 -125 105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
525      32 5.8537E-02 -126 106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
526      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
528      27 0.0513781 33 -34 35 -36 89 -11 u=3 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
529      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=3 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
531      8 4.7208E-02 11 -67 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
532      9 4.7925E-02 67 -68 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
533      15 4.8317E-02 68 -12 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
534      14 8.4932E-02 12 -13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper padding
535      16 3.279692E-02 13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
536      0 132 -133 134 -135 (-21:22:-23:24) u=3 imp:n=1
c   Wrapper
537      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=3 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
538      0 1 -2 3 -4 (-136:137:-138:139) u=3 imp:n=1
c
c   End of Core Pin Geometry Element B (H, L)
c
c
c --- Core Pin Geometry Element A Calandria NACLI Pins 16xC

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c c 23 7.1230E-02 clad 33 6.15349E-02
c
c Lower padding
601 16 3.279692E-02 -8 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower Reflector
602 14 8.4932E-02 8 -9 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
603 15 4.8317E-02 9 -41 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
604 9 4.7925E-02 41 -42 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
605 8 4.7208E-02 42 -10 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
609 27 0.0513781 33 -34 35 -36 10 -82 u=4 imp:n=1 TMP=2.5301E-08
c
c
610 23 7.1230E-02 -91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
611 23 7.1230E-02 -92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
612 23 7.1230E-02 -93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
613 23 7.1230E-02 -94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
614 23 7.1230E-02 -95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
615 23 7.1230E-02 -96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
616 23 7.1230E-02 -97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
617 23 7.1230E-02 -98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
618 23 7.1230E-02 -99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
619 23 7.1230E-02 -100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
620 23 7.1230E-02 -101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
621 23 7.1230E-02 -102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
622 23 7.1230E-02 -103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
623 23 7.1230E-02 -104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
624 23 7.1230E-02 -105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
625 23 7.1230E-02 -106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c
630 33 6.15349E-02 -111 91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
631 33 6.15349E-02 -112 92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
632 33 6.15349E-02 -113 93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
633 33 6.15349E-02 -114 94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
634 33 6.15349E-02 -115 95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
635 33 6.15349E-02 -116 96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
636 33 6.15349E-02 -117 97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
637 33 6.15349E-02 -118 98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
638 33 6.15349E-02 -119 99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
639 33 6.15349E-02 -120 100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
640 33 6.15349E-02 -121 101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
641 33 6.15349E-02 -122 102 82 -83 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
642      33 6.15349E-02 -123 103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
643      33 6.15349E-02 -124 104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
644      33 6.15349E-02 -125 105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
645      33 6.15349E-02 -126 106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
646      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
648      27 0.0513781 33 -34 35 -36 83 -85 u=4 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
650      23 7.1230E-02 -91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
651      23 7.1230E-02 -92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
652      23 7.1230E-02 -93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
653      23 7.1230E-02 -94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
654      23 7.1230E-02 -95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
655      23 7.1230E-02 -96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
656      23 7.1230E-02 -97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
657      23 7.1230E-02 -98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
658      23 7.1230E-02 -99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
659      23 7.1230E-02 -100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
660      23 7.1230E-02 -101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
661      23 7.1230E-02 -102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
662      23 7.1230E-02 -103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
663      23 7.1230E-02 -104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
664      23 7.1230E-02 -105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
665      23 7.1230E-02 -106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
670      33 6.15349E-02 -111 91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
671      33 6.15349E-02 -112 92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
672      33 6.15349E-02 -113 93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
673      33 6.15349E-02 -114 94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
674      33 6.15349E-02 -115 95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
675      33 6.15349E-02 -116 96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
676      33 6.15349E-02 -117 97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
677      33 6.15349E-02 -118 98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
678      33 6.15349E-02 -119 99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
679      33 6.15349E-02 -120 100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
680      33 6.15349E-02 -121 101 85 -86 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
681      33 6.15349E-02 -122 102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
682      33 6.15349E-02 -123 103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
683      33 6.15349E-02 -124 104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
684      33 6.15349E-02 -125 105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
685      33 6.15349E-02 -126 106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
686      0 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
688      27 0.0513781 33 -34 35 -36 86 -88 u=4 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
690      23 7.1230E-02 -91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
691      23 7.1230E-02 -92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
692      23 7.1230E-02 -93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
693      23 7.1230E-02 -94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
694      23 7.1230E-02 -95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
695      23 7.1230E-02 -96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
696      23 7.1230E-02 -97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
697      23 7.1230E-02 -98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
698      23 7.1230E-02 -99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
699      23 7.1230E-02 -100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
700      23 7.1230E-02 -101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
701      23 7.1230E-02 -102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
702      23 7.1230E-02 -103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
703      23 7.1230E-02 -104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
704      23 7.1230E-02 -105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
705      23 7.1230E-02 -106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
710      33 6.15349E-02 -111 91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
711      33 6.15349E-02 -112 92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
712      33 6.15349E-02 -113 93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
713      33 6.15349E-02 -114 94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
714      33 6.15349E-02 -115 95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
715      33 6.15349E-02 -116 96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
716      33 6.15349E-02 -117 97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
717      33 6.15349E-02 -118 98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
718      33 6.15349E-02 -119 99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
719      33 6.15349E-02 -120 100 88 -89 u=4 imp:n=1 TMP=2.5301E-08

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
720      33 6.15349E-02 -121 101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
721      33 6.15349E-02 -122 102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
722      33 6.15349E-02 -123 103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
723      33 6.15349E-02 -124 104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
724      33 6.15349E-02 -125 105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
725      33 6.15349E-02 -126 106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
726      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
728      27 0.0513781 33 -34 35 -36 89 -11 u=4 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
729      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=4 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
731      8 4.7208E-02 11 -67 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
732      9 4.7925E-02 67 -68 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
733      15 4.8317E-02 68 -12 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
734      14 8.4932E-02 12 -13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper padding
735      16 3.279692E-02 13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
736      0 132 -133 134 -135 (-21:22:-23:24) u=4 imp:n=1
c   Wrapper
737      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=4 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
738      0 1 -2 3 -4 (-136:137:-138:139) u=4 imp:n=1
c
c   End of Core Pin Geometry Element A
c
c
c   --- Core Pin Geometry Element J Calandria NACLIV Pins 12xE and 4xUO2
c   E 25 7.1167E-02 28 7.14034E-02 35 5.96942E-02
c   The positions of pin UO2 are the circles 94, 96, 102 and 104
c   Lower padding
801      16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
802      14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
803      15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
804      9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
805      8 4.7208E-02 42 -10 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
809      27 0.0513781 33 -34 35 -36 10 -82 u=5 imp:n=1 TMP=2.5301E-08
c
c
810      25 7.1167E-02 -91 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
811      25 7.1167E-02 -92 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
812      25 7.1167E-02 -93 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
813      28 7.14034E-02 -94 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
814      25 7.1167E-02 -95 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

815      28 7.14034E-02 -96 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
816      25 7.1167E-02 -97 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
817      25 7.1167E-02 -98 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
818      25 7.1167E-02 -99 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
819      25 7.1167E-02 -100 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
820      25 7.1167E-02 -101 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
821      28 7.14034E-02 -102 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
822      25 7.1167E-02 -103 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
823      28 7.14034E-02 -104 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
824      25 7.1167E-02 -105 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
825      25 7.1167E-02 -106 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
c
830      35 5.96942E-02 -111 91 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
831      35 5.96942E-02 -112 92 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
832      35 5.96942E-02 -113 93 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
833      35 5.96942E-02 -114 94 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
834      35 5.96942E-02 -115 95 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
835      35 5.96942E-02 -116 96 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
836      35 5.96942E-02 -117 97 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
837      35 5.96942E-02 -118 98 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
838      35 5.96942E-02 -119 99 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
839      35 5.96942E-02 -120 100 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
840      35 5.96942E-02 -121 101 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
841      35 5.96942E-02 -122 102 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
842      35 5.96942E-02 -123 103 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
843      35 5.96942E-02 -124 104 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
844      35 5.96942E-02 -125 105 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
845      35 5.96942E-02 -126 106 82 -83  u=5 imp:n=1 TMP=2.5301E-08
c
846      0 33 -34 35 -36 82 -83  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
848      27 0.0513781 33 -34 35 -36 83 -85 u=5 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
850      25 7.1167E-02 -91 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
851      25 7.1167E-02 -92 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
852      25 7.1167E-02 -93 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
853      28 7.14034E-02 -94 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
854      25 7.1167E-02 -95 85 -86  u=5 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR - LMFR
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```

c
855      28 7.14034E-02 -96 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
856      25 7.1167E-02 -97 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
857      25 7.1167E-02 -98 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
858      25 7.1167E-02 -99 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
859      25 7.1167E-02 -100 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
860      25 7.1167E-02 -101 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
861      28 7.14034E-02 -102 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
862      25 7.1167E-02 -103 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
863      28 7.14034E-02 -104 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
864      25 7.1167E-02 -105 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
865      25 7.1167E-02 -106 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
c
c
870      35 5.96942E-02 -111 91 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
871      35 5.96942E-02 -112 92 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
872      35 5.96942E-02 -113 93 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
873      35 5.96942E-02 -114 94 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
874      35 5.96942E-02 -115 95 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
875      35 5.96942E-02 -116 96 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
876      35 5.96942E-02 -117 97 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
877      35 5.96942E-02 -118 98 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
878      35 5.96942E-02 -119 99 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
879      35 5.96942E-02 -120 100 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
880      35 5.96942E-02 -121 101 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
881      35 5.96942E-02 -122 102 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
882      35 5.96942E-02 -123 103 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
883      35 5.96942E-02 -124 104 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
884      35 5.96942E-02 -125 105 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
885      35 5.96942E-02 -126 106 85 -86  u=5 imp:n=1 TMP=2.5301E-08
c
886      0 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
888      27 0.0513781 33 -34 35 -36 86 -88 u=5 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
890      25 7.1167E-02 -91 88 -89  u=5 imp:n=1 TMP=2.5301E-08
c
891      25 7.1167E-02 -92 88 -89  u=5 imp:n=1 TMP=2.5301E-08
c
892      25 7.1167E-02 -93 88 -89  u=5 imp:n=1 TMP=2.5301E-08
c
893      28 7.14034E-02 -94 88 -89  u=5 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
894      25 7.1167E-02 -95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
895      28 7.14034E-02 -96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
896      25 7.1167E-02 -97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
897      25 7.1167E-02 -98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
898      25 7.1167E-02 -99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
899      25 7.1167E-02 -100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
900      25 7.1167E-02 -101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
901      28 7.14034E-02 -102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
902      25 7.1167E-02 -103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
903      28 7.14034E-02 -104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
904      25 7.1167E-02 -105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
905      25 7.1167E-02 -106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
910      35 5.96942E-02 -111 91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
911      35 5.96942E-02 -112 92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
912      35 5.96942E-02 -113 93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
913      35 5.96942E-02 -114 94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
914      35 5.96942E-02 -115 95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
915      35 5.96942E-02 -116 96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
916      35 5.96942E-02 -117 97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
917      35 5.96942E-02 -118 98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
918      35 5.96942E-02 -119 99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
919      35 5.96942E-02 -120 100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
920      35 5.96942E-02 -121 101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
921      35 5.96942E-02 -122 102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
922      35 5.96942E-02 -123 103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
923      35 5.96942E-02 -124 104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
924      35 5.96942E-02 -125 105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
925      35 5.96942E-02 -126 106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
926      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
928      27 0.0513781 33 -34 35 -36 89 -11 u=5 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
929      54 6.94698E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=5 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
931      8 4.7208E-02 11 -67 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

932      9 4.7925E-02 67 -68 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
933     15 4.8317E-02 68 -12 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper Reflector
934     14 8.4932E-02 12 -13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper padding
935     16 3.279692E-02 13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
936      0 132 -133 134 -135 (-21:22:-23:24) u=5 imp:n=1
c Wrapper
937     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=5 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
938      0 1 -2 3 -4 (-136:137:-138:139) u=5 imp:n=1
c
c End of Core Pin Geometry Element J
c
c
c --- Core Plate Geometry Element
c Lower padding
1011     16 3.279692E-02 -8 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1012     14 8.4932E-02 8 -9 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
1013     15 4.8317E-02 9 -41 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
1014      9 4.7925E-02 41 -42 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
1015      8 4.7208E-02 42 -10 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na dummy
1022     11 1.216928E-02 10 -504 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1027      3 6.9083E-02 505 -506 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1028      4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-155:156:-157:158:-505:506) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1032     11 1.216928E-02 507 -510 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1035      1 3.9991E-02 151 -152 153 -154 511 -512 u=6 imp:n=1 TMP=2.5301E-08
c Pu canning
1036      2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-151:152:-153:154:-511:512) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1039      3 6.9083E-02 514 -515 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1040      4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-155:156:-157:158:-514:515) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1042     11 1.216928E-02 516 -43 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Insert the 22 central region core cells
c
1051      0 43 -44 21 -22 23 -24 fill=13 (0 0 71.209862) u=6 imp:n=1
c
1052      0 44 -45 21 -22 23 -24 fill=14 (0 0 74.957944) u=6 imp:n=1
c
c
1053      0 45 -46 21 -22 23 -24 fill=13 (0 0 78.706026) u=6 imp:n=1
c
1054      0 46 -47 21 -22 23 -24 fill=14 (0 0 82.454108) u=6 imp:n=1
c
c
1055      0 47 -48 21 -22 23 -24 fill=13 (0 0 86.202190) u=6 imp:n=1

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
1056  0  48 -49 21 -22 23 -24 fill=14 (0 0 89.950272) u=6 imp:n=1
c
c
1057  0  49 -50 21 -22 23 -24 fill=13 (0 0 93.698354) u=6 imp:n=1
c
c
1058  0  50 -51 21 -22 23 -24 fill=14 (0 0 97.446436) u=6 imp:n=1
c
c
1059  0  51 -52 21 -22 23 -24 fill=13 (0 0 101.194518) u=6 imp:n=1
c
c
1060  0  52 -53 21 -22 23 -24 fill=14 (0 0 104.942600) u=6 imp:n=1
c
c
1061  0  53 -54 21 -22 23 -24 fill=13 (0 0 108.690682) u=6 imp:n=1
c
c
1062  0  54 -55 21 -22 23 -24 fill=14 (0 0 112.438764) u=6 imp:n=1
c
c
c
1063  0  55 -56 21 -22 23 -24 fill=13 (0 0 116.186846) u=6 imp:n=1
c
c
1064  0  56 -57 21 -22 23 -24 fill=14 (0 0 119.934928) u=6 imp:n=1
c
c
c
1065  0  57 -58 21 -22 23 -24 fill=13 (0 0 123.683010) u=6 imp:n=1
c
c
1066  0  58 -59 21 -22 23 -24 fill=14 (0 0 127.431092) u=6 imp:n=1
c
c
c
1067  0  59 -60 21 -22 23 -24 fill=13 (0 0 131.179174) u=6 imp:n=1
c
c
1068  0  60 -61 21 -22 23 -24 fill=14 (0 0 134.927256) u=6 imp:n=1
c
c
c
1069  0  61 -62 21 -22 23 -24 fill=13 (0 0 138.675338) u=6 imp:n=1
c
c
1070  0  62 -63 21 -22 23 -24 fill=14 (0 0 142.423420) u=6 imp:n=1
c
c
c
1071  0  63 -64 21 -22 23 -24 fill=13 (0 0 146.171502) u=6 imp:n=1
c
c
1072  0  64 -65 21 -22 23 -24 fill=14 (0 0 149.919584) u=6 imp:n=1
c
c
c
c The top core cell, Cell 2
c
c Na dummy
1082  11 1.216928E-02 65 -404 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1087  3 6.9083E-02 405 -406 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1088  4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-155:156:-157:158:-405:406) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1092  1 3.9991E-02 151 -152 153 -154 408 -409 u=6 imp:n=1 &
      TMP=2.5301E-08
c Pu canning
1093  2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-151:152:-153:154:-408:409) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1102  11 1.216928E-02 410 -413 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1107  3 6.9083E-02 414 -415 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1108  4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-155:156:-157:158:-414:415) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1112  11 1.216928E-02 416 -66 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c

```

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LIQUID METAL FAST REACTOR - LMFR
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```

c
c Upper Axial blanket.
c
1121      8 4.7208E-02 66 -67 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1122      9 4.7925E-02 67 -68 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1123     15 4.8317E-02 68 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1126     14 8.4932E-02 12 -13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1127     16 3.279692E-02 13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Wrapper region
c 1128     17 3.87228E-02 1 -2 3 -4 (-21:22:-23:24) u=6 imp:n=1
c      TMP=2.5301E-08
c gap between plates and wrapper
1131      0 132 -133 134 -135 (-21:22:-23:24) u=6 imp:n=1
c Wrapper
1132     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=6 &
      imp:n=1 TMP=2.5301E-08
c gap outside wrapper
1133      0 1 -2 3 -4 (-136:137:-138:139) u=6 imp:n=1
c
c
c --- Radial Breeder Element
c Lower padding
1241     16 3.279692E-02 -8 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1242     14 8.4932E-02 8 -9 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Radial blanket
1244     15 4.8317E-02 9 -12 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Upper reflector
1246     like 134 but u=7 imp:n=1 TMP=2.5301E-08
c Upper padding
1247     like 135 but u=7 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
1248      0 132 -133 134 -135 (-21:22:-23:24) u=7 imp:n=1
c Wrapper
1249     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=7 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
1250      0 1 -2 3 -4 (-136:137:-138:139) u=7 imp:n=1
c
c
c --- Radial shield
c
1326     12 8.32720E-02 28 -29 30 -31 u=8 imp:n=1 TMP=2.5301E-08
c
1327     13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=8 imp:n=1 &
      TMP=2.5301E-08
c
c
1400     13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly
c
1419      0 189 -190 191 -192 u=10 lat=1
      fill=-3:3 -3:3 0:0
      199 164 162 161 163 165 199
      146 144 142 141 143 145 147
      126 124 122 121 123 125 127
      106 104 102 101 103 105 107
      116 114 112 111 113 115 117
      136 134 132 131 133 135 137
      199 154 152 151 153 155 199
      imp:n=1
c
c --- Fuel Region
c
1429      0 7 -16 -17 fill=10 imp:n=1
c --- Universe
1430      0 -7:16:17 imp:n=0
c

```

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```

c Cell A
c 501    1 6.9985E-02 -71 u=3 imp:n=1 TMP=2.5301E-08
c
c 502    23 0.062241 -74 71 u=3 imp:n=1 TMP=2.5301E-08
c
c 503    5 2.3900E-02 74 u=3 imp:n=1 TMP=2.5301E-08
c
c 504    0 75 -76 77 -78 u=3 fill=1 imp:n=1
c
c Cell E    Modified compositions
c
c 506    2 7.1167E-02 -71 u=4 imp:n=1 TMP=2.5301E-08
c
c 507    24 0.0596942 -74 71 u=4 imp:n=1 TMP=2.5301E-08
c
c 508    5 2.3900E-02 74 u=4 imp:n=1 TMP=2.5301E-08
c
c 509    0 75 -76 77 -78 u=4 fill=2 imp:n=1
c
c 511    0 75 -76 77 -78 lat=1 &
c        fill -2:1 -2:1 0:0 &
c        3 4 3 4 4 3 4 3 3 4 3 4 4 3 4 3 &
c        u=11 imp:n=1
c
c ----- PLATE ELEMENT CELL CARDS -----
c
c The First Regular cell. Cell 1
c
c Na dummy
c
2162    11 1.216928E-02 801 -804 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2167    3 6.9083E-02 805 -806 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2168    4 7.2463E-02 804 -807 21 -22 23 -24 &
        (-155:156:-157:158:-805:806) u=13 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170    7 3.3152E-02 807 -708 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c Pu plate
c Plate core
2172    1 3.9991E-02 151 -152 153 -154 709 -710 u=13 imp:n=1 TMP=2.5301E-08
c Pu canning
2173    2 6.6997E-02 708 -711 21 -22 23 -24 &
        (-151:152:-153:154:-709:710) u=13 imp:n=1 TMP=2.5301E-08
c
c
c Na dummy
c
2182    11 1.216928E-02 711 -814 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2187    3 6.9083E-02 815 -816 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188    4 7.2463E-02 814 -817 21 -22 23 -24 &
        (-155:156:-157:158:-815:816) u=13 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
2192    11 1.216928E-02 817 -820 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c End of Cell 1 beginning of Cell 2
c Na dummy
c
2202    11 1.216928E-02 801 -804 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2207    3 6.9083E-02 805 -806 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08

```


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```

c UO2 plate can
2208  4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=14 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
2211  11 1.216928E-02 807 -810 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2214  1 3.9991E-02 151 -152 153 -154 811 -812 u=14 imp:n=1 TMP=2.5301E-08
C Pu canning
2215  2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-151:152:-153:154:-811:812) u=14 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217  7 3.3152E-02 813 -814 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219  3 6.9083E-02 815 -816 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220  4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=14 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
2222  11 1.216928E-02 817 -820 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c                                     End of plate element cell data
c
c -----
c
c Form the region surrounding groups of 5x5 elements, containing grids
c
c
3001  0 189 -190 191 -192 (-185:186:-187:188) -71 u=100 imp:n=1
c
3002  19 7.403935E-02 189 -190 191 -192 (-185:186:-187:188) 71 -72 &
      u=100 imp:n=1
c
3003  0 189 -190 191 -192 (-185:186:-187:188) 72 -73 u=100 imp:n=1
c
3004  19 7.403935E-02 189 -190 191 -192 (-185:186:-187:188) 73 -74 &
      u=100 imp:n=1
c
3005  0 189 -190 191 -192 (-185:186:-187:188) 74 u=100 imp:n=1
c
c -----
c
c Form arrays of 5x5 elements
c
c                                     Central row
c
c Central array of 5x5 core elements
c
c
3011  0 1 -2 3 -4 u=201 lat=1
      fill=-2:2 -2:2 0:0
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      1 1 1 1 1
      imp:n=1
c
3012  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=101 imp:n=1
c
3013  0 7 -16 185 -186 187 -188 fill=201 u=101 imp:n=1
c
c Middle Left array of 5x5 core elements in row 4

```

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```

c
3014    0    1 -2 3 -4 u=202 lat=1
        fill=-2:2 -2:2 0:0
        4 5 4 2 2
        4 2 4 2 2
        3 2 2 2 2
        4 2 2 2 2
        4 5 2 2 2
        imp:n=1

c
c
c Surround material
c
3015    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=102 imp:n=1
c
c
3016    0  7 -16 185 -186 187 -188 fill=202 u=102 imp:n=1
c
c
c Middle Right array of 5x5 core elements in row 4
c
3017    0    1 -2 3 -4 u=203 lat=1
        fill=-2:2 -2:2 0:0
        2 2 4 5 4
        2 2 4 2 4
        2 2 2 2 3
        2 2 2 2 4
        2 2 3 5 4
        imp:n=1

c
c
c Surround material
c
3018    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=103 imp:n=1
c
c
3019    0  7 -16 185 -186 187 -188 fill=203 u=103 imp:n=1
c
c
c
c Left core edge array of 5x5 elements in row 4
c
3021    0    1 -2 3 -4 u=204 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 6
        7 7 7 7 6
        7 7 7 7 6
        7 7 7 7 6
        7 7 7 7 6
        imp:n=1

c
c
c Surround material
c
3022    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=104 imp:n=1
c
c
3023    0  7 -16 185 -186 187 -188 fill=204 u=104 imp:n=1
c
c
c Right core edge array of 5x5 elements in row 4
c
3024    0    1 -2 3 -4 u=205 lat=1
        fill=-2:2 -2:2 0:0
        6 7 7 7 7
        6 7 7 7 7
        6 7 7 7 7
        6 7 7 7 7
        6 7 7 7 7
        imp:n=1

c
c
c Surround material
c

```

```

3025    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=105 imp:n=1
c
c
3026    0   7 -16 185 -186 187 -188 fill=205 u=105 imp:n=1
c
c
c
c      ROW 3 The row below the central line
c
c
c Middle array of 5x5 core elements in Row 3
c
c
3031        0     1 -2 3 -4 u=211 lat=1
fill=-2:2 -2:2 0:0
1 1 1 1 1
1 1 1 1 1
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
imp:n=1
c
c Surround material
c
3032    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=111 imp:n=1
c
3033    0   7 -16 185 -186 187 -188 fill=211 u=111 imp:n=1
c
c Lower left array of 5x5 core elements in Row 3
c
c
3034        0     1 -2 3 -4 u=212 lat=1
fill=-2:2 -2:2 0:0
6 2 2 1 2
6 2 2 1 2
6 6 4 2 3
7 6 6 3 3
7 7 6 6 6
imp:n=1
c
c Surround material
c
3035    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=112 imp:n=1
c
3036    0   7 -16 185 -186 187 -188 fill=212 u=112 imp:n=1
c
c
c Lower right array of 5x5 core elements in Row 3
c
3037        0     1 -2 3 -4 u=213 lat=1
fill=-2:2 -2:2 0:0
2 2 3 3 6
2 3 3 5 6
3 3 3 6 6
3 3 6 6 7
6 6 6 7 7
imp:n=1
c
c
c Surround material
c
3038    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=113 imp:n=1
c
c
3039    0   7 -16 185 -186 187 -188 fill=213 u=113 imp:n=1
c
c
c
c left array of blanket elements with a single core element
c
c
3041        0     1 -2 3 -4 u=214 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 6
7 7 7 7 7

```

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```

7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3042  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=114 imp:n=1
c
3043  0  7 -16 185 -186 187 -188 fill=214 u=114 imp:n=1
c
c
c right array of blanket elements with two core elements
c
c
3045  0  1 -2 3 -4 u=215 lat=1
      fill=-2:2 -2:2 0:0
      6 7 7 7 7
      6 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3046  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=115 imp:n=1
c
3047  0  7 -16 185 -186 187 -188 fill=215 u=115 imp:n=1
c
c
c          ROW 5 the row above the central line
c
c Central array of 5x5 core elements in Row 5
c
3051  0  1 -2 3 -4 u=221 lat=1
      fill=-2:2 -2:2 0:0
      3 3 3 3 3
      3 3 3 3 3
      3 3 3 3 3
      1 1 1 1 1
      1 1 1 1 1
      imp:n=1
c
c
c Surround material
c
3052  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=121 imp:n=1
c
c
3053  0  7 -16 185 -186 187 -188 fill=221 u=121 imp:n=1
c
c
c Top left array of 5x5 core elements in Row 5
c
3054  0  1 -2 3 -4 u=222 lat=1
      fill=-2:2 -2:2 0:0
      7 7 6 6 6
      7 6 6 3 3
      6 6 4 2 2
      6 5 2 1 2
      6 2 2 1 2
      imp:n=1
c
c
c Surround material
c
3055  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=122 imp:n=1
c
c
3056  0  7 -16 185 -186 187 -188 fill=222 u=122 imp:n=1
c

```

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```

c
c Top right array of 5x5 core elements in Row 5
c
3057    0    1 -2 3 -4 u=223 lat=1
        fill=-2:2 -2:2 0:0
        6 6 6 7 7
        3 3 6 6 7
        2 2 4 6 6
        2 1 2 3 6
        2 1 2 2 6
        imp:n=1

c
c
c Surround material
c
3058    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=123 imp:n=1
c
c
3059    0  7 -16 185 -186 187 -188 fill=223 u=123 imp:n=1
c
c
c
c left array of blanket elements with two core plate elements
c
c
3061    0    1 -2 3 -4 u=224 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 6
        7 7 7 7 6
        imp:n=1

c
c
c Surround material
c
3062    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=124 imp:n=1
c
3063    0  7 -16 185 -186 187 -188 fill=224 u=124 imp:n=1
c
c
c Right array of blanket elements with one core plate element
c
c
3064    0    1 -2 3 -4 u=225 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        6 7 7 7 7
        imp:n=1

c
c
c Surround material
c
3065    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=125 imp:n=1
c
3066    0  7 -16 185 -186 187 -188 fill=225 u=125 imp:n=1
c
c
c          ROW 2 The row two down from the central row
c
c Lower central group
c
c
3071    0    1 -2 3 -4 u=231 lat=1
        fill=-2:2 -2:2 0:0
        6 6 6 6 6
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7

```

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```

        imp:n=1
c
c
c Surround material
c
3072   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=131 imp:n=1
c
3073   0  7 -16 185 -186 187 -188 fill=231 u=131 imp:n=1
c
c
c Left array of blanket elements with one core plate element
c
c
3074     0    1 -2 3 -4 u=232 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 6
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        imp:n=1
c
c
c Surround material
c
3075   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=132 imp:n=1
c
3076   0  7 -16 185 -186 187 -188 fill=232 u=132 imp:n=1
c
c
c
c Right array of blanket elements with one core plate element
c
c
3077     0    1 -2 3 -4 u=233 lat=1
        fill=-2:2 -2:2 0:0
        6 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        imp:n=1
c
c
c Surround material
c
3078   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=133 imp:n=1
c
3079   0  7 -16 185 -186 187 -188 fill=233 u=133 imp:n=1
c
c
c
c ROW 6
c
c Top central array of 5x5 core elements in row 6
c
3081     0    1 -2 3 -4 u=241 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        6 6 6 6 6
        imp:n=1
c
c Surround material
c
3082   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=141 imp:n=1
c
3083   0  7 -16 185 -186 187 -188 fill=241 u=141 imp:n=1
c
c
c
c Left array of blanket elements with one core plate element

```

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```

c
c
3085    0    1 -2 3 -4 u=242 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 6
        imp:n=1

c
c
c Surround material
c
3086    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=142 imp:n=1
c
3087    0 7 -16 185 -186 187 -188 fill=242 u=142 imp:n=1
c
c
c Right central array in Row 6 with one core element (plate)
c
c
3088    0    1 -2 3 -4 u=243 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        6 7 7 7 7
        imp:n=1

c
c Surround material
c
3089    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=143 imp:n=1
c
3090    0 7 -16 185 -186 187 -188 fill=243 u=143 imp:n=1
c
c
c
c *** Blanket-Reflector Arrays ***
c
c ROW 2
c
c Bottom Left
c
c
3111    0    1 -2 3 -4 u=234 lat=1
        fill=-2:2 -2:2 0:0
        8 7 7 7 7
        8 8 7 7 7
        8 8 8 7 7
        8 8 8 8 7
        9 8 8 8 8
        imp:n=1

c
c
c Surround material
c
3112    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=134 imp:n=1
c
3113    0 7 -16 185 -186 187 -188 fill=234 u=134 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
c
3121    0    1 -2 3 -4 u=235 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 8
        7 7 7 8 8
        7 7 8 8 8
        7 8 8 8 8
        8 8 8 8 9
        imp:n=1

```

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```

c
c
c Surround material
c
3122  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=135 imp:n=1
c
3123  0  7 -16 185 -186 187 -188 fill=235 u=135 imp:n=1
c
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
c
3131  0  1 -2 3 -4 u=244 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 8
      8 8 8 8 7
      8 8 8 7 7
      8 8 7 7 7
      8 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3132  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=144 imp:n=1
c
3133  0  7 -16 185 -186 187 -188 fill=244 u=144 imp:n=1
c
c Row 6 Top Right Blanket Reflector Array
c
c
3141  0  1 -2 3 -4 u=245 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 8 9
      7 8 8 8 8
      7 7 8 8 8
      7 7 7 8 8
      7 7 7 7 8
      imp:n=1
c
c
c Surround material
c
3142  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=145 imp:n=1
c
3143  0  7 -16 185 -186 187 -188 fill=245 u=145 imp:n=1
c
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
c
3151  0  1 -2 3 -4 u=254 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1
c
c
c Surround material
c
3152  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=154 imp:n=1
c
3153  0  7 -16 185 -186 187 -188 fill=254 u=154 imp:n=1
c
c Row 1 Mid-Left
c
c

```


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```

3161    0    1 -2 3 -4 u=252 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 7 7
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3162    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=152 imp:n=1
c
3163    0  7 -16 185 -186 187 -188 fill=252 u=152 imp:n=1
c
c Row 1 Central Array
c
3171    0    1 -2 3 -4 u=251 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3172    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=151 imp:n=1
c
3173    0  7 -16 185 -186 187 -188 fill=251 u=151 imp:n=1
c
c Row 1 First Right array
c
c
3181    0    1 -2 3 -4 u=253 lat=1
      fill=-2:2 -2:2 0:0
      7 7 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3182    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=153 imp:n=1
c
3183    0  7 -16 185 -186 187 -188 fill=253 u=153 imp:n=1
c
c Row 1 Far Right
c
c
3191    0    1 -2 3 -4 u=255 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3192    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=155 imp:n=1
c
3193    0  7 -16 185 -186 187 -188 fill=255 u=155 imp:n=1
c
c
c Row 2 Blanket reflector arrays

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Row 2 First Left array
c
c
3201    0    1 -2 3 -4 u=236 lat=1
        fill=-2:2 -2:2 0:0
        9 9 9 8 8
        9 9 9 8 8
        9 9 9 9 8
        9 9 9 9 9
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3202    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=136 imp:n=1
c
3203    0  7 -16 185 -186 187 -188 fill=236 u=136 imp:n=1
c
c Row 2 Far Right
c
c
3211    0    1 -2 3 -4 u=237 lat=1
        fill=-2:2 -2:2 0:0
        8 8 9 9 9
        8 8 9 9 9
        8 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3212    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=137 imp:n=1
c
3213    0  7 -16 185 -186 187 -188 fill=237 u=137 imp:n=1
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
c
3221    0    1 -2 3 -4 u=206 lat=1
        fill=-2:2 -2:2 0:0
        9 8 8 8 7
        9 8 8 8 7
        9 8 8 8 7
        9 8 8 8 7
        9 8 8 8 7
        imp:n=1

c
c
c Surround material
c
3222    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=106 imp:n=1
c
3223    0  7 -16 185 -186 187 -188 fill=206 u=106 imp:n=1
c
c
c Row 4 Far Right
c
c
3231    0    1 -2 3 -4 u=207 lat=1
        fill=-2:2 -2:2 0:0
        7 8 8 8 9
        7 8 8 8 9
        7 8 8 8 9
        7 8 8 8 9
        7 8 8 8 9
        imp:n=1

c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Surround material
c
3232  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=107 imp:n=1
c
3233  0  7 -16 185 -186 187 -188 fill=207 u=107 imp:n=1
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
3241  0  1 -2 3 -4 u=246 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 8
      9 9 9 8 8
      9 9 9 8 8
      imp:n=1
c
c
c Surround material
c
3242  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=146 imp:n=1
c
3243  0  7 -16 185 -186 187 -188 fill=246 u=146 imp:n=1
c
c Row 6 Far Right
c
3251  0  1 -2 3 -4 u=247 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      8 9 9 9 9
      8 8 9 9 9
      8 8 9 9 9
      imp:n=1
c
c
c Surround material
c
3252  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=147 imp:n=1
c
3253  0  7 -16 185 -186 187 -188 fill=247 u=147 imp:n=1
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
c
3261  0  1 -2 3 -4 u=226 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3262  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=126 imp:n=1
c
3263  0  7 -16 185 -186 187 -188 fill=226 u=126 imp:n=1
c
c Row 4 Far Right
c
3271  0  1 -2 3 -4 u=227 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
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```

      8 8 8 9 9
      8 8 8 9 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3272   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=127 imp:n=1
c
3273   0 7 -16 185 -186 187 -188 fill=227 u=127 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays
c
c Row 3 First Left array
c
3281   0 1 -2 3 -4 u=216 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      imp:n=1
c
c
c Surround material
c
3282   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=116 imp:n=1
c
3283   0 7 -16 185 -186 187 -188 fill=216 u=116 imp:n=1
c
c Row 3 Far Right
c
3291   0 1 -2 3 -4 u=217 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      imp:n=1
c
c
c Surround material
c
3292   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=117 imp:n=1
c
3293   0 7 -16 185 -186 187 -188 fill=217 u=117 imp:n=1
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
c
3301   0 1 -2 3 -4 u=264 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 8 8
      9 9 8 8 8
      imp:n=1
c
c
c Surround material
c
3302   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=164 imp:n=1
c
3303   0 7 -16 185 -186 187 -188 fill=264 u=164 imp:n=1
c
c Row 7 Mid-Left

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
3311    0    1 -2 3 -4 u=262 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 7 7
      imp:n=1

c
c
c Surround material
c
3312    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=162 imp:n=1
c
3313    0  7 -16 185 -186 187 -188 fill=262 u=162 imp:n=1
c
c Row 7 Central Array
c
3321    0    1 -2 3 -4 u=261 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      7 7 7 7 7
      imp:n=1

c
c
c Surround material
c
3322    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=161 imp:n=1
c
3323    0  7 -16 185 -186 187 -188 fill=261 u=161 imp:n=1
c
c Row 7 First Right array
c
3331    0    1 -2 3 -4 u=263 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      7 7 8 8 8
      imp:n=1

c
c
c Surround material
c
3332    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=163 imp:n=1
c
3333    0  7 -16 185 -186 187 -188 fill=263 u=163 imp:n=1
c
c Row 7 Far Right
c
3341    0    1 -2 3 -4 u=265 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 9 9
      imp:n=1

c
c
c Surround material
c
3342    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=165 imp:n=1
c
3343    0  7 -16 185 -186 187 -188 fill=265 u=165 imp:n=1
c
c Beyond the reflector 5x5 Region 9
c
3351    0    1 -2 3 -4 u=299 lat=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

fill=-2:2 -2:2 0:0
9 9 9 9 9
9 9 9 9 9
9 9 9 9 9
9 9 9 9 9
9 9 9 9 9
9 9 9 9 9
imp:n=1

c
c
c Surround material
c
3352 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=199 imp:n=1
c
c
3353 0 7 -16 185 -186 187 -188 fill=299 u=199 imp:n=1
c
c
c
c -----
c

c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1 px -2.68605
2 px 2.68605
3 py -2.68605
4 py 2.68605
7 pz 0.0 $ Assembly lower limit
8 pz 30.0 $ End Packing, Start Reflector
9 pz 37.60628 $ End Plenum, Start Lower NU
10 pz 67.77878 $ End Lower NU, Start Fuel
c
11 pz 156.96878 $ End Fuel, Start Upper NU for Pin element
c
12 pz 187.271248 $ End Upper NU, Start Top Reflector
13 pz 194.877528 $ End Reflector, Start Packing
16 pz 224.877528 $ Assembly upper limit
c
c 17 cz 94.9
17 cz 89.5
21 px -2.5335 $ Nominal half-width of plates
22 px 2.5335 $ and calandria outer half-width
23 py -2.5335
24 py 2.5335
28 px -2.54 $ Radial shield half-width
29 px 2.54
30 py -2.54
31 py 2.54
c
33 px -2.45 $ inner half-width of calandria
34 px 2.45
35 py -2.45
36 py 2.45
c
c
c subdivisions in the plate element axial blanket and core cells
c
c 9 pz 37.60628 $ axial reflector / axial blanket
41 pz 45.228780
42 pz 57.951780
c 10 pz 67.77878 $ axial blanket / core
43 pz 71.209862
44 pz 74.957944
45 pz 78.706026
46 pz 82.454108
47 pz 86.202190
48 pz 89.950272
49 pz 93.698354
50 pz 97.446436
51 pz 101.194518
52 pz 104.942600
53 pz 108.690682

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

54 pz 112.438764
55 pz 116.186846
56 pz 119.934928
57 pz 123.683010
58 pz 127.431092
59 pz 131.179174
60 pz 134.927256
61 pz 138.675338
62 pz 142.423420
63 pz 146.171502
64 pz 149.919584
65 pz 153.667666
c
66 pz 157.098748 $ core / axial blanket
c in plate elements (this replaces pz=11)
67 pz 166.925748
68 pz 179.648748
c 12 pz 187.271248 $ axial blanket / reflector
c
c differences in the pin elements ?
c 67 pz 166.925748
c 68 pz 179.648748
c 12 pz 187.271248 $ axial blanket / reflector
c
c Grid plate heights
c
71 pz 31.8
72 pz 62.2
73 pz 162.6
74 pz 193.0
c
c 71 c/z 0 0 0.423 $ fuel pin radius
c 71 c/z 0.6125 0.6125 0.423
c 72 c/z 0 0 0.4305 $ fuel can inner radius
c 73 c/z 0 0 0.488 $ calandria tube inner radius
c 74 c/z 0 0 0.513 $ calandria tube outer radius
c 74 c/z 0.6125 0.6125 0.513
c 75 px 0.0
c 76 px 1.225
c 77 py 0.0
c 78 py 1.225
c 79 cz 1.692
c 80 cz 2.052
c
81 pz 67.77878 $ 0.0
82 pz 68.21878 $ 0.44
83 pz 97.39878 $ 29.62
c 84 pz 97.50878 $ 29.73
85 pz 97.94878 $ 0.44
86 pz 127.12878 $ 29.62
c 87 pz 127.23878 $ 29.73
88 pz 127.67878 $ 0.44
89 pz 156.85878 $ 29.62
90 pz 156.96878 $ 29.73
c
91 c/z -1.785 -1.785 0.423
92 c/z -0.595 -1.785 0.423
93 c/z 0.595 -1.785 0.423
94 c/z 1.785 -1.785 0.423
95 c/z -1.785 -0.595 0.423
96 c/z -0.595 -0.595 0.423
97 c/z 0.595 -0.595 0.423
98 c/z 1.785 -0.595 0.423
99 c/z -1.785 0.595 0.423
100 c/z -0.595 0.595 0.423
101 c/z 0.595 0.595 0.423
102 c/z 1.785 0.595 0.423
103 c/z -1.785 1.785 0.423
104 c/z -0.595 1.785 0.423
105 c/z 0.595 1.785 0.423
106 c/z 1.785 1.785 0.423
c
c
111 c/z -1.785 -1.785 0.513

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

112  c/z -0.595 -1.785 0.513
113  c/z  0.595 -1.785 0.513
114  c/z  1.785 -1.785 0.513
115  c/z -1.785 -0.595 0.513
116  c/z -0.595 -0.595 0.513
117  c/z  0.595 -0.595 0.513
118  c/z  1.785 -0.595 0.513
119  c/z -1.785 0.595 0.513
120  c/z -0.595 0.595 0.513
121  c/z  0.595 0.595 0.513
122  c/z  1.785 0.595 0.513
123  c/z -1.785 1.785 0.513
124  c/z -0.595 1.785 0.513
125  c/z  0.595 1.785 0.513
126  c/z  1.785 1.785 0.513
c
132  px -2.551 $ sheath inner half-width
133  px 2.551
134  py -2.551
135  py 2.551
136  px -2.6272 $ sheath outer half-width
137  px 2.6272
138  py -2.6272
139  py 2.6272
c
c  Widths of plate cores
c  * in plate geometry cores these are 101 to 112
151  px -2.3355 $ Pu plate core width
152  px 2.3355
153  py -2.3355
154  py 2.3355
155  px -2.4255 $ UO2 plate core width
156  px 2.4255
157  py -2.4255
158  py 2.4255
c 159  px -2.4815 $ Na plate core width
c 160  px 2.4815
c 161  py -2.4815
c 162  py 2.4815
c
c
c  coordinates of the elements in 5x5 arrays
c  * in the plate geometry cores these are 81 to 92
c 181  px -8.05815
c 182  px 8.05815
c 183  py -8.05815
c 184  py 8.05815
185  px -13.43025
186  px 13.43025
187  py -13.43025
188  py 13.43025
189  px -13.5635
190  px 13.5635
191  py -13.5635
192  py 13.5635
c
c
c  Cell 2  Axial heights
c
401  pz 153.667666
c 402  pz 153.704013
c 403  pz 154.245013
404  pz 154.281360
405  pz 154.318010
406  pz 154.876010
407  pz 154.912660
408  pz 154.958360
409  pz 155.194360
410  pz 155.240060
c 411  pz 155.276407
c 412  pz 155.817407
413  pz 155.853754
414  pz 155.890404
415  pz 156.448404

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

416    pz    156.485054
c 417    pz    156.521401
c 418    pz    157.062401
419    pz    157.098748
c
c Cell 12 Axial heights
c
501    pz    67.778780
c 502    pz    67.815127
c 503    pz    68.356127
504    pz    68.392474
505    pz    68.429124
506    pz    68.987124
507    pz    69.023774
c 508    pz    69.060121
c 509    pz    69.601121
510    pz    69.637468
511    pz    69.683168
512    pz    69.919168
513    pz    69.964868
514    pz    70.001518
515    pz    70.559518
516    pz    70.596168
c 517    pz    70.632515
c 518    pz    71.173515
519    pz    71.209862
c
c Basic Cell 1 data
c 701    pz    0.000000
c 702    pz    0.036347  $ Na can
c 703    pz    0.577347  $ Na core
c 704    pz    0.613694
c 705    pz    0.650344  $ UO2 can
c 706    pz    1.208344  $ UO2 core
c 707    pz    1.244994
708    pz    1.561994  $ SS
709    pz    1.607694  $ Pu can
710    pz    1.843694  $ Pu core
711    pz    1.889394
c 712    pz    1.925741  $ Na can
c 713    pz    2.466741  $ Na core
c 714    pz    2.503088
c 715    pz    2.539738  $ UO2 can
c 716    pz    3.097738  $ UO2 core
c 717    pz    3.134388
c 718    pz    3.170735  $ Na can
c 719    pz    3.711735  $ Na core
c 720    pz    3.748082  $          Cell 1
c
801    pz    0.000000
c 802    pz    0.036347
c 803    pz    0.577347  $ Na
804    pz    0.613694
805    pz    0.650344
806    pz    1.208344  $ UO2
807    pz    1.244994
c 808    pz    1.281341
c 809    pz    1.822341  $ Na
810    pz    1.858688
811    pz    1.904388
812    pz    2.140388  $ Pu
813    pz    2.186088
814    pz    2.503088  $ SS
815    pz    2.539738
816    pz    3.097738  $ UO2
817    pz    3.134388
c 818    pz    3.170735
c 819    pz    3.711735  $ Na
820    pz    3.748082  $ Cell 11
c
c -----
c
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c ----- TALLY CARDS -----
c
c --- MATERIALS CARDS ---
c
c
C MATERIAL 1 Pu metal plate core
ml      92238.31c  6.8782E-07
        94238.31c  3.0461E-05
        94239.31c  2.8920E-02
        94240.31c  6.9095E-03
        94241.31c  7.3960E-04
        94242.31c  1.8699E-04
        95241.31c  4.5718E-04
        1001.31c   1.2764E-04
        6000.31c   4.2260E-04
        7014.31c   2.4215E-05
        8016.31c   8.8450E-05
        13027.31c  2.2973E-05
        14028.31c  1.4158E-05
        25055.31c  1.4902E-06
        24050.31c  1.5637E-07
        24052.31c  3.0155E-06
        24053.31c  3.4193E-07
        24054.31c  8.5114E-08
        26054.31c  9.5478E-07
        26056.31c  1.4988E-05
        26057.31c  3.4614E-07
        26058.31c  4.6065E-09
        28058.31c  5.8334E-06
        28060.31c  2.2470E-06
        28061.31c  9.7676E-08
        28062.31c  3.1143E-07
        28064.31c  7.9313E-08
        31000.31c  2.0166E-03
c total 3.9991E-02
c MATERIAL 2 Pu plate canning
m2      1001.31c  1.3760E-05
        6000.31c  1.1393E-04
        14028.31c 3.6607E-04
        15031.31c 1.3731E-05
        24050.31c 4.0848E-04
        24052.31c 7.8771E-03
        24053.31c 8.9320E-04
        24054.31c 2.2234E-04
        25055.31c 8.5931E-04
        26054.31c 2.0774E-03
        26056.31c 3.2611E-02
        26057.31c 7.5313E-04
        26058.31c 1.0023E-05
        28058.31c 2.8351E-03
        28060.31c 1.0921E-03
        28061.31c 4.7472E-05
        28062.31c 1.5136E-04
        28064.31c 3.8548E-05
        29063.31c 1.1629E-02
        29065.31c 4.9839E-03
c total 6.6997E-02
C MATERIAL 3 UO2 plate core
m3      1001.31c  3.1773E-05
        6000.31c  1.1808E-05
        8016.31c  4.6008E-02
        13027.31c 3.3911E-06
        14028.31c 2.2967E-05
        25055.31c 8.3273E-08
        26054.31c 7.6610E-08
        26056.31c 1.2026E-06
        26057.31c 2.7774E-08
        26058.31c 3.6962E-10
        28058.31c 8.4906E-07
        28060.31c 3.2705E-07
        28061.31c 1.4217E-08
        28062.31c 4.5329E-08
        28064.31c 1.1544E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

42000.66c 3.3379E-07
92235.31c 1.6544E-04
92238.31c 2.2837E-02
c total 6.9083E-02
c MATERIAL 4 UO2 plate canning
m4      1001.31c 1.9035E-05
        6000.31c 1.2831E-04
        14028.31c 6.4475E-04
        15031.31c 3.5078E-04
        16032.31c 3.6041E-05
        24050.31c 6.0044E-04
        24052.31c 1.1579E-02
        24053.31c 1.3129E-03
        24054.31c 3.2682E-04
        25055.31c 8.5559E-04
        26054.31c 2.8235E-03
        26056.31c 4.4323E-02
        26057.31c 1.0236E-03
        26058.31c 1.3622E-05
        28058.31c 5.7360E-03
        28060.31c 2.2095E-03
        28061.31c 9.6046E-05
        28062.31c 3.0624E-04
        28064.31c 7.7989E-05
c total 7.2463E-02
C MATERIAL 5 sodium plate core
c m5      1001.31c 1.3900E-05
c        8016.31c 5.6492E-06
c        11023.31c 2.3225E-02
c        20040.31c 3.6083E-06
c        26054.31c 9.4595E-09
c        26056.31c 1.4849E-07
c        26057.31c 3.4294E-09
c        26058.31c 4.5639E-11
c total 2.324832E-02
c MATERIAL 6 Sodium plate canning
c m6      1001.31c 2.1631E-05
c        6000.31c 2.9290E-04
c        14028.31c 6.0867E-04
c        15031.31c 3.2795E-05
c        16032.31c 3.3219E-05
c        24050.31c 6.4128E-04
c        24052.31c 1.2366E-02
c        24053.31c 1.4023E-03
c        24054.31c 3.4905E-04
c        25055.31c 1.3570E-03
c        26054.31c 3.2179E-03
c        26056.31c 5.0514E-02
c        26057.31c 1.1666E-03
c        26058.31c 1.5525E-05
c        28058.31c 4.8322E-03
c        28060.31c 1.8614E-03
c        28061.31c 8.0912E-05
c        28062.31c 2.5798E-04
c        28064.31c 6.5701E-05
c        41093.31c 3.1147E-04
c total 7.9429E-02
C MATERIAL 7 40% steel plate
c m7      1001.31c 1.8355E-05
c        6000.31c 8.7794E-05
c        13027.31c 1.1862E-04
c        14028.31c 7.9703E-04
c        15031.31c 4.0018E-05
c        16032.31c 1.4422E-05
c        22000.62c 2.4806E-04
c        24050.31c 6.9120E-04
c        24052.31c 1.3329E-02
c        24053.31c 1.5114E-03
c        24054.31c 3.7622E-04
c        25055.31c 1.4972E-03
c        26054.31c 3.2362E-03
c        26056.31c 5.0801E-02
c        26057.31c 1.1732E-03
c        26058.31c 1.5613E-05

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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c      28058.31c  5.9891E-03
c      28060.31c  2.3070E-03
c      28061.31c  1.0028E-04
c      28062.31c  3.1975E-04
c      28064.31c  8.1431E-05
c      29063.31c  5.0365E-05
c      41093.31c  4.9781E-06
c      42000.66c  8.0988E-05
c
c 40% ss plate smeared over plate region
c
m7      1001.31c  7.3413E-06
        6000.31c  3.5114E-05
        13027.31c 4.7443E-05
        14028.31c  3.1878E-04
        15031.31c  1.6006E-05
        16032.31c  5.7682E-06
        22000.62c 9.9214E-05
        24050.31c  2.7645E-04
        24052.31c  5.3311E-03
        24053.31c  6.0450E-04
        24054.31c  1.5047E-04
        25055.31c  5.9882E-04
        26054.31c  1.2944E-03
        26056.31c  2.0318E-02
        26057.31c  4.6923E-04
        26058.31c  6.2446E-06
        28058.31c  2.3954E-03
        28060.31c  9.2271E-04
        28061.31c  4.0108E-05
        28062.31c  1.2789E-04
        28064.31c  3.2569E-05
        29063.31c  1.4101E-05
        29065.31c  6.0432E-06
        41093.31c  1.9910E-06
        42000.66c 3.2392E-05
c total 3.3152E-02
c
C MATERIAL 8 U8 metal plate
m8      1001.31c  4.4048E-05
        6000.31c  4.9283E-04
        14028.31c 2.1076E-04
        26054.31c  6.1951E-06
        26056.31c  9.7250E-05
        26057.31c  2.2459E-06
        26058.31c  2.9889E-08
        92235.31c  3.3369E-04
        92238.31c  4.6021E-02
c total 4.7208E-02
C MATERIAL 9 U2 metal plate
m9      1001.31c  4.3899E-05
        6000.31c  4.6047E-04
        14028.31c 1.9692E-04
        26054.31c  5.7884E-06
        26056.31c  9.0866E-05
        26057.31c  2.0985E-06
        26058.31c  2.7927E-08
        92235.31c  3.3962E-04
        92238.31c  4.6785E-02
c total 4.7925E-02
c
c MATERIAL 11 Honeycomb dummy plate
c
m11     1001.31c  3.3245E-06
        6000.31c  3.3477E-05
        14028.31c 1.2169E-04
        15031.31c  4.9764E-06
        16032.31c  2.5076E-06
        25055.31c  1.9518E-04
        24050.31c  1.0707E-04
        24052.31c  2.0648E-03
        24053.31c  2.3413E-04
        24054.31c  5.8281E-05
        26054.31c  4.7179E-04

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

26056.31c 7.4061E-03
26057.31c 1.7104E-04
26058.31c 2.2762E-05
28058.31c 8.3019E-04
28060.31c 3.1979E-04
28061.31c 1.3901E-05
28062.31c 4.4323E-05
28064.31c 1.1288E-05
41093.31c 5.2657E-05
c total 1.216928E-02
c
c
c radial shield
ml2 1001.31c 4.6306E-05
6000.31c 6.8972E-04
14028.31c 3.1158E-04
15031.31c 4.2944E-05
16032.31c 3.7110E-05
25055.31c 7.1275E-04
26054.31c 4.9065E-03
26056.31c 7.4517E-02
26057.31c 1.7491E-03
26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
ml3 1001.31c 4.6306E-08
6000.31c 6.8972E-07
14028.31c 3.1158E-07
15031.31c 4.2944E-08
16032.31c 3.7110E-08
25055.31c 7.1275E-07
26054.31c 4.9065E-06
26056.31c 7.4517E-05
26057.31c 1.7491E-06
26058.31c 2.5903E-07
c total 8.32720E-05
c
c Axial shield
ml4 1001.31c 2.5700E-05
6000.31c 5.1066E-04
13027.31c 1.3989E-04
22000.62c 3.9416E-05
24050.31c 1.2213E-06
24052.31c 2.2823E-05
24053.31c 2.5531E-06
24054.31c 6.2449E-07
25055.31c 3.2634E-04
26054.31c 5.0496E-03
26056.31c 7.6690E-02
26057.31c 1.8001E-03
26058.31c 2.6658E-04
28058.31c 1.2564E-06
28060.31c 4.6968E-07
28061.31c 2.2000E-08
28062.31c 6.2769E-08
28064.31c 1.6774E-08
29063.31c 3.1184E-05
29065.31c 1.3364E-05
42000.66c 9.8355E-06
c total 8.4932E-02
c
c Natural Uranium Breeder
ml5 1001.31c 4.4574E-05
6000.31c 4.7140E-04
14028.31c 2.0160E-04
26054.31c 6.1085E-06
26056.31c 9.2771E-05
26057.31c 2.1776E-06
26058.31c 3.2248E-07
92235.31c 3.4209E-04
92238.31c 4.7156E-02
c Total 4.8317E-02
c

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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

c Element top and bottom packing

ml6	1001.31c	3.1777E-05
	6000.31c	9.9996E-05
	13027.31c	8.3095E-06
	24050.31c	6.9087E-08
	24052.31c	1.2911E-06
	24053.31c	1.4442E-07
	24054.31c	3.5326E-08
	25055.31c	1.0785E-04
	26054.31c	1.9605E-03
	26056.31c	2.9775E-02
	26057.31c	6.9890E-04
	26058.31c	1.0350E-04
	28058.31c	1.5636E-07
	28060.31c	5.8452E-08
	28061.31c	2.7378E-09
	28062.31c	7.8115E-09
	28064.31c	2.0875E-09
	29063.31c	6.5270E-06
	29065.31c	2.7973E-06

c Total 3.279692E-02

c

c mild steel wrapper material

ml7	1001.31c	7.5725E-05
	6000.31c	2.3828E-04
	13027.31c	1.9802E-05
	24050.31c	1.6463E-07
	24052.31c	3.0767E-06
	24053.31c	3.4414E-07
	24054.31c	8.4182E-08
	25055.31c	2.5701E-04
	26054.31c	4.6718E-03
	26056.31c	7.0954E-02
	26057.31c	1.6655E-03
	26058.31c	2.4664E-04
	28058.31c	3.7260E-07
	28060.31c	1.3929E-07
	28061.31c	6.5242E-09
	28062.31c	1.8615E-08
	28064.31c	4.9746E-09
	29063.31c	1.5554E-05
	29065.31c	6.6660E-06

c Total 7.81552E-02

c

c

C MATERIAL 18 U8 metal plate

c m18	1001.31c	4.4048E-05
c	6000.31c	4.9283E-04
c	14028.31c	2.1076E-04
c	26054.31c	6.1951E-06
c	26056.31c	9.7250E-05
c	26057.31c	2.2459E-06
c	26058.31c	2.9889E-08
c	92235.31c	3.3369E-04
c	92238.31c	4.6021E-02

c total 4.7208E-02

c

c Superlattice grid plate

c

ml9	1001.31c	2.4442E-04
	6000.31c	2.9057E-04
	14028.31c	4.3858E-05
	15031.31c	1.3256E-05
	16032.31c	4.3530E-05
	25055.31c	2.5785E-04
	26054.31c	4.2756E-03
	26056.31c	6.7114E-02
	26057.31c	1.5500E-03
	26058.31c	2.0627E-04

c Total 19 7.403935E-02

c

c -----

c

c Element C Pin fuel A and E, Calandria NACLIII

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c Pin A
m21      1001.31c   3.2784E-05
          8016.31c   4.6624E-02
          13027.31c  1.1702E-05
          20040.31c   7.8782E-06
          26054.31c   3.3046E-07
          26056.31c   5.1875E-06
          26057.31c   1.1980E-07
          26058.31c   1.5943E-08
          92234.31c   1.3805E-06
          92235.31c   1.4114E-04
          92236.31c   7.9324E-07
          92238.31c   1.9379E-02
          94238.31c   3.7786E-06
          94239.31c   2.9689E-03
          94240.31c   6.7253E-04
          94241.31c   7.0350E-05
          94242.31c   1.7488E-05
          95241.31c   4.7854E-05
c      total 21 6.9985E-02
c
c PinB
c
m22      1001.31c   3.2784E-05
          8016.31c   4.6994E-02
          14028.31c   9.0199E-06
          28058.31c   3.7050E-06
          28060.31c   1.4272E-06
          28061.31c   6.2038E-08
          28062.31c   1.9780E-07
          28064.31c   5.0375E-08
          92234.31c   1.3177E-06
          92235.31c   1.3457E-04
          92236.31c   7.4658E-07
          92238.31c   1.8472E-02
          94238.31c   5.8915E-06
          94239.31c   3.7341E-03
          94240.31c   9.5200E-04
          94241.31c   1.1199E-04
          94242.31c   2.7984E-05
          95241.31c   5.5789E-05
c total 22 7.0537E-02 F 26 7.1415E-02
c
c Pin C
c
M23      1001.31c   3.2784E-05
          8016.31c   4.7434E-02
          13027.31c   1.9730E-05
          14028.31c   7.9741E-06
          26054.31c   4.4958E-07
          26056.31c   7.0574E-06
          26057.31c   1.6298E-07
          26058.31c   2.1690E-08
          28058.31c   7.4523E-06
          28060.31c   2.8707E-06
          28061.31c   1.2478E-07
          28062.31c   3.9787E-07
          28064.31c   1.0132E-07
          92234.31c   1.2863E-06
          92235.31c   1.2997E-04
          92236.31c   7.3103E-07
          92238.31c   1.7843E-02
          94238.31c   6.9094E-06
          94239.31c   4.4708E-03
          94240.31c   1.0602E-03
          94241.31c   1.1598E-04
          94242.31c   3.0047E-05
          95241.31c   5.7784E-05
c total 23 7.1230E-02
c
c Pin D
c
M24      1001.31c   3.2784E-05
          8016.31c   4.7314E-02

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ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

13027.31c	1.8914E-05
14028.31c	2.5099E-05
20040.31c	1.5940E-05
26054.31c	4.0346E-07
26056.31c	6.3335E-06
26057.31c	1.4627E-07
26058.31c	1.9465E-08
28058.31c	9.6247E-06
28060.31c	3.7075E-06
28061.31c	1.6116E-07
28062.31c	5.1385E-07
28064.31c	1.3086E-07
92234.31c	1.4118E-06
92235.31c	1.4266E-04
92236.31c	7.9324E-07
92238.31c	1.9584E-02
94238.31c	4.7348E-06
94239.31c	3.0189E-03
94240.31c	7.5441E-04
94241.31c	8.8443E-05
94242.31c	2.0961E-05
95241.31c	4.0742E-05
c total 24 7.1085E-02	
c	
c Pin E	
m25	1001.31c 3.2784E-05
	8016.31c 4.7317E-02
	13027.31c 9.5250E-06
	14028.31c 4.5753E-05
	20040.31c 3.2062E-05
	26054.31c 6.0326E-07
	26056.31c 9.4699E-06
	26057.31c 2.1870E-07
	26058.31c 2.9105E-08
	92234.31c 1.1295E-06
	92235.31c 1.1465E-04
	92236.31c 6.3771E-07
	92238.31c 1.5739E-02
	94238.31c 9.4851E-06
	94239.31c 6.0438E-03
	94240.31c 1.5103E-03
	94241.31c 1.7707E-04
	94242.31c 4.1953E-05
	95241.31c 8.1559E-05
c	total 25 7.1167E-02
c	
C Pin F	
M26	1001.31c 3.2784E-05
	8016.31c 4.7482E-02
	13027.31c 1.4287E-05
	20040.31c 6.7514E-05
	24050.31c 2.1476E-07
	24052.31c 4.1414E-06
	24053.31c 4.6961E-07
	24054.31c 1.1689E-07
	26054.31c 6.7247E-07
	26056.31c 1.0556E-05
	26057.31c 2.4379E-07
	26058.31c 3.2444E-08
	28058.31c 1.4905E-06
	28060.31c 5.7416E-07
	28061.31c 2.4958E-08
	28062.31c 7.9577E-08
	28064.31c 2.0266E-08
	92234.31c 1.1452E-06
	92235.31c 1.1526E-04
	92236.31c 6.3771E-07
	92238.31c 1.5824E-02
	94238.31c 9.5005E-06
	94239.31c 6.0112E-03
	94240.31c 1.5285E-03
	94241.31c 1.9723E-04
	94242.31c 4.4380E-05
	95241.31c 6.8035E-05

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

C total 26 7.1415E-02
c
c
c Composition of Calandria end plate regions
m27 14028.31c 5.5206E-04
 24050.31c 4.3520E-04
 24052.31c 8.3923E-03
 24053.31c 9.5162E-04
 24054.31c 2.3688E-04
 25055.31c 7.7198E-04
 26054.31c 2.0795E-03
 26056.31c 3.2644E-02
 26057.31c 7.5390E-04
 26058.31c 1.0033E-04
 28058.31c 3.0363E-03
 28060.31c 1.1696E-03
 28061.31c 5.0841E-05
 28062.31c 1.6210E-04
 28064.31c 4.1283E-05

c total 5.13781E-02

c

c UO2 Pin UO2PINC

c

M28 1001.31c 3.2784E-05
 6000.31c 3.2095E-05
 8016.31c 4.7501E-02
 13027.31c 2.3812E-05
 14028.31c 4.0001E-05
 20040.31c 1.2825E-05
 26054.31c 6.5324E-08
 26056.31c 1.0254E-06
 26057.31c 2.3682E-08
 26058.31c 3.1516E-09
 92234.31c 9.7268E-07
 92235.31c 1.7084E-04
 92238.31c 2.3588E-02

c total 28 7.14034E-02

c

c

c -----

c Pin clad plus calandria tube combined

c

C Pin PUPINA clad plus tube (was 23)

c

m31 1001.31c 1.0832E-05
 6000.31c 5.3887E-05
 14028.31c 6.6291E-04
 15031.31c 1.5357E-05
 16032.31c 9.9700E-06
 25055.31c 1.0382E-03
 24050.31c 5.3769E-04
 24052.31c 1.0369E-02
 24053.31c 1.1757E-03
 24054.31c 2.9267E-04
 26054.31c 2.4695E-03
 26056.31c 3.8766E-02
 26057.31c 8.9527E-04
 26058.31c 1.1914E-04
 28058.31c 3.9651E-03
 28060.31c 1.5274E-03
 28061.31c 6.6392E-05
 28062.31c 2.1169E-04
 28064.31c 5.3910E-05

c

C Total 31 6.2241E-02

c

C Pin PUPINB clad plus tube

c

m32 1001.31c 9.2847E-06
 6000.31c 9.6091E-05
 14028.31c 7.8508E-04
 15031.31c 1.6869E-05
 16032.31c 9.2404E-06
 25055.31c 1.0424E-03

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

24050.31c 4.8064E-04
24052.31c 9.2687E-03
24053.31c 1.0510E-03
24054.31c 2.6162E-04
26054.31c 2.3154E-03
26056.31c 3.6347E-02
26057.31c 8.3939E-04
26058.31c 1.1171E-04
28058.31c 3.9370E-03
28060.31c 1.5166E-03
28061.31c 6.5922E-05
28062.31c 2.1019E-04
28064.31c 5.3529E-05
41093.31c 1.1919E-04
c
C Total 32 5.8537E-02 F 36 6.0033E-02
c
C Pin PUPINC clad plus tube
c
m33 1001.31c 1.0832E-05
6000.31c 5.5189E-05
14028.31c 6.5458E-04
15031.31c 1.4602E-05
16032.31c 9.9700E-06
25055.31c 1.0254E-03
24050.31c 5.3131E-04
24052.31c 1.0246E-02
24053.31c 1.1618E-03
24054.31c 2.8919E-04
26054.31c 2.4419E-03
26056.31c 3.8333E-02
26057.31c 8.8527E-04
26058.31c 1.1781E-04
28058.31c 3.9199E-03
28060.31c 1.5099E-03
28061.31c 6.5635E-05
28062.31c 2.0927E-04
28064.31c 5.3296E-05
c
C Total 33 6.15349E-02
c
c Pin PUPIND can plus tube
c
m34 1001.31c 1.0058E-05
6000.31c 8.1804E-05
13027.31c 2.6012E-06
14028.31c 6.7957E-04
15031.31c 1.3847E-05
16032.31c 3.6474E-06
22048.31c 1.1726E-05
25055.31c 8.7351E-04
27059.31c 1.7202E-06
24050.31c 4.9702E-04
24052.31c 9.5846E-03
24053.31c 1.0868E-03
24054.31c 2.7053E-04
26054.31c 2.3766E-03
26056.31c 3.7307E-02
26057.31c 8.6158E-04
26058.31c 1.1466E-04
28058.31c 3.6114E-03
28060.31c 1.3911E-03
28061.31c 6.0470E-05
28062.31c 1.9281E-04
28064.31c 4.9102E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
42000.66c 8.9408E-07
c
C Total 34 5.9086E-02
c
c Pin PUPINE clad plus tube (Was 24)
m35 1001.31c 1.0058E-05
6000.31c 2.9866E-05

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

13027.31c 2.6012E-06
14028.31c 7.4068E-04
15031.31c 5.5388E-06
16032.31c 7.0518E-06
22048.31c 1.1726E-05
25055.31c 8.0111E-04
27059.31c 1.7202E-06
24050.31c 5.0041E-04
24052.31c 9.6500E-03
24053.31c 1.0942E-03
24054.31c 2.7238E-04
26054.31c 2.4012E-03
26056.31c 3.7694E-02
26057.31c 8.7052E-04
26058.31c 1.1585E-04
28058.31c 3.7263E-03
28060.31c 1.4354E-03
28061.31c 6.2394E-05
28062.31c 1.9894E-04
28064.31c 5.0664E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
42000.66c 8.6970E-06

C
C Total      35 5.96942E-02
C
C
C C Pin  PUPINF can plus tube
C
m36      1001.31c 1.0058E-05
        6000.31c 2.9217E-05
        13027.31c 1.7341E-06
        14028.31c 7.4343E-04
        15031.31c 5.5388E-06
        16032.31c 7.2951E-06
        22048.31c 8.7948E-06
        25055.31c 8.0253E-04
        27059.31c 1.3232E-06
        24050.31c 5.0363E-04
        24052.31c 9.7120E-03
        24053.31c 1.1013E-03
        24054.31c 2.7413E-04
        26054.31c 2.4145E-03
        26056.31c 3.7903E-02
        26057.31c 8.7533E-04
        26058.31c 1.1649E-04
        28058.31c 3.7525E-03
        28060.31c 1.4455E-03
        28061.31c 6.2833E-05
        28062.31c 2.0034E-04
        28064.31c 5.1021E-05
        29063.31c 1.2885E-06
        29065.31c 5.5221E-07
        42000.66c 8.6159E-06

C
C      Total   36 6.0033E-02
C
C -----
C
C Compositions of Calandria outer walls
C
C Calandria Walls NACLI Element Cell A and B
m51      1001.31c 3.9844E-05
        6000.31c 2.8167E-04
        14028.31c 6.0229E-04
        15031.31c 7.3471E-05
        16032.31c 3.6808E-05
        25055.31c 1.2214E-03
        24050.31c 6.5153E-04
        24052.31c 1.2564E-02
        24053.31c 1.4247E-03
        24054.31c 3.5463E-04
        26054.31c 2.8589E-03
        26056.31c 4.4878E-02

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

26057.31c	1.0364E-03
26058.31c	1.3793E-04
28058.31c	4.9315E-03
28060.31c	1.8996E-03
28061.31c	8.2574E-05
28062.31c	2.6328E-04
28064.31c	6.7050E-05
C total 51	7.34056E-02
c	
C Calandria walls NACLIIS Element Cell E	
c	
m52	1001.31c 3.8637E-05
6000.31c	6.5351E-04
14028.31c	9.7623E-04
15031.31c	4.7540E-05
16032.31c	3.3014E-05
22048.31c	2.4400E-04
25055.31c	1.1060E-03
27059.31c	1.1151E-05
24050.31c	6.2481E-04
24052.31c	1.2049E-02
24053.31c	1.3662E-03
24054.31c	3.4009E-04
26054.31c	2.7541E-03
26056.31c	4.3233E-02
26057.31c	9.9842E-04
26058.31c	1.3287E-04
28058.31c	5.0735E-03
28060.31c	1.9543E-03
28061.31c	8.4952E-05
28062.31c	2.7086E-04
28064.31c	6.8981E-05
29063.31c	6.9320E-06
29065.31c	3.1020E-06
42000.66c	3.4248E-06
C total 52	7.20749E-02
c	
c Calandria NACLIII Element Cell C and D	
c	
m53	1001.31c 3.9844E-05
6000.31c	1.5948E-04
14028.31c	7.7474E-04
15031.31c	5.2334E-05
16032.31c	2.4551E-05
25055.31c	8.3089E-04
24050.31c	6.1403E-04
24052.31c	1.1841E-02
24053.31c	1.3427E-03
24054.31c	3.3422E-04
26054.31c	2.9672E-03
26056.31c	4.6578E-02
26057.31c	1.0757E-03
26058.31c	1.4315E-04
28058.31c	5.2186E-03
28060.31c	2.0102E-03
28061.31c	8.7382E-05
28062.31c	2.7861E-04
28064.31c	7.0954E-05
42000.66c	2.4862E-05
C total 53	7.44684E-02
c	
C Calandria NACLIV Element 3J and 3L	
m54	1001.31c 3.7430E-05
6000.31c	3.5158E-04
14028.31c	8.2197E-04
15031.31c	6.2274E-05
16032.31c	1.6431E-05
25055.31c	1.0026E-03
24050.31c	5.8931E-04
24052.31c	1.1364E-02
24053.31c	1.2886E-03
24054.31c	3.2077E-04
26054.31c	2.7560E-03
26056.31c	4.3263E-02

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LIQUID METAL FAST REACTOR - LMFR
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```

26057.31c  9.9912E-04
26058.31c  1.3296E-04
28058.31c  4.3943E-03
28060.31c  1.6927E-03
28061.31c  7.3579E-05
28062.31c  2.3460E-04
28064.31c  5.9746E-05
42000.66c  8.8791E-06
C Total  54  6.94698E-02
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 200 1600
ksrc 0.6125 0.6125 77.0 0.6125 -0.6125 87.9
      -0.6125 -0.6125 107.0
      0.6125 0.6125 117.9 0.6125 -0.6125 137.0
      0.6125 0.6125 147.9
      -0.6125 0.6125 77.0 -0.6125 -0.6125 87.9
      0.6125 0.6125 107.0
      -0.6125 0.6125 117.9 -0.6125 -0.6125 137.0
      -0.6125 0.6125 147.9
      11.4633 -0.6125 77.0 11.4633 -0.6125 87.9
      11.4633 -0.6125 107.0
      11.4633 -0.6125 117.9 11.4633 -0.6125 137.0
      11.4633 -0.6125 147.9
      -11.4633 -0.6125 77.0 -11.4633 -0.6125 87.9
      -11.4633 -0.6125 107.0
      -11.4633 -0.6125 117.9 -11.4633 -0.6125 137.0
      -11.4633 -0.6125 147.9
      -0.6125 11.4633 77.0 -0.6125 11.4633 87.9
      -0.6125 11.4633 107.0
      -0.6125 11.4633 117.9 -0.6125 11.4633 137.0
      -0.6125 11.4633 147.9
      -0.6125 -11.4633 77.0 -0.6125 -11.4633 87.9
      -0.6125 -11.4633 107.0
      -0.6125 -11.4633 117.9 -0.6125 -11.4633 137.0
      -0.6125 -11.4633 147.9
      11.4633 11.4633 77.0 11.4633 11.4633 87.9
      11.4633 11.4633 107.0
      11.4633 11.4633 117.9 11.4633 11.4633 137.0
      11.4633 11.4633 147.9
      -11.4633 11.4633 77.0 -11.4633 11.4633 87.9
      -11.4633 11.4633 107.0
      -11.4633 11.4633 117.9 -11.4633 11.4633 137.0
      -11.4633 11.4633 147.9
      11.4633 -11.4633 77.0 11.4633 -11.4633 87.9
      11.4633 -11.4633 107.0
      11.4633 -11.4633 117.9 11.4633 -11.4633 137.0
      11.4633 -11.4633 147.9
      -11.4633 -11.4633 77.0 -11.4633 -11.4633 87.9
      -11.4633 -11.4633 107.0
      -11.4633 -11.4633 117.9 -11.4633 -11.4633 137.0
      -11.4633 -11.4633 147.9
      25.9475 0.6125 77.0 25.9475 0.6125 87.9
      -25.9475 0.6125 107.0
      25.9475 0.6125 117.9 25.9475 0.6125 137.0
      25.9475 0.6125 147.9
      -25.9475 0.6125 77.0 -25.9475 0.6125 87.9
      -25.9475 0.6125 107.0
      -25.9475 0.6125 117.9 -25.9475 0.6125 137.0
      -25.9475 0.6125 147.9
      0.6125 25.9475 77.0 0.6125 25.9475 87.9
      0.6125 25.9475 107.0
      0.6125 25.9475 117.9 0.6125 25.9475 137.0
      0.6125 25.9475 147.9
      0.6125 -25.9475 77.0 0.6125 -25.9475 87.9
      -25.9475 0.6125 107.0
      0.6125 -25.9475 117.9 0.6125 -25.9475 137.0
      0.6125 -25.9475 147.9
      25.9475 25.9475 77.0 25.9475 25.9475 87.9
      25.9475 25.9475 107.0
      25.9475 25.9475 117.9 25.9475 25.9475 137.0
      25.9475 25.9475 147.9
      -25.9475 25.9475 77.0 -25.9475 25.9475 87.9

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
-25.9475 25.9475 107.0
-25.9475 25.9475 117.9 -25.9475 25.9475 137.0
-25.9475 25.9475 147.9
25.9475 -25.9475 77.0 25.9475 -25.9475 87.9
25.9475 -25.9475 107.0
25.9475 -25.9475 117.9 25.9475 -25.9475 137.0
25.9475 -25.9475 147.9
-25.9475 -25.9475 77.0 -25.9475 -25.9475 87.9
-25.9475 -25.9475 107.0
36.9875 0.6125 77.0 36.9875 0.6125 87.9
36.9875 0.6125 107.0
36.9875 0.6125 117.9 36.9875 0.6125 137.0
36.9875 0.6125 147.9
-36.9875 0.6125 77.0 -36.9875 0.6125 87.9
-36.9875 0.6125 107.0
-36.9875 0.6125 117.9 -36.9875 0.6125 137.0
-36.9875 0.6125 147.9
0.6125 36.9875 77.0 0.6125 36.9875 87.9
0.6125 36.9875 107.0
0.6125 36.9875 117.9 0.6125 36.9875 137.0
0.6125 36.9875 147.9
0.6125 -36.9875 77.0 0.6125 -36.9875 87.9
-36.9875 0.6125 107.0
0.6125 -36.9875 117.9 0.6125 -36.9875 137.0
0.6125 -36.9875 147.9
print
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

A4.5 MCNP-JEFF-3.1 Zebra23 Model with Central Plate Zone

Z23 with central plate zone. JEFF-3.1. Gaps & superlattice represented.
c
c The experimental value of k-effective to be used with this model is
c 1.0029 +/- 0.0013
c See www.zebra.webnik.org for details.
c
c ----- CELL CARDS -----
c
c --- Core Pin Geometry Element C Calandria NACLIII Pins 8xA and 8xE
c Fuel m21 and m25, can + tube m31 and m35
c Lower padding
1 16 3.279692E-02 -8 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower Reflector
2 14 8.4932E-02 8 -9 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
3 15 4.8317E-02 9 -41 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
4 9 4.7925E-02 41 -42 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
5 8 4.7208E-02 42 -10 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
9 27 0.0513781 33 -34 35 -36 10 -82 u=1 imp:n=1 TMP=2.5301E-08
c
c
10 25 7.1167E-02 -91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
11 21 0.069985 -92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
12 25 7.1167E-02 -93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
13 21 0.069985 -94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
14 21 0.069985 -95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
15 25 7.1167E-02 -96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
16 21 0.069985 -97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
17 25 7.1167E-02 -98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
18 25 7.1167E-02 -99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
19 21 0.069985 -100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
20 25 7.1167E-02 -101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
21 21 0.069985 -102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
22 21 0.069985 -103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
23 25 7.1167E-02 -104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
24 21 0.069985 -105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
25 25 7.1167E-02 -106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c
30 35 0.0596942 -111 91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
31 31 0.062241 -112 92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
32 35 0.0596942 -113 93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
33 31 0.062241 -114 94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
34 31 0.062241 -115 95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
35 35 0.0596942 -116 96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
36 31 0.062241 -117 97 82 -83 u=1 imp:n=1 TMP=2.5301E-08

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
37      35 0.0596942 -118 98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
38      35 0.0596942 -119 99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
39      31 0.062241 -120 100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
40      35 0.0596942 -121 101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
41      31 0.062241 -122 102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
42      31 0.062241 -123 103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
43      35 0.0596942 -124 104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
44      31 0.062241 -125 105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
45      35 0.0596942 -126 106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
46      43 2.3900E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
48      27 0.0513781 33 -34 35 -36 83 -85 u=1 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
50      25 7.1167E-02 -91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
51      21 0.069985 -92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
52      25 7.1167E-02 -93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
53      21 0.069985 -94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
54      21 0.069985 -95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
55      25 7.1167E-02 -96 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
56      21 0.069985 -97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
57      25 7.1167E-02 -98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
58      25 7.1167E-02 -99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
59      21 0.069985 -100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
60      25 7.1167E-02 -101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
61      21 0.069985 -102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
62      21 0.069985 -103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
63      25 7.1167E-02 -104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
64      21 0.069985 -105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
65      25 7.1167E-02 -106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
70      35 0.0596942 -111 91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
71      31 0.062241 -112 92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
72      35 0.0596942 -113 93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
73      31 0.062241 -114 94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
74      31 0.062241 -115 95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
75      35 0.0596942 -116 96 85 -86 u=1 imp:n=1 TMP=2.5301E-08

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
76      31 0.062241 -117 97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
77      35 0.0596942 -118 98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
78      35 0.0596942 -119 99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
79      31 0.062241 -120 100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
80      35 0.0596942 -121 101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
81      31 0.062241 -122 102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
82      31 0.062241 -123 103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
83      35 0.0596942 -124 104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
84      31 0.062241 -125 105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
85      35 0.0596942 -126 106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
86      43 2.3900E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
88      27 0.0513781 33 -34 35 -36 86 -88 u=1 imp:n=1 TMP=2.5301E-08
c
c Top calandria
c
90      25 7.1167E-02 -91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
91      21 0.069985 -92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
92      25 7.1167E-02 -93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
93      21 0.069985 -94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
94      21 0.069985 -95 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
95      25 7.1167E-02 -96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
96      21 0.069985 -97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
97      25 7.1167E-02 -98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
98      25 7.1167E-02 -99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
99      21 0.069985 -100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
100     25 7.1167E-02 -101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
101     21 0.069985 -102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
102     21 0.069985 -103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
103     25 7.1167E-02 -104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
104     21 0.069985 -105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
105     25 7.1167E-02 -106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
c
110     35 0.0596942 -111 91 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
111     31 0.062241 -112 92 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
112     35 0.0596942 -113 93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
113     31 0.062241 -114 94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
114     31 0.062241 -115 95 88 -89 u=1 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
115      35 0.0596942 -116 96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
116      31 0.062241 -117 97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
117      35 0.0596942 -118 98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
118      35 0.0596942 -119 99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
119      31 0.062241 -120 100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
120      35 0.0596942 -121 101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
121      31 0.062241 -122 102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
122      31 0.062241 -123 103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
123      35 0.0596942 -124 104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
124      31 0.062241 -125 105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
125      35 0.0596942 -126 106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
126      43 2.3900E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
128      27 0.0513781 33 -34 35 -36 89 -11 u=1 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
129      53 7.44684E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=1 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
131      8 4.7208E-02 11 -67 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
132      9 4.7925E-02 67 -68 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
133      15 4.8317E-02 68 -12 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
134      14 8.4932E-02 12 -13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   Upper padding
135      16 3.279692E-02 13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
136      0 132 -133 134 -135 (-21:22:-23:24) u=1 imp:n=1
c   Wrapper
137      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=1 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
138      0 1 -2 3 -4 (-136:137:-138:139) u=1 imp:n=1
c
c   End of Core Pin Geometry Element C
c
c
c   --- Core Pin geometry Element E (& D) NACLIIS Pins 8xD and 8xF
c   D 24 7.1085E-02 F 26 7.1415E-02 clad D 34 5.9086E-02 F 36 6.0033E-02
c   Lower padding
201      16 3.279692E-02 -8 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
202      14 8.4932E-02 8 -9 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
203      15 4.8317E-02 9 -41 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
204      9 4.7925E-02 41 -42 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
205      8 4.7208E-02 42 -10 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
209      27 0.0513781 33 -34 35 -36 10 -82 u=2 imp:n=1 TMP=2.5301E-08
c
c
210      26 7.1415E-02 -91 82 -83 u=2 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
211      24 7.1085E-02 -92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
212      26 7.1415E-02 -93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
213      24 7.1085E-02 -94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
214      24 7.1085E-02 -95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
215      26 7.1415E-02 -96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
216      24 7.1085E-02 -97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
217      26 7.1415E-02 -98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
218      26 7.1415E-02 -99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
219      24 7.1085E-02 -100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
220      26 7.1415E-02 -101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
221      24 7.1085E-02 -102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
222      24 7.1085E-02 -103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
223      26 7.1415E-02 -104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
224      24 7.1085E-02 -105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
225      26 7.1415E-02 -106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c
230      36 6.0033E-02 -111 91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
231      34 5.9086E-02 -112 92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
232      36 6.0033E-02 -113 93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
233      34 5.9086E-02 -114 94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
234      34 5.9086E-02 -115 95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
235      36 6.0033E-02 -116 96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
236      34 5.9086E-02 -117 97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
237      36 6.0033E-02 -118 98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
238      36 6.0033E-02 -119 99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
239      34 5.9086E-02 -120 100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
240      36 6.0033E-02 -121 101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
241      34 5.9086E-02 -122 102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
242      34 5.9086E-02 -123 103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
243      36 6.0033E-02 -124 104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
244      34 5.9086E-02 -125 105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
245      36 6.0033E-02 -126 106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
246      42 2.43914E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
248      27 0.0513781 33 -34 35 -36 83 -85 u=2 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

250	26	7.1415E-02	-91	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
251	24	7.1085E-02	-92	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
252	26	7.1415E-02	-93	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
253	24	7.1085E-02	-94	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
254	24	7.1085E-02	-95	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
255	26	7.1415E-02	-96	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
256	24	7.1085E-02	-97	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
257	26	7.1415E-02	-98	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
258	26	7.1415E-02	-99	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
259	24	7.1085E-02	-100	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
260	26	7.1415E-02	-101	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
261	24	7.1085E-02	-102	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
262	24	7.1085E-02	-103	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
263	26	7.1415E-02	-104	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
264	24	7.1085E-02	-105	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
265	26	7.1415E-02	-106	85	-86	u=2	imp:n=1	TMP=2.5301E-08
c								
c								
c								
270	36	6.0033E-02	-111	91	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
271	34	5.9086E-02	-112	92	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
272	36	6.0033E-02	-113	93	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
273	34	5.9086E-02	-114	94	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
274	34	5.9086E-02	-115	95	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
275	36	6.0033E-02	-116	96	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
276	34	5.9086E-02	-117	97	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
277	36	6.0033E-02	-118	98	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
278	36	6.0033E-02	-119	99	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
279	34	5.9086E-02	-120	100	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
280	36	6.0033E-02	-121	101	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
281	34	5.9086E-02	-122	102	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
282	34	5.9086E-02	-123	103	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
283	36	6.0033E-02	-124	104	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
284	34	5.9086E-02	-125	105	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
285	36	6.0033E-02	-126	106	85	-86	u=2	imp:n=1 TMP=2.5301E-08
c								
286	42	2.43914E-02	33	-34	35	-36	85	-86 &
			111	112	113	114	115	116 117 118 119 120 121 122 123 124 125 126 &
			u=2	imp:n=1	TMP=2.5301E-08			
c								
c								
c								
288	27	0.0513781	33	-34	35	-36	86	-88 u=2 imp:n=1 TMP=2.5301E-08
c								

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c  Top calandria
c
c  290      26 7.1415E-02 -91 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  291      24 7.1085E-02 -92 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  292      26 7.1415E-02 -93 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  293      24 7.1085E-02 -94 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  294      24 7.1085E-02 -95 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  295      26 7.1415E-02 -96 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  296      24 7.1085E-02 -97 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  297      26 7.1415E-02 -98 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  298      26 7.1415E-02 -99 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  299      24 7.1085E-02 -100 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  300      26 7.1415E-02 -101 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  301      24 7.1085E-02 -102 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  302      24 7.1085E-02 -103 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  303      26 7.1415E-02 -104 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  304      24 7.1085E-02 -105 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  305      26 7.1415E-02 -106 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c
c
c  310      36 6.0033E-02 -111 91 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  311      34 5.9086E-02 -112 92 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  312      36 6.0033E-02 -113 93 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  313      34 5.9086E-02 -114 94 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  314      34 5.9086E-02 -115 95 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  315      36 6.0033E-02 -116 96 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  316      34 5.9086E-02 -117 97 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  317      36 6.0033E-02 -118 98 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  318      36 6.0033E-02 -119 99 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  319      34 5.9086E-02 -120 100 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  320      36 6.0033E-02 -121 101 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  321      34 5.9086E-02 -122 102 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  322      34 5.9086E-02 -123 103 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  323      36 6.0033E-02 -124 104 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  324      34 5.9086E-02 -125 105 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  325      36 6.0033E-02 -126 106 88 -89  u=2 imp:n=1 TMP=2.5301E-08
c
c  326      42 2.43914E-02 33 -34 35 -36 88 -89  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c  Top plate of top calandria
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

328      27 0.0513781 33 -34 35 -36 89 -11 u=2 imp:n=1 TMP=2.5301E-08
c
c Calandria outer wall
c
329      52 7.20749E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=2 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
331      8 4.7208E-02 11 -67 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
332      9 4.7925E-02 67 -68 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
333     15 4.8317E-02 68 -12 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper Reflector
334     14 8.4932E-02 12 -13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Upper padding
335     16 3.279692E-02 13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
336      0 132 -133 134 -135 (-21:22:-23:24) u=2 imp:n=1
c Wrapper
337     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=2 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
338      0 1 -2 3 -4 (-136:137:-138:139) u=2 imp:n=1
c
c End of Core Pin Geometry Element E (D)
c
c
c --- Core Pin Geometry Element B (H, L) Calandria NACL Pins 11xB and 5xF
c B 22 7.0537E-02 F 26 7.1415E-02 clad 32 5.8537E-02 F 36 6.0033E-02
c Pin F is in circles 93 98 99 101 and 104
c
c Lower padding
401     16 3.279692E-02 -8 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower Reflector
402     14 8.4932E-02 8 -9 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
403     15 4.8317E-02 9 -41 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
404      9 4.7925E-02 41 -42 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
405      8 4.7208E-02 42 -10 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
409     27 0.0513781 33 -34 35 -36 10 -82 u=3 imp:n=1 TMP=2.5301E-08
c
c
410     22 7.0537E-02 -91 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
411     22 7.0537E-02 -92 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
412     26 7.1415E-02 -93 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
413     22 7.0537E-02 -94 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
414     22 7.0537E-02 -95 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
415     22 7.0537E-02 -96 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
416     22 7.0537E-02 -97 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
417     26 7.1415E-02 -98 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
418     26 7.1415E-02 -99 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
419     22 7.0537E-02 -100 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
420     26 7.1415E-02 -101 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
421     22 7.0537E-02 -102 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
422     22 7.0537E-02 -103 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
423     26 7.1415E-02 -104 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

424      22 7.0537E-02 -105 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
425      22 7.0537E-02 -106 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
c
430      32 5.8537E-02 -111 91 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
431      32 5.8537E-02 -112 92 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
432      36 6.0033E-02 -113 93 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
433      32 5.8537E-02 -114 94 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
434      32 5.8537E-02 -115 95 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
435      32 5.8537E-02 -116 96 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
436      32 5.8537E-02 -117 97 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
437      36 6.0033E-02 -118 98 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
438      36 6.0033E-02 -119 99 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
439      32 5.8537E-02 -120 100 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
440      36 6.0033E-02 -121 101 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
441      32 5.8537E-02 -122 102 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
442      32 5.8537E-02 -123 103 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
443      36 6.0033E-02 -124 104 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
444      32 5.8537E-02 -125 105 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
445      32 5.8537E-02 -126 106 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
446      41 2.41414E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
448      27 0.0513781 33 -34 35 -36 83 -85 u=3 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
450      22 7.0537E-02 -91 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
451      22 7.0537E-02 -92 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
452      26 7.1415E-02 -93 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
453      22 7.0537E-02 -94 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
454      22 7.0537E-02 -95 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
455      22 7.0537E-02 -96 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
456      22 7.0537E-02 -97 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
457      26 7.1415E-02 -98 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
458      26 7.1415E-02 -99 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
459      22 7.0537E-02 -100 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
460      26 7.1415E-02 -101 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
461      22 7.0537E-02 -102 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
462      22 7.0537E-02 -103 85 -86 u=3 imp:n=1 TMP=2.5301E-08
c
463      26 7.1415E-02 -104 85 -86 u=3 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
464      22 7.0537E-02 -105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
465      22 7.0537E-02 -106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
c
c
470      32 5.8537E-02 -111 91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
471      32 5.8537E-02 -112 92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
472      36 6.0033E-02 -113 93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
473      32 5.8537E-02 -114 94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
474      32 5.8537E-02 -115 95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
475      32 5.8537E-02 -116 96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
476      32 5.8537E-02 -117 97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
477      36 6.0033E-02 -118 98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
478      36 6.0033E-02 -119 99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
479      32 5.8537E-02 -120 100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
480      36 6.0033E-02 -121 101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
481      32 5.8537E-02 -122 102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
482      32 5.8537E-02 -123 103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
483      36 6.0033E-02 -124 104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
484      32 5.8537E-02 -125 105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
485      32 5.8537E-02 -126 106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
486      41 2.41414E-02 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
488      27 0.0513781 33 -34 35 -36 86 -88 u=3 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
490      22 7.0537E-02 -91 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
491      22 7.0537E-02 -92 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
492      26 7.1415E-02 -93 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
493      22 7.0537E-02 -94 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
494      22 7.0537E-02 -95 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
495      22 7.0537E-02 -96 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
496      22 7.0537E-02 -97 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
497      26 7.1415E-02 -98 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
498      26 7.1415E-02 -99 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
499      22 7.0537E-02 -100 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
500      26 7.1415E-02 -101 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
501      22 7.0537E-02 -102 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
502      22 7.0537E-02 -103 88 -89  u=3 imp:n=1 TMP=2.5301E-08

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
503      26 7.1415E-02 -104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
504      22 7.0537E-02 -105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
505      22 7.0537E-02 -106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
c
c
510      32 5.8537E-02 -111 91 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
511      32 5.8537E-02 -112 92 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
512      36 6.0033E-02 -113 93 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
513      32 5.8537E-02 -114 94 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
514      32 5.8537E-02 -115 95 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
515      32 5.8537E-02 -116 96 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
516      32 5.8537E-02 -117 97 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
517      36 6.0033E-02 -118 98 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
518      36 6.0033E-02 -119 99 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
519      32 5.8537E-02 -120 100 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
520      36 6.0033E-02 -121 101 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
521      32 5.8537E-02 -122 102 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
522      32 5.8537E-02 -123 103 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
523      36 6.0033E-02 -124 104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
524      32 5.8537E-02 -125 105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
525      32 5.8537E-02 -126 106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
526      41 2.41414E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
528      27 0.0513781 33 -34 35 -36 89 -11 u=3 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
529      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=3 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
531      8 4.7208E-02 11 -67 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
532      9 4.7925E-02 67 -68 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
533      15 4.8317E-02 68 -12 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
534      14 8.4932E-02 12 -13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper padding
535      16 3.279692E-02 13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
536      0 132 -133 134 -135 (-21:22:-23:24) u=3 imp:n=1
c   Wrapper
537      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=3 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
538      0 1 -2 3 -4 (-136:137:-138:139) u=3 imp:n=1
c
c   End of Core Pin Geometry Element B (H, L)
c
c
c --- Core Pin Geometry Element A Calandria NACL Pins 16xC

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c c 23 7.1230E-02 clad 33 6.15349E-02
c
c Lower padding
601 16 3.279692E-02 -8 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower Reflector
602 14 8.4932E-02 8 -9 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
603 15 4.8317E-02 9 -41 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
604 9 4.7925E-02 41 -42 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
605 8 4.7208E-02 42 -10 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
609 27 0.0513781 33 -34 35 -36 10 -82 u=4 imp:n=1 TMP=2.5301E-08
c
c
610 23 7.1230E-02 -91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
611 23 7.1230E-02 -92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
612 23 7.1230E-02 -93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
613 23 7.1230E-02 -94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
614 23 7.1230E-02 -95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
615 23 7.1230E-02 -96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
616 23 7.1230E-02 -97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
617 23 7.1230E-02 -98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
618 23 7.1230E-02 -99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
619 23 7.1230E-02 -100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
620 23 7.1230E-02 -101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
621 23 7.1230E-02 -102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
622 23 7.1230E-02 -103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
623 23 7.1230E-02 -104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
624 23 7.1230E-02 -105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
625 23 7.1230E-02 -106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c
630 33 6.15349E-02 -111 91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
631 33 6.15349E-02 -112 92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
632 33 6.15349E-02 -113 93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
633 33 6.15349E-02 -114 94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
634 33 6.15349E-02 -115 95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
635 33 6.15349E-02 -116 96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
636 33 6.15349E-02 -117 97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
637 33 6.15349E-02 -118 98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
638 33 6.15349E-02 -119 99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
639 33 6.15349E-02 -120 100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
640 33 6.15349E-02 -121 101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
641 33 6.15349E-02 -122 102 82 -83 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
642      33 6.15349E-02 -123 103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
643      33 6.15349E-02 -124 104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
644      33 6.15349E-02 -125 105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
645      33 6.15349E-02 -126 106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
646      41 2.41414E-02 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
648      27 0.0513781 33 -34 35 -36 83 -85 u=4 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
650      23 7.1230E-02 -91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
651      23 7.1230E-02 -92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
652      23 7.1230E-02 -93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
653      23 7.1230E-02 -94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
654      23 7.1230E-02 -95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
655      23 7.1230E-02 -96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
656      23 7.1230E-02 -97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
657      23 7.1230E-02 -98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
658      23 7.1230E-02 -99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
659      23 7.1230E-02 -100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
660      23 7.1230E-02 -101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
661      23 7.1230E-02 -102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
662      23 7.1230E-02 -103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
663      23 7.1230E-02 -104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
664      23 7.1230E-02 -105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
665      23 7.1230E-02 -106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
670      33 6.15349E-02 -111 91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
671      33 6.15349E-02 -112 92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
672      33 6.15349E-02 -113 93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
673      33 6.15349E-02 -114 94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
674      33 6.15349E-02 -115 95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
675      33 6.15349E-02 -116 96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
676      33 6.15349E-02 -117 97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
677      33 6.15349E-02 -118 98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
678      33 6.15349E-02 -119 99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
679      33 6.15349E-02 -120 100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
680      33 6.15349E-02 -121 101 85 -86 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
681      33 6.15349E-02 -122 102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
682      33 6.15349E-02 -123 103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
683      33 6.15349E-02 -124 104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
684      33 6.15349E-02 -125 105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
685      33 6.15349E-02 -126 106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
686      41 2.41414E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
688      27 0.0513781 33 -34 35 -36 86 -88 u=4 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
690      23 7.1230E-02 -91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
691      23 7.1230E-02 -92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
692      23 7.1230E-02 -93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
693      23 7.1230E-02 -94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
694      23 7.1230E-02 -95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
695      23 7.1230E-02 -96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
696      23 7.1230E-02 -97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
697      23 7.1230E-02 -98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
698      23 7.1230E-02 -99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
699      23 7.1230E-02 -100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
700      23 7.1230E-02 -101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
701      23 7.1230E-02 -102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
702      23 7.1230E-02 -103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
703      23 7.1230E-02 -104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
704      23 7.1230E-02 -105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
705      23 7.1230E-02 -106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
710      33 6.15349E-02 -111 91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
711      33 6.15349E-02 -112 92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
712      33 6.15349E-02 -113 93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
713      33 6.15349E-02 -114 94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
714      33 6.15349E-02 -115 95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
715      33 6.15349E-02 -116 96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
716      33 6.15349E-02 -117 97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
717      33 6.15349E-02 -118 98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
718      33 6.15349E-02 -119 99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
719      33 6.15349E-02 -120 100 88 -89 u=4 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
720      33 6.15349E-02 -121 101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
721      33 6.15349E-02 -122 102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
722      33 6.15349E-02 -123 103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
723      33 6.15349E-02 -124 104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
724      33 6.15349E-02 -125 105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
725      33 6.15349E-02 -126 106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
726      41 2.41414E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c Top plate of top calandria
c
728      27 0.0513781 33 -34 35 -36 89 -11 u=4 imp:n=1 TMP=2.5301E-08
c
c Calandria outer wall
c
729      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=4 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
731      8 4.7208E-02 11 -67 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
732      9 4.7925E-02 67 -68 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
733      15 4.8317E-02 68 -12 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Upper Reflector
734      14 8.4932E-02 12 -13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Upper padding
735      16 3.279692E-02 13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
736      0 132 -133 134 -135 (-21:22:-23:24) u=4 imp:n=1
c Wrapper
737      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=4 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
738      0 1 -2 3 -4 (-136:137:-138:139) u=4 imp:n=1
c
c End of Core Pin Geometry Element A
c
c
c --- Core Pin Geometry Element J Calandria NACLIV Pins 12xE and 4xUO2
c E 25 7.1167E-02 28 7.1400E-02 35 5.96942E-02
c The positions of pin UO2 are the circles 94, 96, 102 and 104
c Lower padding
801      16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower Reflector
802      14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
803      15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
804      9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
805      8 4.7208E-02 42 -10 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
809      27 0.0513781 33 -34 35 -36 10 -82 u=5 imp:n=1 TMP=2.5301E-08
c
c
810      25 7.1167E-02 -91 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
811      25 7.1167E-02 -92 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
812      25 7.1167E-02 -93 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
813      28 7.1400E-02 -94 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
814      25 7.1167E-02 -95 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c

```

815	28	7.1400E-02	-96	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
816	25	7.1167E-02	-97	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
817	25	7.1167E-02	-98	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
818	25	7.1167E-02	-99	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
819	25	7.1167E-02	-100	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
820	25	7.1167E-02	-101	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
821	28	7.1400E-02	-102	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
822	25	7.1167E-02	-103	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
823	28	7.1400E-02	-104	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
824	25	7.1167E-02	-105	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
825	25	7.1167E-02	-106	82	-83	u=5	imp:n=1	TMP=2.5301E-08	
830	35	5.96942E-02	-111	91	82	-83	u=5	imp:n=1	TMP=2.5301E-08
831	35	5.96942E-02	-112	92	82	-83	u=5	imp:n=1	TMP=2.5301E-08
832	35	5.96942E-02	-113	93	82	-83	u=5	imp:n=1	TMP=2.5301E-08
833	35	5.96942E-02	-114	94	82	-83	u=5	imp:n=1	TMP=2.5301E-08
834	35	5.96942E-02	-115	95	82	-83	u=5	imp:n=1	TMP=2.5301E-08
835	35	5.96942E-02	-116	96	82	-83	u=5	imp:n=1	TMP=2.5301E-08
836	35	5.96942E-02	-117	97	82	-83	u=5	imp:n=1	TMP=2.5301E-08
837	35	5.96942E-02	-118	98	82	-83	u=5	imp:n=1	TMP=2.5301E-08
838	35	5.96942E-02	-119	99	82	-83	u=5	imp:n=1	TMP=2.5301E-08
839	35	5.96942E-02	-120	100	82	-83	u=5	imp:n=1	TMP=2.5301E-08
840	35	5.96942E-02	-121	101	82	-83	u=5	imp:n=1	TMP=2.5301E-08
841	35	5.96942E-02	-122	102	82	-83	u=5	imp:n=1	TMP=2.5301E-08
842	35	5.96942E-02	-123	103	82	-83	u=5	imp:n=1	TMP=2.5301E-08
843	35	5.96942E-02	-124	104	82	-83	u=5	imp:n=1	TMP=2.5301E-08
844	35	5.96942E-02	-125	105	82	-83	u=5	imp:n=1	TMP=2.5301E-08
845	35	5.96942E-02	-126	106	82	-83	u=5	imp:n=1	TMP=2.5301E-08
846	44	2.4049E-02	33	-34	35	-36	82	-83	& 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 & u=5 imp:n=1 TMP=2.5301E-08
Top and bottom calandria plates									
848	27	0.0513781	33	-34	35	-36	83	-85	u=5 imp:n=1 TMP=2.5301E-08
Middle calandria									
850	25	7.1167E-02	-91	85	-86	u=5	imp:n=1	TMP=2.5301E-08	
851	25	7.1167E-02	-92	85	-86	u=5	imp:n=1	TMP=2.5301E-08	
852	25	7.1167E-02	-93	85	-86	u=5	imp:n=1	TMP=2.5301E-08	
853	28	7.1400E-02	-94	85	-86	u=5	imp:n=1	TMP=2.5301E-08	
854	25	7.1167E-02	-95	85	-86	u=5	imp:n=1	TMP=2.5301E-08	

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LIQUID METAL FAST REACTOR - LMFR
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```

c
855      28 7.1400E-02 -96 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
856      25 7.1167E-02 -97 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
857      25 7.1167E-02 -98 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
858      25 7.1167E-02 -99 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
859      25 7.1167E-02 -100 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
860      25 7.1167E-02 -101 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
861      28 7.1400E-02 -102 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
862      25 7.1167E-02 -103 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
863      28 7.1400E-02 -104 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
864      25 7.1167E-02 -105 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
865      25 7.1167E-02 -106 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
870      35 5.96942E-02 -111 91 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
871      35 5.96942E-02 -112 92 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
872      35 5.96942E-02 -113 93 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
873      35 5.96942E-02 -114 94 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
874      35 5.96942E-02 -115 95 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
875      35 5.96942E-02 -116 96 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
876      35 5.96942E-02 -117 97 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
877      35 5.96942E-02 -118 98 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
878      35 5.96942E-02 -119 99 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
879      35 5.96942E-02 -120 100 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
880      35 5.96942E-02 -121 101 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
881      35 5.96942E-02 -122 102 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
882      35 5.96942E-02 -123 103 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
883      35 5.96942E-02 -124 104 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
884      35 5.96942E-02 -125 105 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
885      35 5.96942E-02 -126 106 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
886      44 2.4049E-02 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
888      27 0.0513781 33 -34 35 -36 86 -88 u=5 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
890      25 7.1167E-02 -91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
891      25 7.1167E-02 -92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
892      25 7.1167E-02 -93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
893      28 7.1400E-02 -94 88 -89 u=5 imp:n=1 TMP=2.5301E-08

```

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```

c
894      25 7.1167E-02 -95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
895      28 7.1400E-02 -96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
896      25 7.1167E-02 -97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
897      25 7.1167E-02 -98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
898      25 7.1167E-02 -99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
899      25 7.1167E-02 -100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
900      25 7.1167E-02 -101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
901      28 7.1400E-02 -102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
902      25 7.1167E-02 -103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
903      28 7.1400E-02 -104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
904      25 7.1167E-02 -105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
905      25 7.1167E-02 -106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
910      35 5.96942E-02 -111 91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
911      35 5.96942E-02 -112 92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
912      35 5.96942E-02 -113 93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
913      35 5.96942E-02 -114 94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
914      35 5.96942E-02 -115 95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
915      35 5.96942E-02 -116 96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
916      35 5.96942E-02 -117 97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
917      35 5.96942E-02 -118 98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
918      35 5.96942E-02 -119 99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
919      35 5.96942E-02 -120 100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
920      35 5.96942E-02 -121 101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
921      35 5.96942E-02 -122 102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
922      35 5.96942E-02 -123 103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
923      35 5.96942E-02 -124 104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
924      35 5.96942E-02 -125 105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
925      35 5.96942E-02 -126 106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
926      44 2.4049E-02 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
928      27 0.0513781 33 -34 35 -36 89 -11 u=5 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
929      54 6.94698E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=5 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
931      8 4.7208E-02 11 -67 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08

```


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```

932      9 4.7925E-02 67 -68 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
933     15 4.8317E-02 68 -12 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper Reflector
934     14 8.4932E-02 12 -13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper padding
935     16 3.279692E-02 13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
936      0 132 -133 134 -135 (-21:22:-23:24) u=5 imp:n=1
c Wrapper
937     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=5 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
938      0 1 -2 3 -4 (-136:137:-138:139) u=5 imp:n=1
c
c End of Core Pin Geometry Element J
c
c
c --- Core Plate Geometry Element
c Lower padding
1011     16 3.279692E-02 -8 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1012     14 8.4932E-02 8 -9 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
1013     15 4.8317E-02 9 -41 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
1014      9 4.7925E-02 41 -42 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
1015      8 4.7208E-02 42 -10 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na plate core
1022      5 2.324832E-02 502 -503 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1023      6 7.9429E-02 10 -504 21 -22 23 -24 &
      (-159:160:-161:162:-502:503) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1027      3 6.9083E-02 505 -506 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1028      4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-155:156:-157:158:-505:506) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1032      5 2.324832E-02 508 -509 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1033      6 7.9429E-02 507 -510 21 -22 23 -24 &
      (-159:160:-161:162:-508:509) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1035      1 3.9991E-02 151 -152 153 -154 511 -512 u=6 imp:n=1 TMP=2.5301E-08
c Pu canning
1036      2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-151:152:-153:154:-511:512) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1039      3 6.9083E-02 514 -515 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1040      4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-155:156:-157:158:-514:515) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1042      5 2.324832E-02 517 -518 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1043      6 7.9429E-02 516 -43 21 -22 23 -24 &
      (-159:160:-161:162:-517:518) u=6 imp:n=1 TMP=2.5301E-08
c
c Insert the 22 central region core cells
c
1051      0 43 -44 21 -22 23 -24 fill=13 (0 0 71.209862) u=6 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

1052    0  44 -45 21 -22 23 -24 fill=14 (0 0 74.957944) u=6 imp:n=1
c
c
1053    0  45 -46 21 -22 23 -24 fill=13 (0 0 78.706026) u=6 imp:n=1
c
1054    0  46 -47 21 -22 23 -24 fill=14 (0 0 82.454108) u=6 imp:n=1
c
c
1055    0  47 -48 21 -22 23 -24 fill=13 (0 0 86.202190) u=6 imp:n=1
c
1056    0  48 -49 21 -22 23 -24 fill=14 (0 0 89.950272) u=6 imp:n=1
c
c
1057    0  49 -50 21 -22 23 -24 fill=13 (0 0 93.698354) u=6 imp:n=1
c
1058    0  50 -51 21 -22 23 -24 fill=14 (0 0 97.446436) u=6 imp:n=1
c
c
1059    0  51 -52 21 -22 23 -24 fill=13 (0 0 101.194518) u=6 imp:n=1
c
1060    0  52 -53 21 -22 23 -24 fill=14 (0 0 104.942600) u=6 imp:n=1
c
c
1061    0  53 -54 21 -22 23 -24 fill=13 (0 0 108.690682) u=6 imp:n=1
c
1062    0  54 -55 21 -22 23 -24 fill=14 (0 0 112.438764) u=6 imp:n=1
c
c
1063    0  55 -56 21 -22 23 -24 fill=13 (0 0 116.186846) u=6 imp:n=1
c
1064    0  56 -57 21 -22 23 -24 fill=14 (0 0 119.934928) u=6 imp:n=1
c
c
1065    0  57 -58 21 -22 23 -24 fill=13 (0 0 123.683010) u=6 imp:n=1
c
1066    0  58 -59 21 -22 23 -24 fill=14 (0 0 127.431092) u=6 imp:n=1
c
c
1067    0  59 -60 21 -22 23 -24 fill=13 (0 0 131.179174) u=6 imp:n=1
c
1068    0  60 -61 21 -22 23 -24 fill=14 (0 0 134.927256) u=6 imp:n=1
c
c
1069    0  61 -62 21 -22 23 -24 fill=13 (0 0 138.675338) u=6 imp:n=1
c
1070    0  62 -63 21 -22 23 -24 fill=14 (0 0 142.423420) u=6 imp:n=1
c
c
1071    0  63 -64 21 -22 23 -24 fill=13 (0 0 146.171502) u=6 imp:n=1
c
1072    0  64 -65 21 -22 23 -24 fill=14 (0 0 149.919584) u=6 imp:n=1
c
c
c The top core cell, Cell 2
c
c Na plate core
1082    5 2.324832E-02 402 -403 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
c Na plate can
1083    6 7.9429E-02 65 -404 21 -22 23 -24 &
      (-159:160:-161:162:-402:403) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1087    3 6.9083E-02 405 -406 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1088    4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-155:156:-157:158:-405:406) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1092    1 3.9991E-02 151 -152 153 -154 408 -409 u=6 imp:n=1 &
      TMP=2.5301E-08
c Pu canning
1093    2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-151:152:-153:154:-408:409) u=6 imp:n=1 TMP=2.5301E-08
c

```

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```

c Na plate core
1102 5 2.324832E-02 411 -412 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
C Na plate can
1103 6 7.9429E-02 410 -413 21 -22 23 -24 &
      (-159:160:-161:162:-411:412) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1107 3 6.9083E-02 414 -415 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1108 4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-155:156:-157:158:-414:415) u=6 imp:n=1 TMP=2.5301E-08
c
c Na plate core
1112 5 2.324832E-02 417 -418 159 -160 161 -162 u=6 imp:n=1 TMP=2.5301E-08
C Na plate can
1113 6 7.9429E-02 416 -419 21 -22 23 -24 &
      (-159:160:-161:162:-417:418) u=6 imp:n=1 TMP=2.5301E-08
c
c
c Upper Axial blanket.
c
1121 8 4.7208E-02 66 -67 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1122 9 4.7925E-02 67 -68 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1123 15 4.8317E-02 68 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1126 14 8.4932E-02 12 -13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1127 16 3.279692E-02 13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Wrapper region
c 1128 17 3.87228E-02 1 -2 3 -4 (-21:22:-23:24) u=6 imp:n=1
      TMP=2.5301E-08
c gap between plates and wrapper
1131 0 132 -133 134 -135 (-21:22:-23:24) u=6 imp:n=1
c Wrapper
1132 17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=6 &
      imp:n=1 TMP=2.5301E-08
c gap outside wrapper
1133 0 1 -2 3 -4 (-136:137:-138:139) u=6 imp:n=1
c
c
c --- Radial Breeder Element
c Lower padding
1241 16 3.279692E-02 -8 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1242 14 8.4932E-02 8 -9 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Radial blanket
1244 15 4.8317E-02 9 -12 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Upper reflector
1246 like 134 but u=7 imp:n=1 TMP=2.5301E-08
c Upper padding
1247 like 135 but u=7 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
1248 0 132 -133 134 -135 (-21:22:-23:24) u=7 imp:n=1
c Wrapper
1249 17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=7 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
1250 0 1 -2 3 -4 (-136:137:-138:139) u=7 imp:n=1
c
c
c
c --- Radial shield
c
1326 12 8.32720E-02 28 -29 30 -31 u=8 imp:n=1 TMP=2.5301E-08
c
1327 13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=8 imp:n=1 &
      TMP=2.5301E-08
c
c
1400 13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly

```

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```

c
1419    0   189 -190 191 -192 u=10 lat=1
        fill=-3:3 -3:3 0:0
        199 164 162 161 163 165 199
        146 144 132 141 132 145 147
        126 132 122 121 123 132 127
        106 104 102 101 103 105 107
        116 132 112 111 113 132 117
        136 134 132 131 132 135 137
        199 154 152 151 153 155 199
        imp:n=1

c
c --- Fuel Region
c
1429    0 7 -16 -17 fill=10 imp:n=1
c --- Universe
1430    0 -7:16:17 imp:n=0
c
c Cell A
c 501    1 6.9985E-02 -71 u=3 imp:n=1 TMP=2.5301E-08
c
c 502    23 0.062241 -74 71 u=3 imp:n=1 TMP=2.5301E-08
c
c 503    5 2.3900E-02 74 u=3 imp:n=1 TMP=2.5301E-08
c
c 504    0 75 -76 77 -78 u=3 fill=1 imp:n=1
c
c Cell E   Modified compositions
c
c 506    2 7.1167E-02 -71 u=4 imp:n=1 TMP=2.5301E-08
c
c 507    24 0.0596942 -74 71 u=4 imp:n=1 TMP=2.5301E-08
c
c 508    5 2.3900E-02 74 u=4 imp:n=1 TMP=2.5301E-08
c
c 509    0 75 -76 77 -78 u=4 fill=2 imp:n=1
c
c 511    0 75 -76 77 -78 lat=1 &
c        fill -2:1 -2:1 0:0 &
c        3 4 3 4 4 3 4 3 3 4 3 4 3 4 3 &
c        u=11 imp:n=1
c
c
c ----- PLATE ELEMENT CELL CARDS -----
c
c The First Regular cell. Cell 1
c
c Na plate
c Na plate core
2162    5 2.324832E-02 802 -803 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
c Na plate can
2163    6 7.9429E-02 801 -804 21 -22 23 -24 &
        (-159:160:-161:162:-802:803) u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2167    3 6.9083E-02 805 -806 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2168    4 7.2463E-02 804 -807 21 -22 23 -24 &
        (-155:156:-157:158:-805:806) u=13 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170    7 3.3152E-02 807 -708 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c Pu plate
c Plate core
2172    1 3.9991E-02 151 -152 153 -154 709 -710 u=13 imp:n=1 TMP=2.5301E-08
c Pu canning
2173    2 6.6997E-02 708 -711 21 -22 23 -24 &
        (-151:152:-153:154:-709:710) u=13 imp:n=1 TMP=2.5301E-08
c
c
c Na plate
c Na plate core

```

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```

2182   5 2.324832E-02 712 -713 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
C Na plate can
2183   6 7.9429E-02 711 -814 21 -22 23 -24 &
      (-159:160:-161:162:-712:713) u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2187   3 6.9083E-02 815 -816 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188   4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=13 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2192   5 2.324832E-02 818 -819 159 -160 161 -162 u=13 imp:n=1 TMP=2.5301E-08
C Na plate can
2193   6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-159:160:-161:162:-818:819) u=13 imp:n=1 TMP=2.5301E-08
c
c End of Cell 1 beginning of Cell 2
c Na plate
c Na plate core
2202   5 2.324832E-02 802 -803 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2203   6 7.9429E-02 801 -804 21 -22 23 -24 &
      (-159:160:-161:162:-802:803) u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2207   3 6.9083E-02 805 -806 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2208   4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=14 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2211   5 2.324832E-02 808 -809 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2212   6 7.9429E-02 807 -810 21 -22 23 -24 &
      (-159:160:-161:162:-808:809) u=14 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2214   1 3.9991E-02 151 -152 153 -154 811 -812 u=14 imp:n=1 TMP=2.5301E-08
C Pu canning
2215   2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-151:152:-153:154:-811:812) u=14 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217   7 3.3152E-02 813 -814 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219   3 6.9083E-02 815 -816 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220   4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=14 imp:n=1 TMP=2.5301E-08
c
c Na plate
c Na plate core
2222   5 2.324832E-02 818 -819 159 -160 161 -162 u=14 imp:n=1 TMP=2.5301E-08
C Na plate can
2223   6 7.9429E-02 817 -820 21 -22 23 -24 &
      (-159:160:-161:162:-818:819) u=14 imp:n=1 TMP=2.5301E-08
c
c
c End of plate element cell data
c
c
c -----
c
c Form the region surrounding groups of 5x5 elements, containing grids
c
c
3001   0 189 -190 191 -192 (-185:186:-187:188) -71 u=100 imp:n=1

```

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```

c
3002  20 7.403935E-02  189 -190 191 -192  (-185:186:-187:188) 71 -72 &
      u=100 imp:n=1
c
3003  0  189 -190 191 -192  (-185:186:-187:188) 72 -73 u=100 imp:n=1
c
3004  20 7.403935E-02  189 -190 191 -192  (-185:186:-187:188) 73 -74 &
      u=100 imp:n=1
c
3005  0  189 -190 191 -192  (-185:186:-187:188) 74 u=100 imp:n=1
c
c
c -----
c
c Form arrays of 5x5 elements
c
c                               Central row
c
c Central array of 5x5 core elements
c
c
3011  0  1 -2 3 -4 u=201 lat=1
      fill=-2:2 -2:2 0:0
      6 6 6 6 6
      6 6 6 6 6
      6 6 6 6 6
      6 6 6 6 6
      6 6 6 6 6
      imp:n=1
c
3012  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=101 imp:n=1
c
3013  0 7 -16 185 -186 187 -188 fill=201 u=101 imp:n=1
c
c
c Middle Left array of 5x5 core elements in row 4
c
3014  0  1 -2 3 -4 u=202 lat=1
      fill=-2:2 -2:2 0:0
      4 5 4 2 6
      4 2 4 2 6
      3 2 2 2 6
      4 2 2 2 6
      4 5 2 2 6
      imp:n=1
c
c
c Surround material
c
3015  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=102 imp:n=1
c
c
3016  0 7 -16 185 -186 187 -188 fill=202 u=102 imp:n=1
c
c
c Middle Right array of 5x5 core elements in row 4
c
3017  0  1 -2 3 -4 u=203 lat=1
      fill=-2:2 -2:2 0:0
      6 2 4 5 4
      6 2 4 2 4
      6 2 2 2 3
      6 2 2 2 4
      6 2 3 5 4
      imp:n=1
c
c
c Surround material
c
3018  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=103 imp:n=1
c
c
3019  0 7 -16 185 -186 187 -188 fill=203 u=103 imp:n=1
c

```

```

c
c
c Left edge array of 5x5 core elements in row 4
c
3021    0    1 -2 3 -4 u=204 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        imp:n=1

c
c
c Surround material
c
3022    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=104 imp:n=1
c
c
3023    0 7 -16 185 -186 187 -188 fill=204 u=104 imp:n=1
c
c
c Right edge array of 5x5 core elements in row 4
c
3024    0    1 -2 3 -4 u=205 lat=1
        fill=-2:2 -2:2 0:0
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        imp:n=1

c
c
c Surround material
c
3025    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=105 imp:n=1
c
c
3026    0 7 -16 185 -186 187 -188 fill=205 u=105 imp:n=1
c
c
c
c
c ROW 3 The row below the central line
c
c
c Middle array of 5x5 core elements in Row 3
c
c
3031    0    1 -2 3 -4 u=211 lat=1
        fill=-2:2 -2:2 0:0
        6 6 6 6 6
        1 1 1 1 1
        3 3 3 3 3
        3 3 3 3 3
        3 3 3 3 3
        imp:n=1

c
c
c Surround material
c
3032    0   189 -190 191 -192   (-185:186:-187:188) fill=100 u=111 imp:n=1
c
3033    0 7 -16 185 -186 187 -188 fill=211 u=111 imp:n=1
c
c Lower left array of 5x5 core elements in Row 3
c
c
3034    0    1 -2 3 -4 u=212 lat=1
        fill=-2:2 -2:2 0:0
        1 2 2 1 2
        1 2 2 1 2
        7 1 4 2 3
        7 7 1 3 3
        7 7 7 1 1
        imp:n=1

```

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```

c
c Surround material
c
3035  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=112 imp:n=1
c
3036  0  7 -16 185 -186 187 -188 fill=212 u=112 imp:n=1
c
c
c Lower right array of 5x5 core elements in Row 3
c
3037      0   1 -2 3 -4 u=213 lat=1
      fill=-2:2 -2:2 0:0
      2 2 3 3 1
      2 3 3 5 1
      3 3 3 1 7
      3 3 5 7 7
      1 1 7 7 7
      imp:n=1
c
c
c Surround material
c
3038  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=113 imp:n=1
c
c
3039  0  7 -16 185 -186 187 -188 fill=213 u=113 imp:n=1
c
c
c
c          ROW 5 the row above the central line
c
c Central array of 5x5 core elements in Row 5
c
3051      0   1 -2 3 -4 u=221 lat=1
      fill=-2:2 -2:2 0:0
      3 3 3 3 3
      3 3 3 3 3
      3 3 3 3 3
      1 1 1 1 1
      6 6 6 6 6
      imp:n=1
c
c
c Surround material
c
3052  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=121 imp:n=1
c
c
3053  0  7 -16 185 -186 187 -188 fill=221 u=121 imp:n=1
c
c
c Top left array of 5x5 core elements in Row 5
c
3054      0   1 -2 3 -4 u=222 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 2 2
      7 7 2 3 3
      7 2 4 2 2
      1 5 2 1 2
      1 2 2 1 2
      imp:n=1
c
c
c Surround material
c
3055  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=122 imp:n=1
c
c
3056  0  7 -16 185 -186 187 -188 fill=222 u=122 imp:n=1
c
c
c Top right array of 5x5 core elements in Row 5
c
3057      0   1 -2 3 -4 u=223 lat=1

```


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```

fill=-2:2 -2:2 0:0
1 1 7 7 7
3 3 2 7 7
2 2 4 2 7
2 1 2 3 1
2 1 2 2 1
imp:n=1
c
c
c Surround material
c
3058 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=123 imp:n=1
c
c
3059 0 7 -16 185 -186 187 -188 fill=223 u=123 imp:n=1
c
c
c
c ROW 2 The row two down from the central row
c
c Lower central group
c
c
3071 0 1 -2 3 -4 u=231 lat=1
fill=-2:2 -2:2 0:0
1 1 1 1 1
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3072 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=131 imp:n=1
c
3073 0 7 -16 185 -186 187 -188 fill=231 u=131 imp:n=1
c
c
c ROW 6
c
c Top central array of 5x5 core elements in row 6
c
3074 0 1 -2 3 -4 u=241 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
1 1 1 1 1
imp:n=1
c
c Surround material
c
3075 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=141 imp:n=1
c
3076 0 7 -16 185 -186 187 -188 fill=241 u=141 imp:n=1
c
c
c
c 5x5 array of blanket elements
c
c
3101 0 1 -2 3 -4 u=232 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c

```

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```

c Surround material
c
3102  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=132 imp:n=1
c
3103  0  7 -16 185 -186 187 -188 fill=232 u=132 imp:n=1
c
c
c *** Blanket-Reflector Arrays ***
c
c ROW 2
c
c Bottom Left
c
c
3111  0  1 -2 3 -4 u=234 lat=1
      fill=-2:2 -2:2 0:0
      8 7 7 7 7
      8 8 7 7 7
      8 8 8 7 7
      8 8 8 8 7
      9 8 8 8 8
      imp:n=1
c
c
c Surround material
c
3112  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=134 imp:n=1
c
3113  0  7 -16 185 -186 187 -188 fill=234 u=134 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
c
3121  0  1 -2 3 -4 u=235 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 8
      7 7 7 8 8
      7 7 8 8 8
      7 8 8 8 8
      8 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3122  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=135 imp:n=1
c
3123  0  7 -16 185 -186 187 -188 fill=235 u=135 imp:n=1
c
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
c
3131  0  1 -2 3 -4 u=244 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 8
      8 8 8 8 7
      8 8 8 7 7
      8 8 7 7 7
      8 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3132  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=144 imp:n=1
c
3133  0  7 -16 185 -186 187 -188 fill=244 u=144 imp:n=1
c
c Row 6 Top Right Blanket Reflector Array
c

```

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```

c
3141    0    1 -2 3 -4 u=245 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 8 9
      7 8 8 8 8
      7 7 8 8 8
      7 7 7 8 8
      7 7 7 7 8
      imp:n=1

c
c
c Surround material
c
3142    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=145 imp:n=1
c
3143    0  7 -16 185 -186 187 -188 fill=245 u=145 imp:n=1
c
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
c
3151    0    1 -2 3 -4 u=254 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3152    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=154 imp:n=1
c
3153    0  7 -16 185 -186 187 -188 fill=254 u=154 imp:n=1
c
c Row 1 Mid-Left
c
c
3161    0    1 -2 3 -4 u=252 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 7 7
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3162    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=152 imp:n=1
c
3163    0  7 -16 185 -186 187 -188 fill=252 u=152 imp:n=1
c
c Row 1 Central Array
c
3171    0    1 -2 3 -4 u=251 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3172    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=151 imp:n=1
c

```

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```

3173   0 7 -16 185 -186 187 -188 fill=251 u=151 imp:n=1
c
c Row 1 First Right array
c
c
3181     0   1 -2 3 -4 u=253 lat=1
      fill=-2:2 -2:2 0:0
      7 7 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3182     0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=153 imp:n=1
c
3183     0 7 -16 185 -186 187 -188 fill=253 u=153 imp:n=1
c
c Row 1 Far Right
c
c
3191     0   1 -2 3 -4 u=255 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3192     0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=155 imp:n=1
c
3193     0 7 -16 185 -186 187 -188 fill=255 u=155 imp:n=1
c
c
c Row 2 Blanket reflector arrays
c
c Row 2 First Left array
c
c
3201     0   1 -2 3 -4 u=236 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 8 8
      9 9 9 8 8
      9 9 9 9 8
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3202     0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=136 imp:n=1
c
3203     0 7 -16 185 -186 187 -188 fill=236 u=136 imp:n=1
c
c Row 2 Far Right
c
c
3211     0   1 -2 3 -4 u=237 lat=1
      fill=-2:2 -2:2 0:0
      8 8 9 9 9
      8 8 9 9 9
      8 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c

```

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```

c
c Surround material
c
3212   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=137 imp:n=1
c
3213   0  7 -16 185 -186 187 -188 fill=237 u=137 imp:n=1
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
c
3221   0   1 -2 3 -4 u=206 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3222   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=106 imp:n=1
c
3223   0  7 -16 185 -186 187 -188 fill=206 u=106 imp:n=1
c
c
c Row 4 Far Right
c
c
3231   0   1 -2 3 -4 u=207 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3232   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=107 imp:n=1
c
3233   0  7 -16 185 -186 187 -188 fill=207 u=107 imp:n=1
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
c
3241   0   1 -2 3 -4 u=246 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 8
      9 9 9 8 8
      9 9 9 8 8
      9 9 9 8 8
      imp:n=1
c
c
c Surround material
c
3242   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=146 imp:n=1
c
3243   0  7 -16 185 -186 187 -188 fill=246 u=146 imp:n=1
c
c Row 6 Far Right
c
c
3251   0   1 -2 3 -4 u=247 lat=1
      fill=-2:2 -2:2 0:0

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

      9 9 9 9 9
      9 9 9 9 9
      8 9 9 9 9
      8 8 9 9 9
      8 8 9 9 9
      imp:n=1
c
c
c Surround material
c
3252   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=147 imp:n=1
c
3253   0  7 -16 185 -186 187 -188 fill=247 u=147 imp:n=1
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
c
3261   0   1 -2 3 -4 u=226 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3262   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=126 imp:n=1
c
3263   0  7 -16 185 -186 187 -188 fill=226 u=126 imp:n=1
c
c Row 4 Far Right
c
3271   0   1 -2 3 -4 u=227 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3272   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=127 imp:n=1
c
3273   0  7 -16 185 -186 187 -188 fill=227 u=127 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays
c
c Row 3 First Left array
c
3281   0   1 -2 3 -4 u=216 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      imp:n=1
c
c
c Surround material
c
3282   0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=116 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

3283   0 7 -16 185 -186 187 -188 fill=216 u=116 imp:n=1
c
c Row 3 Far Right
c
3291   0   1 -2 3 -4 u=217 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      imp:n=1
c
c
c Surround material
c
3292   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=117 imp:n=1
c
3293   0 7 -16 185 -186 187 -188 fill=217 u=117 imp:n=1
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
c
3301   0   1 -2 3 -4 u=264 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 8 8
      9 9 8 8 8
      imp:n=1
c
c
c Surround material
c
3302   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=164 imp:n=1
c
3303   0 7 -16 185 -186 187 -188 fill=264 u=164 imp:n=1
c
c Row 7 Mid-Left
c
3311   0   1 -2 3 -4 u=262 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 7 7
      imp:n=1
c
c
c Surround material
c
3312   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=162 imp:n=1
c
3313   0 7 -16 185 -186 187 -188 fill=262 u=162 imp:n=1
c
c Row 7 Central Array
c
3321   0   1 -2 3 -4 u=261 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3322   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=161 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
3323  0 7 -16 185 -186 187 -188 fill=261 u=161 imp:n=1
c
c Row 7 First Right array
c
3331    0   1 -2 3 -4 u=263 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      7 7 8 8 8
      imp:n=1

c
c
c Surround material
c
3332  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=163 imp:n=1
c
3333  0 7 -16 185 -186 187 -188 fill=263 u=163 imp:n=1
c
c Row 7 Far Right
c
3341    0   1 -2 3 -4 u=265 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 9 9
      imp:n=1

c
c
c Surround material
c
3342  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=165 imp:n=1
c
3343  0 7 -16 185 -186 187 -188 fill=265 u=165 imp:n=1
c
c Beyond the reflector 5x5 Region 9
c
3351    0   1 -2 3 -4 u=299 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3352  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=199 imp:n=1
c
c
c
c
c -----
c
c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1      px -2.68605
2      px 2.68605
3      py -2.68605
4      py 2.68605
7      pz 0.0 $ Assembly lower limit
8      pz 30.0 $ End Packing, Start Reflector
9      pz 37.60628 $ End Plenum, Start Lower NU

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

10    pz 67.77878 $ End Lower NU, Start Fuel
c
11    pz 156.96878 $ End Fuel, Start Upper NU for Pin element
c
12    pz 187.271248 $ End Upper NU, Start Top Reflector
13    pz 194.877528 $ End Reflector, Start Packing
16    pz 224.877528 $ Assembly upper limit
c
17    cz 94.9
c
21    px -2.5335 $ Nominal half-width of plates
22    px 2.5335 $ and calandria outer half-width
23    py -2.5335
24    py 2.5335
28    px -2.54 $ Radial shield half-width
29    px 2.54
30    py -2.54
31    py 2.54
c
33    px -2.45 $ inner half-width of calandria
34    px 2.45
35    py -2.45
36    py 2.45
c
c
c subdivisions in the plate element axial blanket and core cells
c
c      9 pz 37.60628 $ axial reflector / axial blanket
41    pz 45.228780
42    pz 57.951780
c      10 pz 67.77878 $ axial blanket / core
43    pz 71.209862
44    pz 74.957944
45    pz 78.706026
46    pz 82.454108
47    pz 86.202190
48    pz 89.950272
49    pz 93.698354
50    pz 97.446436
51    pz 101.194518
52    pz 104.942600
53    pz 108.690682
54    pz 112.438764
55    pz 116.186846
56    pz 119.934928
57    pz 123.683010
58    pz 127.431092
59    pz 131.179174
60    pz 134.927256
61    pz 138.675338
62    pz 142.423420
63    pz 146.171502
64    pz 149.919584
65    pz 153.667666
c
66    pz 157.098748 $ core / axial blanket
c      in plate elements (this replaces pz=11)
67    pz 166.925748
68    pz 179.648748
c      12 pz 187.271248 $ axial blanket / reflector
c
c differences in the pin elements ?
c 67    pz 166.925748
c 68    pz 179.648748
c      12 pz 187.271248 $ axial blanket / reflector
c
c Grid plate heights
c
71    pz 31.8
72    pz 62.2
73    pz 162.6
74    pz 193.0
c
c 71    c/z 0 0 0.423          $ fuel pin radius

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c 71      c/z 0.6125 0.6125 0.423
c 72      c/z 0 0 0.4305          $ fuel can inner radius
c 73      c/z 0 0 0.488          $ calandria tube inner radius
c 74      c/z 0 0 0.513          $ calandria tube outer radius
c 74      c/z 0.6125 0.6125 0.513
c 75      px 0.0
c 76      px 1.225
c 77      py 0.0
c 78      py 1.225
c 79      cz 1.692
c 80      cz 2.052
c
81      pz 67.77878 $ 0.0
82      pz 68.21878 $ 0.44
83      pz 97.39878 $ 29.62
c 84      pz 97.50878 $ 29.73
85      pz 97.94878 $ 0.44
86      pz 127.12878 $ 29.62
87      pz 127.23878 $ 29.73
88      pz 127.67878 $ 0.44
89      pz 156.85878 $ 29.62
90      pz 156.96878 $ 29.73
c
91      c/z -1.785 -1.785 0.423
92      c/z -0.595 -1.785 0.423
93      c/z 0.595 -1.785 0.423
94      c/z 1.785 -1.785 0.423
95      c/z -1.785 -0.595 0.423
96      c/z -0.595 -0.595 0.423
97      c/z 0.595 -0.595 0.423
98      c/z 1.785 -0.595 0.423
99      c/z -1.785 0.595 0.423
100     c/z -0.595 0.595 0.423
101     c/z 0.595 0.595 0.423
102     c/z 1.785 0.595 0.423
103     c/z -1.785 1.785 0.423
104     c/z -0.595 1.785 0.423
105     c/z 0.595 1.785 0.423
106     c/z 1.785 1.785 0.423
c
c
111     c/z -1.785 -1.785 0.513
112     c/z -0.595 -1.785 0.513
113     c/z 0.595 -1.785 0.513
114     c/z 1.785 -1.785 0.513
115     c/z -1.785 -0.595 0.513
116     c/z -0.595 -0.595 0.513
117     c/z 0.595 -0.595 0.513
118     c/z 1.785 -0.595 0.513
119     c/z -1.785 0.595 0.513
120     c/z -0.595 0.595 0.513
121     c/z 0.595 0.595 0.513
122     c/z 1.785 0.595 0.513
123     c/z -1.785 1.785 0.513
124     c/z -0.595 1.785 0.513
125     c/z 0.595 1.785 0.513
126     c/z 1.785 1.785 0.513
c
132     px -2.551 $ sheath inner half-width
133     px 2.551
134     py -2.551
135     py 2.551
136     px -2.6272 $ sheath outer half-width
137     px 2.6272
138     py -2.6272
139     py 2.6272
c
c      Widths of plate cores
c      * in plate geometry cores these are 101 to 112
151     px -2.3355 $ Pu plate core width
152     px 2.3355
153     py -2.3355
154     py 2.3355
155     px -2.4255 $ UO2 plate core width

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

156    px 2.4255
157    py -2.4255
158    py 2.4255
159    px -2.4815 $ Na plate core width
160    px 2.4815
161    py -2.4815
162    py 2.4815
c
c
c coordinates of the elements in 5x5 arrays
c * in the plate geometry cores these are 81 to 92
181    px -8.05815
182    px 8.05815
183    py -8.05815
184    py 8.05815
185    px -13.43025
186    px 13.43025
187    py -13.43025
188    py 13.43025
189    px -13.5635
190    px 13.5635
191    py -13.5635
192    py 13.5635
c
c
c Cell 2 Axial heights
c
401    pz 153.667666
402    pz 153.704013
403    pz 154.245013
404    pz 154.281360
405    pz 154.318010
406    pz 154.876010
407    pz 154.912660
408    pz 154.958360
409    pz 155.194360
410    pz 155.240060
411    pz 155.276407
412    pz 155.817407
413    pz 155.853754
414    pz 155.890404
415    pz 156.448404
416    pz 156.485054
417    pz 156.521401
418    pz 157.062401
419    pz 157.098748
c
c Cell 12 Axial heights
c
501    pz 67.778780
502    pz 67.815127
503    pz 68.356127
504    pz 68.392474
505    pz 68.429124
506    pz 68.987124
507    pz 69.023774
508    pz 69.060121
509    pz 69.601121
510    pz 69.637468
511    pz 69.683168
512    pz 69.919168
513    pz 69.964868
514    pz 70.001518
515    pz 70.559518
516    pz 70.596168
517    pz 70.632515
518    pz 71.173515
519    pz 71.209862
c
c Basic Cell 1 data
c 701    pz 0.000000
c 702    pz 0.036347 $ Na can
c 703    pz 0.577347 $ Na core
c 704    pz 0.613694

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c 705    pz    0.650344    $ UO2 can
c 706    pz    1.208344    $ UO2 core
c 707    pz    1.244994
708      pz    1.561994    $ SS
709      pz    1.607694    $ Pu can
710      pz    1.843694    $ Pu core
711      pz    1.889394
712      pz    1.925741    $ Na can
713      pz    2.466741    $ Na core
c 714      pz    2.503088
c 715      pz    2.539738    $ UO2 can
c 716      pz    3.097738    $ UO2 core
c 717      pz    3.134388
c 718      pz    3.170735    $ Na can
c 719      pz    3.711735    $ Na core
c 720      pz    3.748082    $          Cell 1

```

```

c
801      pz    0.000000
802      pz    0.036347
803      pz    0.577347    $ Na
804      pz    0.613694
805      pz    0.650344
806      pz    1.208344    $ UO2
807      pz    1.244994
808      pz    1.281341
809      pz    1.822341    $ Na
810      pz    1.858688
811      pz    1.904388
812      pz    2.140388    $ Pu
813      pz    2.186088
814      pz    2.503088    $ SS
815      pz    2.539738
816      pz    3.097738    $ UO2
817      pz    3.134388
818      pz    3.170735
819      pz    3.711735    $ Na
820      pz    3.748082    $ Cell 11

```

```

c
c -----
c

```

```

c
c
c ----- TALLY CARDS -----
c

```

```

c --- MATERIALS CARDS ---
c
c

```

C MATERIAL 1 Pu metal plate core

```

ml      92238.31c    6.8782E-07
      94238.31c    3.0461E-05
      94239.31c    2.8920E-02
      94240.31c    6.9095E-03
      94241.31c    7.3960E-04
      94242.31c    1.8699E-04
      95241.31c    4.5718E-04
      1001.31c    1.2764E-04
      6000.31c    4.2260E-04
      7014.31c    2.4215E-05
      8016.31c    8.8450E-05
      13027.31c    2.2973E-05
      14028.31c    1.4158E-05
      25055.31c    1.4902E-06
      24050.31c    1.5637E-07
      24052.31c    3.0155E-06
      24053.31c    3.4193E-07
      24054.31c    8.5114E-08
      26054.31c    9.5478E-07
      26056.31c    1.4988E-05
      26057.31c    3.4614E-07
      26058.31c    4.6065E-09
      28058.31c    5.8334E-06
      28060.31c    2.2470E-06
      28061.31c    9.7676E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

28062.31c 3.1143E-07
28064.31c 7.9313E-08
31000.31c 2.0166E-03
c total 3.9991E-02
c MATERIAL 2 Pu plate canning
m2 1001.31c 1.3760E-05
6000.31c 1.1393E-04
14028.31c 3.6607E-04
15031.31c 1.3731E-05
24050.31c 4.0848E-04
24052.31c 7.8771E-03
24053.31c 8.9320E-04
24054.31c 2.2234E-04
25055.31c 8.5931E-04
26054.31c 2.0774E-03
26056.31c 3.2611E-02
26057.31c 7.5313E-04
26058.31c 1.0023E-05
28058.31c 2.8351E-03
28060.31c 1.0921E-03
28061.31c 4.7472E-05
28062.31c 1.5136E-04
28064.31c 3.8548E-05
29063.31c 1.1629E-02
29065.31c 4.9839E-03
c total 6.6997E-02
C MATERIAL 3 UO2 plate core
m3 1001.31c 3.1773E-05
6000.31c 1.1808E-05
8016.31c 4.6008E-02
13027.31c 3.3911E-06
14028.31c 2.2967E-05
25055.31c 8.3273E-08
26054.31c 7.6610E-08
26056.31c 1.2026E-06
26057.31c 2.7774E-08
26058.31c 3.6962E-10
28058.31c 8.4906E-07
28060.31c 3.2705E-07
28061.31c 1.4217E-08
28062.31c 4.5329E-08
28064.31c 1.1544E-08
42000.66c 3.3379E-07
92235.31c 1.6544E-04
92238.31c 2.2837E-02
c total 6.9083E-02
c MATERIAL 4 UO2 plate canning
m4 1001.31c 1.9035E-05
6000.31c 1.2831E-04
14028.31c 6.4475E-04
15031.31c 3.5078E-04
16032.31c 3.6041E-05
24050.31c 6.0044E-04
24052.31c 1.1579E-02
24053.31c 1.3129E-03
24054.31c 3.2682E-04
25055.31c 8.5559E-04
26054.31c 2.8235E-03
26056.31c 4.4323E-02
26057.31c 1.0236E-03
26058.31c 1.3622E-05
28058.31c 5.7360E-03
28060.31c 2.2095E-03
28061.31c 9.6046E-05
28062.31c 3.0624E-04
28064.31c 7.7989E-05
c total 7.2463E-02
C MATERIAL 5 sodium plate core
m5 1001.31c 1.3900E-05
8016.31c 5.6492E-06
11023.31c 2.3225E-02
20040.31c 3.6083E-06
26054.31c 9.4595E-09
26056.31c 1.4849E-07

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

26057.31c 3.4294E-09
26058.31c 4.5639E-11
c total 2.324832E-02
c MATERIAL 6 Sodium plate canning
m6      1001.31c 2.1631E-05
        6000.31c 2.9290E-04
        14028.31c 6.0867E-04
        15031.31c 3.2795E-05
        16032.31c 3.3219E-05
        24050.31c 6.4128E-04
        24052.31c 1.2366E-02
        24053.31c 1.4023E-03
        24054.31c 3.4905E-04
        25055.31c 1.3570E-03
        26054.31c 3.2179E-03
        26056.31c 5.0514E-02
        26057.31c 1.1666E-03
        26058.31c 1.5525E-05
        28058.31c 4.8322E-03
        28060.31c 1.8614E-03
        28061.31c 8.0912E-05
        28062.31c 2.5798E-04
        28064.31c 6.5701E-05
        41093.31c 3.1147E-04
c total 7.9429E-02
C MATERIAL 7 40% steel plate
c m7      1001.31c 1.8355E-05
c        6000.31c 8.7794E-05
c        13027.31c 1.1862E-04
c        14028.31c 7.9703E-04
c        15031.31c 4.0018E-05
c        16032.31c 1.4422E-05
c        22000.62c 2.4806E-04
c        24050.31c 6.9120E-04
c        24052.31c 1.3329E-02
c        24053.31c 1.5114E-03
c        24054.31c 3.7622E-04
c        25055.31c 1.4972E-03
c        26054.31c 3.2362E-03
c        26056.31c 5.0801E-02
c        26057.31c 1.1732E-03
c        26058.31c 1.5613E-05
c        28058.31c 5.9891E-03
c        28060.31c 2.3070E-03
c        28061.31c 1.0028E-04
c        28062.31c 3.1975E-04
c        28064.31c 8.1431E-05
c        29063.31c 5.0365E-05
c        41093.31c 4.9781E-06
c        42000.66c 8.0988E-05
c
c 40% ss plate smeared over plate region
c
m7      1001.31c 7.3413E-06
        6000.31c 3.5114E-05
        13027.31c 4.7443E-05
        14028.31c 3.1878E-04
        15031.31c 1.6006E-05
        16032.31c 5.7682E-06
        22000.62c 9.9214E-05
        24050.31c 2.7645E-04
        24052.31c 5.3311E-03
        24053.31c 6.0450E-04
        24054.31c 1.5047E-04
        25055.31c 5.9882E-04
        26054.31c 1.2944E-03
        26056.31c 2.0318E-02
        26057.31c 4.6923E-04
        26058.31c 6.2446E-06
        28058.31c 2.3954E-03
        28060.31c 9.2271E-04
        28061.31c 4.0108E-05
        28062.31c 1.2789E-04
        28064.31c 3.2569E-05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

29063.31c 1.4101E-05
29065.31c 6.0432E-06
41093.31c 1.9910E-06
42000.66c 3.2392E-05
c total 3.3152E-02
c
C MATERIAL 8 U8 metal plate
m8 1001.31c 4.4048E-05
6000.31c 4.9283E-04
14028.31c 2.1076E-04
26054.31c 6.1951E-06
26056.31c 9.7250E-05
26057.31c 2.2459E-06
26058.31c 2.9889E-08
92235.31c 3.3369E-04
92238.31c 4.6021E-02
c total 4.7208E-02
C MATERIAL 9 U2 metal plate
m9 1001.31c 4.3899E-05
6000.31c 4.6047E-04
14028.31c 1.9692E-04
26054.31c 5.7884E-06
26056.31c 9.0866E-05
26057.31c 2.0985E-06
26058.31c 2.7927E-08
92235.31c 3.3962E-04
92238.31c 4.6785E-02
c total 4.7925E-02
c
c
c radial shield
ml2 1001.31c 4.6306E-05
6000.31c 6.8972E-04
14028.31c 3.1158E-04
15031.31c 4.2944E-05
16032.31c 3.7110E-05
25055.31c 7.1275E-04
26054.31c 4.9065E-03
26056.31c 7.4517E-02
26057.31c 1.7491E-03
26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
ml3 1001.31c 4.6306E-08
6000.31c 6.8972E-07
14028.31c 3.1158E-07
15031.31c 4.2944E-08
16032.31c 3.7110E-08
25055.31c 7.1275E-07
26054.31c 4.9065E-06
26056.31c 7.4517E-05
26057.31c 1.7491E-06
26058.31c 2.5903E-07
c total 8.32720E-05
c
c Axial shield
ml4 1001.31c 2.5700E-05
6000.31c 5.1066E-04
13027.31c 1.3989E-04
22000.62c 3.9416E-05
24050.31c 1.2213E-06
24052.31c 2.2823E-05
24053.31c 2.5531E-06
24054.31c 6.2449E-07
25055.31c 3.2634E-04
26054.31c 5.0496E-03
26056.31c 7.6690E-02
26057.31c 1.8001E-03
26058.31c 2.6658E-04
28058.31c 1.2564E-06
28060.31c 4.6968E-07
28061.31c 2.2000E-08
28062.31c 6.2769E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

28064.31c 1.6774E-08
29063.31c 3.1184E-05
29065.31c 1.3364E-05
42000.66c 9.8355E-06
c total 8.4932E-02
c
c Natural Uranium Breeder
ml5 1001.31c 4.4574E-05
    6000.31c 4.7140E-04
    14028.31c 2.0160E-04
    26054.31c 6.1085E-06
    26056.31c 9.2771E-05
    26057.31c 2.1776E-06
    26058.31c 3.2248E-07
    92235.31c 3.4209E-04
    92238.31c 4.7156E-02
c Total 4.8317E-02
c
c Element top and bottom packing
ml6 1001.31c 3.1777E-05
    6000.31c 9.9996E-05
    13027.31c 8.3095E-06
    24050.31c 6.9087E-08
    24052.31c 1.2911E-06
    24053.31c 1.4442E-07
    24054.31c 3.5326E-08
    25055.31c 1.0785E-04
    26054.31c 1.9605E-03
    26056.31c 2.9775E-02
    26057.31c 6.9890E-04
    26058.31c 1.0350E-04
    28058.31c 1.5636E-07
    28060.31c 5.8452E-08
    28061.31c 2.7378E-09
    28062.31c 7.8115E-09
    28064.31c 2.0875E-09
    29063.31c 6.5270E-06
    29065.31c 2.7973E-06
c Total 3.279692E-02
c
c mild steel wrapper material
ml7 1001.31c 7.5725E-05
    6000.31c 2.3828E-04
    13027.31c 1.9802E-05
    24050.31c 1.6463E-07
    24052.31c 3.0767E-06
    24053.31c 3.4414E-07
    24054.31c 8.4182E-08
    25055.31c 2.5701E-04
    26054.31c 4.6718E-03
    26056.31c 7.0954E-02
    26057.31c 1.6655E-03
    26058.31c 2.4664E-04
    28058.31c 3.7260E-07
    28060.31c 1.3929E-07
    28061.31c 6.5242E-09
    28062.31c 1.8615E-08
    28064.31c 4.9746E-09
    29063.31c 1.5554E-05
    29065.31c 6.6660E-06
c Total 7.81552E-02
c
c
c MATERIAL 18 U8 metal plate
ml8 1001.31c 4.4048E-05
    6000.31c 4.9283E-04
    14028.31c 2.1076E-04
    26054.31c 6.1951E-06
    26056.31c 9.7250E-05
    26057.31c 2.2459E-06
    26058.31c 2.9889E-08
    92235.31c 3.3369E-04
    92238.31c 4.6021E-02
c total 4.7208E-02

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

C MATERIAL 19 U2 metal plate
m19      1001.31c  4.3899E-05
          6000.31c  4.6047E-04
          14028.31c 1.9692E-04
          26054.31c 5.7884E-06
          26056.31c 9.0866E-05
          26057.31c 2.0985E-06
          26058.31c 2.7927E-07
          92235.31c 3.3962E-04
          92238.31c 4.6785E-02
c total 4.7925E-02
c
c
c Superlattice grid plate
c
m20      1001.31c  2.4442E-04
          6000.31c  2.9057E-04
          14028.31c 4.3858E-05
          15031.31c 1.3256E-05
          16032.31c 4.3530E-05
          25055.31c 2.5785E-04
          26054.31c 4.2756E-03
          26056.31c 6.7114E-02
          26057.31c 1.5500E-03
          26058.31c 2.0627E-04
c Total 20 7.403935E-02
c
c -----
c
c Element C Pin fuel A and E, Calandria NACLIII
c Pin A
m21      1001.31c  3.2784E-05
          8016.31c  4.6606E-02
          8017.31c  1.7700E-05
          13027.31c 1.1702E-05
          20040.31c  7.8782E-06
          26054.31c  3.3046E-07
          26056.31c  5.1875E-06
          26057.31c  1.1980E-07
          26058.31c  1.5943E-08
          92234.31c  1.3805E-06
          92235.31c  1.4114E-04
          92236.31c  7.9324E-07
          92238.31c  1.9379E-02
          94238.31c  3.7786E-06
          94239.31c  2.9689E-03
          94240.31c  6.7253E-04
          94241.31c  7.0350E-05
          94242.31c  1.7488E-05
          95241.31c  4.7854E-05
c      total 21 6.9985E-02
c
c
c PinB
c
m22      1001.31c  3.2784E-05
          8016.31c  4.6976E-02
          8017.31c  1.7800E-05
          14028.31c  9.0199E-06
          28058.31c  3.7050E-06
          28060.31c  1.4272E-06
          28061.31c  6.2038E-08
          28062.31c  1.9780E-07
          28064.31c  5.0375E-08
          92234.31c  1.3177E-06
          92235.31c  1.3457E-04
          92236.31c  7.4658E-07
          92238.31c  1.8472E-02
          94238.31c  5.8915E-06
          94239.31c  3.7341E-03
          94240.31c  9.5200E-04
          94241.31c  1.1199E-04
          94242.31c  2.7984E-05
          95241.31c  5.5789E-05
c total 22 7.0537E-02 F 26 7.1415E-02

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
c
c Pin C
c
M23      1001.31c  3.2784E-05
      8016.31c  4.7416E-02
      8017.31c  1.8000E-05
      13027.31c  1.9730E-05
      14028.31c  7.9741E-06
      26054.31c  4.4958E-07
      26056.31c  7.0574E-06
      26057.31c  1.6298E-07
      26058.31c  2.1690E-08
      28058.31c  7.4523E-06
      28060.31c  2.8707E-06
      28061.31c  1.2478E-07
      28062.31c  3.9787E-07
      28064.31c  1.0132E-07
      92234.31c  1.2863E-06
      92235.31c  1.2997E-04
      92236.31c  7.3103E-07
      92238.31c  1.7843E-02
      94238.31c  6.9094E-06
      94239.31c  4.4708E-03
      94240.31c  1.0602E-03
      94241.31c  1.1598E-04
      94242.31c  3.0047E-05
      95241.31c  5.7784E-05
```

c total 23 7.1230E-02

```
c
c Pin D
c
```

```
M24      1001.31c  3.2784E-05
      8016.31c  4.7296E-02
      8017.31c  1.8000E-05
      13027.31c  1.8914E-05
      14028.31c  2.5099E-05
      20040.31c  1.5940E-05
      26054.31c  4.0346E-07
      26056.31c  6.3335E-06
      26057.31c  1.4627E-07
      26058.31c  1.9465E-08
      28058.31c  9.6247E-06
      28060.31c  3.7075E-06
      28061.31c  1.6116E-07
      28062.31c  5.1385E-07
      28064.31c  1.3086E-07
      92234.31c  1.4118E-06
      92235.31c  1.4266E-04
      92236.31c  7.9324E-07
      92238.31c  1.9584E-02
      94238.31c  4.7348E-06
      94239.31c  3.0189E-03
      94240.31c  7.5441E-04
      94241.31c  8.8443E-05
      94242.31c  2.0961E-05
      95241.31c  4.0742E-05
```

c total 24 7.1085E-02

```
c
c Pin E
c
```

```
m25      1001.31c  3.2784E-05
      8016.31c  4.7299E-02
      8017.31c  1.7970E-05
      13027.31c  9.5250E-06
      14028.31c  4.5753E-05
      20040.31c  3.2062E-05
      26054.31c  6.0326E-07
      26056.31c  9.4699E-06
      26057.31c  2.1870E-07
      26058.31c  2.9105E-08
      92234.31c  1.1295E-06
      92235.31c  1.1465E-04
      92236.31c  6.3771E-07
      92238.31c  1.5739E-02
      94238.31c  9.4851E-06
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

94239.31c  6.0438E-03
94240.31c  1.5103E-03
94241.31c  1.7707E-04
94242.31c  4.1953E-05
95241.31c  8.1559E-05
c    total 25 7.1167E-02
c
C Pin F
M26      1001.31c  3.2784E-05
8016.31c  4.7464E-02
8017.31c  1.8032E-05
13027.31c 1.4287E-05
20040.31c  6.7514E-05
24050.31c  2.1476E-07
24052.31c  4.1414E-06
24053.31c  4.6961E-07
24054.31c  1.1689E-07
26054.31c  6.7247E-07
26056.31c  1.0556E-05
26057.31c  2.4379E-07
26058.31c  3.2444E-08
28058.31c  1.4905E-06
28060.31c  5.7416E-07
28061.31c  2.4958E-08
28062.31c  7.9577E-08
28064.31c  2.0266E-08
92234.31c  1.1452E-06
92235.31c  1.1526E-04
92236.31c  6.3771E-07
92238.31c  1.5824E-02
94238.31c  9.5005E-06
94239.31c  6.0112E-03
94240.31c  1.5285E-03
94241.31c  1.9723E-04
94242.31c  4.4380E-05
95241.31c  6.8035E-05
C total 26 7.1415E-02
c
c
c Composition of Calandria end plate regions
m27      14028.31c  5.5206E-04
24050.31c  4.3520E-04
24052.31c  8.3923E-03
24053.31c  9.5162E-04
24054.31c  2.3688E-04
25055.31c  7.7198E-04
26054.31c  2.0795E-03
26056.31c  3.2644E-02
26057.31c  7.5390E-04
26058.31c  1.0033E-04
28058.31c  3.0363E-03
28060.31c  1.1696E-03
28061.31c  5.0841E-05
28062.31c  1.6210E-04
28064.31c  4.1283E-05
c total 5.13781E-02
c
c UO2 Pin UO2PINC
c
M28      1001.31c  3.2784E-05
6000.31c  3.2095E-05
8016.31c  4.7501E-02
13027.31c  2.3812E-05
14028.31c  4.0001E-05
20040.31c  1.2825E-05
26054.31c  6.5324E-08
26056.31c  1.0254E-06
26057.31c  2.3682E-08
26058.31c  3.1516E-09
92234.31c  9.7268E-07
92235.31c  1.7084E-04
92238.31c  2.3588E-02
c total 28 7.1400E-02
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c -----
c Pin clad plus calandria tube combined
c
C Pin PUPINA clad plus tube (was 23)
c
m31      1001.31c 1.0832E-05
        6000.31c 5.3887E-05
        14028.31c 6.6291E-04
        15031.31c 1.5357E-05
        16032.31c 9.9700E-06
        25055.31c 1.0382E-03
        24050.31c 5.3769E-04
        24052.31c 1.0369E-02
        24053.31c 1.1757E-03
        24054.31c 2.9267E-04
        26054.31c 2.4695E-03
        26056.31c 3.8766E-02
        26057.31c 8.9527E-04
        26058.31c 1.1914E-04
        28058.31c 3.9651E-03
        28060.31c 1.5274E-03
        28061.31c 6.6392E-05
        28062.31c 2.1169E-04
        28064.31c 5.3910E-05

c
C      Total 31 6.2241E-02
c
C Pin PUPINB   clad plus tube
c
m32      1001.31c 9.2847E-06
        6000.31c 9.6091E-05
        14028.31c 7.8508E-04
        15031.31c 1.6869E-05
        16032.31c 9.2404E-06
        25055.31c 1.0424E-03
        24050.31c 4.8064E-04
        24052.31c 9.2687E-03
        24053.31c 1.0510E-03
        24054.31c 2.6162E-04
        26054.31c 2.3154E-03
        26056.31c 3.6347E-02
        26057.31c 8.3939E-04
        26058.31c 1.1171E-04
        28058.31c 3.9370E-03
        28060.31c 1.5166E-03
        28061.31c 6.5922E-05
        28062.31c 2.1019E-04
        28064.31c 5.3529E-05
        41093.31c 1.1919E-04

c
C Total 32 5.8537E-02 F 36 6.0033E-02
c
C Pin PUPINC   clad plus tube
c
m33      1001.31c 1.0832E-05
        6000.31c 5.5189E-05
        14028.31c 6.5458E-04
        15031.31c 1.4602E-05
        16032.31c 9.9700E-06
        25055.31c 1.0254E-03
        24050.31c 5.3131E-04
        24052.31c 1.0246E-02
        24053.31c 1.1618E-03
        24054.31c 2.8919E-04
        26054.31c 2.4419E-03
        26056.31c 3.8333E-02
        26057.31c 8.8527E-04
        26058.31c 1.1781E-04
        28058.31c 3.9199E-03
        28060.31c 1.5099E-03
        28061.31c 6.5635E-05
        28062.31c 2.0927E-04
        28064.31c 5.3296E-05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

c
C Total 33 6.15349E-02

c
c Pin PUPIND can plus tube

c
m34 1001.31c 1.0058E-05
6000.31c 8.1804E-05
13027.31c 2.6012E-06
14028.31c 6.7957E-04
15031.31c 1.3847E-05
16032.31c 3.6474E-06
22048.31c 1.1726E-05
25055.31c 8.7351E-04
27059.31c 1.7202E-06
24050.31c 4.9702E-04
24052.31c 9.5846E-03
24053.31c 1.0868E-03
24054.31c 2.7053E-04
26054.31c 2.3766E-03
26056.31c 3.7307E-02
26057.31c 8.6158E-04
26058.31c 1.1466E-04
28058.31c 3.6114E-03
28060.31c 1.3911E-03
28061.31c 6.0470E-05
28062.31c 1.9281E-04
28064.31c 4.9102E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
42000.66c 8.9408E-07

c
C Total 34 5.9086E-02

c
c Pin PUPINE clad plus tube (Was 24)

m35 1001.31c 1.0058E-05
6000.31c 2.9866E-05
13027.31c 2.6012E-06
14028.31c 7.4068E-04
15031.31c 5.5388E-06
16032.31c 7.0518E-06
22048.31c 1.1726E-05
25055.31c 8.0111E-04
27059.31c 1.7202E-06
24050.31c 5.0041E-04
24052.31c 9.6500E-03
24053.31c 1.0942E-03
24054.31c 2.7238E-04
26054.31c 2.4012E-03
26056.31c 3.7694E-02
26057.31c 8.7052E-04
26058.31c 1.1585E-04
28058.31c 3.7263E-03
28060.31c 1.4354E-03
28061.31c 6.2394E-05
28062.31c 1.9894E-04
28064.31c 5.0664E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
42000.66c 8.6970E-06

c
C Total 35 5.96942E-02

c
C Pin PUPINF can plus tube

c
m36 1001.31c 1.0058E-05
6000.31c 2.9217E-05
13027.31c 1.7341E-06
14028.31c 7.4343E-04
15031.31c 5.5388E-06
16032.31c 7.2951E-06
22048.31c 8.7948E-06
25055.31c 8.0253E-04
27059.31c 1.3232E-06

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

24050.31c  5.0363E-04
24052.31c  9.7120E-03
24053.31c  1.1013E-03
24054.31c  2.7413E-04
26054.31c  2.4145E-03
26056.31c  3.7903E-02
26057.31c  8.7533E-04
26058.31c  1.1649E-04
28058.31c  3.7525E-03
28060.31c  1.4455E-03
28061.31c  6.2833E-05
28062.31c  2.0034E-04
28064.31c  5.1021E-05
29063.31c  1.2885E-06
29065.31c  5.5221E-07
42000.66c  8.6159E-06
c
c   Total   36  6.0033E-02
c
c
c -----
c
c Calandria sodium contents
c
c sodium NACLII element A and B
m41   1001.31c  5.5075E-06
      8016.31c  6.4605E-06
      11023.31c 2.4129E-02
      20040.31c 1.1080E-07
      26056.31c 3.0847E-07
c   total 41 2.41414E-02
c
c sodium NACLIIIS element E
m42   1001.31c  1.1205E-05
      8016.31c  1.0767E-06
      11023.31c 2.4379E-02
      20040.31c 9.5521E-08
c   total 42 2.43914E-02
c sodium NACLIII element C (was 25)
m43   1001.31c  7.5966E-06
      8016.31c  3.5892E-06
      11023.31c 2.3888E-02
      19039.31c 3.4270E-07
      20040.31c 6.6865E-07
c   total 43 2.3900E-02
c sodium NACLIV Element J
m44   1001.31c  7.5966E-06
      8016.31c  3.5892E-06
      11023.31c 2.4037E-02
      19039.31c 3.4270E-07
      20040.31c 6.6865E-07
c   total 44 2.4049E-02
c sodium NACLIV Element H
m45   1001.31c  7.5966E-06
      8016.31c  3.5892E-06
      11023.31c 2.3829E-02
      19039.31c 3.4270E-07
      20040.31c 6.6865E-07
c   total 45 2.3841E-02
c
c -----
c
c -----
c
c Compositions of Calandria outer walls
c
c Calandria Walls NACLII Element Cell A and B
m51   1001.31c  3.9844E-05
      6000.31c  2.8167E-04
      14028.31c 6.0229E-04
      15031.31c 7.3471E-05
      16032.31c 3.6808E-05
      25055.31c 1.2214E-03

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

24050.31c  6.5153E-04
24052.31c  1.2564E-02
24053.31c  1.4247E-03
24054.31c  3.5463E-04
26054.31c  2.8589E-03
26056.31c  4.4878E-02
26057.31c  1.0364E-03
26058.31c  1.3793E-04
28058.31c  4.9315E-03
28060.31c  1.8996E-03
28061.31c  8.2574E-05
28062.31c  2.6328E-04
28064.31c  6.7050E-05
C total 51 7.34056E-02
c
c
C Calandria walls NACLIIS Element Cell E
c
m52      1001.31c  3.8637E-05
        6000.31c  6.5351E-04
        14028.31c  9.7623E-04
        15031.31c  4.7540E-05
        16032.31c  3.3014E-05
        22048.31c  2.4400E-04
        25055.31c  1.1060E-03
        27059.31c  1.1151E-05
        24050.31c  6.2481E-04
        24052.31c  1.2049E-02
        24053.31c  1.3662E-03
        24054.31c  3.4009E-04
        26054.31c  2.7541E-03
        26056.31c  4.3233E-02
        26057.31c  9.9842E-04
        26058.31c  1.3287E-04
        28058.31c  5.0735E-03
        28060.31c  1.9543E-03
        28061.31c  8.4952E-05
        28062.31c  2.7086E-04
        28064.31c  6.8981E-05
        29063.31c  6.9320E-06
        29065.31c  3.1020E-06
        42000.66c  3.4248E-06
C total 52 7.20749E-02
c
c Calandria NACLIII Element Cell C and D (was m28)
c Error in repeat of Mn in m28
m53      1001.31c  3.9844E-05
        6000.31c  1.5948E-04
        14028.31c  7.7474E-04
        15031.31c  5.2334E-05
        16032.31c  2.4551E-05
        25055.31c  8.3089E-04
        24050.31c  6.1403E-04
        24052.31c  1.1841E-02
        24053.31c  1.3427E-03
        24054.31c  3.3422E-04
        26054.31c  2.9672E-03
        26056.31c  4.6578E-02
        26057.31c  1.0757E-03
        26058.31c  1.4315E-04
        28058.31c  5.2186E-03
        28060.31c  2.0102E-03
        28061.31c  8.7382E-05
        28062.31c  2.7861E-04
        28064.31c  7.0954E-05
        42000.66c  2.4862E-05
C total 53 7.44684E-02
c
c
C Calandria NACLIV Element 3J and 3L
m54      1001.31c  3.7430E-05
        6000.31c  3.5158E-04
        14028.31c  8.2197E-04
        15031.31c  6.2274E-05

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
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```

16032.31c 1.6431E-05
25055.31c 1.0026E-03
24050.31c 5.8931E-04
24052.31c 1.1364E-02
24053.31c 1.2886E-03
24054.31c 3.2077E-04
26054.31c 2.7560E-03
26056.31c 4.3263E-02
26057.31c 9.9912E-04
26058.31c 1.3296E-04
28058.31c 4.3943E-03
28060.31c 1.6927E-03
28061.31c 7.3579E-05
28062.31c 2.3460E-04
28064.31c 5.9746E-05
42000.66c 8.8791E-06
C Total 54 6.94698E-02
c
C Calandria NACLIV Element 3H
m55 1001.31c 3.8637E-05
6000.31c 2.6343E-04
14028.31c 6.4389E-04
15031.31c 6.8560E-05
16032.31c 1.7190E-05
25055.31c 9.6934E-04
24050.31c 6.0091E-04
24052.31c 1.1588E-02
24053.31c 1.3140E-03
24054.31c 3.2708E-04
26054.31c 2.8877E-03
26056.31c 4.5330E-02
26057.31c 1.0469E-03
26058.31c 1.3932E-04
28058.31c 4.9377E-03
28060.31c 1.9020E-03
28061.31c 8.2679E-05
28062.31c 2.6362E-04
28064.31c 6.7135E-05
42000.66c 8.8791E-06
C Total 55 7.2497E-02
c
C Calandria VCLVI
m56 1001.31c 3.8637E-05
6000.31c 2.4762E-04
14028.31c 9.5110E-04
15031.31c 4.5654E-05
16032.31c 2.3793E-05
25055.31c 8.6191E-04
24050.31c 6.0122E-04
24052.31c 1.1594E-02
24053.31c 1.3147E-03
24054.31c 3.2725E-04
26054.31c 2.8292E-03
26056.31c 4.4413E-02
26057.31c 1.0257E-03
26058.31c 1.3650E-04
28058.31c 4.6653E-03
28060.31c 1.7971E-03
28061.31c 7.8117E-05
28062.31c 2.4907E-04
28064.31c 6.3431E-05
42000.66c 2.4862E-05
C Total 56 7.12882E-02
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 100 1500
ksrc 0.0 0.0 77.0 0.0 0.0 87.9 0.0 0.0 107.0
0.0 0.0 117.9 0.0 0.0 137.0 0.0 0.0 147.9
10.74 0.0 77.0 10.74 0.0 87.9 10.74 0.0 107.0
10.74 0.0 117.9 10.74 0.0 137.0 10.74 0.0 147.9
-10.74 0.0 77.0 -10.74 0.0 87.9 -10.74 0.0 107.0
-10.74 0.0 117.9 -10.74 0.0 137.0 -10.74 0.0 147.9
0.0 10.74 77.0 0.0 10.74 87.9 0.0 10.74 107.0

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```
0.0 10.74 117.9 0.0 10.74 137.0 0.0 10.74 147.9
0.0 -10.74 77.0 0.0 -10.74 87.9 -10.74 0.0 107.0
0.0 -10.74 117.9 0.0 -10.74 137.0 0.0 -10.74 147.9
10.74 10.74 77.0 10.74 10.74 87.9 10.74 10.74 107.0
10.74 10.74 117.9 10.74 10.74 137.0 10.74 10.74 147.9
-10.74 10.74 77.0 -10.74 10.74 87.9 -10.74 10.74 107.0
-10.74 10.74 117.9 -10.74 10.74 137.0 -10.74 10.74 147.9
10.74 -10.74 77.0 10.74 -10.74 87.9 10.74 -10.74 107.0
10.74 -10.74 117.9 10.74 -10.74 137.0 10.74 -10.74 147.9
-10.74 -10.74 77.0 -10.74 -10.74 87.9 -10.74 -10.74 107.0
-10.74 -10.74 117.9 -10.74 -10.74 137.0 -10.74 -10.74 147.9
25.335 0.0 77.0 25.335 0.0 87.9 25.335 0.0 107.0
25.335 0.0 117.9 25.335 0.0 137.0 25.335 0.0 147.9
-25.335 0.0 77.0 -25.335 0.0 87.9 -25.335 0.0 107.0
-25.335 0.0 117.9 -25.335 0.0 137.0 -25.335 0.0 147.9
0.0 25.335 77.0 0.0 25.335 87.9 0.0 25.335 107.0
0.0 25.335 117.9 0.0 25.335 137.0 0.0 25.335 147.9
0.0 -25.335 77.0 0.0 -25.335 87.9 -25.335 0.0 107.0
0.0 -25.335 117.9 0.0 -25.335 137.0 0.0 -25.335 147.9
25.335 25.335 77.0 25.335 25.335 87.9 25.335 25.335 107.0
25.335 25.335 117.9 25.335 25.335 137.0 25.335 25.335 147.9
-25.335 25.335 77.0 -25.335 25.335 87.9 -25.335 25.335 107.0
-25.335 25.335 117.9 -25.335 25.335 137.0 -25.335 25.335 147.9
25.335 -25.335 77.0 25.335 -25.335 87.9 25.335 -25.335 107.0
25.335 -25.335 117.9 25.335 -25.335 137.0 25.335 -25.335 147.9
-25.335 -25.335 77.0 -25.335 -25.335 87.9 -25.335 -25.335 107.0
37.6 0.0 77.0 37.6 0.0 87.9 37.6 0.0 107.0
37.6 0.0 117.9 37.6 0.0 137.0 37.6 0.0 147.9
-37.6 0.0 77.0 -37.6 0.0 87.9 -37.6 0.0 107.0
-37.6 0.0 117.9 -37.6 0.0 137.0 -37.6 0.0 147.9
0.0 37.6 77.0 0.0 37.6 87.9 0.0 37.6 107.0
0.0 37.6 117.9 0.0 37.6 137.0 0.0 37.6 147.9
0.0 -37.6 77.0 0.0 -37.6 87.9 -37.6 0.0 107.0
0.0 -37.6 117.9 0.0 -37.6 137.0 0.0 -37.6 147.9
```

Print

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

A4.6 MCNP-JEFF-3.1 Zebra25 Model with Central Plate Zone

```
Z25 with central plate array. Superlattice and void gaps. JEFF-3.1
c Pin Elements C, E, B, A and J are represented and the equivalent pin cells
c for Pin Elements D, H and L
c The experimental value of k-effective to be used with this model is
c      1.0014 +/- 0.0013
c See www.zebra.webnik.org for details.
c c Na dummy region for honeycomb (Z element).
c 11 1.216928E-02 10 -504 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c ----- CELL CARDS -----
c
c --- Core Pin Geometry Element C Calandria NACLIII Pins 8xA and 8xE
c Fuel m21 and m25, can + tube m31 and m35
c Lower padding
c 1 16 3.279692E-02 -8 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower Reflector
c 2 14 8.4932E-02 8 -9 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
c 3 15 4.8317E-02 9 -41 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
c 4 9 4.7925E-02 41 -42 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
c 5 8 4.7208E-02 42 -10 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
c 9 27 0.0513781 33 -34 35 -36 10 -82 u=1 imp:n=1 TMP=2.5301E-08
c
c
c 10 25 7.1167E-02 -91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 11 21 0.069985 -92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 12 25 7.1167E-02 -93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 13 21 0.069985 -94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 14 21 0.069985 -95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 15 25 7.1167E-02 -96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 16 21 0.069985 -97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 17 25 7.1167E-02 -98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 18 25 7.1167E-02 -99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 19 21 0.069985 -100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 20 25 7.1167E-02 -101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 21 21 0.069985 -102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 22 21 0.069985 -103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 23 25 7.1167E-02 -104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 24 21 0.069985 -105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 25 25 7.1167E-02 -106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c
c 30 35 0.0596942 -111 91 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 31 31 0.062241 -112 92 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 32 35 0.0596942 -113 93 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
c 33 31 0.062241 -114 94 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

34      31 0.062241 -115 95 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
35      35 0.0596942 -116 96 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
36      31 0.062241 -117 97 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
37      35 0.0596942 -118 98 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
38      35 0.0596942 -119 99 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
39      31 0.062241 -120 100 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
40      35 0.0596942 -121 101 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
41      31 0.062241 -122 102 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
42      31 0.062241 -123 103 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
43      35 0.0596942 -124 104 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
44      31 0.062241 -125 105 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
45      35 0.0596942 -126 106 82 -83 u=1 imp:n=1 TMP=2.5301E-08
c
46      0 33 -34 35 -36 82 -83 &
        111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
        u=1 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
48      27 0.0513781 33 -34 35 -36 83 -85 u=1 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
50      25 7.1167E-02 -91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
51      21 0.069985 -92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
52      25 7.1167E-02 -93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
53      21 0.069985 -94 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
54      21 0.069985 -95 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
55      25 7.1167E-02 -96 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
56      21 0.069985 -97 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
57      25 7.1167E-02 -98 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
58      25 7.1167E-02 -99 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
59      21 0.069985 -100 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
60      25 7.1167E-02 -101 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
61      21 0.069985 -102 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
62      21 0.069985 -103 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
63      25 7.1167E-02 -104 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
64      21 0.069985 -105 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
65      25 7.1167E-02 -106 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
c
c
c
70      35 0.0596942 -111 91 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
71      31 0.062241 -112 92 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c
72      35 0.0596942 -113 93 85 -86 u=1 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

73      31 0.062241 -114 94 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
74      31 0.062241 -115 95 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
75      35 0.0596942 -116 96 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
76      31 0.062241 -117 97 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
77      35 0.0596942 -118 98 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
78      35 0.0596942 -119 99 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
79      31 0.062241 -120 100 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
80      35 0.0596942 -121 101 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
81      31 0.062241 -122 102 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
82      31 0.062241 -123 103 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
83      35 0.0596942 -124 104 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
84      31 0.062241 -125 105 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
85      35 0.0596942 -126 106 85 -86  u=1 imp:n=1 TMP=2.5301E-08
c
86      0 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
88      27 0.0513781 33 -34 35 -36 86 -88 u=1 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
90      25 7.1167E-02 -91 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
91      21 0.069985 -92 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
92      25 7.1167E-02 -93 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
93      21 0.069985 -94 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
94      21 0.069985 -95 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
95      25 7.1167E-02 -96 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
96      21 0.069985 -97 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
97      25 7.1167E-02 -98 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
98      25 7.1167E-02 -99 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
99      21 0.069985 -100 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
100     25 7.1167E-02 -101 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
101     21 0.069985 -102 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
102     21 0.069985 -103 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
103     25 7.1167E-02 -104 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
104     21 0.069985 -105 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
105     25 7.1167E-02 -106 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
c
c
c
110     35 0.0596942 -111 91 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c
111     31 0.062241 -112 92 88 -89  u=1 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

112      35 0.0596942 -113 93 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
113      31 0.062241 -114 94 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
114      31 0.062241 -115 95 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
115      35 0.0596942 -116 96 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
116      31 0.062241 -117 97 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
117      35 0.0596942 -118 98 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
118      35 0.0596942 -119 99 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
119      31 0.062241 -120 100 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
120      35 0.0596942 -121 101 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
121      31 0.062241 -122 102 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
122      31 0.062241 -123 103 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
123      35 0.0596942 -124 104 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
124      31 0.062241 -125 105 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
125      35 0.0596942 -126 106 88 -89 u=1 imp:n=1 TMP=2.5301E-08
c
126      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=1 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
128      27 0.0513781 33 -34 35 -36 89 -11 u=1 imp:n=1 TMP=2.5301E-08
c
c Calandria outer wall
c
129      53 7.44684E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=1 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
131      8 4.7208E-02 11 -67 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
132      9 4.7925E-02 67 -68 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
133      15 4.8317E-02 68 -12 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Upper Reflector
134      14 8.4932E-02 12 -13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c Upper padding
135      16 3.279692E-02 13 21 -22 23 -24 u=1 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
136      0 132 -133 134 -135 (-21:22:-23:24) u=1 imp:n=1
c Wrapper
137      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=1 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
138      0 1 -2 3 -4 (-136:137:-138:139) u=1 imp:n=1
c
c End of Core Pin Geometry Element C
c
c
c --- Core Pin geometry Element E (& D) NACLIIS Pins 8xD and 8xF
c   D 24 7.1085E-02 F 26 7.1415E-02 clad D 34 5.9086E-02 F 36 6.0033E-02
c Lower padding
201      16 3.279692E-02 -8 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Lower Reflector
202      14 8.4932E-02 8 -9 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
203      15 4.8317E-02 9 -41 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
204      9 4.7925E-02 41 -42 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
205      8 4.7208E-02 42 -10 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c Minicalandria
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c Bottom plate
209      27 0.0513781 33 -34 35 -36 10 -82 u=2 imp:n=1 TMP=2.5301E-08
c
c
c 210      26 7.1415E-02 -91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 211      24 7.1085E-02 -92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 212      26 7.1415E-02 -93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 213      24 7.1085E-02 -94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 214      24 7.1085E-02 -95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 215      26 7.1415E-02 -96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 216      24 7.1085E-02 -97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 217      26 7.1415E-02 -98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 218      26 7.1415E-02 -99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 219      24 7.1085E-02 -100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 220      26 7.1415E-02 -101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 221      24 7.1085E-02 -102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 222      24 7.1085E-02 -103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 223      26 7.1415E-02 -104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 224      24 7.1085E-02 -105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 225      26 7.1415E-02 -106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c
c 230      36 6.0033E-02 -111 91 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 231      34 5.9086E-02 -112 92 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 232      36 6.0033E-02 -113 93 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 233      34 5.9086E-02 -114 94 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 234      34 5.9086E-02 -115 95 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 235      36 6.0033E-02 -116 96 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 236      34 5.9086E-02 -117 97 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 237      36 6.0033E-02 -118 98 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 238      36 6.0033E-02 -119 99 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 239      34 5.9086E-02 -120 100 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 240      36 6.0033E-02 -121 101 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 241      34 5.9086E-02 -122 102 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 242      34 5.9086E-02 -123 103 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 243      36 6.0033E-02 -124 104 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 244      34 5.9086E-02 -125 105 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 245      36 6.0033E-02 -126 106 82 -83 u=2 imp:n=1 TMP=2.5301E-08
c
c 246      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
248      27 0.0513781 33 -34 35 -36 83 -85 u=2 imp:n=1 TMP=2.5301E-08
c
c  Middle calandria
c
c  250      26 7.1415E-02 -91 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  251      24 7.1085E-02 -92 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  252      26 7.1415E-02 -93 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  253      24 7.1085E-02 -94 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  254      24 7.1085E-02 -95 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  255      26 7.1415E-02 -96 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  256      24 7.1085E-02 -97 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  257      26 7.1415E-02 -98 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  258      26 7.1415E-02 -99 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  259      24 7.1085E-02 -100 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  260      26 7.1415E-02 -101 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  261      24 7.1085E-02 -102 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  262      24 7.1085E-02 -103 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  263      26 7.1415E-02 -104 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  264      24 7.1085E-02 -105 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  265      26 7.1415E-02 -106 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c
c
c  270      36 6.0033E-02 -111 91 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  271      34 5.9086E-02 -112 92 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  272      36 6.0033E-02 -113 93 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  273      34 5.9086E-02 -114 94 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  274      34 5.9086E-02 -115 95 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  275      36 6.0033E-02 -116 96 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  276      34 5.9086E-02 -117 97 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  277      36 6.0033E-02 -118 98 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  278      36 6.0033E-02 -119 99 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  279      34 5.9086E-02 -120 100 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  280      36 6.0033E-02 -121 101 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  281      34 5.9086E-02 -122 102 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  282      34 5.9086E-02 -123 103 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  283      36 6.0033E-02 -124 104 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  284      34 5.9086E-02 -125 105 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  285      36 6.0033E-02 -126 106 85 -86  u=2 imp:n=1 TMP=2.5301E-08
c
c  286      0 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=2 imp:n=1 TMP=2.5301E-08

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
c Top and bottom calandria plates
c
288      27 0.0513781 33 -34 35 -36 86 -88 u=2 imp:n=1 TMP=2.5301E-08
c
c Top calandria
c
290      26 7.1415E-02 -91 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
291      24 7.1085E-02 -92 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
292      26 7.1415E-02 -93 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
293      24 7.1085E-02 -94 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
294      24 7.1085E-02 -95 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
295      26 7.1415E-02 -96 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
296      24 7.1085E-02 -97 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
297      26 7.1415E-02 -98 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
298      26 7.1415E-02 -99 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
299      24 7.1085E-02 -100 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
300      26 7.1415E-02 -101 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
301      24 7.1085E-02 -102 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
302      24 7.1085E-02 -103 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
303      26 7.1415E-02 -104 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
304      24 7.1085E-02 -105 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
305      26 7.1415E-02 -106 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
c
c
c
310      36 6.0033E-02 -111 91 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
311      34 5.9086E-02 -112 92 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
312      36 6.0033E-02 -113 93 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
313      34 5.9086E-02 -114 94 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
314      34 5.9086E-02 -115 95 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
315      36 6.0033E-02 -116 96 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
316      34 5.9086E-02 -117 97 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
317      36 6.0033E-02 -118 98 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
318      36 6.0033E-02 -119 99 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
319      34 5.9086E-02 -120 100 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
320      36 6.0033E-02 -121 101 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
321      34 5.9086E-02 -122 102 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
322      34 5.9086E-02 -123 103 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
323      36 6.0033E-02 -124 104 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
324      34 5.9086E-02 -125 105 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
325      36 6.0033E-02 -126 106 88 -89 u=2 imp:n=1 TMP=2.5301E-08
c
326      0 33 -34 35 -36 88 -89 &

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
u=2 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
328      27 0.0513781 33 -34 35 -36 89 -11 u=2 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
329      52 7.20749E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=2 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
331      8 4.7208E-02 11 -67 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
332      9 4.7925E-02 67 -68 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
333      15 4.8317E-02 68 -12 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
334      14 8.4932E-02 12 -13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   Upper padding
335      16 3.279692E-02 13 21 -22 23 -24 u=2 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
336      0 132 -133 134 -135 (-21:22:-23:24) u=2 imp:n=1
c   Wrapper
337      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=2 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
338      0 1 -2 3 -4 (-136:137:-138:139) u=2 imp:n=1
c
c   End of Core Pin Geometry Element E (D)
c
c
c --- Core Pin Geometry Element B (H, L) Calandria NACLI Pins 11xB and 5xF
c B 22 7.0537E-02 F 26 7.1415E-02 clad 32 5.8537E-02 F 36 6.0033E-02
c Pin F is in circles 93 98 99 101 and 104
c
c   Lower padding
401      16 3.279692E-02 -8 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
402      14 8.4932E-02 8 -9 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
403      15 4.8317E-02 9 -41 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
404      9 4.7925E-02 41 -42 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
405      8 4.7208E-02 42 -10 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
409      27 0.0513781 33 -34 35 -36 10 -82 u=3 imp:n=1 TMP=2.5301E-08
c
c
410      22 7.0537E-02 -91 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
411      22 7.0537E-02 -92 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
412      26 7.1415E-02 -93 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
413      22 7.0537E-02 -94 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
414      22 7.0537E-02 -95 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
415      22 7.0537E-02 -96 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
416      22 7.0537E-02 -97 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
417      26 7.1415E-02 -98 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
418      26 7.1415E-02 -99 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
419      22 7.0537E-02 -100 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
420      26 7.1415E-02 -101 82 -83 u=3 imp:n=1 TMP=2.5301E-08
c
421      22 7.0537E-02 -102 82 -83 u=3 imp:n=1 TMP=2.5301E-08

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c
422      22 7.0537E-02 -103 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
423      26 7.1415E-02 -104 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
424      22 7.0537E-02 -105 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
425      22 7.0537E-02 -106 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
c
430      32 5.8537E-02 -111 91 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
431      32 5.8537E-02 -112 92 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
432      36 6.0033E-02 -113 93 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
433      32 5.8537E-02 -114 94 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
434      32 5.8537E-02 -115 95 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
435      32 5.8537E-02 -116 96 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
436      32 5.8537E-02 -117 97 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
437      36 6.0033E-02 -118 98 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
438      36 6.0033E-02 -119 99 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
439      32 5.8537E-02 -120 100 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
440      36 6.0033E-02 -121 101 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
441      32 5.8537E-02 -122 102 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
442      32 5.8537E-02 -123 103 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
443      36 6.0033E-02 -124 104 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
444      32 5.8537E-02 -125 105 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
445      32 5.8537E-02 -126 106 82 -83  u=3 imp:n=1 TMP=2.5301E-08
c
446      0 33 -34 35 -36 82 -83  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
448      27 0.0513781 33 -34 35 -36 83 -85 u=3 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
450      22 7.0537E-02 -91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
451      22 7.0537E-02 -92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
452      26 7.1415E-02 -93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
453      22 7.0537E-02 -94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
454      22 7.0537E-02 -95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
455      22 7.0537E-02 -96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
456      22 7.0537E-02 -97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
457      26 7.1415E-02 -98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
458      26 7.1415E-02 -99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
459      22 7.0537E-02 -100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
460      26 7.1415E-02 -101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

461      22 7.0537E-02 -102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
462      22 7.0537E-02 -103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
463      26 7.1415E-02 -104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
464      22 7.0537E-02 -105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
465      22 7.0537E-02 -106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
c
c
470      32 5.8537E-02 -111 91 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
471      32 5.8537E-02 -112 92 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
472      36 6.0033E-02 -113 93 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
473      32 5.8537E-02 -114 94 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
474      32 5.8537E-02 -115 95 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
475      32 5.8537E-02 -116 96 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
476      32 5.8537E-02 -117 97 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
477      36 6.0033E-02 -118 98 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
478      36 6.0033E-02 -119 99 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
479      32 5.8537E-02 -120 100 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
480      36 6.0033E-02 -121 101 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
481      32 5.8537E-02 -122 102 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
482      32 5.8537E-02 -123 103 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
483      36 6.0033E-02 -124 104 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
484      32 5.8537E-02 -125 105 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
485      32 5.8537E-02 -126 106 85 -86  u=3 imp:n=1 TMP=2.5301E-08
c
486      0 33 -34 35 -36 85 -86  &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
488      27 0.0513781 33 -34 35 -36 86 -88 u=3 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
490      22 7.0537E-02 -91 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
491      22 7.0537E-02 -92 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
492      26 7.1415E-02 -93 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
493      22 7.0537E-02 -94 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
494      22 7.0537E-02 -95 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
495      22 7.0537E-02 -96 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
496      22 7.0537E-02 -97 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
497      26 7.1415E-02 -98 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
498      26 7.1415E-02 -99 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c
499      22 7.0537E-02 -100 88 -89  u=3 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

500      26 7.1415E-02 -101 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
501      22 7.0537E-02 -102 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
502      22 7.0537E-02 -103 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
503      26 7.1415E-02 -104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
504      22 7.0537E-02 -105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
505      22 7.0537E-02 -106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
c
c
510      32 5.8537E-02 -111 91 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
511      32 5.8537E-02 -112 92 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
512      36 6.0033E-02 -113 93 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
513      32 5.8537E-02 -114 94 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
514      32 5.8537E-02 -115 95 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
515      32 5.8537E-02 -116 96 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
516      32 5.8537E-02 -117 97 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
517      36 6.0033E-02 -118 98 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
518      36 6.0033E-02 -119 99 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
519      32 5.8537E-02 -120 100 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
520      36 6.0033E-02 -121 101 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
521      32 5.8537E-02 -122 102 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
522      32 5.8537E-02 -123 103 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
523      36 6.0033E-02 -124 104 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
524      32 5.8537E-02 -125 105 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
525      32 5.8537E-02 -126 106 88 -89 u=3 imp:n=1 TMP=2.5301E-08
c
526      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=3 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
528      27 0.0513781 33 -34 35 -36 89 -11 u=3 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
529      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=3 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
531      8 4.7208E-02 11 -67 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
532      9 4.7925E-02 67 -68 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
533      15 4.8317E-02 68 -12 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
534      14 8.4932E-02 12 -13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   Upper padding
535      16 3.279692E-02 13 21 -22 23 -24 u=3 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
536      0 132 -133 134 -135 (-21:22:-23:24) u=3 imp:n=1
c   Wrapper
537      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=3 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
538      0 1 -2 3 -4 (-136:137:-138:139) u=3 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
c End of Core Pin Geometry Element B (H, L)
c
c
c --- Core Pin Geometry Element A Calandria NACLI Pins 16xC
c c 23 7.1230E-02 clad 33 6.15349E-02
c
c Lower padding
601      16 3.279692E-02 -8 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower Reflector
602      14 8.4932E-02 8 -9 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Lower NatU Breeder bottom section
603      15 4.8317E-02 9 -41 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
604      9 4.7925E-02 41 -42 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
605      8 4.7208E-02 42 -10 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c Minicalandria
c
c Bottom plate
609      27 0.0513781 33 -34 35 -36 10 -82 u=4 imp:n=1 TMP=2.5301E-08
c
c
c 610      23 7.1230E-02 -91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 611      23 7.1230E-02 -92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 612      23 7.1230E-02 -93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 613      23 7.1230E-02 -94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 614      23 7.1230E-02 -95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 615      23 7.1230E-02 -96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 616      23 7.1230E-02 -97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 617      23 7.1230E-02 -98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 618      23 7.1230E-02 -99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 619      23 7.1230E-02 -100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 620      23 7.1230E-02 -101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 621      23 7.1230E-02 -102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 622      23 7.1230E-02 -103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 623      23 7.1230E-02 -104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 624      23 7.1230E-02 -105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 625      23 7.1230E-02 -106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c
c 630      33 6.15349E-02 -111 91 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 631      33 6.15349E-02 -112 92 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 632      33 6.15349E-02 -113 93 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 633      33 6.15349E-02 -114 94 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 634      33 6.15349E-02 -115 95 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 635      33 6.15349E-02 -116 96 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 636      33 6.15349E-02 -117 97 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 637      33 6.15349E-02 -118 98 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
c 638      33 6.15349E-02 -119 99 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

639      33 6.15349E-02 -120 100 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
640      33 6.15349E-02 -121 101 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
641      33 6.15349E-02 -122 102 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
642      33 6.15349E-02 -123 103 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
643      33 6.15349E-02 -124 104 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
644      33 6.15349E-02 -125 105 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
645      33 6.15349E-02 -126 106 82 -83 u=4 imp:n=1 TMP=2.5301E-08
c
646      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c Top and bottom calandria plates
c
648      27 0.0513781 33 -34 35 -36 83 -85 u=4 imp:n=1 TMP=2.5301E-08
c
c Middle calandria
c
650      23 7.1230E-02 -91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
651      23 7.1230E-02 -92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
652      23 7.1230E-02 -93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
653      23 7.1230E-02 -94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
654      23 7.1230E-02 -95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
655      23 7.1230E-02 -96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
656      23 7.1230E-02 -97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
657      23 7.1230E-02 -98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
658      23 7.1230E-02 -99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
659      23 7.1230E-02 -100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
660      23 7.1230E-02 -101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
661      23 7.1230E-02 -102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
662      23 7.1230E-02 -103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
663      23 7.1230E-02 -104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
664      23 7.1230E-02 -105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
665      23 7.1230E-02 -106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
c
670      33 6.15349E-02 -111 91 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
671      33 6.15349E-02 -112 92 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
672      33 6.15349E-02 -113 93 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
673      33 6.15349E-02 -114 94 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
674      33 6.15349E-02 -115 95 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
675      33 6.15349E-02 -116 96 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
676      33 6.15349E-02 -117 97 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
677      33 6.15349E-02 -118 98 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

678      33 6.15349E-02 -119 99 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
679      33 6.15349E-02 -120 100 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
680      33 6.15349E-02 -121 101 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
681      33 6.15349E-02 -122 102 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
682      33 6.15349E-02 -123 103 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
683      33 6.15349E-02 -124 104 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
684      33 6.15349E-02 -125 105 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
685      33 6.15349E-02 -126 106 85 -86 u=4 imp:n=1 TMP=2.5301E-08
c
686      0 33 -34 35 -36 85 -86 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
688      27 0.0513781 33 -34 35 -36 86 -88 u=4 imp:n=1 TMP=2.5301E-08
c
c   Top calandria
c
690      23 7.1230E-02 -91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
691      23 7.1230E-02 -92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
692      23 7.1230E-02 -93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
693      23 7.1230E-02 -94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
694      23 7.1230E-02 -95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
695      23 7.1230E-02 -96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
696      23 7.1230E-02 -97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
697      23 7.1230E-02 -98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
698      23 7.1230E-02 -99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
699      23 7.1230E-02 -100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
700      23 7.1230E-02 -101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
701      23 7.1230E-02 -102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
702      23 7.1230E-02 -103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
703      23 7.1230E-02 -104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
704      23 7.1230E-02 -105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
705      23 7.1230E-02 -106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
c
c
c
710      33 6.15349E-02 -111 91 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
711      33 6.15349E-02 -112 92 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
712      33 6.15349E-02 -113 93 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
713      33 6.15349E-02 -114 94 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
714      33 6.15349E-02 -115 95 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
715      33 6.15349E-02 -116 96 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
716      33 6.15349E-02 -117 97 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

717      33 6.15349E-02 -118 98 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
718      33 6.15349E-02 -119 99 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
719      33 6.15349E-02 -120 100 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
720      33 6.15349E-02 -121 101 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
721      33 6.15349E-02 -122 102 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
722      33 6.15349E-02 -123 103 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
723      33 6.15349E-02 -124 104 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
724      33 6.15349E-02 -125 105 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
725      33 6.15349E-02 -126 106 88 -89 u=4 imp:n=1 TMP=2.5301E-08
c
726      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=4 imp:n=1 TMP=2.5301E-08
c
c   Top plate of top calandria
c
728      27 0.0513781 33 -34 35 -36 89 -11 u=4 imp:n=1 TMP=2.5301E-08
c
c   Calandria outer wall
c
729      51 7.34056E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=4 &
      imp:n=1 TMP=2.5301E-08
c
c   Upper NatU Blanket
731      8 4.7208E-02 11 -67 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
732      9 4.7925E-02 67 -68 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
733      15 4.8317E-02 68 -12 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper Reflector
734      14 8.4932E-02 12 -13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   Upper padding
735      16 3.279692E-02 13 21 -22 23 -24 u=4 imp:n=1 TMP=2.5301E-08
c   gap between plates and wrapper
736      0 132 -133 134 -135 (-21:22:-23:24) u=4 imp:n=1
c   Wrapper
737      17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=4 imp:n=1 &
      TMP=2.5301E-08
c   gap outside wrapper
738      0 1 -2 3 -4 (-136:137:-138:139) u=4 imp:n=1
c
c   End of Core Pin Geometry Element A
c
c
c   --- Core Pin Geometry Element J Calandria NACLIV Pins 12xE and 4xUO2
c   E 25 7.1167E-02 28 7.1400E-02 35 5.96942E-02
c   The positions of pin UO2 are the circles 94, 96, 102 and 104
c   Lower padding
801      16 3.279692E-02 -8 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Lower Reflector
802      14 8.4932E-02 8 -9 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Lower NatU Breeder bottom section
803      15 4.8317E-02 9 -41 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Middle section of Lower Blanket
804      9 4.7925E-02 41 -42 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Top section of lower blanket
805      8 4.7208E-02 42 -10 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c   Minicalandria
c
c   Bottom plate
809      27 0.0513781 33 -34 35 -36 10 -82 u=5 imp:n=1 TMP=2.5301E-08
c
c
810      25 7.1167E-02 -91 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
811      25 7.1167E-02 -92 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
812      25 7.1167E-02 -93 82 -83 u=5 imp:n=1 TMP=2.5301E-08

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
813      28 7.1400E-02 -94 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
814      25 7.1167E-02 -95 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
815      28 7.1400E-02 -96 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
816      25 7.1167E-02 -97 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
817      25 7.1167E-02 -98 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
818      25 7.1167E-02 -99 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
819      25 7.1167E-02 -100 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
820      25 7.1167E-02 -101 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
821      28 7.1400E-02 -102 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
822      25 7.1167E-02 -103 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
823      28 7.1400E-02 -104 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
824      25 7.1167E-02 -105 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
825      25 7.1167E-02 -106 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
c
830      35 5.96942E-02 -111 91 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
831      35 5.96942E-02 -112 92 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
832      35 5.96942E-02 -113 93 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
833      35 5.96942E-02 -114 94 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
834      35 5.96942E-02 -115 95 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
835      35 5.96942E-02 -116 96 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
836      35 5.96942E-02 -117 97 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
837      35 5.96942E-02 -118 98 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
838      35 5.96942E-02 -119 99 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
839      35 5.96942E-02 -120 100 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
840      35 5.96942E-02 -121 101 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
841      35 5.96942E-02 -122 102 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
842      35 5.96942E-02 -123 103 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
843      35 5.96942E-02 -124 104 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
844      35 5.96942E-02 -125 105 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
845      35 5.96942E-02 -126 106 82 -83 u=5 imp:n=1 TMP=2.5301E-08
c
846      0 33 -34 35 -36 82 -83 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c   Top and bottom calandria plates
c
848      27 0.0513781 33 -34 35 -36 83 -85 u=5 imp:n=1 TMP=2.5301E-08
c
c   Middle calandria
c
850      25 7.1167E-02 -91 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c
851      25 7.1167E-02 -92 85 -86 u=5 imp:n=1 TMP=2.5301E-08
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

852	25	7.1167E-02	-93	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
853	28	7.1400E-02	-94	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
854	25	7.1167E-02	-95	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
855	28	7.1400E-02	-96	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
856	25	7.1167E-02	-97	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
857	25	7.1167E-02	-98	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
858	25	7.1167E-02	-99	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
859	25	7.1167E-02	-100	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
860	25	7.1167E-02	-101	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
861	28	7.1400E-02	-102	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
862	25	7.1167E-02	-103	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
863	28	7.1400E-02	-104	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
864	25	7.1167E-02	-105	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
865	25	7.1167E-02	-106	85	-86	u=5	imp:n=1	TMP=2.5301E-08
c								
c								
c								
870	35	5.96942E-02	-111	91	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
871	35	5.96942E-02	-112	92	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
872	35	5.96942E-02	-113	93	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
873	35	5.96942E-02	-114	94	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
874	35	5.96942E-02	-115	95	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
875	35	5.96942E-02	-116	96	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
876	35	5.96942E-02	-117	97	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
877	35	5.96942E-02	-118	98	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
878	35	5.96942E-02	-119	99	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
879	35	5.96942E-02	-120	100	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
880	35	5.96942E-02	-121	101	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
881	35	5.96942E-02	-122	102	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
882	35	5.96942E-02	-123	103	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
883	35	5.96942E-02	-124	104	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
884	35	5.96942E-02	-125	105	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
885	35	5.96942E-02	-126	106	85	-86	u=5	imp:n=1
c								TMP=2.5301E-08
886	0	33	-34	35	-36	85	-86	&
								111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
								u=5 imp:n=1 TMP=2.5301E-08
c								
c								Top and bottom calandria plates
c								
888	27	0.0513781	33	-34	35	-36	86	-88 u=5 imp:n=1 TMP=2.5301E-08
c								
c								Top calandria
c								
890	25	7.1167E-02	-91	88	-89	u=5	imp:n=1	TMP=2.5301E-08
c								

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

891      25 7.1167E-02 -92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
892      25 7.1167E-02 -93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
893      28 7.1400E-02 -94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
894      25 7.1167E-02 -95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
895      28 7.1400E-02 -96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
896      25 7.1167E-02 -97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
897      25 7.1167E-02 -98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
898      25 7.1167E-02 -99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
899      25 7.1167E-02 -100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
900      25 7.1167E-02 -101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
901      28 7.1400E-02 -102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
902      25 7.1167E-02 -103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
903      28 7.1400E-02 -104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
904      25 7.1167E-02 -105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
905      25 7.1167E-02 -106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
c
c
910      35 5.96942E-02 -111 91 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
911      35 5.96942E-02 -112 92 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
912      35 5.96942E-02 -113 93 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
913      35 5.96942E-02 -114 94 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
914      35 5.96942E-02 -115 95 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
915      35 5.96942E-02 -116 96 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
916      35 5.96942E-02 -117 97 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
917      35 5.96942E-02 -118 98 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
918      35 5.96942E-02 -119 99 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
919      35 5.96942E-02 -120 100 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
920      35 5.96942E-02 -121 101 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
921      35 5.96942E-02 -122 102 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
922      35 5.96942E-02 -123 103 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
923      35 5.96942E-02 -124 104 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
924      35 5.96942E-02 -125 105 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
925      35 5.96942E-02 -126 106 88 -89 u=5 imp:n=1 TMP=2.5301E-08
c
926      0 33 -34 35 -36 88 -89 &
      111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 &
      u=5 imp:n=1 TMP=2.5301E-08
c
c      Top plate of top calandria
c
928      27 0.0513781 33 -34 35 -36 89 -11 u=5 imp:n=1 TMP=2.5301E-08
c
c      Calandria outer wall
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

929      54 6.94698E-02 21 -22 23 -24 10 -11 (-33 :34 :-35 :36 :-10 :11) u=5 &
      imp:n=1 TMP=2.5301E-08
c
c Upper NatU Blanket
931      8 4.7208E-02 11 -67 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
932      9 4.7925E-02 67 -68 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
933     15 4.8317E-02 68 -12 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper Reflector
934     14 8.4932E-02 12 -13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c Upper padding
935     16 3.279692E-02 13 21 -22 23 -24 u=5 imp:n=1 TMP=2.5301E-08
c gap between plates and wrapper
936      0 132 -133 134 -135 (-21:22:-23:24) u=5 imp:n=1
c Wrapper
937     17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=5 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
938      0 1 -2 3 -4 (-136:137:-138:139) u=5 imp:n=1
c
c End of Core Pin Geometry Element J
c
c
c
c --- Core Plate Geometry Element with sodium dummy Z plate
c Lower padding
1011     16 3.279692E-02 -8 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1012     14 8.4932E-02 8 -9 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
1013     15 4.8317E-02 9 -41 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
1014      9 4.7925E-02 41 -42 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
1015      8 4.7208E-02 42 -10 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na dummy
1022     11 1.216928E-02 10 -504 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1027      3 6.9083E-02 505 -506 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1028      4 7.2463E-02 504 -507 21 -22 23 -24 &
      (-155:156:-157:158:-505:506) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1032     11 1.216928E-02 507 -510 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1035      1 3.9991E-02 151 -152 153 -154 511 -512 u=6 imp:n=1 TMP=2.5301E-08
c Pu canning
1036      2 6.6997E-02 510 -513 21 -22 23 -24 &
      (-151:152:-153:154:-511:512) u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1039      3 6.9083E-02 514 -515 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1040      4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-155:156:-157:158:-514:515) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1042     11 1.216928E-02 516 -43 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Insert the 22 central region core cells
c
1051      0 43 -44 21 -22 23 -24 fill=13 (0 0 71.209862) u=6 imp:n=1
c
1052      0 44 -45 21 -22 23 -24 fill=14 (0 0 74.957944) u=6 imp:n=1
c
c
1053      0 45 -46 21 -22 23 -24 fill=13 (0 0 78.706026) u=6 imp:n=1

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
1054    0  46 -47 21 -22 23 -24 fill=14 (0 0 82.454108) u=6 imp:n=1
c
c
1055    0  47 -48 21 -22 23 -24 fill=13 (0 0 86.202190) u=6 imp:n=1
c
c
1056    0  48 -49 21 -22 23 -24 fill=14 (0 0 89.950272) u=6 imp:n=1
c
c
1057    0  49 -50 21 -22 23 -24 fill=13 (0 0 93.698354) u=6 imp:n=1
c
c
1058    0  50 -51 21 -22 23 -24 fill=14 (0 0 97.446436) u=6 imp:n=1
c
c
1059    0  51 -52 21 -22 23 -24 fill=13 (0 0 101.194518) u=6 imp:n=1
c
1060    0  52 -53 21 -22 23 -24 fill=14 (0 0 104.942600) u=6 imp:n=1
c
c
1061    0  53 -54 21 -22 23 -24 fill=13 (0 0 108.690682) u=6 imp:n=1
c
1062    0  54 -55 21 -22 23 -24 fill=14 (0 0 112.438764) u=6 imp:n=1
c
c
1063    0  55 -56 21 -22 23 -24 fill=13 (0 0 116.186846) u=6 imp:n=1
c
1064    0  56 -57 21 -22 23 -24 fill=14 (0 0 119.934928) u=6 imp:n=1
c
c
1065    0  57 -58 21 -22 23 -24 fill=13 (0 0 123.683010) u=6 imp:n=1
c
1066    0  58 -59 21 -22 23 -24 fill=14 (0 0 127.431092) u=6 imp:n=1
c
c
1067    0  59 -60 21 -22 23 -24 fill=13 (0 0 131.179174) u=6 imp:n=1
c
1068    0  60 -61 21 -22 23 -24 fill=14 (0 0 134.927256) u=6 imp:n=1
c
c
1069    0  61 -62 21 -22 23 -24 fill=13 (0 0 138.675338) u=6 imp:n=1
c
1070    0  62 -63 21 -22 23 -24 fill=14 (0 0 142.423420) u=6 imp:n=1
c
c
1071    0  63 -64 21 -22 23 -24 fill=13 (0 0 146.171502) u=6 imp:n=1
c
1072    0  64 -65 21 -22 23 -24 fill=14 (0 0 149.919584) u=6 imp:n=1
c
c
c The top core cell, Cell 2
c
c Na dummy
1082    11 1.216928E-02 65 -404 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1087    3 6.9083E-02 405 -406 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1088    4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-155:156:-157:158:-405:406) u=6 imp:n=1 TMP=2.5301E-08
c
c Pu Plate core
1092    1 3.9991E-02 151 -152 153 -154 408 -409 u=6 imp:n=1 &
      TMP=2.5301E-08
c Pu canning
1093    2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-151:152:-153:154:-408:409) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1102    11 1.216928E-02 410 -413 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c UO2 core
1107    3 6.9083E-02 414 -415 155 -156 157 -158 u=6 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1108    4 7.2463E-02 413 -416 21 -22 23 -24 &

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```
(-155:156:-157:158:-414:415) u=6 imp:n=1 TMP=2.5301E-08
c
c Na dummy
1112 11 1.216928E-02 416 -66 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c
c Upper Axial blanket.
c
1121 8 4.7208E-02 66 -67 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1122 9 4.7925E-02 67 -68 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
1123 15 4.8317E-02 68 -12 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1126 14 8.4932E-02 12 -13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c Upper padding
1127 16 3.279692E-02 13 21 -22 23 -24 u=6 imp:n=1 TMP=2.5301E-08
c
c Wrapper region
c gap between plates and wrapper
1131 0 132 -133 134 -135 (-21:22:-23:24) u=6 imp:n=1
c Wrapper
1132 17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=6 &
imp:n=1 TMP=2.5301E-08
c gap outside wrapper
1133 0 1 -2 3 -4 (-136:137:-138:139) u=6 imp:n=1
c
c End of Z plate element
c
c Y plate element
c
c
c --- Core Plate Geometry Element with sodium dummy Y plate
c Lower padding
1211 16 3.279692E-02 -8 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1212 14 8.4932E-02 8 -9 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c Lower section of the NatU Blanket
1213 15 4.8317E-02 9 -41 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c Middle section of Lower Blanket
1214 9 4.7925E-02 41 -42 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c Top section of lower blanket
1215 8 4.7208E-02 42 -10 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c
c Fuelled section
c
c Lowest core Cell, Cell 12
c
c Na dummy region. The Y ring
1221 0 10 -504 -109 u=12 imp:n=1
c Steel region
1222 10 8.84614E-02 10 -504 109 -110 u=12 imp:n=1 TMP=2.5301E-08
c
1223 0 10 -504 21 -22 23 -24 110 u=12 imp:n=1
c
c UO2 core
1227 3 6.9083E-02 505 -506 155 -156 157 -158 u=12 imp:n=1 TMP=2.5301E-08
c UO2 plate can
1228 4 7.2463E-02 504 -507 21 -22 23 -24 &
(-155:156:-157:158:-505:506) u=12 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
1231 0 507 -510 -109 u=12 imp:n=1
c Steel region
1232 10 8.84614E-02 507 -510 109 -110 u=12 imp:n=1 TMP=2.5301E-08
c
1233 0 507 -510 21 -22 23 -24 110 u=12 imp:n=1
c
c Pu Plate core
1235 1 3.9991E-02 151 -152 153 -154 511 -512 u=12 imp:n=1 TMP=2.5301E-08
c Pu canning
1236 2 6.6997E-02 510 -513 21 -22 23 -24 &
(-151:152:-153:154:-511:512) u=12 imp:n=1 TMP=2.5301E-08
c
c UO2 core
```

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```

1239   3 6.9083E-02 514 -515 155 -156 157 -158 u=12  imp:n=1 TMP=2.5301E-08
c UO2 plate can
1240   4 7.2463E-02 513 -516 21 -22 23 -24 &
      (-155:156:-157:158:-514:515) u=12  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
1243   0 516 -43 -109 u=12  imp:n=1
C Steel region
1244  10 8.84614E-02 516 -43 109 -110 u=12  imp:n=1 TMP=2.5301E-08
c
1245   0 516 -43 21 -22 23 -24 110 u=12  imp:n=1
c
c Insert the 22 central region core cells
c
1251   0 43 -44 21 -22 23 -24 fill=15 (0 0 71.21678) u=12  imp:n=1
c
1252   0 44 -45 21 -22 23 -24 fill=16 (0 0 74.97178) u=12  imp:n=1
c
c
1253   0 45 -46 21 -22 23 -24 fill=15 (0 0 78.72678) u=12  imp:n=1
c
1254   0 46 -47 21 -22 23 -24 fill=16 (0 0 82.48178) u=12  imp:n=1
c
c
1255   0 47 -48 21 -22 23 -24 fill=15 (0 0 86.23678) u=12  imp:n=1
c
1256   0 48 -49 21 -22 23 -24 fill=16 (0 0 89.99178) u=12  imp:n=1
c
c
1257   0 49 -50 21 -22 23 -24 fill=15 (0 0 93.74678) u=12  imp:n=1
c
1258   0 50 -51 21 -22 23 -24 fill=16 (0 0 97.50178) u=12  imp:n=1
c
c
1259   0 51 -52 21 -22 23 -24 fill=15 (0 0 101.25678) u=12  imp:n=1
c
1260   0 52 -53 21 -22 23 -24 fill=16 (0 0 105.01178) u=12  imp:n=1
c
c
1261   0 53 -54 21 -22 23 -24 fill=15 (0 0 108.76678) u=12  imp:n=1
c
1262   0 54 -55 21 -22 23 -24 fill=16 (0 0 112.52178) u=12  imp:n=1
c
c
1263   0 55 -56 21 -22 23 -24 fill=15 (0 0 116.27678) u=12  imp:n=1
c
1264   0 56 -57 21 -22 23 -24 fill=16 (0 0 120.03178) u=12  imp:n=1
c
c
1265   0 57 -58 21 -22 23 -24 fill=15 (0 0 123.78678) u=12  imp:n=1
c
1266   0 58 -59 21 -22 23 -24 fill=16 (0 0 127.54178) u=12  imp:n=1
c
c
1267   0 59 -60 21 -22 23 -24 fill=15 (0 0 131.29678) u=12  imp:n=1
c
1268   0 60 -61 21 -22 23 -24 fill=16 (0 0 135.05178) u=12  imp:n=1
c
c
1269   0 61 -62 21 -22 23 -24 fill=15 (0 0 138.80678) u=12  imp:n=1
c
1270   0 62 -63 21 -22 23 -24 fill=16 (0 0 142.56178) u=12  imp:n=1
c
c
1271   0 63 -64 21 -22 23 -24 fill=15 (0 0 146.31678) u=12  imp:n=1
c
1272   0 64 -65 21 -22 23 -24 fill=16 (0 0 150.07178) u=12  imp:n=1
c
c
c The top core cell, Cell 2
c
c Na dummy region. The Y ring
1275   0 65 -404 -109 u=12  imp:n=1
C Steel region

```

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```

1276  10 8.84614E-02 65 -404 109 -110 u=12  imp:n=1 TMP=2.5301E-08
c
1277  0 65 -404 21 -22 23 -24 110 u=12  imp:n=1
c
c UO2 core
1278  3 6.9083E-02 405 -406 155 -156 157 -158 u=12  imp:n=1 TMP=2.5301E-08
c UO2 plate can
1279  4 7.2463E-02 404 -407 21 -22 23 -24 &
      (-155:156:-157:158:-405:406) u=12  imp:n=1 TMP=2.5301E-08
c
C Pu Plate core
1280  1 3.9991E-02 151 -152 153 -154 408 -409 u=12  imp:n=1 &
      TMP=2.5301E-08
C Pu canning
1281  2 6.6997E-02 407 -410 21 -22 23 -24 &
      (-151:152:-153:154:-408:409) u=12  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
1282  0 410 -413 -109 u=12  imp:n=1
C Steel region
1283  10 8.84614E-02 410 -413 109 -110 u=12  imp:n=1 TMP=2.5301E-08
c
1284  0 410 -413 21 -22 23 -24 110 u=12  imp:n=1
c
c UO2 core
1285  3 6.9083E-02 414 -415 155 -156 157 -158 u=12  imp:n=1 TMP=2.5301E-08
c UO2 plate can
1286  4 7.2463E-02 413 -416 21 -22 23 -24 &
      (-155:156:-157:158:-414:415) u=12  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
1287  0 416 -11 -109 u=12  imp:n=1
C Steel region
1288  10 8.84614E-02 416 -11 109 -110 u=12  imp:n=1 TMP=2.5301E-08
c
1289  0 416 -11 21 -22 23 -24 110 u=12  imp:n=1
c
c
c Upper Axial blanket.
c
1321  8 4.7208E-02 11 -67 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
1322  9 4.7925E-02 67 -68 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
1323  15 4.8317E-02 68 -12 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c
c Upper Reflector
1326  14 8.4932E-02 12 -13 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c Upper padding
1327  16 3.279692E-02 13 21 -22 23 -24 u=12 imp:n=1 TMP=2.5301E-08
c
c Wrapper region
c gap between plates and wrapper
1331  0 132 -133 134 -135 (-21:22:-23:24) u=12 imp:n=1
c Wrapper
1332  17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=12 &
      imp:n=1 TMP=2.5301E-08
c gap outside wrapper
1333  0 1 -2 3 -4 (-136:137:-138:139) u=12 imp:n=1
c
c
c End of Y element
c
c --- Radial Breeder Element
c Lower padding
1441  16 3.279692E-02 -8 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Lower Reflector
1442  14 8.4932E-02 8 -9 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Radial blanket
1444  15 4.8317E-02 9 -12 21 -22 23 -24 u=7 imp:n=1 TMP=2.5301E-08
c Upper reflector
1446  like 134 but u=7 imp:n=1 TMP=2.5301E-08
c Upper padding
1447  like 135 but u=7 imp:n=1 TMP=2.5301E-08
c Wrapper region
c gap between plates and wrapper
1448  0 132 -133 134 -135 (-21:22:-23:24) u=7 imp:n=1

```


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```

c Wrapper
1449 17 7.81552E-02 136 -137 138 -139 (-132:133:-134:135) u=7 imp:n=1 &
      TMP=2.5301E-08
c gap outside wrapper
1450 0 1 -2 3 -4 (-136:137:-138:139) u=7 imp:n=1
c
c
c --- Radial shield
c
1466 12 8.32720E-02 28 -29 30 -31 u=8 imp:n=1 TMP=2.5301E-08
c
1467 13 8.32720E-05 1 -2 3 -4 (-28:29:-30:31) u=8 imp:n=1 &
      TMP=2.5301E-08
c
c
1468 13 8.32720E-05 1 -2 3 -4 u=9 imp:n=1 TMP=2.5301E-08
c
c --- Assembly
c
1471 0 189 -190 191 -192 u=10 lat=1
      fill=-3:3 -3:3 0:0
      199 164 162 161 163 165 199
      146 144 142 141 143 145 147
      126 124 122 121 123 125 127
      106 104 102 101 103 105 107
      116 114 112 111 113 115 117
      136 134 132 131 133 135 137
      199 154 152 151 153 155 199
      imp:n=1
c
c --- Fuel Region
c
1472 0 7 -16 -17 fill=10 imp:n=1
c --- Universe
1473 0 -7:16:17 imp:n=0
c
c Cell A
c 501 1 6.9985E-02 -71 u=3 imp:n=1 TMP=2.5301E-08
c
c 502 23 0.062241 -74 71 u=3 imp:n=1 TMP=2.5301E-08
c
c 503 5 2.3900E-02 74 u=3 imp:n=1 TMP=2.5301E-08
c
c 504 0 75 -76 77 -78 u=3 fill=1 imp:n=1
c
c Cell E Modified compositions
c
c 506 2 7.1167E-02 -71 u=4 imp:n=1 TMP=2.5301E-08
c
c 507 24 0.0596942 -74 71 u=4 imp:n=1 TMP=2.5301E-08
c
c 508 5 2.3900E-02 74 u=4 imp:n=1 TMP=2.5301E-08
c
c 509 0 75 -76 77 -78 u=4 fill=2 imp:n=1
c
c 511 0 75 -76 77 -78 lat=1 &
      fill -2:1 -2:1 0:0 &
      3 4 3 4 4 3 4 3 3 4 3 4 3 4 3 4 3 &
      u=11 imp:n=1
c
c
c ----- PLATE ELEMENT CELL CARDS -----
c
c The First Regular cell. Cell 1
c
c Na dummy
c
c 2162 11 1.216928E-02 801 -804 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
2162 11 1.216928E-02 -804 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2167 3 6.9083E-02 805 -806 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08

```

```

c UO2 plate can
2168 4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=13 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2170 7 3.3152E-02 807 -708 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2172 1 3.9991E-02 151 -152 153 -154 709 -710 u=13 imp:n=1 TMP=2.5301E-08
C Pu canning
2173 2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-151:152:-153:154:-709:710) u=13 imp:n=1 TMP=2.5301E-08
c
c
c Na dummy
c
2182 11 1.216928E-02 711 -814 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2187 3 6.9083E-02 815 -816 155 -156 157 -158 u=13 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2188 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=13 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
c 2192 11 1.216928E-02 817 -820 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
2192 11 1.216928E-02 817 21 -22 23 -24 u=13 imp:n=1 TMP=2.5301E-08
c
c
c End of Cell 1 beginning of Cell 2
c
c Na dummy
c
c 2202 11 1.216928E-02 801 -804 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
2202 11 1.216928E-02 -804 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2207 3 6.9083E-02 805 -806 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2208 4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=14 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
2211 11 1.216928E-02 807 -810 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2214 1 3.9991E-02 151 -152 153 -154 811 -812 u=14 imp:n=1 TMP=2.5301E-08
C Pu canning
2215 2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-151:152:-153:154:-811:812) u=14 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2217 7 3.3152E-02 813 -814 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2219 3 6.9083E-02 815 -816 155 -156 157 -158 u=14 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2220 4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=14 imp:n=1 TMP=2.5301E-08
c
c Na dummy
c
c 2222 11 1.216928E-02 817 -820 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
2222 11 1.216928E-02 817 21 -22 23 -24 u=14 imp:n=1 TMP=2.5301E-08
c
c
c End of plate element cell data for Z plate
c
c
c Cell data for Y plate

```

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```

c
c
c The First Regular cell. Cell 1 with the Y ring
c
c Na dummy region. The Y ring
c 2361  0 801 -804 -109 u=15  imp:n=1
2361  0 -804 -109 u=15  imp:n=1
C Steel region
c 2362  10 8.84614E-02 801 -804 109 -110 u=15  imp:n=1 TMP=2.5301E-08
2362  10 8.84614E-02 -804 109 -110 u=15  imp:n=1 TMP=2.5301E-08
c
c 2363  0 801 -804 21 -22 23 -24 110 u=15  imp:n=1
2363  0 -804 21 -22 23 -24 110 u=15  imp:n=1
c
c UO2 plate
c UO2 core
2367  3 6.9083E-02 805 -806 155 -156 157 -158 u=15  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2368  4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=15  imp:n=1 TMP=2.5301E-08
c
c Steel plate
2370  7 3.3152E-02 807 -708 21 -22 23 -24 u=15  imp:n=1 TMP=2.5301E-08
c
c Pu plate
C Plate core
2372  1 3.9991E-02 151 -152 153 -154 709 -710 u=15  imp:n=1 TMP=2.5301E-08
C Pu canning
2373  2 6.6997E-02 708 -711 21 -22 23 -24 &
      (-151:152:-153:154:-709:710) u=15  imp:n=1 TMP=2.5301E-08
c
c
c Na dummy region. The Y ring
2381  0 711 -814 -109 u=15  imp:n=1
C Steel region
2382  10 8.84614E-02 711 -814 109 -110 u=15  imp:n=1 TMP=2.5301E-08
c
2383  0 711 -814 21 -22 23 -24 110 u=15  imp:n=1
c
c UO2 plate
c UO2 core
2387  3 6.9083E-02 815 -816 155 -156 157 -158 u=15  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2388  4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=15  imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
c 2391  0 817 -820 -109 u=15  imp:n=1
2391  0 817 -109 u=15  imp:n=1
C Steel region
c 2392  10 8.84614E-02 817 -820 109 -110 u=15  imp:n=1 TMP=2.5301E-08
2392  10 8.84614E-02 817 109 -110 u=15  imp:n=1 TMP=2.5301E-08
c
c 2393  0 817 -820 21 -22 23 -24 110 u=15 imp:n=1
2393  0 817 21 -22 23 -24 110 u=15 imp:n=1
c
c
c                                     End of Cell 1 beginning of Cell 2
c
c Na dummy region. The Y ring
c 2401  0 801 -804 -109 u=16  imp:n=1
2401  0 -804 -109 u=16  imp:n=1
C Steel region
c 2402  10 8.84614E-02 801 -804 109 -110 u=16  imp:n=1 TMP=2.5301E-08
2402  10 8.84614E-02 -804 109 -110 u=16  imp:n=1 TMP=2.5301E-08
c
c 2403  0 801 -804 21 -22 23 -24 110 u=16  imp:n=1
2403  0 -804 21 -22 23 -24 110 u=16  imp:n=1
c UO2 plate
c UO2 core
2407  3 6.9083E-02 805 -806 155 -156 157 -158 u=16  imp:n=1 TMP=2.5301E-08
c UO2 plate can
2408  4 7.2463E-02 804 -807 21 -22 23 -24 &
      (-155:156:-157:158:-805:806) u=16  imp:n=1 TMP=2.5301E-08
c

```

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```

c Na dummy region. The Y ring
2410  0 807 -810 -109 u=16 imp:n=1
C Steel region
2411  10 8.84614E-02 807 -810 109 -110 u=16 imp:n=1 TMP=2.5301E-08
c
2412  0 807 -810 21 -22 23 -24 110 u=16 imp:n=1
c
c Pu plate
C Plate core
2414  1 3.9991E-02 151 -152 153 -154 811 -812 u=16 imp:n=1 TMP=2.5301E-08
C Pu canning
2415  2 6.6997E-02 810 -813 21 -22 23 -24 &
      (-151:152:-153:154:-811:812) u=16 imp:n=1 TMP=2.5301E-08
c
c Steel plate
2417  7 3.3152E-02 813 -814 21 -22 23 -24 u=16 imp:n=1 TMP=2.5301E-08
c
c UO2 plate
c UO2 core
2419  3 6.9083E-02 815 -816 155 -156 157 -158 u=16 imp:n=1 TMP=2.5301E-08
c UO2 plate can
2420  4 7.2463E-02 814 -817 21 -22 23 -24 &
      (-155:156:-157:158:-815:816) u=16 imp:n=1 TMP=2.5301E-08
c
c Na dummy region. The Y ring
c 2422  0 817 -820 -109 u=16 imp:n=1
2422  0 817 -109 u=16 imp:n=1
C Steel region
c 2423  10 8.84614E-02 817 -820 109 -110 u=16 imp:n=1 TMP=2.5301E-08
2423  10 8.84614E-02 817 109 -110 u=16 imp:n=1 TMP=2.5301E-08
c
c 2424  0 817 -820 21 -22 23 -24 110 u=16 imp:n=1
2424  0 817 21 -22 23 -24 110 u=16 imp:n=1
c
c
c -----
c Form the region surrounding groups of 5x5 elements, containing grids
c
c
3001  0 189 -190 191 -192 (-185:186:-187:188) -71 u=100 imp:n=1
c
3002  20 7.403935E-02 189 -190 191 -192 (-185:186:-187:188) 71 -72 &
      u=100 imp:n=1
c
3003  0 189 -190 191 -192 (-185:186:-187:188) 72 -73 u=100 imp:n=1
c
3004  20 7.403935E-02 189 -190 191 -192 (-185:186:-187:188) 73 -74 &
      u=100 imp:n=1
c
3005  0 189 -190 191 -192 (-185:186:-187:188) 74 u=100 imp:n=1
c
c
c -----
c Form arrays of 5x5 elements
c
c
c Central row
c
c Central array of 5x5 core elements
c
c
3011  0 1 -2 3 -4 u=201 lat=1
      fill=-2:2 -2:2 0:0
      12 12 12 12 12
      6 12 12 12 12
      12 12 12 12 12
      12 12 12 12 12
      12 12 12 12 6
      imp:n=1
c
3012  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=101 imp:n=1
c
3013  0 7 -16 185 -186 187 -188 fill=201 u=101 imp:n=1

```

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```

c
c
c Middle Left array of 5x5 core elements in row 4
c
3014    0    1 -2 3 -4 u=202 lat=1
        fill=-2:2 -2:2 0:0
        4 5 4 6 6
        4 2 4 6 6
        3 2 2 12 12
        4 2 2 12 12
        4 5 2 6 6
        imp:n=1

c
c
c Surround material
c
3015    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=102 imp:n=1
c
c
c
3016    0  7 -16 185 -186 187 -188 fill=202 u=102 imp:n=1
c
c
c Middle Right array of 5x5 core elements in row 4
c
3017    0    1 -2 3 -4 u=203 lat=1
        fill=-2:2 -2:2 0:0
        6 6 4 5 4
        6 6 4 2 4
        12 6 2 2 3
        6 6 2 2 4
        6 12 3 5 4
        imp:n=1

c
c
c Surround material
c
3018    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=103 imp:n=1
c
c
c
3019    0  7 -16 185 -186 187 -188 fill=203 u=103 imp:n=1
c
c
c
c Left core edge array of 5x5 elements in row 4
c
3021    0    1 -2 3 -4 u=204 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        7 7 7 7 1
        imp:n=1

c
c
c Surround material
c
3022    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=104 imp:n=1
c
c
c
3023    0  7 -16 185 -186 187 -188 fill=204 u=104 imp:n=1
c
c
c Right core edge array of 5x5 elements in row 4
c
3024    0    1 -2 3 -4 u=205 lat=1
        fill=-2:2 -2:2 0:0
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        1 7 7 7 7
        imp:n=1

c

```

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```

c
c Surround material
c
3025  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=105 imp:n=1
c
c
3026  0  7 -16 185 -186 187 -188 fill=205 u=105 imp:n=1
c
c
c                               ROW 3 The row below the central line
c
c
c Middle array of 5x5 core elements in Row 3
c
c
3031  0  1 -2 3 -4 u=211 lat=1
      fill=-2:2 -2:2 0:0
      6 12 6 6 6
      6 12 6 6 6
      3 3 3 3 3
      3 3 3 3 3
      3 3 3 3 3
      imp:n=1
c
c Surround material
c
3032  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=111 imp:n=1
c
3033  0  7 -16 185 -186 187 -188 fill=211 u=111 imp:n=1
c
c Lower left array of 5x5 core elements in Row 3
c
c
3034  0  1 -2 3 -4 u=212 lat=1
      fill=-2:2 -2:2 0:0
      1 2 2 1 12
      1 2 2 1 2
      1 1 4 2 3
      7 1 2 3 3
      7 7 2 1 1
      imp:n=1
c
c Surround material
c
3035  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=112 imp:n=1
c
3036  0  7 -16 185 -186 187 -188 fill=212 u=112 imp:n=1
c
c
c Lower right array of 5x5 core elements in Row 3
c
c
3037  0  1 -2 3 -4 u=213 lat=1
      fill=-2:2 -2:2 0:0
      6 1 2 2 1
      2 1 2 2 1
      3 3 4 1 1
      3 3 2 1 7
      1 1 2 7 7
      imp:n=1
c
c Surround material
c
3038  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=113 imp:n=1
c
c
3039  0  7 -16 185 -186 187 -188 fill=213 u=113 imp:n=1
c
c
c left array of blanket elements with a single core element
c
c
3041  0  1 -2 3 -4 u=214 lat=1

```

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```

fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3042  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=114 imp:n=1
c
3043  0  7 -16 185 -186 187 -188 fill=214 u=114 imp:n=1
c
c
c right array of blanket elements with two core elements
c
c
3045  0  1 -2 3 -4 u=215 lat=1
fill=-2:2 -2:2 0:0
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3046  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=115 imp:n=1
c
3047  0  7 -16 185 -186 187 -188 fill=215 u=115 imp:n=1
c
c
c ROW 5 the row above the central line
c
c Central array of 5x5 core elements in Row 5
c
3051  0  1 -2 3 -4 u=221 lat=1
fill=-2:2 -2:2 0:0
3 3 3 3 3
3 3 3 3 3
3 3 3 3 3
6 6 6 12 6
6 6 6 12 6
imp:n=1
c
c
c Surround material
c
3052  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=121 imp:n=1
c
c
3053  0  7 -16 185 -186 187 -188 fill=221 u=121 imp:n=1
c
c
c Top left array of 5x5 core elements in Row 5
c
3054  0  1 -2 3 -4 u=222 lat=1
fill=-2:2 -2:2 0:0
7 7 2 1 1
7 1 2 3 3
1 1 4 2 2
1 3 2 1 2
1 2 2 1 6
imp:n=1
c
c
c Surround material
c
3055  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=122 imp:n=1
c

```

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```

c
3056  0 7 -16 185 -186 187 -188 fill=222 u=122 imp:n=1
c
c
c Top right array of 5x5 core elements in Row 5
c
3057  0 1 -2 3 -4 u=223 lat=1
      fill=-2:2 -2:2 0:0
      1 1 2 7 7
      3 3 2 1 7
      2 2 4 2 2
      2 1 2 3 1
      6 1 2 2 1
      imp:n=1
c
c
c Surround material
c
3058  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=123 imp:n=1
c
c
3059  0 7 -16 185 -186 187 -188 fill=223 u=123 imp:n=1
c
c
c
c left array of blanket elements with two core plate elements
c
c
3061  0 1 -2 3 -4 u=224 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3062  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=124 imp:n=1
c
3063  0 7 -16 185 -186 187 -188 fill=224 u=124 imp:n=1
c
c
c Right array of blanket elements with one core plate element
c
c
3064  0 1 -2 3 -4 u=225 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3065  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=125 imp:n=1
c
3066  0 7 -16 185 -186 187 -188 fill=225 u=125 imp:n=1
c
c
c ROW 2 The row two down from the central row
c
c Lower central group
c
c
3071  0 1 -2 3 -4 u=231 lat=1
      fill=-2:2 -2:2 0:0
      1 1 1 1 1
      7 7 7 7 7

```


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```

7 7 7 7 7
7 7 7 7 7
7 7 7 7 7
imp:n=1
c
c
c Surround material
c
3072  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=131 imp:n=1
c
3073  0  7 -16 185 -186 187 -188 fill=231 u=131 imp:n=1
c
c
c Array of blanket elements
c
c
3074  0  1 -2 3 -4 u=232 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3075  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=132 imp:n=1
c
3076  0  7 -16 185 -186 187 -188 fill=232 u=132 imp:n=1
c
c
c
c Right array of blanket elements with one core element
c
c
3077  0  1 -2 3 -4 u=233 lat=1
      fill=-2:2 -2:2 0:0
      2 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3078  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=133 imp:n=1
c
3079  0  7 -16 185 -186 187 -188 fill=233 u=133 imp:n=1
c
c
c
c ROW 6
c
c Top central array of 5x5 core elements in row 6
c
3081  0  1 -2 3 -4 u=241 lat=1
      fill=-2:2 -2:2 0:0
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      7 7 7 7 7
      1 1 1 1 1
      imp:n=1
c
c Surround material
c
3082  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=141 imp:n=1
c
3083  0  7 -16 185 -186 187 -188 fill=241 u=141 imp:n=1
c

```

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LIQUID METAL FAST REACTOR – LMFR
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```

c
c
c Left array of blanket elements with one core element
c
c
3085    0    1 -2 3 -4 u=242 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 3
        imp:n=1

c
c
c Surround material
c
3086    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=142 imp:n=1
c
3087    0  7 -16 185 -186 187 -188 fill=242 u=142 imp:n=1
c
c
c Right central array in Row 6
c
c
3088    0    1 -2 3 -4 u=243 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        7 7 7 7 7
        imp:n=1

c
c Surround material
c
3089    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=143 imp:n=1
c
3090    0  7 -16 185 -186 187 -188 fill=243 u=143 imp:n=1
c
c
c
c
c *** Blanket-Reflector Arrays ***
c
c ROW 2
c
c Bottom Left
c
c
3111    0    1 -2 3 -4 u=234 lat=1
        fill=-2:2 -2:2 0:0
        8 7 7 7 7
        8 8 7 7 7
        8 8 8 7 7
        8 8 8 8 7
        9 8 8 8 8
        imp:n=1

c
c
c Surround material
c
3112    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=134 imp:n=1
c
3113    0  7 -16 185 -186 187 -188 fill=234 u=134 imp:n=1
c
c
c Row 2 Bottom Right Blanket Reflector Array
c
c
3121    0    1 -2 3 -4 u=235 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 8
        7 7 7 8 8

```

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```

      7 7 8 8 8
      7 8 8 8 8
      8 8 8 8 9
      imp:n=1
c
c
c Surround material
c
3122   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=135 imp:n=1
c
3123   0  7 -16 185 -186 187 -188 fill=235 u=135 imp:n=1
c
c
c ROW 6
c
c Top Left Blanket-Reflector Array
c
c
3131   0   1 -2 3 -4 u=244 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 8
      8 8 8 8 7
      8 8 8 7 7
      8 8 7 7 7
      8 7 7 7 7
      imp:n=1
c
c
c Surround material
c
3132   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=144 imp:n=1
c
3133   0  7 -16 185 -186 187 -188 fill=244 u=144 imp:n=1
c
c Row 6 Top Right Blanket Reflector Array
c
c
3141   0   1 -2 3 -4 u=245 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 8 9
      7 8 8 8 8
      7 7 8 8 8
      7 7 7 8 8
      7 7 7 7 8
      imp:n=1
c
c
c Surround material
c
3142   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=145 imp:n=1
c
3143   0  7 -16 185 -186 187 -188 fill=245 u=145 imp:n=1
c
c
c Row 1 Blanket - Reflector arrays
c
c Row 1 First Left array
c
c
3151   0   1 -2 3 -4 u=254 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 9 8 8
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1
c
c
c Surround material
c
3152   0  189 -190 191 -192   (-185:186:-187:188) fill=100 u=154 imp:n=1
c
3153   0  7 -16 185 -186 187 -188 fill=254 u=154 imp:n=1

```

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```

c
c Row 1 Mid-Left
c
c
3161    0    1 -2 3 -4 u=252 lat=1
        fill=-2:2 -2:2 0:0
        8 8 8 7 7
        8 8 8 8 8
        8 8 8 8 8
        9 9 9 8 8
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3162    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=152 imp:n=1
c
3163    0  7 -16 185 -186 187 -188 fill=252 u=152 imp:n=1
c
c Row 1 Central Array
c
3171    0    1 -2 3 -4 u=251 lat=1
        fill=-2:2 -2:2 0:0
        7 7 7 7 7
        8 8 8 8 8
        8 8 8 8 8
        8 8 8 8 8
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3172    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=151 imp:n=1
c
3173    0  7 -16 185 -186 187 -188 fill=251 u=151 imp:n=1
c
c Row 1 First Right array
c
c
3181    0    1 -2 3 -4 u=253 lat=1
        fill=-2:2 -2:2 0:0
        7 7 8 8 8
        8 8 8 8 8
        8 8 8 8 8
        8 8 9 9 9
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3182    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=153 imp:n=1
c
3183    0  7 -16 185 -186 187 -188 fill=253 u=153 imp:n=1
c
c Row 1 Far Right
c
c
3191    0    1 -2 3 -4 u=255 lat=1
        fill=-2:2 -2:2 0:0
        8 8 8 9 9
        8 8 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        9 9 9 9 9
        imp:n=1

c
c
c Surround material
c
3192    0  189 -190 191 -192 (-185:186:-187:188) fill=100 u=155 imp:n=1
c

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

3193   0 7 -16 185 -186 187 -188 fill=255 u=155 imp:n=1
c
c
c Row 2 Blanket reflector arrays
c
c Row 2 First Left array
c
c
3201   0 1 -2 3 -4 u=236 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 8 8
      9 9 9 8 8
      9 9 9 9 8
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3202   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=136 imp:n=1
c
3203   0 7 -16 185 -186 187 -188 fill=236 u=136 imp:n=1
c
c Row 2 Far Right
c
c
3211   0 1 -2 3 -4 u=237 lat=1
      fill=-2:2 -2:2 0:0
      8 8 9 9 9
      8 8 9 9 9
      8 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3212   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=137 imp:n=1
c
3213   0 7 -16 185 -186 187 -188 fill=237 u=137 imp:n=1
c
c Row 4 Blanket- Reflector arrays
c
c
c Row 4 First Left array
c
c
3221   0 1 -2 3 -4 u=206 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1

c
c
c Surround material
c
3222   0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=106 imp:n=1
c
3223   0 7 -16 185 -186 187 -188 fill=206 u=106 imp:n=1
c
c
c Row 4 Far Right
c
c
3231   0 1 -2 3 -4 u=207 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      7 8 8 8 9

```

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LIQUID METAL FAST REACTOR – LMFR
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```

7 8 8 8 9
7 8 8 8 9
imp:n=1
c
c
c Surround material
c
3232  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=107 imp:n=1
c
3233  0  7 -16 185 -186 187 -188 fill=207 u=107 imp:n=1
c
c Row 6 Blanket- Reflector arrays
c
c
c Row 6 First Left array
c
3241  0  1 -2 3 -4 u=246 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 8
      9 9 9 8 8
      9 9 9 8 8
      imp:n=1
c
c
c Surround material
c
3242  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=146 imp:n=1
c
3243  0  7 -16 185 -186 187 -188 fill=246 u=146 imp:n=1
c
c Row 6 Far Right
c
3251  0  1 -2 3 -4 u=247 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      8 9 9 9 9
      8 8 9 9 9
      8 8 9 9 9
      imp:n=1
c
c
c Surround material
c
3252  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=147 imp:n=1
c
3253  0  7 -16 185 -186 187 -188 fill=247 u=147 imp:n=1
c
c
c Row 5 Blanket- Reflector arrays
c
c
c Row 5 First Left array
c
c
3261  0  1 -2 3 -4 u=226 lat=1
      fill=-2:2 -2:2 0:0
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      9 8 8 8 7
      9 8 8 8 7
      imp:n=1
c
c
c Surround material
c
3262  0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=126 imp:n=1
c
3263  0  7 -16 185 -186 187 -188 fill=226 u=126 imp:n=1
c
c Row 4 Far Right

```

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```

c
3271    0    1 -2 3 -4 u=227 lat=1
      fill=-2:2 -2:2 0:0
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      7 8 8 8 9
      7 8 8 8 9
      imp:n=1

c
c
c Surround material
c
3272    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=127 imp:n=1
c
3273    0  7 -16 185 -186 187 -188 fill=227 u=127 imp:n=1
c
c
c Row 3 Blanket- Reflector arrays
c
c Row 3 First Left array
c
3281    0    1 -2 3 -4 u=216 lat=1
      fill=-2:2 -2:2 0:0
      9 8 8 8 7
      9 8 8 8 7
      9 9 8 8 8
      9 9 8 8 8
      9 9 8 8 8
      imp:n=1

c
c
c Surround material
c
3282    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=116 imp:n=1
c
3283    0  7 -16 185 -186 187 -188 fill=216 u=116 imp:n=1
c
c Row 3 Far Right
c
3291    0    1 -2 3 -4 u=217 lat=1
      fill=-2:2 -2:2 0:0
      7 8 8 8 9
      7 8 8 8 9
      8 8 8 9 9
      8 8 8 9 9
      8 8 8 9 9
      imp:n=1

c
c
c Surround material
c
3292    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=117 imp:n=1
c
3293    0  7 -16 185 -186 187 -188 fill=217 u=117 imp:n=1
c
c Row 7 Blanket - Reflector arrays
c
c Row 7 First Left array
c
c
3301    0    1 -2 3 -4 u=264 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 8 8
      9 9 8 8 8
      imp:n=1

c
c
c Surround material
c
3302    0  189 -190 191 -192  (-185:186:-187:188) fill=100 u=164 imp:n=1

```

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```

c
3303  0 7 -16 185 -186 187 -188 fill=264 u=164 imp:n=1
c
c Row 7 Mid-Left
c
3311  0 1 -2 3 -4 u=262 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 8 8
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 7 7
      imp:n=1

c
c
c Surround material
c
3312  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=162 imp:n=1
c
3313  0 7 -16 185 -186 187 -188 fill=262 u=162 imp:n=1
c
c Row 7 Central Array
c
3321  0 1 -2 3 -4 u=261 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      8 8 8 8 8
      7 7 7 7 7
      imp:n=1

c
c
c Surround material
c
3322  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=161 imp:n=1
c
3323  0 7 -16 185 -186 187 -188 fill=261 u=161 imp:n=1
c
c Row 7 First Right array
c
3331  0 1 -2 3 -4 u=263 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 8 8
      8 8 8 8 8
      7 7 8 8 8
      imp:n=1

c
c
c Surround material
c
3332  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=163 imp:n=1
c
3333  0 7 -16 185 -186 187 -188 fill=263 u=163 imp:n=1
c
c Row 7 Far Right
c
3341  0 1 -2 3 -4 u=265 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      8 8 9 9 9
      8 8 8 9 9
      imp:n=1

c
c
c Surround material
c
3342  0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=165 imp:n=1
c
3343  0 7 -16 185 -186 187 -188 fill=265 u=165 imp:n=1

```


ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

c
c Beyond the reflector 5x5 Region 9
c
3351 0 1 -2 3 -4 u=299 lat=1
      fill=-2:2 -2:2 0:0
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      9 9 9 9 9
      imp:n=1

c
c
c Surround material
c
3352 0 189 -190 191 -192 (-185:186:-187:188) fill=100 u=199 imp:n=1
c
c
3353 0 7 -16 185 -186 187 -188 fill=299 u=199 imp:n=1
c
c
c
c -----
c
c
c ----- SURFACE CARDS -----
c
c Lattice 2 (Assembly) Elementary cell surfaces
1 px -2.68605
2 px 2.68605
3 py -2.68605
4 py 2.68605
7 pz 0.0 $ Assembly lower limit
8 pz 30.0 $ End Packing, Start Reflector
9 pz 37.60628 $ End Plenum, Start Lower NU
10 pz 67.77878 $ End Lower NU, Start Fuel
c
11 pz 156.96878 $ End Fuel, Start Upper NU for Pin element
c
12 pz 187.271248 $ End Upper NU, Start Top Reflector
13 pz 194.877528 $ End Reflector, Start Packing
16 pz 224.877528 $ Assembly upper limit
c
c 17 cz 94.9
17 cz 89.5
21 px -2.5335 $ Nominal half-width of plates
22 px 2.5335 $ and calandria outer half-width
23 py -2.5335
24 py 2.5335
28 px -2.54 $ Radial shield half-width
29 px 2.54
30 py -2.54
31 py 2.54
c
33 px -2.45 $ inner half-width of calandria
34 px 2.45
35 py -2.45
36 py 2.45
c
c subdivisions in the plate element axial blanket and core cells
c
c 9 pz 37.60628 $ axial reflector / axial blanket
41 pz 45.228780
42 pz 57.951780
c 10 pz 67.77878 $ axial blanket / core
43 pz 71.209862
44 pz 74.957944
45 pz 78.706026
46 pz 82.454108
47 pz 86.202190
48 pz 89.950272
49 pz 93.698354

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

50    pz 97.446436
51    pz 101.194518
52    pz 104.942600
53    pz 108.690682
54    pz 112.438764
55    pz 116.186846
56    pz 119.934928
57    pz 123.683010
58    pz 127.431092
59    pz 131.179174
60    pz 134.927256
61    pz 138.675338
62    pz 142.423420
63    pz 146.171502
64    pz 149.919584
65    pz 153.667666
c
66    pz 157.098748 $ core / axial blanket
c    in plate elements (this replaces pz=11)
67    pz 166.925748
68    pz 179.648748
c    12 pz 187.271248 $ axial blanket / reflector
c
c differences in the pin elements ?
c 67    pz 166.925748
c 68    pz 179.648748
c    12 pz 187.271248 $ axial blanket / reflector
c
c Grid plate heights
c
71    pz 31.8
72    pz 62.2
73    pz 162.6
74    pz 193.0
c
c 71    c/z 0 0 0.423          $ fuel pin radius
c 71    c/z 0.6125 0.6125 0.423
c 72    c/z 0 0 0.4305        $ fuel can inner radius
c 73    c/z 0 0 0.488         $ calandria tube inner radius
c 74    c/z 0 0 0.513         $ calandria tube outer radius
c 74    c/z 0.6125 0.6125 0.513
c 75    px 0.0
c 76    px 1.225
c 77    py 0.0
c 78    py 1.225
c 79    cz 1.692
c 80    cz 2.052
c
81    pz 67.77878 $ 0.0
82    pz 68.21878 $ 0.44
83    pz 97.39878 $ 29.62
c 84    pz 97.50878 $ 29.73
85    pz 97.94878 $ 0.44
86    pz 127.12878 $ 29.62
87    pz 127.23878 $ 29.73
88    pz 127.67878 $ 0.44
89    pz 156.85878 $ 29.62
90    pz 156.96878 $ 29.73
c
91    c/z -1.785 -1.785 0.423
92    c/z -0.595 -1.785 0.423
93    c/z 0.595 -1.785 0.423
94    c/z 1.785 -1.785 0.423
95    c/z -1.785 -0.595 0.423
96    c/z -0.595 -0.595 0.423
97    c/z 0.595 -0.595 0.423
98    c/z 1.785 -0.595 0.423
99    c/z -1.785 0.595 0.423
100   c/z -0.595 0.595 0.423
101   c/z 0.595 0.595 0.423
102   c/z 1.785 0.595 0.423
103   c/z -1.785 1.785 0.423
104   c/z -0.595 1.785 0.423
105   c/z 0.595 1.785 0.423

```

ZEBRA-LMFR-EXP-001
LIQUID METAL FAST REACTOR - LMFR
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```

106   c/z   1.785 1.785 0.423
c
c   the sodium dummy plate type X and Y (ring shaped)
109   cz 2.3
c
110   cz 2.5334
c
111   c/z  -1.785 -1.785 0.513
112   c/z  -0.595 -1.785 0.513
113   c/z   0.595 -1.785 0.513
114   c/z   1.785 -1.785 0.513
115   c/z  -1.785 -0.595 0.513
116   c/z  -0.595 -0.595 0.513
117   c/z   0.595 -0.595 0.513
118   c/z   1.785 -0.595 0.513
119   c/z  -1.785 0.595 0.513
120   c/z  -0.595 0.595 0.513
121   c/z   0.595 0.595 0.513
122   c/z   1.785 0.595 0.513
123   c/z  -1.785 1.785 0.513
124   c/z  -0.595 1.785 0.513
125   c/z   0.595 1.785 0.513
126   c/z   1.785 1.785 0.513
c
132   px -2.551 $ sheath inner half-width
133   px 2.551
134   py -2.551
135   py 2.551
136   px -2.6272 $ sheath outer half-width
137   px 2.6272
138   py -2.6272
139   py 2.6272
c
c   Widths of plate cores
c   * in plate geometry cores these are 101 to 112
151   px -2.3355 $ Pu plate core width
152   px 2.3355
153   py -2.3355
154   py 2.3355
155   px -2.4255 $ UO2 plate core width
156   px 2.4255
157   py -2.4255
158   py 2.4255
159   px -2.4815 $ Na plate core width
160   px 2.4815
161   py -2.4815
162   py 2.4815
c
c
c   coordinates of the elements in 5x5 arrays
c   * in the plate geometry cores these are 81 to 92
181   px -8.05815
182   px 8.05815
183   py -8.05815
184   py 8.05815
185   px -13.43025
186   px 13.43025
187   py -13.43025
188   py 13.43025
189   px -13.5635
190   px 13.5635
191   py -13.5635
192   py 13.5635
c
c
c   Cell 2   Axial heights
c
401   pz   153.667666
402   pz   153.704013
403   pz   154.245013
404   pz   154.281360
405   pz   154.318010
406   pz   154.876010
407   pz   154.912660

```

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LIQUID METAL FAST REACTOR – LMFR
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408	pz	154.958360	
409	pz	155.194360	
410	pz	155.240060	
411	pz	155.276407	
412	pz	155.817407	
413	pz	155.853754	
414	pz	155.890404	
415	pz	156.448404	
416	pz	156.485054	
417	pz	156.521401	
418	pz	157.062401	
419	pz	157.098748	
c			
c Cell 12 Axial heights			
c			
501	pz	67.778780	
502	pz	67.815127	
503	pz	68.356127	
504	pz	68.392474	
505	pz	68.429124	
506	pz	68.987124	
507	pz	69.023774	
508	pz	69.060121	
509	pz	69.601121	
510	pz	69.637468	
511	pz	69.683168	
512	pz	69.919168	
513	pz	69.964868	
514	pz	70.001518	
515	pz	70.559518	
516	pz	70.596168	
517	pz	70.632515	
518	pz	71.173515	
519	pz	71.209862	
c			
c Basic Cell 1 data			
c 701	pz	0.000000	
c 702	pz	0.037500	
c 703	pz	0.578500	\$ Na
c 704	pz	0.616000	
c 705	pz	0.652650	
c 706	pz	1.210650	\$ UO2
c 707	pz	1.247300	
708	pz	1.564300	\$ SS
709	pz	1.610000	\$ Pu can
710	pz	1.846000	\$ Pu core
711	pz	1.891700	
712	pz	1.929200	\$ Na can
713	pz	2.470200	\$ Na core
c 714	pz	2.507700	\$ SS
c 715	pz	2.544350	
c 716	pz	3.102350	\$ UO2
c 717	pz	3.139000	
c 718	pz	3.176500	
c 719	pz	3.717500	\$ Na
c 720	pz	3.755000	\$ Cell 1
c			
801	pz	0.000000	
802	pz	0.037500	
803	pz	0.578500	\$ Na
804	pz	0.616000	
805	pz	0.652650	
806	pz	1.210650	\$ UO2
807	pz	1.247300	
808	pz	1.284800	
809	pz	1.825800	\$ Na
810	pz	1.863300	
811	pz	1.909000	
812	pz	2.145000	\$ Pu
813	pz	2.190700	
814	pz	2.507700	\$ SS
815	pz	2.544350	
816	pz	3.102350	\$ UO2
817	pz	3.139000	

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LIQUID METAL FAST REACTOR - LMFR
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```

818    pz    3.176500
819    pz    3.717500  $ Na
820    pz    3.755000  $ Cell 11
c
c
c -----
c
c
c ----- TALLY CARDS -----
c
c --- MATERIALS CARDS ---
c
c
c MATERIAL 1 Pu metal plate core
ml      92238.31c  6.8782E-07
      94238.31c  3.0461E-05
      94239.31c  2.8920E-02
      94240.31c  6.9095E-03
      94241.31c  7.3960E-04
      94242.31c  1.8699E-04
      95241.31c  4.5718E-04
      1001.31c   1.2764E-04
      6000.31c   4.2260E-04
      7014.31c   2.4215E-05
      8016.31c   8.8450E-05
      13027.31c  2.2973E-05
      14028.31c  1.4158E-05
      25055.31c  1.4902E-06
      24050.31c  1.5637E-07
      24052.31c  3.0155E-06
      24053.31c  3.4193E-07
      24054.31c  8.5114E-08
      26054.31c  9.5478E-07
      26056.31c  1.4988E-05
      26057.31c  3.4614E-07
      26058.31c  4.6065E-09
      28058.31c  5.8334E-06
      28060.31c  2.2470E-06
      28061.31c  9.7676E-08
      28062.31c  3.1143E-07
      28064.31c  7.9313E-08
      31000.31c  2.0166E-03
c total 3.9991E-02
c MATERIAL 2 Pu plate canning
m2      1001.31c  1.3760E-05
      6000.31c   1.1393E-04
      14028.31c  3.6607E-04
      15031.31c  1.3731E-05
      24050.31c  4.0848E-04
      24052.31c  7.8771E-03
      24053.31c  8.9320E-04
      24054.31c  2.2234E-04
      25055.31c  8.5931E-04
      26054.31c  2.0774E-03
      26056.31c  3.2611E-02
      26057.31c  7.5313E-04
      26058.31c  1.0023E-05
      28058.31c  2.8351E-03
      28060.31c  1.0921E-03
      28061.31c  4.7472E-05
      28062.31c  1.5136E-04
      28064.31c  3.8548E-05
      29063.31c  1.1629E-02
      29065.31c  4.9839E-03
c total 6.6997E-02
c MATERIAL 3 UO2 plate core
m3      1001.31c  3.1773E-05
      6000.31c   1.1808E-05
      8016.31c   4.6008E-02
      13027.31c  3.3911E-06
      14028.31c  2.2967E-05
      25055.31c  8.3273E-08

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

26054.31c 7.6610E-08
26056.31c 1.2026E-06
26057.31c 2.7774E-08
26058.31c 3.6962E-10
28058.31c 8.4906E-07
28060.31c 3.2705E-07
28061.31c 1.4217E-08
28062.31c 4.5329E-08
28064.31c 1.1544E-08
42000.66c 3.3379E-07
92235.31c 1.6544E-04
92238.31c 2.2837E-02
c total 6.9083E-02
c MATERIAL 4 UO2 plate canning
m4 1001.31c 1.9035E-05
6000.31c 1.2831E-04
14028.31c 6.4475E-04
15031.31c 3.5078E-04
16032.31c 3.6041E-05
24050.31c 6.0044E-04
24052.31c 1.1579E-02
24053.31c 1.3129E-03
24054.31c 3.2682E-04
25055.31c 8.5559E-04
26054.31c 2.8235E-03
26056.31c 4.4323E-02
26057.31c 1.0236E-03
26058.31c 1.3622E-05
28058.31c 5.7360E-03
28060.31c 2.2095E-03
28061.31c 9.6046E-05
28062.31c 3.0624E-04
28064.31c 7.7989E-05
c total 7.2463E-02
C MATERIAL 5 sodium plate core
m5 1001.31c 1.3900E-05
8016.31c 5.6492E-06
11023.31c 2.3225E-02
20040.31c 3.6083E-06
26054.31c 9.4595E-09
26056.31c 1.4849E-07
26057.31c 3.4294E-09
26058.31c 4.5639E-11
c total 2.324832E-02
c MATERIAL 6 Sodium plate canning
m6 1001.31c 2.1631E-05
6000.31c 2.9290E-04
14028.31c 6.0867E-04
15031.31c 3.2795E-05
16032.31c 3.3219E-05
24050.31c 6.4128E-04
24052.31c 1.2366E-02
24053.31c 1.4023E-03
24054.31c 3.4905E-04
25055.31c 1.3570E-03
26054.31c 3.2179E-03
26056.31c 5.0514E-02
26057.31c 1.1666E-03
26058.31c 1.5525E-05
28058.31c 4.8322E-03
28060.31c 1.8614E-03
28061.31c 8.0912E-05
28062.31c 2.5798E-04
28064.31c 6.5701E-05
41093.31c 3.1147E-04
c total 7.9429E-02
C MATERIAL 7 40% steel plate
c m7 1001.31c 1.8355E-05
c 6000.31c 8.7794E-05
c 13027.31c 1.1862E-04
c 14028.31c 7.9703E-04
c 15031.31c 4.0018E-05
c 16032.31c 1.4422E-05
c 22000.62c 2.4806E-04

```

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LIQUID METAL FAST REACTOR - LMFR
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```
c      24050.31c  6.9120E-04
c      24052.31c  1.3329E-02
c      24053.31c  1.5114E-03
c      24054.31c  3.7622E-04
c      25055.31c  1.4972E-03
c      26054.31c  3.2362E-03
c      26056.31c  5.0801E-02
c      26057.31c  1.1732E-03
c      26058.31c  1.5613E-05
c      28058.31c  5.9891E-03
c      28060.31c  2.3070E-03
c      28061.31c  1.0028E-04
c      28062.31c  3.1975E-04
c      28064.31c  8.1431E-05
c      29063.31c  5.0365E-05
c      41093.31c  4.9781E-06
c      42000.66c  8.0988E-05
```

```
c
c 40% ss plate smeared over plate region
```

```
c
m7      1001.31c  7.3413E-06
      6000.31c  3.5114E-05
      13027.31c  4.7443E-05
      14028.31c  3.1878E-04
      15031.31c  1.6006E-05
      16032.31c  5.7682E-06
      22000.62c  9.9214E-05
      24050.31c  2.7645E-04
      24052.31c  5.3311E-03
      24053.31c  6.0450E-04
      24054.31c  1.5047E-04
      25055.31c  5.9882E-04
      26054.31c  1.2944E-03
      26056.31c  2.0318E-02
      26057.31c  4.6923E-04
      26058.31c  6.2446E-06
      28058.31c  2.3954E-03
      28060.31c  9.2271E-04
      28061.31c  4.0108E-05
      28062.31c  1.2789E-04
      28064.31c  3.2569E-05
      29063.31c  1.4101E-05
      29065.31c  6.0432E-06
      41093.31c  1.9910E-06
      42000.66c  3.2392E-05
```

```
c total 3.3152E-02
```

```
c
```

```
C MATERIAL 8 U8 metal plate
```

```
m8      1001.31c  4.4048E-05
      6000.31c  4.9283E-04
      14028.31c  2.1076E-04
      26054.31c  6.1951E-06
      26056.31c  9.7250E-05
      26057.31c  2.2459E-06
      26058.31c  2.9889E-08
      92235.31c  3.3369E-04
      92238.31c  4.6021E-02
```

```
c total 4.7208E-02
```

```
C MATERIAL 9 U2 metal plate
```

```
m9      1001.31c  4.3899E-05
      6000.31c  4.6047E-04
      14028.31c  1.9692E-04
      26054.31c  5.7884E-06
      26056.31c  9.0866E-05
      26057.31c  2.0985E-06
      26058.31c  2.7927E-08
      92235.31c  3.3962E-04
      92238.31c  4.6785E-02
```

```
c total 4.7925E-02
```

```
c
```

```
c
```

```
c MATERIAL 10 Dummy plate Y
```

```
c
```

```
m10      1001.31c  2.4073E-05
```

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LIQUID METAL FAST REACTOR – LMFR
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```

6000.31c 2.5251E-04
14028.31c 7.4610E-04
15031.31c 1.7803E-05
16032.31c 1.7195E-05
25055.31c 1.5006E-03
24050.31c 7.0597E-04
24052.31c 1.3614E-02
24053.31c 1.5437E-03
24054.31c 3.8427E-04
26054.31c 3.5001E-03
26056.31c 5.4943E-02
26057.31c 1.2689E-03
26058.31c 1.6886E-04
28058.31c 6.3995E-03
28060.31c 2.4651E-03
28061.31c 1.0716E-04
28062.31c 3.4166E-04
28064.31c 8.7011E-05
41093.31c 3.7393E-04
c total 8.84614E-02
c
c MATERIAL 11 Honeycomb dummy plate
c
m11      1001.31c 3.3245E-06
        6000.31c 3.3477E-05
        14028.31c 1.2169E-04
        15031.31c 4.9764E-06
        16032.31c 2.5076E-06
        25055.31c 1.9518E-04
        24050.31c 1.0707E-04
        24052.31c 2.0648E-03
        24053.31c 2.3413E-04
        24054.31c 5.8281E-05
        26054.31c 4.7179E-04
        26056.31c 7.4061E-03
        26057.31c 1.7104E-04
        26058.31c 2.2762E-05
        28058.31c 8.3019E-04
        28060.31c 3.1979E-04
        28061.31c 1.3901E-05
        28062.31c 4.4323E-05
        28064.31c 1.1288E-05
        41093.31c 5.2657E-05
c total 1.216928E-02
c
c
c radial shield
m12      1001.31c 4.6306E-05
        6000.31c 6.8972E-04
        14028.31c 3.1158E-04
        15031.31c 4.2944E-05
        16032.31c 3.7110E-05
        25055.31c 7.1275E-04
        26054.31c 4.9065E-03
        26056.31c 7.4517E-02
        26057.31c 1.7491E-03
        26058.31c 2.5903E-04
c total 8.32720E-02
c
c radial shield void surround low density
m13      1001.31c 4.6306E-08
        6000.31c 6.8972E-07
        14028.31c 3.1158E-07
        15031.31c 4.2944E-08
        16032.31c 3.7110E-08
        25055.31c 7.1275E-07
        26054.31c 4.9065E-06
        26056.31c 7.4517E-05
        26057.31c 1.7491E-06
        26058.31c 2.5903E-07
c total 8.32720E-05
c
c Axial shield
m14      1001.31c 2.5700E-05

```


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LIQUID METAL FAST REACTOR - LMFR
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6000.31c	5.1066E-04
13027.31c	1.3989E-04
22000.62c	3.9416E-05
24050.31c	1.2213E-06
24052.31c	2.2823E-05
24053.31c	2.5531E-06
24054.31c	6.2449E-07
25055.31c	3.2634E-04
26054.31c	5.0496E-03
26056.31c	7.6690E-02
26057.31c	1.8001E-03
26058.31c	2.6658E-04
28058.31c	1.2564E-06
28060.31c	4.6968E-07
28061.31c	2.2000E-08
28062.31c	6.2769E-08
28064.31c	1.6774E-08
29063.31c	3.1184E-05
29065.31c	1.3364E-05
42000.66c	9.8355E-06
c total 8.4932E-02	
c	
c Natural Uranium Breeder	
ml5	1001.31c 4.4574E-05
	6000.31c 4.7140E-04
	14028.31c 2.0160E-04
	26054.31c 6.1085E-06
	26056.31c 9.2771E-05
	26057.31c 2.1776E-06
	26058.31c 3.2248E-07
	92235.31c 3.4209E-04
	92238.31c 4.7156E-02
c Total 4.8317E-02	
c	
c Element top and bottom packing	
ml6	1001.31c 3.1777E-05
	6000.31c 9.9996E-05
	13027.31c 8.3095E-06
	24050.31c 6.9087E-08
	24052.31c 1.2911E-06
	24053.31c 1.4442E-07
	24054.31c 3.5326E-08
	25055.31c 1.0785E-04
	26054.31c 1.9605E-03
	26056.31c 2.9775E-02
	26057.31c 6.9890E-04
	26058.31c 1.0350E-04
	28058.31c 1.5636E-07
	28060.31c 5.8452E-08
	28061.31c 2.7378E-09
	28062.31c 7.8115E-09
	28064.31c 2.0875E-09
	29063.31c 6.5270E-06
	29065.31c 2.7973E-06
c Total 3.279692E-02	
c	
c mild steel wrapper material	
ml7	1001.31c 7.5725E-05
	6000.31c 2.3828E-04
	13027.31c 1.9802E-05
	24050.31c 1.6463E-07
	24052.31c 3.0767E-06
	24053.31c 3.4414E-07
	24054.31c 8.4182E-08
	25055.31c 2.5701E-04
	26054.31c 4.6718E-03
	26056.31c 7.0954E-02
	26057.31c 1.6655E-03
	26058.31c 2.4664E-04
	28058.31c 3.7260E-07
	28060.31c 1.3929E-07
	28061.31c 6.5242E-09
	28062.31c 1.8615E-08
	28064.31c 4.9746E-09

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LIQUID METAL FAST REACTOR – LMFR
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```

29063.31c 1.5554E-05
29065.31c 6.6660E-06
c Total      7.81552E-02
c
c
C MATERIAL 18 U8 metal plate
m18      1001.31c  4.4048E-05
        6000.31c  4.9283E-04
        14028.31c 2.1076E-04
        26054.31c  6.1951E-06
        26056.31c  9.7250E-05
        26057.31c  2.2459E-06
        26058.31c  2.9889E-08
        92235.31c  3.3369E-04
        92238.31c  4.6021E-02
c total 4.7208E-02
C MATERIAL 19 U2 metal plate
m19      1001.31c  4.3899E-05
        6000.31c  4.6047E-04
        14028.31c 1.9692E-04
        26054.31c  5.7884E-06
        26056.31c  9.0866E-05
        26057.31c  2.0985E-06
        26058.31c  2.7927E-07
        92235.31c  3.3962E-04
        92238.31c  4.6785E-02
c total 4.7925E-02
c
c
c Superlattice grid plate
c
m20      1001.31c  2.4442E-04
        6000.31c  2.9057E-04
        14028.31c 4.3858E-05
        15031.31c  1.3256E-05
        16032.31c  4.3530E-05
        25055.31c  2.5785E-04
        26054.31c  4.2756E-03
        26056.31c  6.7114E-02
        26057.31c  1.5500E-03
        26058.31c  2.0627E-04
c Total 19 7.403935E-02
c
c -----
c
c Element C Pin fuel A and E, Calandria NACLIII
c Pin A
m21      1001.31c  3.2784E-05
        8016.31c  4.6606E-02
        8017.31c  1.7700E-05
        13027.31c  1.1702E-05
        20040.31c  7.8782E-06
        26054.31c  3.3046E-07
        26056.31c  5.1875E-06
        26057.31c  1.1980E-07
        26058.31c  1.5943E-08
        92234.31c  1.3805E-06
        92235.31c  1.4114E-04
        92236.31c  7.9324E-07
        92238.31c  1.9379E-02
        94238.31c  3.7786E-06
        94239.31c  2.9689E-03
        94240.31c  6.7253E-04
        94241.31c  7.0350E-05
        94242.31c  1.7488E-05
        95241.31c  4.7854E-05
c      total 21 6.9985E-02
c
c PinB
c
m22      1001.31c  3.2784E-05
        8016.31c  4.6976E-02
        8017.31c  1.7800E-05
        14028.31c  9.0199E-06

```

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```

28058.31c 3.7050E-06
28060.31c 1.4272E-06
28061.31c 6.2038E-08
28062.31c 1.9780E-07
28064.31c 5.0375E-08
92234.31c 1.3177E-06
92235.31c 1.3457E-04
92236.31c 7.4658E-07
92238.31c 1.8472E-02
94238.31c 5.8915E-06
94239.31c 3.7341E-03
94240.31c 9.5200E-04
94241.31c 1.1199E-04
94242.31c 2.7984E-05
95241.31c 5.5789E-05

```

c total 22 7.0537E-02 F 26 7.1415E-02

c

c Pin C

c

M23 1001.31c 3.2784E-05

```

8016.31c 4.7416E-02
8017.31c 1.8000E-05
13027.31c 1.9730E-05
14028.31c 7.9741E-06
26054.31c 4.4958E-07
26056.31c 7.0574E-06
26057.31c 1.6298E-07
26058.31c 2.1690E-08
28058.31c 7.4523E-06
28060.31c 2.8707E-06
28061.31c 1.2478E-07
28062.31c 3.9787E-07
28064.31c 1.0132E-07
92234.31c 1.2863E-06
92235.31c 1.2997E-04
92236.31c 7.3103E-07
92238.31c 1.7843E-02
94238.31c 6.9094E-06
94239.31c 4.4708E-03
94240.31c 1.0602E-03
94241.31c 1.1598E-04
94242.31c 3.0047E-05
95241.31c 5.7784E-05

```

c total 23 7.1230E-02

c

c Pin D

c

M24 1001.31c 3.2784E-05

```

8016.31c 4.7296E-02
8017.31c 1.8000E-05
13027.31c 1.8914E-05
14028.31c 2.5099E-05
20040.31c 1.5940E-05
26054.31c 4.0346E-07
26056.31c 6.3335E-06
26057.31c 1.4627E-07
26058.31c 1.9465E-08
28058.31c 9.6247E-06
28060.31c 3.7075E-06
28061.31c 1.6116E-07
28062.31c 5.1385E-07
28064.31c 1.3086E-07
92234.31c 1.4118E-06
92235.31c 1.4266E-04
92236.31c 7.9324E-07
92238.31c 1.9584E-02
94238.31c 4.7348E-06
94239.31c 3.0189E-03
94240.31c 7.5441E-04
94241.31c 8.8443E-05
94242.31c 2.0961E-05
95241.31c 4.0742E-05

```

c total 24 7.1085E-02

c

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LIQUID METAL FAST REACTOR – LMFR
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```

c Pin E
m25      1001.31c    3.2784E-05
          8016.31c    4.7299E-02
          8017.31c    1.7970E-05
          13027.31c   9.5250E-06
          14028.31c   4.5753E-05
          20040.31c   3.2062E-05
          26054.31c   6.0326E-07
          26056.31c   9.4699E-06
          26057.31c   2.1870E-07
          26058.31c   2.9105E-08
          92234.31c   1.1295E-06
          92235.31c   1.1465E-04
          92236.31c   6.3771E-07
          92238.31c   1.5739E-02
          94238.31c   9.4851E-06
          94239.31c   6.0438E-03
          94240.31c   1.5103E-03
          94241.31c   1.7707E-04
          94242.31c   4.1953E-05
          95241.31c   8.1559E-05
c        total 25 7.1167E-02
c
C Pin F
M26      1001.31c    3.2784E-05
          8016.31c    4.7464E-02
          8017.31c    1.8032E-05
          13027.31c   1.4287E-05
          20040.31c   6.7514E-05
          24050.31c   2.1476E-07
          24052.31c   4.1414E-06
          24053.31c   4.6961E-07
          24054.31c   1.1689E-07
          26054.31c   6.7247E-07
          26056.31c   1.0556E-05
          26057.31c   2.4379E-07
          26058.31c   3.2444E-08
          28058.31c   1.4905E-06
          28060.31c   5.7416E-07
          28061.31c   2.4958E-08
          28062.31c   7.9577E-08
          28064.31c   2.0266E-08
          92234.31c   1.1452E-06
          92235.31c   1.1526E-04
          92236.31c   6.3771E-07
          92238.31c   1.5824E-02
          94238.31c   9.5005E-06
          94239.31c   6.0112E-03
          94240.31c   1.5285E-03
          94241.31c   1.9723E-04
          94242.31c   4.4380E-05
          95241.31c   6.8035E-05
C total 26 7.1415E-02
c
c
c Composition of Calandria end plate regions
m27      14028.31c    5.5206E-04
          24050.31c    4.3520E-04
          24052.31c    8.3923E-03
          24053.31c    9.5162E-04
          24054.31c    2.3688E-04
          25055.31c    7.7198E-04
          26054.31c    2.0795E-03
          26056.31c    3.2644E-02
          26057.31c    7.5390E-04
          26058.31c    1.0033E-04
          28058.31c    3.0363E-03
          28060.31c    1.1696E-03
          28061.31c    5.0841E-05
          28062.31c    1.6210E-04
          28064.31c    4.1283E-05
c total 5.13781E-02
c
c UO2 Pin UO2PINC

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

c
M28      1001.31c  3.2784E-05
          8016.31c  3.2095E-05
          8017.31c  4.7483E-02
          13027.31c 1.8000E-05
          14028.31c  2.3812E-05
          20040.31c  4.0001E-05
          26054.31c  1.2825E-05
          26056.31c  6.5324E-08
          26057.31c  1.0254E-06
          26058.31c  2.3682E-08
          92234.31c  9.7268E-07
          92235.31c  1.7604E-04
          92238.31c  2.3580E-02
c total  28  7.1400E-02
c
c
c -----
c Pin clad plus calandria tube combined
c
C Pin PUPINA clad plus tube (was 23)
c
m31      1001.31c  1.0832E-05
          6000.31c  5.3887E-05
          14028.31c  6.6291E-04
          15031.31c  1.5357E-05
          16032.31c  9.9700E-06
          25055.31c  1.0382E-03
          24050.31c  5.3769E-04
          24052.31c  1.0369E-02
          24053.31c  1.1757E-03
          24054.31c  2.9267E-04
          26054.31c  2.4695E-03
          26056.31c  3.8766E-02
          26057.31c  8.9527E-04
          26058.31c  1.1914E-04
          28058.31c  3.9651E-03
          28060.31c  1.5274E-03
          28061.31c  6.6392E-05
          28062.31c  2.1169E-04
          28064.31c  5.3910E-05
c
C      Total  31  6.2241E-02
c
C Pin PUPINB   clad plus tube
c
m32      1001.31c  9.2847E-06
          6000.31c  9.6091E-05
          14028.31c  7.8508E-04
          15031.31c  1.6869E-05
          16032.31c  9.2404E-06
          25055.31c  1.0424E-03
          24050.31c  4.8064E-04
          24052.31c  9.2687E-03
          24053.31c  1.0510E-03
          24054.31c  2.6162E-04
          26054.31c  2.3154E-03
          26056.31c  3.6347E-02
          26057.31c  8.3939E-04
          26058.31c  1.1171E-04
          28058.31c  3.9370E-03
          28060.31c  1.5166E-03
          28061.31c  6.5922E-05
          28062.31c  2.1019E-04
          28064.31c  5.3529E-05
          41093.31c  1.1919E-04
c
C Total   32  5.8537E-02 F 36  6.0033E-02
c
C Pin PUPINC   clad plus tube
c
m33      1001.31c  1.0832E-05
          6000.31c  5.5189E-05
          14028.31c  6.5458E-04

```

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

15031.31c 1.4602E-05
16032.31c 9.9700E-06
25055.31c 1.0254E-03
24050.31c 5.3131E-04
24052.31c 1.0246E-02
24053.31c 1.1618E-03
24054.31c 2.8919E-04
26054.31c 2.4419E-03
26056.31c 3.8333E-02
26057.31c 8.8527E-04
26058.31c 1.1781E-04
28058.31c 3.9199E-03
28060.31c 1.5099E-03
28061.31c 6.5635E-05
28062.31c 2.0927E-04
28064.31c 5.3296E-05
c
C Total 33 6.15349E-02
c
c Pin PUPIND can plus tube
c
m34 1001.31c 1.0058E-05
6000.31c 8.1804E-05
13027.31c 2.6012E-06
14028.31c 6.7957E-04
15031.31c 1.3847E-05
16032.31c 3.6474E-06
22048.31c 1.1726E-05
25055.31c 8.7351E-04
27059.31c 1.7202E-06
24050.31c 4.9702E-04
24052.31c 9.5846E-03
24053.31c 1.0868E-03
24054.31c 2.7053E-04
26054.31c 2.3766E-03
26056.31c 3.7307E-02
26057.31c 8.6158E-04
26058.31c 1.1466E-04
28058.31c 3.6114E-03
28060.31c 1.3911E-03
28061.31c 6.0470E-05
28062.31c 1.9281E-04
28064.31c 4.9102E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07
42000.66c 8.9408E-07
c
C Total 34 5.9086E-02
c
c Pin PUPINE clad plus tube (Was 24)
m35 1001.31c 1.0058E-05
6000.31c 2.9866E-05
13027.31c 2.6012E-06
14028.31c 7.4068E-04
15031.31c 5.5388E-06
16032.31c 7.0518E-06
22048.31c 1.1726E-05
25055.31c 8.0111E-04
27059.31c 1.7202E-06
24050.31c 5.0041E-04
24052.31c 9.6500E-03
24053.31c 1.0942E-03
24054.31c 2.7238E-04
26054.31c 2.4012E-03
26056.31c 3.7694E-02
26057.31c 8.7052E-04
26058.31c 1.1585E-04
28058.31c 3.7263E-03
28060.31c 1.4354E-03
28061.31c 6.2394E-05
28062.31c 1.9894E-04
28064.31c 5.0664E-05
29063.31c 1.7181E-06
29065.31c 7.3632E-07

```

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LIQUID METAL FAST REACTOR - LMFR
CRIT-SPEC-REAC-RRATE

```

42000.66c 8.6970E-06
c
C Total      35 5.96942E-02
c
c
C Pin  PUPINF can plus tube
c
m36      1001.31c 1.0058E-05
        6000.31c 2.9217E-05
        13027.31c 1.7341E-06
        14028.31c 7.4343E-04
        15031.31c 5.5388E-06
        16032.31c 7.2951E-06
        22048.31c 8.7948E-06
        25055.31c 8.0253E-04
        27059.31c 1.3232E-06
        24050.31c 5.0363E-04
        24052.31c 9.7120E-03
        24053.31c 1.1013E-03
        24054.31c 2.7413E-04
        26054.31c 2.4145E-03
        26056.31c 3.7903E-02
        26057.31c 8.7533E-04
        26058.31c 1.1649E-04
        28058.31c 3.7525E-03
        28060.31c 1.4455E-03
        28061.31c 6.2833E-05
        28062.31c 2.0034E-04
        28064.31c 5.1021E-05
        29063.31c 1.2885E-06
        29065.31c 5.5221E-07
        42000.66c 8.6159E-06
c
c      Total  36 6.0033E-02
c
c
c -----
c
c Calandria sodium contents
c
C sodium NACLII element A and B
m41      1001.31c 5.5075E-06
        8016.31c 6.4605E-06
        11023.31c 2.4129E-02
        20040.31c 1.1080E-07
        26056.31c 3.0847E-07
c      total 41 2.41414E-02
c
C sodium NACLIIIS element E
m42      1001.31c 1.1205E-05
        8016.31c 1.0767E-06
        11023.31c 2.4379E-02
        20040.31c 9.5521E-08
c      total 42 2.43914E-02
C sodium NACLIII element C (was 25)
m43      1001.31c 7.5966E-06
        8016.31c 3.5892E-06
        11023.31c 2.3888E-02
        19039.31c 3.4270E-07
        20040.31c 6.6865E-07
c      total 43 2.3900E-02
C sodium NACLIV Element J
m44      1001.31c 7.5966E-06
        8016.31c 3.5892E-06
        11023.31c 2.4037E-02
        19039.31c 3.4270E-07
        20040.31c 6.6865E-07
c      total 44 2.4049E-02
C sodium NACLIV Element H
m45      1001.31c 7.5966E-06
        8016.31c 3.5892E-06
        11023.31c 2.3829E-02
        19039.31c 3.4270E-07
        20040.31c 6.6865E-07

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LIQUID METAL FAST REACTOR – LMFR
CRIT-SPEC-REAC-RRATE

```

c  total 45 2.3841E-02
c
c -----
c
c -----
c
C Compositions of Calandria outer walls
c
C Calandria Walls NACLI Element Cell A and B
m51      1001.31c  3.9844E-05
        6000.31c  2.8167E-04
        14028.31c 6.0229E-04
        15031.31c  7.3471E-05
        16032.31c  3.6808E-05
        25055.31c  1.2214E-03
        24050.31c  6.5153E-04
        24052.31c  1.2564E-02
        24053.31c  1.4247E-03
        24054.31c  3.5463E-04
        26054.31c  2.8589E-03
        26056.31c  4.4878E-02
        26057.31c  1.0364E-03
        26058.31c  1.3793E-04
        28058.31c  4.9315E-03
        28060.31c  1.8996E-03
        28061.31c  8.2574E-05
        28062.31c  2.6328E-04
        28064.31c  6.7050E-05
C total 51 7.34056E-02
c
c
C Calandria walls NACLIIS Element Cell E
c
m52      1001.31c  3.8637E-05
        6000.31c  6.5351E-04
        14028.31c  9.7623E-04
        15031.31c  4.7540E-05
        16032.31c  3.3014E-05
        22048.31c  2.4400E-04
        25055.31c  1.1060E-03
        27059.31c  1.1151E-05
        24050.31c  6.2481E-04
        24052.31c  1.2049E-02
        24053.31c  1.3662E-03
        24054.31c  3.4009E-04
        26054.31c  2.7541E-03
        26056.31c  4.3233E-02
        26057.31c  9.9842E-04
        26058.31c  1.3287E-04
        28058.31c  5.0735E-03
        28060.31c  1.9543E-03
        28061.31c  8.4952E-05
        28062.31c  2.7086E-04
        28064.31c  6.8981E-05
        29063.31c  6.9320E-06
        29065.31c  3.1020E-06
        42000.66c  3.4248E-06
C total 52 7.20749E-02
c
c Calandria NACLIIS Element Cell C and D (was m28)
c Error in repeat of Mn in m28
m53      1001.31c  3.9844E-05
        6000.31c  1.5948E-04
        14028.31c  7.7474E-04
        15031.31c  5.2334E-05
        16032.31c  2.4551E-05
        25055.31c  8.3089E-04
        24050.31c  6.1403E-04
        24052.31c  1.1841E-02
        24053.31c  1.3427E-03
        24054.31c  3.3422E-04
        26054.31c  2.9672E-03
        26056.31c  4.6578E-02

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LIQUID METAL FAST REACTOR - LMFR
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26057.31c	1.0757E-03
26058.31c	1.4315E-04
28058.31c	5.2186E-03
28060.31c	2.0102E-03
28061.31c	8.7382E-05
28062.31c	2.7861E-04
28064.31c	7.0954E-05
42000.66c	2.4862E-05
C total 53	7.44684E-02
c	
c	
C Calandria NACLIV Element 3J and 3L	
m54	1001.31c 3.7430E-05
6000.31c	3.5158E-04
14028.31c	8.2197E-04
15031.31c	6.2274E-05
16032.31c	1.6431E-05
25055.31c	1.0026E-03
24050.31c	5.8931E-04
24052.31c	1.1364E-02
24053.31c	1.2886E-03
24054.31c	3.2077E-04
26054.31c	2.7560E-03
26056.31c	4.3263E-02
26057.31c	9.9912E-04
26058.31c	1.3296E-04
28058.31c	4.3943E-03
28060.31c	1.6927E-03
28061.31c	7.3579E-05
28062.31c	2.3460E-04
28064.31c	5.9746E-05
42000.66c	8.8791E-06
C Total 54	6.94698E-02
c	
C Calandria NACLIV Element 3H	
m55	1001.31c 3.8637E-05
6000.31c	2.6343E-04
14028.31c	6.4389E-04
15031.31c	6.8560E-05
16032.31c	1.7190E-05
25055.31c	9.6934E-04
24050.31c	6.0091E-04
24052.31c	1.1588E-02
24053.31c	1.3140E-03
24054.31c	3.2708E-04
26054.31c	2.8877E-03
26056.31c	4.5330E-02
26057.31c	1.0469E-03
26058.31c	1.3932E-04
28058.31c	4.9377E-03
28060.31c	1.9020E-03
28061.31c	8.2679E-05
28062.31c	2.6362E-04
28064.31c	6.7135E-05
42000.66c	8.8791E-06
C Total 55	7.2497E-02
c	
C Calandria VCLVI	
m56	1001.31c 3.8637E-05
6000.31c	2.4762E-04
14028.31c	9.5110E-04
15031.31c	4.5654E-05
16032.31c	2.3793E-05
25055.31c	8.6191E-04
24050.31c	6.0122E-04
24052.31c	1.1594E-02
24053.31c	1.3147E-03
24054.31c	3.2725E-04
26054.31c	2.8292E-03
26056.31c	4.4413E-02
26057.31c	1.0257E-03
26058.31c	1.3650E-04
28058.31c	4.6653E-03
28060.31c	1.7971E-03

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28061.31c 7.8117E-05
28062.31c 2.4907E-04
28064.31c 6.3431E-05
42000.66c 2.4862E-05
C Total 56 7.12882E-02
c
c
c
c --- MODE CARDS ---
mode n
kcode 10000 1.0 100 1500
ksrc 0.0 0.0 77.0 0.0 0.0 87.9 0.0 0.0 107.0
      0.0 0.0 117.9 0.0 0.0 137.0 0.0 0.0 147.9
      10.74 0.0 77.0 10.74 0.0 87.9 10.74 0.0 107.0
      10.74 0.0 117.9 10.74 0.0 137.0 10.74 0.0 147.9
      -10.74 0.0 77.0 -10.74 0.0 87.9 -10.74 0.0 107.0
      -10.74 0.0 117.9 -10.74 0.0 137.0 -10.74 0.0 147.9
      0.0 10.74 77.0 0.0 10.74 87.9 0.0 10.74 107.0
      0.0 10.74 117.9 0.0 10.74 137.0 0.0 10.74 147.9
      0.0 -10.74 77.0 0.0 -10.74 87.9 -10.74 0.0 107.0
      0.0 -10.74 117.9 0.0 -10.74 137.0 0.0 -10.74 147.9
      10.74 10.74 77.0 10.74 10.74 87.9 10.74 10.74 107.0
      10.74 10.74 117.9 10.74 10.74 137.0 10.74 10.74 147.9
      -10.74 10.74 77.0 -10.74 10.74 87.9 -10.74 10.74 107.0
      -10.74 10.74 117.9 -10.74 10.74 137.0 -10.74 10.74 147.9
      10.74 -10.74 77.0 10.74 -10.74 87.9 10.74 -10.74 107.0
      10.74 -10.74 117.9 10.74 -10.74 137.0 10.74 -10.74 147.9
      -10.74 -10.74 77.0 -10.74 -10.74 87.9 -10.74 -10.74 107.0
      -10.74 -10.74 117.9 -10.74 -10.74 137.0 -10.74 -10.74 147.9
      25.335 0.0 77.0 25.335 0.0 87.9 25.335 0.0 107.0
      25.335 0.0 117.9 25.335 0.0 137.0 25.335 0.0 147.9
      -25.335 0.0 77.0 -25.335 0.0 87.9 -25.335 0.0 107.0
      -25.335 0.0 117.9 -25.335 0.0 137.0 -25.335 0.0 147.9
      0.0 25.335 77.0 0.0 25.335 87.9 0.0 25.335 107.0
      0.0 25.335 117.9 0.0 25.335 137.0 0.0 25.335 147.9
      0.0 -25.335 77.0 0.0 -25.335 87.9 -25.335 0.0 107.0
      0.0 -25.335 117.9 0.0 -25.335 137.0 0.0 -25.335 147.9
      25.335 25.335 77.0 25.335 25.335 87.9 25.335 25.335 107.0
      25.335 25.335 117.9 25.335 25.335 137.0 25.335 25.335 147.9
      -25.335 25.335 77.0 -25.335 25.335 87.9 -25.335 25.335 107.0
      -25.335 25.335 117.9 -25.335 25.335 137.0 -25.335 25.335 147.9
      25.335 -25.335 77.0 25.335 -25.335 87.9 25.335 -25.335 107.0
      25.335 -25.335 117.9 25.335 -25.335 137.0 25.335 -25.335 147.9
      -25.335 -25.335 77.0 -25.335 -25.335 87.9 -25.335 -25.335 107.0
      37.6 0.0 77.0 37.6 0.0 87.9 37.6 0.0 107.0
      37.6 0.0 117.9 37.6 0.0 137.0 37.6 0.0 147.9
      -37.6 0.0 77.0 -37.6 0.0 87.9 -37.6 0.0 107.0
      -37.6 0.0 117.9 -37.6 0.0 137.0 -37.6 0.0 147.9
      0.0 37.6 77.0 0.0 37.6 87.9 0.0 37.6 107.0
      0.0 37.6 117.9 0.0 37.6 137.0 0.0 37.6 147.9
      0.0 -37.6 77.0 0.0 -37.6 87.9 -37.6 0.0 107.0
      0.0 -37.6 117.9 0.0 -37.6 137.0 0.0 -37.6 147.9
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