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Neutronics Benchmarks for the Utilization of Mixed-Oxide Fuel: Joint U.S./Russian Progress Report for Fiscal Year 1997

Volume 4, Part 8—Neutron Poison Plates in Assemblies Containing Homogeneous Mixtures of Polystyrene-Moderated Plutonium and Uranium Oxides

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NEUTRON POISON PLATES IN ASSEMBLIES CONTAINING HOMOGENEOUS MIXTURES OF POLYSTYRENE-MODERATED PLUTONIUM AND URANIUM OXIDES

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NEUTRON POISON PLATES IN ASSEMBLIES CONTAINING HOMOGENEOUS MIXTURES OF POLYSTYRENE-MODERATED PLUTONIUM AND URANIUM OXIDES[a]

1 Detailed Description

1.1 Overview of Experiment

In the 1970s at the Battelle Pacific Northwest Laboratory (PNL), a series of critical experiments using a remotely operated Split-Table Machine was performed with homogeneous mixtures of (Pu-U)O_2-polystyrene fuels in the form of square compacts having different heights. The experiments determined the critical geometric configurations of MOX fuel assemblies with and without neutron poison plates. With respect to PuO_2 content and moderation [H/(Pu+U) atomic] ratio (MR), two different homogeneous (Pu-U)O_2-polystyrene mixtures were considered: Mixture 1) 14.62 wt% PuO_2 with 30.6 MR, and Mixture 2) 30.3 wt% PuO_2 with 2.8 MR. In all mixtures, the uranium was depleted to about 0.151 wt% U^{235}. Assemblies contained copper, copper-cadmium or aluminum neutron poison plates having thicknesses up to ~2.5 cm.

This evaluation contains 22 experiments for Mixture 1, and 10 for Mixture 2 compacts. For Mixture 1, there are 10 configurations with copper plates, 6 with aluminum, and 5 with copper-cadmium. One experiment contained no poison plate. For Mixture 2 compacts, there are 3 configurations with copper, 3 with aluminum, and 3 with copper-cadmium poison plates. One experiment contained no poison plate.

1.2 Description of Experimental Configuration

A large glove box within a heavily shielded cell located at the PNL Critical Mass Laboratory (CML) was used for the experiments. The floor surface of CML is 1067 cm square, with 152-cm-thick side walls (except for a 91-cm-thick south wall) and a 61-cm-thick roof and floor [Smolen 1994]. A remotely operated Split-Table Machine (STM) shown in Figure 1 was used for performing the experiments. Each table half, one stationary and the other movable, had a steel frame. One of the table halves formed a surface 76-cm wide and 61-cm long, and the other formed a surface 76-cm wide and 46-cm long. The table surfaces were 51-cm above the floor level. A 30-cm thick aluminum honeycomb with an effective density of 0.037 g/cm^3 covered both table halves [Richey 1965]. The geometric dimensions of each fuel mixture, including unclad, clad and clad + void compacts are listed in Table 1. For each poison, thicknesses of plates and plate + void are given in Table 2. The uncertainties in the compact dimensions are also shown in these tables [Bierman 1974].

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Keywords: critical experiment, mixed oxide fuel, Plexiglas-reflected, plutonium, polystyrene-moderated, uranium

Table 1. Fuel compact dimensions

Compacts	Length (cm)	Width (cm)	Height (cm)
Mixture 1			
Unclad	5.090± 0.005	5.090± 0.025	5.090± 0.005; 3.400± 0.044; 1.384± 0.039
Clad	5.121± 0.005	5.137± 0.005	5.121± 0.005; 3.431± 0.044; 1.415± 0.039
Clad + void	5.130± 0.010	5.190± 0.025	5.130± 0.010; 3.440± 0.048; 1.424± 0.043
Mixture 2			
Unclad	5.090± 0.005	5.083± 0.026	5.090± 0.005; 1.339± 0.026
Clad	5.114± 0.009	5.170± 0.026	5.114± 0.006; 1.363± 0.026
Clad + void	5.118± 0.015	5.174± 0.030	5.118± 0.015; 1.367± 0.026

Table 2. Copper poison plates for Mixture 1 compacts

Plate number	Plate thickness (cm)	Plate + Void thickness (cm)	Reduced density[a] (%)	Plate mass (kg)
1	0.337± 0.008	0.40± 0.06	83.8	6.440± 0.013
2	0.637± 0.003	0.71± 0.07	87.8	11.985± 0.024
3	1.290± 0.004	1.35± 0.06	94.1	24.425± 0.049
4	1.927± 0.005	2.02± 0.09	93.8	36.410± 0.072
5	2.580± 0.006	2.70± 0.10	94.0	48.785± 0.096
6	0.337± 0.008	0.40± 0.06	83.8	6.440± 0.013
7	0.337± 0.008	0.37± 0.03	90.6	6.440± 0.013
8	1.290± 0.004	1.33± 0.04	95.5	24.425± 0.049
9	1.927± 0.005	1.98± 0.05	95.7	36.410± 0.073
10	2.565± 0.006	2.68± 0.06	94.1	48.470± 0.014
11	0.337± 0.008	0.37± 0.03	90.2	6.415± 0.013
12	1.290± 0.004	1.33± 0.03	95.3	24.360± 0.049
13	1.927± 0.005	1.98± 0.05	95.8	36.450± 0.072
14	2.565± 0.006	2.68± 0.06	94.1	48.450± 0.096

[a]Plate mass per plate and void volume relative to 8.913 g/cm^3.

Table 3. Aluminum poison plates for Mixture 1 compacts

Plate number	Plate thickness (cm)	Plate + Void thickness (cm)	Reduced density[a] (%)	Plate mass (kg)
1	0.316± 0.001	0.40± 0.08	77.1	1.790± 0.025
2	0.645± 0.002	0.73± 0.08	86.5	3.665± 0.012
3	1.983± 0.004	2.06± 0.07	94.2	11.270± 0.049
4	2.676± 0.002	2.75± 0.07	95.5	15.250± 0.034
5	0.316± 0.001	0.34± 0.02	90.7	1.790± 0.025
6	2.628± 0.004	2.68± 0.05	96.0	14.940± 0.056
7	0.317± 0.002	0.34± 0.02	90.7	1.790± 0.025
8	2.629± 0.013	2.69± 0.05	95.8	14.965± 0.031

[a]Plate mass per plate and void volume relative to 2.692 g/cm^3.

Table 4. Copper-Cadmium poison plates for Mixture 1 compacts

Plate number	Plate thickness (cm)	Plate + Void thickness (cm)	Reduced density[a] (%)	Plate mass (kg)
1	0.368± 0.005	0.43± 0.06	83.6	6.905± 0.014
2	2.160± 0.006	2.30± 0.10	91.9	40.635± 0.081
3	0.368± 0.005	0.43± 0.06	83.6	6.905± 0.014
4	0.368± 0.005	0.43± 0.06	86.6	6.905± 0.014
5	0.368± 0.005	0.41± 0.04	87.6	6.905± 0.014
6	0.354± 0.005	0.39± 0.03	89.2	6.685± 0.013

[a]Plate mass per plate and void volume relative to 8.910 g/cm^3.

Table 5. Poison plates for Mixture 2 compacts

Plate number	Plate thickness (cm)	Plate +Void thickness (cm)	Reduced density[a] (%)	Plate mass (kg)
Copper				
1	0.337± 0.008	0.41± 0.07	82.2	6.440± 0.013
2	0.974± 0.008	1.02± 0.07	94.5	18.425± 0.037
3	1.964± 0.012	2.06± 0.08	95.0	37.280± 0.075
Aluminum				
1	0.316± 0.001	0.39± 0.07	79.5	1.790± 0.025
2	0.961± 0.002	1.01± 0.05	93.5	5.455± 0.044
3	1.971± 0.005	2.04± 0.08	95.0	11.185± 0.083
Copper-Cadmium plates				
1	0.386± 0.005	0.46± 0.07	78.5	6.905± 0.014
2	1.085± 0.005	1.18± 0.09	90.5	20.419± 0.040
3	2.160± 0.006	2.28± 0.09	93.2	40.635± 0.081

[a]Relative to respective densities reported in Tables 2-4.

Arrays of the same fuel mixture compacts with and without poison plates were stacked together on the STM. The assemblies had a base of 9↔9 fuel compacts having different heights. The poison plates were positioned horizontally in the assemblies. The plate cross-section dimensions were the same as the 9↔9 assembly dimensions. The thicknesses of the plates are given in Tables 2-5. To approach criticality, the smaller size compacts were used by incrementally loading them onto the top face of each assembly in a symmetrical manner with respect to neutron flux. In all assembly configurations, a 15-cm-thick methacrylate plastic (Plexiglas) reflector was used.

1.3 Description of Material Data

Two-different homogeneous (Pu-U)O_2-polystyrene mixtures with respect to PuO_2 content and MR were considered. Mixture 1 contained 14.62 wt% PuO_2 with 30.6 MR, and Mixture 2 contained 30.3 wt% PuO_2 with 2.8 MR. The number densities of these mixture compacts including clad and Plexiglas reflector are shown in Table 6. The uranium was depleted to about 0.151 wt% U^{235} in all mixtures. For the poison plates, three compositions under the names of copper, aluminum, copper-cadmium were considered; the material contents are listed in Table 7. Additional material properties of Mixtures 1 and 2 compacts, and the particle size distribution for fuel mixtures are displayed in Tables 8 and 9, respectively.

Table 6. Composition of fuel mixtures and reflector material

Nuclide	Atomic density (E+24[a] atom/cm^3)			
	Mixture 1	Mixture 2	Clad	Reflector
Am^{241}	4.036E-07[b]	1.017E-05[c]		
Pu^{238}	0.0	2.288E-06		
Pu^{239}	1.954E-04	2.186E-03		
Pu^{240}	1.702E-05	2.927E-04		
Pu^{241}	1.211E-06	5.875E-05		
Pu^{242}	0.0	6.751E-06		
U^{235}	1.904E-06	9.269E-06		
U^{238}	1.252E-03	6.162E-03		
O	3.023E-03	1.864E-02		1.428E-02
H	4.489E-02	2.432E-02	4.489E-02	5.712E-02
C	4.412E-02	2.660E-02	3.110E-02	3.570E-02
Cl			7.240E-03	

[a]Read E+24 as 10^{24}.
[b]Isotopic analysis made on May 28, 1970. Experiments performed May 1973.
[c]Isotopic analysis made on Dec. 2, 1971. Experiments performed June 1973.

Table 7. Composition of neutron poison plates

Element	Copper (8.913 g/ cm^3) (wt%)	Copper-Cadmium (8.910 g/ cm^3) (wt%)	Aluminum (2.692 g/cm^3) (wt%)
Cu	99.960	98.685	0.14
Cd	—	0.989	—
Al	—	—	97.98
Zn	0.001	0.007	0.25
Sn	—	0.250	—
Ni	—	0.010	—
Fe	0.003	0.020	0.70
Cr	—	—	0.15
Mn	—	0.009	0.15
Mg	0.001	—	0.08
Ti	—	—	0.15
Si	0.001	0.004	0.40
O	0.030	0.019	—
C	0.004	0.002	—
B	—	0.005	—

Table 8. Material densities of plutonium, uranium,and clad

Material density (g/cm^3)	Mixture 1	Mixture 2
Cladding	1.12	1.12
Uranium	0.495± 0.005	2.438 ± 0.023
Plutonium	0.085± 0.001	1.012 ± 0.010
Fuel compact density	1.615± 0.017	4.520 ± 0.043
Clad mass per compact (g)	3.175	2.432

Table 9. Particle size distribution in PuO_2-UO_2 polystyrene fuels

Distribution (%)	Particle diameter (μm)		
	PuO_2	UO_2	Polystyrene
95	<20	<40	<225
50	<8	<9	<150
5	<2	<2	<50

1.4 Supplemental Experimental Measurements

No additional experimental data were found.

2 Evaluation of Experimental Data

Material densities for fuel compacts, cladding and stacking void dimensions were well documented.

The geometric units of fuel compacts and poison plates were reported both in inches and the SI units in the text and in some tables. However, the SI units were used in this evaluation to be consistent with the units of critical experiment configurations.

The exact configurations of experiments including the number of compacts used in loading the assemblies were not provided. Instead, experimental corrections in critical heights were given.

For each type of fuel, the effects of the cladding and stacking voids were experimentally determined. This is not explained in detail in [Bierman 1974]. Instead, earlier studies were referenced. In those studies [Bierman 1973], the experimentally corrected dimensions of solid fuels were determined by extrapolation. In other words, the critical heights for a particular mixture were plotted as a function of layers of cladding material. The critical height data points were extrapolated to zero cladding to determine the critical height of solid fuels only.

The total mass and thickness of copper, copper-cadmium, or aluminum poison plates in some of the assemblies were the sum of several thinner plates stacked on top of one another to achieve the plate thicknesses that are given in Tables 2-5. However, the number of thinner plates summed to obtain the combined poison plate thicknesses were not given.

For Mixture 1, it was reported that the fuel regions can be expressed as homogeneous regions of PuO_2+UO_2+polystyrene fuel only by reducing the amount of fuel in each assembly 3.92 %. In addition, the reduced density for homogenization of poison plate mass and void volume was reported for simplifying the calculational model. However, in this evaluation, no simplifications were considered in modeling the experiments.

3 Benchmark Specifications

3.1 Description of Model

The benchmark models consisted of 9×9 arrays of square compacts each containing the same mixture material. Arrays of compacts with and without poison plates were stacked together on the STM. Each compact contained the cladding material with specified heights and stacking voids described in Section 1.2. The geometric heights of the compacts were variable while the width and the length of the compacts were the same in loading the critical assemblies. The poison plates were positioned horizontally in the assemblies. All assemblies contained 9↔9 base fuel compacts and are fully reflected by 15-cm-thick Plexiglas.

3.2 Dimensions

The critical dimensions and configurations for Mixtures 1 and 2 experiments are given in Tables 10-13. These tables can be used to obtain a more simplified geometry description of each assembly. The number of fuel layers above, below, and between (when applicable) the poison plates are given. Fractional layers should be treated as full layers of thinner fuel compacts having a thickness equal to the fractional layer times the full-sized compact. Table 14 contains critical dimensions, in terms of number of compacts, for the experiments free from poison plates.

In Tables 10-12, the first column contains the case number. The second column gives the number of 3.4-cm-thick fuel compact layers below the poison plate. The third column contains the poison plate number whose geometric dimensions are given in Section 1.2. The fourth (and sixth) columns show the number of fuel layers having 5.09- and 1.384-cm-thick compacts above (and below) the poison plate. The fifth column describes the second poison plate number (if any). The last column gives the effective number of fuel layer compacts expressed as 5.09-cm-thick fuel compacts.

In Table 13 for Mixture 2 experiments, the assemblies contained a single poison plate layer. The first column in Table 13 contains the experiment identification number. The second column contains the number of 5.09-cm-thick fuel compact layers below poison plate. The third column gives the poison plate number. The fourth column shows the number of fuel layers having 5.09- and 1.339-cm-thick compacts above the poison plate. The last column gives the total number of fuel layers in terms of 5.09-cm-thick fuel compacts.

Table 10. Critical configurations for Mixture 1 compacts with copper neutron poison plates

Case	Fuel layers below poison plate	Poison plate number	Fuel layers above poison plate		Poison plate number	Fuel layers above poison plate		Total layers of fuel[b]
	3.4 cm		5.09 cm	1.384 cm		5.09 cm	1.384 cm	5.09 cm
1	3	1	2	2.415	—	—	—	4.661± 0.005
2	3	2	2	3.110	—	—	—	4.850± 0.004
3	3	3	3	0.463	—	—	—	5.130± 0.010
4	3	4	3	1.136	—	—	—	5.313± 0.005
5	3	5	3	1.746	—	—	—	5.479± 0.001
6	[a]	6	1	2.349	—	—	—	4.643± 0.005
7	3	7	1	0	11	1	3.603	4.984± 0.005
8	3	8	1	0	12	2	3.584	5.979± 0.005
9	3	9	1	0	13	3	1.129	6.311± 0.003
10	3	10	1	0	14	3	2.092	6.573± 0.003

[a]Three layers of 3.4cm plus one layer of 5.09-cm-thick fuel compacts below poison plate.

[b]Total layers of fuel compacts expressed as equivalent 5.09-cm-thick compacts. Multiply by 0.9608 to correct for the reactivity effects of stacking voids and the cladding.

Table 11. Critical configurations for Mixture 1 compacts with aluminum neutron poison plates

Case	Fuel layers below poison plate	Poison plate number	Fuel layers above poison plate		Poison plate number	Fuel layers above poison plate		Total layers of fuel[a]
	3.4 cm		5.09 cm	1.384 cm		5.09 cm	1.384 cm	5.09 cm
1	3	1	2	1.548	—	—	—	4.425± 0.003
2	3	2	2	1.739	—	—	—	4.477± 0.007
3	3	3	2	2.713	—	—	—	4.742± 0.004
4	3	4	2	3.158	—	—	—	4.863± 0.003
5	3	5	1	0	7	1	1.812	4.497± 0.002
6	3	6	1	0	8	2	1.151	5.317± 0.003

[a]Total layers of fuel compacts expressed as equivalent 5.09-cm-thick compacts. Multiply by 0.9608 to correct for the reactivity effects of stacking voids and the cladding.

Table 12. Critical configurations for Mixture 1 compacts with copper-cadmium neutron poison plates

Case	Fuel layers below poison plate	Poison plate number	Fuel layers above poison plate		Poison plate number	Fuel layers above poison plate		Total layers of fuel[c]
	3.4 cm		5.09 cm	1.384 cm		5.09 cm	1.384 cm	5.09 cm
1	3	1	3	0.757	—	—	—	5.210± 0.003
2	3	2	3	2.698	—	—	—	5.738± 0.006
3	[a]	3	2	0.952	—	—	—	5.263± 0.003
4	[b]	4	0	3.463	—	—	—	4.946± 0.002
5	3	5	1	0	6	3	0.331	6.094± 0.022

[a]Three layers of 3.4 cm plus one layer of 5.09-cm-thick fuel compacts below poison plate.
[b]Three layers of 3.4 cm plus two layers of 5.09-cm-thick fuel compacts below poison plate.
[c]Total layers of fuel compacts expressed as equivalent 5.09-cm-thick compacts. Multiply by 0.9608 to correct for the reactivity effects of stacking voids and the cladding.

Table 13. Critical configurations for Mixture 2 compacts with poison plates

Case	Fuel layers below poison plate	Poison plate number	Fuel layers above poison plate		Total layers of fuel[a]
	5.09 cm		5.09 cm	1.339 cm	5.09 cm
Copper poison plates					
1	3	1	2	0.502	5.119 ± 0.010
2	3	2	2	1.321	5.313 ± 0.004
3	3	3	2	2.536	5.601 ± 0.013
Aluminum poison plates					
1	3	1	2	0.342	5.081 ± 0.012
2	3	2	2	0.873	5.207 ± 0.016
3	3	3	2	1.688	5.400 ± 0.004
Copper-Cadmium poison plates					
1	3	1	2	0.738	5.175 ± 0.010
2	3	2	2	1.827	5.433 ± 0.003
3	3	3	2	3.468	5.822 ± 0.007

[a]Total layers of fuel compacts expressed as equivalent 5.09-cm-thick compacts. Multiply by 0.9608 to correct for the reactivity effects of stacking voids and the cladding.

Table 14. Critical configurations with no poison plate

Case	Fuel layers			Total layers of fuel[a]
Mixture 1				
	3.4 cm	5.09 cm	1.384 cm	5.09 cm
1	3	2	1.276	4.351 ± 0.004
Mixture 2				
	3.4 cm	5.09 cm	1.339 cm	5.09 cm
1	—	4	4.207	4.997 ± 0.013

[a]Total layers of fuel compacts expressed as equivalent 5.09-cm-thick compacts. Multiply by 0.9608 to correct for the reactivity effects of stacking voids and the cladding.

3.3 Material Data

The number densities of Mixtures 1 and 2 are given in Table 6, and poison plate composition data are provided in Table 7.

3.4 Temperature Data

No temperature data was provided.

4 Results of Sample Calculations

The sample k_{eff} calculations were performed using MCNP4A with continuous energy cross sections based on the ENDF/B-VI library. Polyethylene thermal cross sections (poly.01t card) are used for both fuel mixtures and Plexiglas. In calculations, 4000 particle histories, 200 active and 25 skipped generations were used. However, additional particle histories were run if k_{eff} had not attained a constant level after 800000 active particle histories. In Tables 15-17, the calculated k_{eff} values are listed. Sample input listings are given in Section 6.

Table 15. MCNP k_{eff} for Mixture 1 experiments in Tables 10–12

Case	Copper poison plate	Aluminum poison plate	Copper-Cadmium poison plate
1	1.01158 ± 0.00098	1.00989 ± 0.00093	1.01166 ± 0.00092
2	1.00840 ± 0.00099	1.01159 ± 0.00094	1.00912 ± 0.00095
3	1.01164 ± 0.00093	1.01125 ± 0.00099	1.01324 ± 0.00104
4	1.00928 ± 0.00094	1.00969 ± 0.00098	1.01093 ± 0.00094
5	1.01030 ± 0.00101	1.01231 ± 0.00094	1.01134 ± 0.00064
6	1.01206 ± 0.00092	1.00770 ± 0.00099	
7	1.01225 ± 0.00096		
8	1.01162 ± 0.00101		
9	1.00745 ± 0.00086		
10	1.00744 ± 0.00098		

Table 16. MCNP k_{eff} for Mixture 2 experiments in Table 13

Case	Copper poison plate	Aluminum poison plate	Copper-Cadmium poison plate
1	0.99808 ± 0.00081	0.99993 ± 0.00096	0.99889 ± 0.00094
2	0.99912 ± 0.00081	1.00060 ± 0.00081	0.99856 ± 0.00084
3	0.99953 ± 0.00087	1.00021 ± 0.00082	1.00020 ± 0.00086

Table 17. MCNP k_{eff} for experiments free from poison plate

Case	Mixture 1	Mixture 2
1	1.01160 ± 0.00093	1.00234 ± 0.00087

Acknowledgments: John White, Oak Ridge National Laboratory, and Rollin Harding of Brookhaven National Laboratory provided the “zinc” library based on the ENDL92 evaluation.

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2.11.6 Sample MCNP Input Listings

```
CASE 1: 14.62 wt% PuO2; H:(U+Pu)=30.6
c    Copper  poison plate
C Cell Cards
C -Full Compacts (5.09 x 5.09 x 3.44)
C
1     1 0.0935009386 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  Copper Poison plate (0.337 cm thick+0.063 cm void)
C
6     0         15 -22 17 -24 20 -25        imp:n=1
7     4 -8.913  15 -22 17 -24 25 -26        imp:n=1
8     0         15 -22 17 -24 26 -27        imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.09 x 5.09)
9     1 0.0935009386 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x2 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-1:0 -8:0 -8:0  3 161R  $9x9x2 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C -Smaller Fuel blocks Above poison plates (5.09 x 5.09 x 1.384)
C
14     1 0.0935009386 36 -37 3 -4 5 -6  u=5 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
15     2 0.08323   35 -38 9 -10 11 -12
             #14              u=5 imp:n=1 $  3M-Clad
16     0     #14 #15           u=5 imp:n=1 $  Stacking Void
C 9x9x2 Fuel Blocks
17     0    34 -39 15 -16 17 -18      imp:n=1 lat=1 u=6
           fill=-1:0 -8:0 -8:0  5 161R  $9x9x2 Fuel Blocks
18     0  40 -41 21 -22 23 -24 fill=6 imp:n=1
C
C  Fractional Layer
C
19    1 0.0935009386   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #18 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
```

```
C Full Size Fuel Compacts
1     pz  0.02
2     pz  3.42     $ Fuel Height
3     px  0.02
4     px  5.11     $ Fuel Length
5     py  0.05
6     py  5.14     $ Fuel Width
C Clad Compacts
7     pz  0.0045
8     pz  3.4355
9     px  0.0045
10    px  5.1255
11    py  0.0265
12    py  5.1635
C Stacked Compacts (Fuel+Clad+Void)
13    pz  0.0
14    pz  3.440
15    px  0.0
16    px  5.130
17    py  0.0
18    py  5.190
C Window Surfaces
19    pz  0.000001
20    pz 10.319999
21    px  0.000001
22    px 46.169999
23    py  0.000001
24    py 46.709999
C
C poison plate+void
C
25    pz 10.3515
26    pz 10.6885
27    pz 10.72
C
C Fuel layers above poison plate
C
28    pz 10.7245
29    pz 10.74
30    pz 15.83
31    pz 15.8455
32    pz 15.85
C
C Windows
C
33   pz 10.720001
34   pz 20.979999
C
C smaller size compacts
C
35   pz 20.9845
36   pz 21.0
37   pz 22.384
38   pz 22.3995
39   pz 22.404
C
C Windows
C
```

```
40   pz 20.980001
41   pz 23.827999
C
C Fractional layer
C
42   pz 24.40236
C
C Reflector
C
43    pz -15.
44    pz  39.40236
45    px -15.
46    px  61.17
47    py -15.
48    py  61.71

kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 4.036e-7 94239.60c 1.954e-4
      94240.60c 1.702e-5 94241.60c 1.211e-6
      92235.60c 1.904e-6 92238.60c 1.252e-3  8016.60c 3.023e-3
       1001.60c 4.489e-2  6000.60c 4.412e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
      $ Plexiglas Reflector Composition
m1t   poly.01t
m2t   poly.01t
m3t   poly.01t
m4    29000.50c -0.9996  26000.55c -3.0e-5 30000.40c -1.0e-5
      12000.60c -1.0e-5  14000.60c -1.0e-5  8016.60c -3.0e-4
       6000.60c -4.0e-5
```

```
CASE 1 (TAble 11): 14.62 wt% PuO2; H:(U+Pu)=30.6
C       Aluminum poison plate
C Cell Cards
C -Full Compacts (5.09 x 5.09 x 3.44)
C
1     1 0.0935009386 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  Copper Poison plate (0.316 cm thick+0.084 cm void)
C
6     0         21 -22 23 -24 20 -25        imp:n=1
7     4 -2.692  21 -22 23 -24 25 -26        imp:n=1
8     0         21 -22 23 -24 26 -27        imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.09 x 5.09)
9     1 0.0935009386 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x2 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-1:0 -8:0 -8:0  3 161R  $9x9x2 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C -Smaller Fuel blocks Above poison plates (5.09 x 5.09 x 1.384)
C
14     1 0.0935009386 36 -37 3 -4 5 -6  u=5 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
15     2 0.08323   35 -38 9 -10 11 -12
             #14              u=5 imp:n=1 $  3M-Clad
16     0     #14 #15           u=5 imp:n=1 $  Stacking Void
C 9x9x1 Fuel Blocks
17     0    34 -39 15 -16 17 -18      imp:n=1 lat=1 u=6
           fill=0:0 -8:0 -8:0  5 80R  $9x9x1 Fuel Blocks
18     0  40 -41 21 -22 23 -24 fill=6 imp:n=1
C
C  Fractional Layer
C
19    1 0.0935009386   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #18 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
C Full Size Fuel Compacts
1     pz  0.02
2     pz  3.42     $ Fuel Height
3     px  0.02
```

```
4     px  5.11     $ Fuel Length
5     py  0.05
6     py  5.14     $ Fuel Width
C Clad Compacts
7     pz  0.0045
8     pz  3.4355
9     px  0.0045
10    px  5.1255
11    py  0.0265
12    py  5.1635
C Stacked Compacts (Fuel+Clad+Void)
13    pz  0.0
14    pz  3.440
15    px  0.0
16    px  5.130
17    py  0.0
18    py  5.190
C Window Surfaces
19    pz  0.000001
20    pz 10.319999
21    px  0.000001
22    px 46.169999
23    py  0.000001
24    py 46.709999
C
C poison plate+void
C
25    pz 10.3362
26    pz 10.678
27    pz 10.72
C
C Fuel layers above poison plate
C
28    pz 10.7245
29    pz 10.74
30    pz 15.83
31    pz 15.8455
32    pz 15.85
C
C Windows
C
33   pz 10.720001
34   pz 20.979999
C
C smaller size compacts
C
35   pz 20.9845
36   pz 21.0
37   pz 22.384
38   pz 22.3995
39   pz 22.404
C
C Windows
C
40   pz 20.980001
41   pz 22.403999
C
C Fractional layer
```

```
C
42   pz 23.162432
C
C Reflector
C
43    pz -15.
44    pz  38.162432
45    px -15.
46    px  61.17
47    py -15.
48    py  61.71

kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 4.036e-7 94239.60c 1.954e-4
      94240.60c 1.702e-5 94241.60c 1.211e-6
      92235.60c 1.904e-6 92238.60c 1.252e-3  8016.60c 3.023e-3
       1001.60c 4.489e-2  6000.60c 4.412e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
      $ Plexiglas Reflector Composition
m1t   poly.01t
m2t   poly.01t
m3t   poly.01t
m4    29000.50c -0.14e-2  13027.50c -0.9798  30000.40c -0.25e-2
      26000.55c -0.70e-2  24000.50c -0.15e-2 25055.50c -0.15e-2
      12000.60c -0.08e-2  22000.35c -0.15e-2 14000.60c -0.40e-2
```

```
CASE 1 (Table 12): 14.62 wt% PuO2; H:(U+Pu)=30.6
C CuCd poison plate
C Cell Cards
C -Full Compacts (5.09 x 5.09 x 3.44)
C
1     1 0.0935009386 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  Copper Poison plate (0.368 cm thick+0.062 cm void)
C
6     0         21 -22 23 -24 20 -25        imp:n=1
7     4 -8.910  21 -22 23 -24 25 -26        imp:n=1
8     0         21 -22 23 -24 26 -27        imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.09 x 5.09)
9     1 0.0935009386 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x3 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-2:0 -8:0 -8:0  3 242R  $9x9x3 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C  Fractional Layer
C
19    1 0.0935009386   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
C Full Size Fuel Compacts
1     pz  0.02
2     pz  3.42     $ Fuel Height
3     px  0.02
4     px  5.11     $ Fuel Length
5     py  0.05
6     py  5.14     $ Fuel Width
C Clad Compacts
7     pz  0.0045
8     pz  3.4355
9     px  0.0045
10    px  5.1255
11    py  0.0265
12    py  5.1635
C Stacked Compacts (Fuel+Clad+Void)
```

```
13    pz  0.0
14    pz  3.440
15    px  0.0
16    px  5.130
17    py  0.0
18    py  5.190
C Window Surfaces
19    pz  0.000001
20    pz 10.319999
21    px  0.000001
22    px 46.169999
23    py  0.000001
24    py 46.709999
C
C poison plate+void
C
25    pz 10.351
26    pz 10.719
27    pz 10.75
C
C Fuel layers above poison plate
C
28    pz 10.7545
29    pz 10.77
30    pz 15.86
31    pz 15.8755
32    pz 15.88
C
C Windows
C
33   pz 10.750001
34   pz 26.139999
C
41   pz 26.14
C
C Fractional layer
C
42   pz 27.187688
C
C Reflector
C
43    pz -15.187688
44    pz  42.
45    px -15.
46    px  61.17
47    py -15.
48    py  61.71

kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 4.036e-7 94239.60c 1.954e-4
      94240.60c 1.702e-5 94241.60c 1.211e-6
      92235.60c 1.904e-6 92238.60c 1.252e-3  8016.60c 3.023e-3
       1001.60c 4.489e-2  6000.60c 4.412e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
```

```
      $ Plexiglas Reflector Composition
m1t   poly.01t
m2t   poly.01t
m3t   poly.01t
m4    29000.50c -0.98685  48000.50c -0.989e-2 30000.40c -7.0e-5
      50000.35c -0.25e-2  28000.50c -0.01e-2
      26000.55c -0.02e-2  25055.50c -9.0e-5    5010.50c -5.0e-5
      14000.60c -4.0e-5    8016.50c -0.019e-2  6000.50c -2.0e-5
```

```
CASE 1: (Table 13) 30.3 wt% PuO2; H:(U+Pu)=2.8 - Copper Poison Plate
C Cell Cards
C -Full Compacts (5.09 x 5.083 x 5.09)
C
1     1 0.078287928 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-Polystyrene
Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  Copper Poison plate (0.337 cm thick+0.073 cm void)
C
6     0           15 -22 17 -24 20 -25       imp:n=1
7     4 -8.913    15 -22 17 -24 25 -26       imp:n=1
8     0           15 -22 17 -24 26 -27       imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.083 x 1.339)
9     1 0.078287928 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x2 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-1:0 -8:0 -8:0  3 161R  $9x9x2 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C -Smaller Fuel blocks Above poison plates (5.09 x 5.083 x 1.384)
C
c 14     1 0.078287928 36 -37 3 -4 5 -6  u=5 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
c 15     2 0.08323   35 -38 9 -10 11 -12
c             #14              u=5 imp:n=1 $  3M-Clad
c 16     0     #14 #15           u=5 imp:n=1 $  Stacking Void
C 9x9x2 Fuel Blocks
c 17     0    34 -39 15 -16 17 -18      imp:n=1 lat=1 u=6
c            fill=-1:0 -8:0 -8:0  5 161R  $9x9x2 Fuel Blocks
c 18     0  40 -41 21 -22 23 -24 fill=6 imp:n=1
C
C  Fractional Layer
C
19    1 0.078287928   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
C Full Size Fuel Compacts
1     pz  0.014
2     pz  5.104     $ Fuel Height
3     px  0.014
4     px  5.104     $ Fuel Length
```

```
5     py  0.0455
6     py  5.1285     $ Fuel Width
C Clad Compacts
7     pz  0.002
8     pz  5.116
9     px  0.002
10    px  5.116
11    py  0.002
12    py  5.172
C Stacked Compacts (Fuel+Clad+Void)
13    pz  0.0
14    pz  5.118
15    px  0.0
16    px  5.118
17    py  0.0
18    py  5.174
C Window Surfaces
19    pz  0.000001
20    pz 15.353999
21    px  0.000001
22    px 46.061999
23    py  0.000001
24    py 46.565999
C
C poison plate+void
C
25    pz 15.3905
26    pz 15.7275
27    pz 15.764
C
C Fuel layers above poison plate
C
28    pz 15.766
29    pz 15.778
30    pz 20.868
31    pz 20.880
32    pz 20.882
C
C Windows
C
33   pz 15.764001
34   pz 25.999999
C
41   pz 26.0
C
C Fractional layer
C
42   pz 26.672178
C
C Reflector
C
43    pz -15.
44    pz  41.672178
45    px -15.
46    px  61.062
47    py -15.
48    py  61.566
```

```
kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 1.017e-5 94238.60c 2.288e-6 94239.60c 2.186e-3
      94240.60c 2.927e-4 94241.60c 5.875e-5 94242.60c 6.751e-6
      92235.60c 9.269e-6 92238.60c 6.162e-3  8016.60c 1.864e-2
       1001.60c 2.432e-2  6000.60c 2.660e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
      $ Plexiglas Reflector Composition
m1t   poly.01t
m2t   poly.01t
m3t   poly.01t
m4    29000.50c -0.9996  26000.55c -3.0e-5 30000.40c -1.0e-5
      12000.60c -1.0e-5  14000.60c -1.0e-5  8016.60c -3.0e-4
       6000.60c -4.0e-5
```

```
CASE 1: (Table 13) 30.3 wt% PuO2; H:(U+Pu)=2.8  - Aluminum Poison Plate
C Cell Cards
C -Full Compacts (5.09 x 5.083 x 5.09)
C
1     1 0.078287928 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-Polystyrene
Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  aluminum Poison plate (0.316 cm thick+0.074 cm void)
C
6     0           15 -22 17 -24 20 -25       imp:n=1
7     4 -2.692    15 -22 17 -24 25 -26       imp:n=1
8     0           15 -22 17 -24 26 -27       imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.083 x 1.339)
9     1 0.078287928 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x2 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-1:0 -8:0 -8:0  3 161R  $9x9x2 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C  Fractional Layer
C
19    1 0.078287928   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
C Full Size Fuel Compacts
1     pz  0.014
2     pz  5.104     $ Fuel Height
3     px  0.014
4     px  5.104     $ Fuel Length
5     py  0.0455
6     py  5.1285     $ Fuel Width
C Clad Compacts
7     pz  0.002
8     pz  5.116
9     px  0.002
10    px  5.116
11    py  0.002
12    py  5.172
C Stacked Compacts (Fuel+Clad+Void)
13    pz  0.0
14    pz  5.118
```

```
15    px  0.0
16    px  5.118
17    py  0.0
18    py  5.174
C Window Surfaces
19    pz  0.000001
20    pz 15.353999
21    px  0.000001
22    px 46.061999
23    py  0.000001
24    py 46.565999
C
C poison plate+void
C
25    pz 15.391
26    pz 15.707
27    pz 15.744
C
C Fuel layers above poison plate
C
28    pz 15.746
29    pz 15.758
30    pz 20.848
31    pz 20.860
32    pz 20.862
C
C Windows
C
33   pz 15.744001
34   pz 25.979999
41   pz 25.98
C
C Fractional layer
C
42   pz 26.437938
C
C Reflector
C
43    pz -15.
44    pz  41.437938
45    px -15.
46    px  61.062
47    py -15.
48    py  61.566

kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 1.017e-5 94238.60c 2.288e-6 94239.60c 2.186e-3
      94240.60c 2.927e-4 94241.60c 5.875e-5 94242.60c 6.751e-6
      92235.60c 9.269e-6 92238.60c 6.162e-3  8016.60c 1.864e-2
       1001.60c 2.432e-2  6000.60c 2.660e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
      $ Plexiglas Reflector Composition
m1t   poly.01t
m2t   poly.01t
```

```
m3t   poly.01t
m4    29000.50c -0.14e-2  13027.50c -0.9798  30000.40c -0.25e-2
      26000.55c -0.70e-2  24000.50c -0.15e-2 25055.50c -0.15e-2
      12000.60c -0.08e-2  22000.35c -0.15e-2 14000.60c -0.40e-2
```

```
CASE 1: (Table 13) 30.3 wt% PuO2; H:(U+Pu)=2.8 - Copper-cadmium Poison
Plate
C Cell Cards
C -Full Compacts (5.09 x 5.083 x 5.09)
C
1     1 0.078287928 1 -2 3 -4 5 -6  u=1 imp:n=1 $ (Pu+U)O_2-Polystyrene
Mixture
2     2 0.08323   7 -8 9 -10 11 -12
             #1                    u=1 imp:n=1 $  3M-Clad
3     0      #1 #2            u=1 imp:n=1 $  Stacking Void
C  9x9x3 Fuel Blocks
4     0    13 -14 15 -16 17 -18      imp:n=1 lat=1 u=2
          fill=-2:0 -8:0 -8:0  1 242R  $9x9x3 Fuel Blocks
5     0  19 -20 21 -22 23 -24 fill=2 imp:n=1
C
C  Copper-Cadmium Poison plate (0.386 cm thick+0.074 cm void)
C
6     0           15 -22 17 -24 20 -25       imp:n=1
7     4 -8.910    15 -22 17 -24 25 -26       imp:n=1
8     0           15 -22 17 -24 26 -27       imp:n=1
C -Fuel blocks Above poison plates (5.09 x 5.083 x 5.09)
9     1 0.078287928 29 -30 3 -4 5 -6  u=3 imp:n=1 $ (Pu+U)O_2-
Polystyrene Mixture
10    2 0.08323   28 -31 9 -10 11 -12
             #9               u=3 imp:n=1 $  3M-Clad
11     0     #9 #10           u=3 imp:n=1 $  Stacking Void
C
C 9x9x2 Fuel Blocks
C
12     0    27 -32 15 -16 17 -18      imp:n=1 lat=1 u=4
           fill=-1:0 -8:0 -8:0  3 161R  $9x9x2 Fuel Blocks
13     0  33 -34 21 -22 23 -24 fill=4 imp:n=1
C
C  Fractional Layer
C
19    1 0.078287928   41 -42 21 -22 23 -24    imp:n=1
C
20    3 0.1071  #5 #6 #7 #8 #13 #19  43 -44 45 -46 47 -48  imp:n=1
                             $Plexiglas Reflector
21    0 -43:44:-45:46:-47:48   imp:n=0 $ Outside of Critical Assembly

C Surface Cards
C Full Size Fuel Compacts
1     pz  0.014
2     pz  5.104     $ Fuel Height
3     px  0.014
4     px  5.104     $ Fuel Length
5     py  0.0455
6     py  5.1285     $ Fuel Width
C Clad Compacts
7     pz  0.002
8     pz  5.116
9     px  0.002
10    px  5.116
11    py  0.002
12    py  5.172
C Stacked Compacts (Fuel+Clad+Void)
13    pz  0.0
```

```
14    pz  5.118
15    px  0.0
16    px  5.118
17    py  0.0
18    py  5.174
C Window Surfaces
19    pz  0.000001
20    pz 15.353999
21    px  0.000001
22    px 46.061999
23    py  0.000001
24    py 46.565999
C
C poison plate+void
C
25    pz 15.391
26    pz 15.777
27    pz 15.814
C
C Fuel layers above poison plate
C
28    pz 15.816
29    pz 15.828
30    pz 20.918
31    pz 20.930
32    pz 20.932
C
C Windows
C
33   pz 15.814001
34   pz 26.049999
C
41   pz 26.05
C
C Fractional layer
C
42   pz 27.038182
C
C Reflector
C
43    pz -15.
44    pz  42.038182
45    px -15.
46    px  61.062
47    py -15.
48    py  61.566

kcode 4000 1 25 225
ksrc  23. 23. 5.0
c print
m1    95241.60c 1.017e-5 94238.60c 2.288e-6 94239.60c 2.186e-3
      94240.60c 2.927e-4 94241.60c 5.875e-5 94242.60c 6.751e-6
      92235.60c 9.269e-6 92238.60c 6.162e-3  8016.60c 1.864e-2
       1001.60c 2.432e-2  6000.60c 2.660e-2  $ Fuel Composition
m2     1001.60c 4.489e-2  6000.60c 3.110e-2 17000.60c 7.240e-3
      $ Clad Composition
m3     1001.60c 5.712e-2  6000.60c 3.570e-2  8016.60c 1.428e-2
      $ Plexiglas Reflector Composition
```

```
m1t   poly.01t
m2t   poly.01t
m3t   poly.01t
m4    29000.50c -0.98685  48000.50c -0.989e-2 30000.40c -7.0e-5
      50000.35c -0.25e-2  28000.50c -0.01e-2
      26000.55c -0.02e-2  25055.50c -9.0e-5    5010.50c -5.0e-5
      14000.60c -4.0e-5    8016.50c -0.019e-2  6000.50c -2.0e-5
```

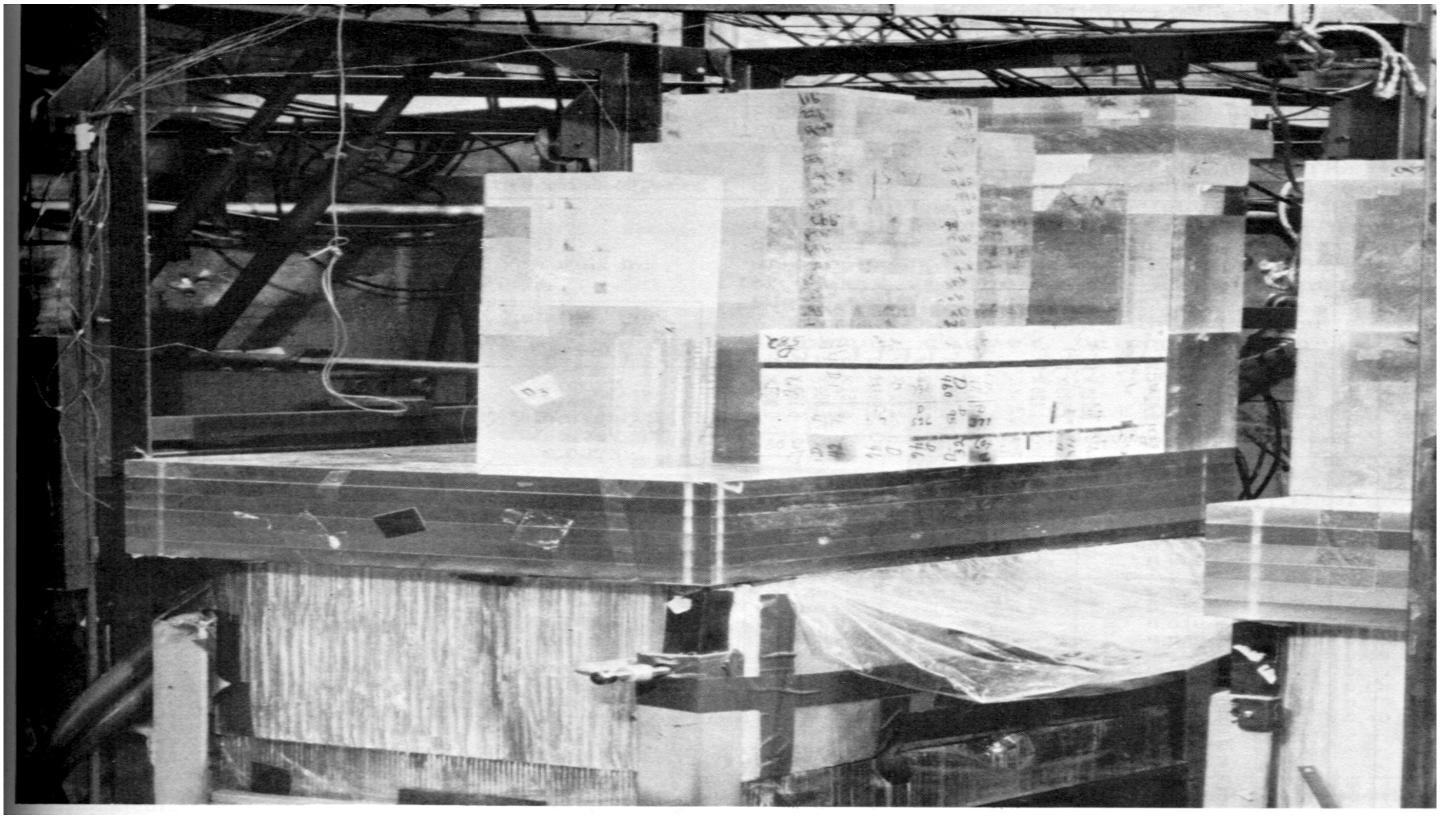

Fig. 1. Experimental assembly with part of the reflector removed.

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